Report of the Committee on

ENVIRONMENTAL HEALTH PROBLEMS

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE

Public Health Service

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ENVIRONMENTAL HEALTH PROBLEMS

to the Surgeon General

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LETTER OF TRANSMITTAL

Honorable LUTHER TERRY
SURGEON GENERAL
U.S. PUBLIC HEALTH SERVICE

DEAR DR. TERRY:

The Committee on Environmental Health Problems, established by you during August 1, 1961, was asked to develop long-range objectives for the environmental health program of the Public Health Service. To be given special attention were the problems of manpower, intramural vs. extramural research, and relationships with other Federal agencies.

The Committee completed its review in time to submit a report by the requested date, November 1, 1961. Herewith is the report. A summary of the conclusions and recommendations developed by the Committee is presented at the start of the report.

The Committee found the charge to be challenging and worthy of the most serious consideration. They will be pleased if their report communicates effectively their feeling for the magnitude and importance of the problems encountered in environmental health, and equally for the magnitude and importance of the steps which the Committee feels are involved in meeting these problems.

The Committee expressed its appreciation for the freedom of action given to it, for the willing and effective cooperation shown by the Public Health Service and its Bureau of State Services (Environmental Health), and for the services of the staff "resource representatives" selected from the personnel of the Bureau.

Respectfully submitted.

PAUL M. GROSS, *Chairman*

November 1, 1961

Foreword

A Committee on Environmental Health Problems was set up by the Surgeon General, U.S. Public Health Service, during August 1961 and met for the first time on August 23, 1961, in Washington. The charge to the Committee was based upon background developed within the Service and within other parts of the Government,[1] and was in summary as follows:

> The Committee is to develop long-range objectives for the environmental health program of the Public Health Service, including consideration of research and of the operating surveillance and control programs, giving special consideration to—
>
> (i) Manpower requirements.
>
> (ii) The roles of intramural and extramural research efforts.
>
> (iii) The relationships of the current and any proposed Public Health Service programs and facilities to those of other Federal agencies.
>
> The Committee is to deliver its final report by November 1, 1961.

After discussing its terms of reference at its first meeting, the Committee, acutely aware of the limited time for completing a large task, organized itself into a series of working Subcommittees. One group of Subcommittees was asked to study the current and projected programs of the Bureau of State Services (Environmental Health) and to provide an appraisal of the extent to which these programs are commensurate with the national need, and, should they appear inadequate, to make appropriate recommendations.

From its own prior understanding of the problems of environmental health, the Committee furthermore appointed a group of Subcommittees especially charged with a study of certain broader aspects of environmental health, not specifically identified with existing programs, as these related to the broad mission of the Public Health Service as a whole with respect to environmental health.

These Subcommittees were given wide latitude to engage the services of supplementary consultants with specialized competence in the relevant areas.[2] The reports of these Subcommittees appear as part of this volume.

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[1] See Appendix for the minutes of a meeting of the President's Science Advisory Committee ad hoc Panel on Environmental Health, May 18, 1961, and for a letter to the Secretary of Health, Education, and Welfare from the Deputy Director of the Budget, July 5, 1961.

[2] A listing of membership of Subcommittees and names of consultants appears in the Appendix.

The full Committee met on five occasions. It early determined that it could best fulfill its task by providing an analysis-review of the ongoing programs, an appraisal of the national needs in environmental health, an evaluation of the role of the Public Health Service in meeting these needs and of mechanisms by which these needs might be met, and a projection of broad but firm guidelines within which the future program of the Public Health Service might be developed. The Subcommittee reports were extremely useful to the full Committee as background against which this broad evaluation and projection were developed, but the Committee did not discuss all of the many and detailed proposals of the Subcommittees for purposes of their endorsement, modification, or rejection. Thus, the Subcommittee reports are presented as originally submitted to the Committee.

Included in the membership of the Committee[3] were persons who were also members of the standing advisory committees for each Division of the Bureau of Environmental Health. The Public Health Service itself provided much source information; furthermore, the staff of the Bureau, Division chiefs, and certain persons designated as resource representatives attended the meetings (other than executive sessions) of the Committee and Subcommittees.

[3] Designated on Committee membership list in the Appendix.

Contents

Report of the Committee on *ENVIRONMENTAL HEALTH PROBLEMS*

CONCLUSIONS AND RECOMMENDATIONS

The Committee has reviewed the problems which face this nation in the field of environmental health, particularly as they relate to the mission of the Public Health Service. The Service has established programs dealing with certain aspects of environmental health. However, the growth of our technology and the urbanization of American society have proceeded at a pace with which the Service's current programs are not prepared to cope. From its total evaluation of the problem, the Committee concludes—

> That a national need exists for establishment and maintenance of a vigorous and integrated effort to maintain controls over the human environment compatible with projections of change in both population and the environment itself.
>
> That the current "categorical" approaches represented by Public Health Service divisional programs are incapable of providing either (*a*) the necessary cognizance of combined multiple effects of environmental impacts or (*b*) the depth of effort required by individual divisional programs.
>
> That accommodation to the national needs in environmental health will require the establishment of a strong focal center adequately staffed and equipped to prosecute an effective and integrated program within the Public Health Service and to manage and coordinate a strong extramural research, training, and technical support program utilizing the available institutional resources of the nation.
>
> That an adequate legislative basis for a sufficient national program in environmental health does not exist at present.

One of the factors missing in the current efforts of the Service is a place at which primary responsibility for the control of environmental hazards comes to a focus. The Committee believes that immediate action should be taken to establish a center where the operational, research, and training programs of the Service in environmental health can be brought together. This is not to say that all of these functions of the Service should be centralized. On the contrary, many must remain close to the place where environmental hazards exist. However, the complexity of the problem requires that the Service's programs be designed with a total perspective toward the environmental health needs of the nation. This perspective can best be gained by a concentration of primary effort at a Center.

Therefore, the Committee makes the recommendations given in the following paragraphs:

1. PUBLIC HEALTH SERVICE RESPONSIBILITY IN ENVIRONMENTAL HEALTH

a. A major national effort, both governmental and nongovernmental, must be started if the environmental health problems resulting from the rapid growth of our highly technological civilization are to be adequately understood and if measures for their control and ultimate prevention are to be developed.

b. It is essential that the Federal Government assume leadership in the research and development effort required to supply knowledge and techniques to the discrete State and local agencies of all types engaged in prevention and control activities for alleviation of threats to health from the environment.

c. The focus of this national effort should be centered in the U.S. Public Health Service.

d. The leadership of the Public Health Service in the prosecution of a national environmental health program should utilize to the fullest possible extent existing university, industrial, governmental, and other research and technological capabilities through grants and contracts for research, demonstrations, and educational and training facilities. Extramural extensions of the Federal activity should comprise a major fraction of the total annual effort.

2. MANPOWER NEEDS

a. In undertaking a national program in environmental health, high priority should be given to the early initiation of adequate training programs for a wide range of personnel in the physical, biological, and social sciences. These efforts should include the strengthening of the divisional training programs, the creation of a new program of institutional grants for comprehensive environmental health training, and the continued support of the Service's short-term, internal programs. Funds in excess of $25 million are urgently needed to place these programs in full operation. Training effort of this magnitude will not create an imbalance with other scientific needs of the United States.

b. Strong efforts are needed to improve the status and income levels of environmental health scientists to permit Federal, State, and local health agencies to recruit needed personnel.

3. NEED FOR A NATIONAL ENVIRONMENTAL HEALTH CENTER

To implement effectively the development of a focal point within the U.S. Public Health Service for an enhanced and major national effort in environmental health, the Committee recommends the establishment of a Center for Environmental Health, which should include the following elements:

a. The headquarters activities of the present operational programs, including their administration, fundamental and applied research, and the national pool of resource personnel who supply information and assistance relating to control activities to the dispersed regional laboratories and instrumentalities operating wherever preventive and control measures are required.

b. The administrative headquarters of a unified environmental health grants program in support of fellowships, university training programs, university-related research projects, and demonstration grants to properly constituted agencies.

c. Appropriate facilities for the conduct of special training programs.

d. A new "Office of Environmental Health Sciences," independent of the divisional structure and with separate budgetary provision, consisting of scientific groups reporting to the scientist who is Director of the Office of Environmental Health Sciences. These groups, which would include biological, physical, and social scientists as well as mathematicians, would study basic problems in environmental health, undertake research on problems of common interest to the several divisions where desirable, provide central services in mathematics, statistics, data processing, information storage and retrieval, instrumentation and analytical laboratory procedures, etc., and provide advice and consultation to the Bureau of Environmental Health with respect to the overall direction of research. Beyond these functions, these groups would be specifically charged with the continuing responsibility for an overall purview of the entire field of environmental health.

4. LOCATION OF THE ENVIRONMENTAL HEALTH CENTER

The Committee recommends that the Environmental Health Center, including the Office of Environmental Health Sciences, be located in the Washington area.

5. PROGRAMS IN ENVIRONMENTAL HEALTH

a. The Bureau of State Services (Environmental Health) is presently organized into five working divisions, a structure which evolved as needs were recognized. It is recommended that, as soon as possible, each of the operating programs be strengthened materially with respect to staff and facilities, so as to accomplish their specific missions more effectively.

b. In view of the growing environmental health hazards resulting from rapidly changing technology and increasing population the country over, the Committee recommends the continuing development of regional facilities, supplementary to the Center, with adequate staff and facilities to conduct applications research, training and control activities appropriate to the regions involved.

c. The Committee recommends that as the Public Health Service moves toward the broader and more comprehensive effort here proposed, every effort be made to conserve the real strengths of the present program during the transition period and that intensive study be given to an optimal organization pattern for environmental health activities within the U.S. Public Health Service.

6. RELATIONSHIP OF PROGRAMS OF BUREAU OF ENVIRONMENTAL HEALTH TO THOSE OF OTHER FEDERAL AGENCIES

The broad scope of the problem of environmental health relates to virtually all of man's activities. It is to be expected, therefore, that the specific programs of the Bureau of State Services (Environmental Health) will frequently be contiguous with those of other agencies. It is imperative therefore that continuing effective liaison be maintained between the Bureau and other national, State, and local agencies so as to maximize the effectiveness of each while avoiding unnecessary duplication of effort.

7. NEED FOR LEGISLATION

a. The Committee recommends that the Public Health Service seek such legislation as may be required to establish a Bureau of Environmental Health with necessary authorization to conduct research, training and technical support activities, and to administer a broad program of extramural training, research, demonstration, and institutional support grants and contracts. Such authorization should be in addition to existing legislation governing operation of the divisional programs. It should be designed to supplement, rather than limit, the existing authority for divisional operation.

b. The Committee recommends that a statutory Advisory Council on Environmental Health be established to advise the Surgeon General on matters concerning policy, operations, research and training in the field of Environmental Health. This council would also serve as an advisory group for the Environmental Health Center, including the Office of Environmental Health Sciences.

Additional conclusions and recommendations, appropriate to the more detailed consideration of subject matter, appear in the Subcommittee reports.

The Committee's Review of Environmental Health Problems

General Background: The Effort Needed in Environmental Health

Resources Required for the Needed Effort in Environmental Health

Problems in Enviromental Health: Some Examples

General Background: The Effort Needed in Environmental Health

It has been stated that "the history of Public Health is . . . the story of man's endeavors to protect himself and his community against disease."[1] Its role today must be enlarged to include provision for the positive protection of the healthy against the adverse influences of a highly complex technological society which operates in evermore crowded communities.

"The past 50 years have witnessed an unprecedented overall trend toward the improvement of community health. Yet, this advance has not been uniform either within communities or between various parts of the world. A large group of countries generally underdeveloped in an economic and technological sense, and often new as independent nations, still have problems of preventable disease like those with which the countries of western Europe and the United States had to cope 75 to 50 years ago. . . . However, in economically more fortunate countries, such as the United States, Great Britain, and a number of others in Western Europe, the actual problems of community health are very different. . . . a whole set of newer problems has appeared, and it is with these that the community health program of the next 50 years will have to be concerned.

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". . . as the problems of communicable disease have declined in urgency, the community health program has broadened to include, wherever feasible, other elements and situations that may adversely affect the physical and mental well-being of people in the community. The widening horizons of public health have in recent years come to include such problems as accident prevention and mental health, as well as renewed emphasis on the control of the physical environment. With our expanding and changing industrial technology have come environmental alterations of increasing complexity. The once dominant problems of bacterially contaminated air, water, and food have now been replaced in considerable degree by chemical pollution, and the possible relation of this condition to the induction of cancer. Recent years have also brought about an increasing amount of discussion of the social and economic changes accompanying our expanding industrialism.

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[1] George Rosen, *A History of Public Health* (New York: MD Publications, Inc., 1958, p. 14).

"Recent years have brought an increasing awareness of the problem of atmospheric pollution. . . . In the same category is the new and important field of radiological health. . . . Then there is the problem of housing."[2]

As the nature of public health problems has changed over the years, local, State, and Federal governmental relationships with respect to meeting these problems have also been evolving to the present pattern. A former Surgeon General of the U.S. Public Health Service has noted that the Public Health Service is unique in the number and scope of its responsibilities, within the Federal Government and in the Nation, for environmental health.[3] He also portrayed in greater detail the scope of environmental health and the nature of the problems faced. Major program areas around which the Public Health Service is organized[4] are water supply and pollution control, air pollution, radiological health, milk and food protection, occupational health, and environmental engineering, including accident prevention and protection against solid wastes. The scope and details of these current problems are reviewed in the reports of the Divisional Subcommittees.

What factors will determine the nature and magnitude of an adequate national environmental health program in the future? Projections and predictions abound which purport to describe the growth of the American population in the remainder of this century, and the increasing fraction of older individuals in the population; the ever-increasing complexity of our technology; the development of new industries; and increasing reliance on nuclear power; the magnitude of the gross national product; the magnitude of the national agricultural effort; the introduction of new chemicals into our food, water, air, clothing, tools, and toys; the coalescence of huge metropolitan areas; altered means of communication and transportation; new modes of dress; increased leisure time and the demand for recreational facilities. The exact magnitude of any one of these projections may be open to question, but their trend is all too apparent. And from these technological, agricultural, economic, and social changes must, inevitably, arise a panoply of diverse problems in environmental health which must be solved before they are permitted to become acute.

Many of these problems have been identified and are presented in detail, in the Subcommittee reports. It is from consideration of the nature and magnitude of these problems that the broad guidelines of the necessary national effort in environmental health emerge. A few examples illustrating this principle are presented later in this report.

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[2] *Ibid.*, p. 486–489.

[3] "Environmental Health." The Surgeon General's Report to the House Committee on Appropriations. U.S. Public Health Service, Department of Health, Education, and Welfare, January 1960.

[4] See Appendix for statement of present organization.

It is apparent from these examples, and from many others cited in the Subcommittee reports, that there are numerous functions, such as epidemiology and biostatistics, which are common to environmental health programs. Some of these functions are even now ongoing in current programs, albeit at an inadequate level. One approach to a strengthened national environmental health program would be simply to expand each of the ongoing programs and staff each so as to permit apparently adequate performance in all desirable functions. Indeed, this has been the history of the U.S. Public Health Service program based upon specific "categorical" legislation. But the Committee is strongly of the opinion that this is not a sound basis of an adequate long-range national program in environmental health. Ultimately, this must result in unnecessary duplication of effort while completely failing to provide an integrative synthesis of those facets of the various environmental health problems which are held in common. In consequence, the Committee recommends the creation of a comprehensive Environmental Health Center.

As presently envisioned, the Center would contain the following:

1. The headquarters activities of the present operational programs, including their administration, fundamental and applied research, and the national pool of resource personnel who supply information and assistance relating to control activities to the dispersed regional laboratories and instrumentalities operating wherever preventive and control measure are required.

2. The administrative headquarters of a unified environmental health grants program in support of fellowships, university training programs, university-related research projects and demonstration grants to properly constituted agencies.

3. Appropriate facilities for the conduct of special training programs.

4. A new "Office of Environmental Health Sciences," independent of the Divisional structure and with separate budgetary provision, consisting of scientific groups reporting to the scientist who is Director of the Office of Environmental Health Sciences. These groups which would be specifically charged with the continuing responsibility for an overall purview of the entire field of environmental health, would include biological, physical, and social scientists as well as mathematicians, free to study basic problems in environmental health and undertake research on problems of common interest to the several operating units where desirable, while providing central services in mathematics, statistics, data processing, information storage and retrieval, instrumentation and analytical laboratory procedures, etc., and providing advice and consultation to the Bureau of Environmental Health, with respect to the overall direction of research.

It is the Office of Environmental Health Sciences, in particular, which will make possible an integrated national environmental health program while avoiding unnecessary duplication of effort. It offers a new method of attacking those facets of environmental health problems which are common to many of the operational programs. By its integrated approach it can identify and appraise environmental health problems which are not under consideration. At the same time it can

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develop protection criteria which are based on *all* aspects of the environment.

The Committee considers that one of the strongest arguments for the Center is that it provides a focal point for the entire national environmental health program. By locating the operational programs contiguous to each other and to the Office of Environmental Health Sciences, the following advantages accrue:

1. There will be available to all units central facilities and personnel for such functions as toxicology, epidemiology, applied mathematics, instrumentation, systems analysis, data processing and information storage and retrieval.

2. Each operational unit will have available to it a large pool of scientific specialists and experts for advice and consultation. By the same token it provides an effective device for cross-fertilization both as between operational programs and between disciplines.

3. Clearly such a Center provides a sounder and more comprehensive structure for the conduct of both intramural and extramural training programs.

4. It will minimize unnecessary duplication of effort in both fundamental and applied research programs.

5. It will make possible within the Center a coordination of the efforts of the individual operating programs and will provide a base for more effective relations with other related institutions both within and without the government.

Clearly, the success of the Center is entirely contingent upon the caliber of its scientific personnel. It may well be necessary to take extraordinary measures with respect to salary structures, working conditions, etc., in order to recruit and hold top-level scientists.

The total environmental health program of the Public Health Service should be so designed and funded as to provide for fullest possible utilization of the Nation's existing scientific manpower, research capabilities, and regulatory agencies. The Committee believes that this objective can be achieved through a well-planned system of grants and contracts for research, demonstration, training and program operations, managed from a national Center.

While a substantial proportion of the entire program should be developed extramurally, the effective employment of such dispersed national resources will require the existence of an intramural activity in depth and breadth sufficient to evaluate, review, and maintain intelligent working relationships with the external programs. Competence and facilities for such management, and for translation of the resulting findings into control practice, will best be developed within a unified Environmental Health Center.

With the need for and development of a Center identified as the major focal point for environmental health within the Public Health Service, the role of regional and field stations and facilities must be considered.

It is the Committee's opinion that such field stations and laboratories can best serve a particular environmental health program and obtain fundamental and applied data relating to some specific limited projects (such as shellfish or saline water problems).

If a Center of the type recommended is developed, considerations arise as to choice of location for such a center. In addition to the present operational programs, it is essential to have top-level personnel available drawn from the natural and social sciences and mathematics under the Office of Environmental Health Sciences. This group would perform functions of the types delineated in the first four Subcommittee reports.

Beyond the performance of such functions, this group would provide a necessary internal core of scientific leadership whose responsibility would be to provide overall guidance and direction to the major effort necessary in relation to environmental health problems. No present program of governmental health activity exceeds in scope and complexity that which will be involved in environmental health.

Cogent arguments relating to the shortage of and competition for top-level scientific talent can be made,[6] which appear to have considerable validity and which point to a more segmented development of strong scientific leadership groups located near and working with major university centers.

The Committee carefully weighed and discussed the import of these arguments as they related to their concept of the 5- to 10-year needs for manpower, facilities, and resources, reasonably commensurate with the level which would be required for a major effort in solving environmental health problems. There is a need for central focus and leadership in a Public Health Service environmental health program of the type envisaged. This program must be related to other Public Health Service activities as well as government agency programs related to environmental problems.

Immediate planning must be undertaken for the staffing, organization, and facilities of central environmental health groups within the Public Health Service. Even if such planning proceeds rapidly, the benefits that the Committee envisages from focal centralization of this type will probably not be realized in less than 4 years.

After examining all the operational, regulatory, and research aspects of the proposed and existing programs in environmental health, the Committee recommends that the Environmental Health Center, including the Office of Environmental Health Sciences, should be located in the Washington area. Our reasons for this are based on the necessity for the regulatory and operational aspects of the environmental health program to be contiguous. Similarly, the operational and research programs in environmental health can function much more effectively if they are in close contact with one another.

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[6] See the minutes of a meeting of the President's Science Advisory Committee ad hoc Panel on Environmental Health, in the Appendix to this report.

Similarly, there are many Public Health Service interdepartmental problems which arise that call for frequent and interdisciplinary review. Proximity to the National Institutes of Health with the Clinical Center and the National Library of Medicine is essential for research and access to clinics and patients. Another cogent reason is the need for contact with many other Government agencies and departments working in ancillary fields in environmental health such as the Defense Department, Interior Department (Bureau of Mines), Commerce Department (Bureau of Standards and Weather Bureau), and the Atomic Energy Commission.

An example concerns the relationship of the Division of Radiological Health to the Atomic Energy Commission. The Subcommittee considering the radiological health program believes that this problem should be dealt with, as soon as possible, by the creation of a Radiation Hazards Research Liaison Committee composed of the Chief of the Division of Radiological Health, Public Health Service, an appropriate representative of the Atomic Energy Commission, and such other personnel from the two agencies as may be needed. This committee would meet at frequent intervals to review Public Health Service and Atomic Energy Commission radiation research programs and to plan and devise ways and means whereby the resources of one agency may be used to advance fully the programs of the other. This committee would review budgetary proposals in all areas of common interest before annual budgets are submitted for consideration to the Bureau of the Budget. Although a Radiation Hazards Research Liaison Committee of the type set forth here may not resolve all of the questions of program duplication, it should go a long way to resolve misunderstandings concerning the content of Atomic Energy Commission and Public Health Service programs in radiological health and will assure Congress that the full resources of both agencies are being brought to bear on the radiological problems of the Nation.

Resources Required for the Needed Effort in Environmental Health

It is self-evident from the above discussion that the character and magnitude of the effort required, not only in the natural and social sciences but in medical, public health, and engineering practice, demands new resources and application of these resources in new ways.

While the Committee, as a result of studies and discussion, felt that it had achieved comprehension of the broad nature and magnitude of the effort and resources which will be needed in the next 5- to 10-year period, it did not feel that these needs could be projected in any great detail with much real validity. Obvious reasons for this were the severely limited timespan of the Committee's operation (about 2 months), and the important fact that the conditions encountered in the environment which affect health are changing rapidly and all too often unpredictably. An excellent example of this unpredictability is found in the almost overnight change in the dimensions of the fallout problem because of the recent long series of Russian bomb tests.

With these reservations as to delineation in any detail of a future program, the Committee in the following summation gives its best estimates of the nature, order of magnitude, and priorities in time which it believes will be required to develop soundly the major national effort in environmental health which should be carried forward.

Development of the program outlined in this report will require a high-quality central scientific staff and the provision of facilities and supporting resources. In view of the present large deficiency of resources in relation to environmental problems, a more rapid buildup of scientific staff in the immediate years ahead than in the ensuing years is considered necessary. For the central scientific staff a growth from the present core of 125 to approximately 300 by 1965 is recommended. By 1970 the central scientific staff needed is estimated at 450.

Based on these projections for scientific personnel, and applying ratios and costs for supporting staff and resources from Government and industrial experience, the annual operating cost of the Environmental Health Center is expected to be $50 million in 1970.

For all field operations, including regional laboratories and stations, field studies, decentralized training, basic data collection and analysis, regulatory and technical assistance activities, a like cost is foreseen. Thus, total intramural operations by the Public Health Service for environmental health activities is projected at $100 million by 1970.

Research and training are expected to account for at least 50 percent, $50 million, of this total.

The extramural program of grant support for training and research, demonstrations, and State and local program development should be much larger than the intramural operations in order to provide the required scientific and technical manpower and for the necessary acceleration of the total national effort. A ratio of extramural support to intramural research and training operations of 5 to 1 is recommended for the period to 1970. This would amount to $250 million and place the total requirement by 1970 at $350 million.[1] The Committee believes these estimates to be reasonable and the program goals to be achieved with these resources attainable.

Resource needs are in terms of manpower, facilities, and budgetary support, and those relating to scientific manpower for the program are the most important. Obviously without the availability of a sufficient number of natural and social scientists of the varied levels of ability and experience and the much larger numbers of technically trained ancillary groups needed for the research implementation, survey and control aspects of a large and broad effort in environmental health such a program cannot be effective.

The future manpower requirements of a national environmental health program can be broadly classified into subprofessional and professional categories:

1. *Subprofessional.*—The need for large numbers of individuals with varying levels of experience, ability, and specialized training who will man the operational, control, and surveillance units concerned with environmental health of county, city, State, and industrial health departments and groups.

By and large, the training techniques needed for this subprofessional type of training are known and effectively carried out through a variety of short-term courses and seminars and inservice types of activity presently largely centered in the U.S. Public Health Service. As is pointed out in the report of the Subcommittee on Manpower Resources and Training (table III), an average of some 2800 individuals were trained per year in this way in the period 1956–61. The estimate of the annual training needs in this category by 1965 is for the training of some 10,000 such individuals and several times this number annually by 1970.

Thus training of this type will be limited by the availability of in-house instructional manpower for such short-term in-house activities, by space and facilities, and by budgetary support. This is a large and somewhat difficult task in the Committee's view, but one which can be accomplished if there is proper appreciation of the need for adequate staffing, facilities and funds commensurate with numbers of trainees to be handled.

2. *Professional.*—In the area of scientific and professional manpower availability and training for environmental health needs, the problem is quite different. This is in large measure a segment of the overall national problem of providing an adequate supply of highly trained scientists, engineers, physicians, and allied professionals sufficient to meet the country's growing demands.

[1] Excluding grants for construction of public works such as those for municipal waste treatment.

Studies of the professional scientific manpower problem with which the Nation is faced have been made by many groups so that discussion of this problem in any detail will not be entered into here, except to the extent that it is relevant to the environmental health problems.

For this purpose, reference is made to one of the most recent of these studies made by the National Science Foundation.[a]

Some data from this report will give a background perspective against which to appraise the environmental health manpower problems at the scientific and professional level. This report (pp. 18–19) estimated that there were 1,400,000 scientists, engineers, and teachers of science in the United States in 1960–61, this number included 12,000 M.D.'s doing research, but not all M.D.'s. Of this total but not including any M.D.'s, there were 87,000 scientists and engineers who were Ph. D.'s or Sc. D.'s. By 1970, according to the National Science Foundation estimate (p. 14), this figure of 87,000 should reach 168,000 Ph. D.'s and Sc. D.'s, or just about double.

With this background it is of interest to look at the figures for manpower in this scientific and professional category estimated to be engaged in environmental health activities in the Public Health Service in 1962 (Subcommittee on Manpower Resources and Training Report, Table I). For 1962 the estimate is 125 which is probably a reasonably reliable figure. If allowance is made for the differences between 1960–61 and 1962, it would seem fair to say the environmental health program needs in the Public Health Service in 1960–61 accounted for about 0.15 percent of the total national pool of 87,000 individuals in this category in 1960–61.

If the projections of Table I (Report of Subcommittee on Manpower Resources and Training) are reasonably valid, the Public Health Service requirements for professional scientific Ph. D.- and Sc. D.-trained manpower would rise to about 0.24 percent of the national pool in 1965, and to about 0.27 percent of the total national pool of 168,000 estimated to be available by 1970. These increases in withdrawal from the national pool for the Public Health Service staffing and their rate of increase in the next 10 years do not appear to the Committee to be too difficult of achievement nor alarming in their potential effect on nationally available manpower resources of this type. It should be pointed out, however, that there are some individual disciplines vital to the environmental health program in which marked expansion of training efforts will be necessary to fulfill the manpower needs. (See, for example, the Report of the Subcommittee on Pharmacology, Toxicology, etc.)

The total national scientific manpower requirement is much more difficult to estimate or project to the future. As noted above, the total scientific manpower pool for the Nation was estimated to be about 1,400,000 in 1960–61 (National Science Foundation report). Of this

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[a] National Science Foundation, "Investing in Scientific Progress 1961–70," Washington, D.C., 1961. (Report NSF 61–27.)

total, approximately 2 percent were engaged in environmental health activities[8] in 1961. The best projection of this percentage engaged nationally in environmental health activities in 1970 available to the committee is about 2.6 percent.

If this situation is broadly as stated, it has important implications for training needs at the graduate and engineering school levels, for the types of personnel needed:

1. The Department of Health, Education, and Welfare through the Public Health Service should actively support moves of other agencies (especially the National Science Foundation) to increase the national pool of scientists and engineers at the Ph. D. or equivalent level.
2. Through suitable conferences, seminars, and educational campaigns aimed at the graduate and engineering schools, the Public Health Service should point out the need, career opportunities, and intellectual challenge that the developing program in environmental health presents to Ph. D.'s and engineers in the wide range of contributing disciplines from mathematics, physics, and chemistry through biology, the premedical sciences, the earth sciences, and the relevant social sciences.
3. The research grants programs, especially those with graduate and engineering student training components, should be liberalized and broadened so as to actively involve more university investigators in the broad range of disciplines mentioned. Such wider involvement will prove one of the most important ways of orienting the thinking in the average engineering or graduate school toward the existing and emerging problems of environmental health and their challenge to students interested in careers in basic or applied research.

[8] This includes individuals in water and sewage works fields, in State and local health departments, teaching, research, public works, and in private and consulting practice.

Problems in Environmental Health: Some Examples

Example 1

THE PROBLEM OF AIR POLLUTION

Polluted air is a product of industrialization, urbanization, and human mobility, all of which will continue to increase rapidly in the years ahead. The concern with air pollution in urban areas relates to the emission of a variety of gases and particles, often followed by secondary reactions in the air. Recent evidence has made clear that all metropolitan areas have limited air resources. Even in areas where the meteorological conditions are favorable, air resources are being heavily utilized, and in some cases acceptable concentration limits have been exceeded. Basically, the total potential quantity of pollutants discharged to the atmosphere relates to two factors—the size of the population, and the per capita use of energy and materials.

That air pollutants can affect health has been demonstrated conclusively in several disasters in which many people were made ill and human deaths occurred. Among the more dramatic are the episodes in Donora, Pa., where 20 people died; and in London in 1952, when the normal mortality rate was exceeded by 4,000 additional deaths in a single week. A growing body of circumstantial evidence testifies that long-term low-level air pollution exposures can contribute to and aggravate chronic diseases which affect large numbers of our population. Economic damages to crops, animals, and structures are manifest—totaling billions of dollars annually.

The national application of what we now know about controlling air pollutants is unsatisfactory.

Procedures for the identification of specific compounds contributing to air pollution are largely tedious and expensive, and few laboratories are equipped to undertake such determinations. The chemical composition and physical state in which air pollutants occur are of increasing importance; for example, particle size as it relates to the physiology of the pulmonary system. For only a small number of the simpler gases such as sulfur dioxide, hydrogen sulfide, and carbon monoxide are analytic methods available and for these, simpler and less expensive procedures are desirable. There is need to measure at frequent intervals such substances as aldehydes, olefins, polynuclear aromatic compounds, and others, the number of which will be multiplied many times over in the years ahead.

The history of technology indicates that the patterns and the types of these emissions and sources will change in the future. However, the precise direction in which these changes will occur cannot be predicted.

In all urban areas motor vehicle emissions are in varying degrees already a significant source of pollution. The interrelationship between hydrocarbons and oxides of nitrogen when photochemical air pollution (smog) is produced in the presence of sunlight needs futher elucidation. The role of particulates in the formation of smog and the mechanism by which smog irritates the eyes and causes damage to vegetation will require further research.

The formation of ozone and other oxidants, associated with undesirable biologic effects and characteristic of photochemical smog, is known to result from reactions among gases at concentrations of a very low order at which they are relatively innocuous. Control of such secondary reactions requires identification of the participating primary pollutants and determination of the relative importance of each in the photochemical processes. Changing technology necessitates fundamental studies in photochemistry. The identification of primary reactants associated with secondary toxicants will facilitate the development of more effective and less costly controls. Adequate knowledge of the intermediate and secondary products must be acquired before their biologic effects can be fully assayed and understood.

A fundamental scientific problem is that of establishing relationships between meteorological parameters and dispersive capacities. Objective determination of reasonable emission rates and the degree of control required for single sources in a given community are dependent to a considerable extent on research in this area.

Studies are required that will provide a sound basis for future estimates of national losses from (1) damage to crops and livestock, horticultural products, and other types of vegetation; (2) corrosion of materials and soiling of surfaces; and (3) interference with ground and air transportation. Economic losses due to the expenses of illness and diminished productivity resulting from air pollution are unknown, as are the effects of air pollution upon the general well-being of healthy individuals.

It is already recognized that mortality surveys, by themselves, are not sensitive enough to reflect the subtle influence of minute concentrations of toxins in the atmosphere. The use of morbidity data for this purpose has been hampered by the fact that concurrent air sampling and usable morbidity data have been almost nonexistent. Any leads that indicate differences in morbidity—or less probably, in mortality—must be followed in an attempt to relate health effects to a specific pollutant or class of pollutants. To complicate the problem, traditional statistical methodology requires improvement by incorporation of better methods for analyzing the vast quantities of data that accrue from long-term observations. Too, the problems of measuring morbidity have required development of new techniques. Assessment of illness due to air pollution requires more, generally, than the usual medical questionnaire or routine physical examination. Some objective measures of physiological processes and their changes have been developed and more are required.

Since the respiratory tract is the portal of entry for inhaled substances, an intensive effort has been directed toward pulmonary function testing as an indicator of the physiologic effects of air pollutants. Procedures that had previously seemed adequate for day-to-day followup of patients responding to treatment, for single observations in the routine diagnostic workup of the clinic, and for the measurement of gross functional aberrations, have not proved suitable for use in the field.

Until pulmonary function testing is standardized, epidemiologic studies that rely on such measurements as an index of physiologic changes will have little comparability. Studies, now underway, to assess methods and evaluate techniques must be intensified. Research on health effects has been mainly an attempt to associate individual pollutants with a group of diseases. Research must also be directed toward tissues other than those with which pollutants make first contact.

We know that human panels exposed to irradiated mixtures of individual hydrocarbons and nitrogen dioxide experience eye irritation. The problem of what constituents in smog are actually responsible for this biologic manifestation will probably not be resolved until an objective test—perhaps an electrophysiologic technique—can be devised, that will permit precise measurements, reflect sensory components, and eliminate psychic influences. Apparently a number of factors in the original mixture determine the occurrence and the degree of eye irritation. The reaction products mainly responsible are thought to be formaldehyde, acrolein, and peroxyacyl nitrate.

Because a number of statistical studies have indicated a higher incidence of lung cancer in urban than in rural areas and because such well-known experimental carcinogens as benzpyrene have been found in community air, the finger of suspicion has been pointing for some time to atmospheric benzpyrene and related aromatic polycyclic hydrocarbons as at least contributory etiologic agents in lung cancer. Certainly it does not seem possible to attribute the alarming increase in lung cancer incidence to smoking alone. A growing body of experimental evidence incriminates atmospheric hydrocarbons.

All organic fractions of airborne particulate matter from U.S. cities are capable of producing local skin tumors after subcutaneous injection in mice, and chronic low-level exposure seems to be more injurious than brief heavy exposure. Animals exposed to both the virus of influenza and inhalation of ozonized gasoline develop true epidermoid cancers in the lung. The applicability of such evidence to human disease is as yet uncertain, but the research leads now developed should be followed up intensively.

A causal relationship between air pollution and the group of chronic obstructive ventilatory diseases that appear to be increasing in incidence in this country has not been definitely established. But isolated research findings that asthmatic attacks occur more frequently on days with smog damage to plants, that emphysema patients improve on breathing filtered air after several days' exposure to smog, and that the daily course of patients with chronic obstructive respiratory disease fluctuates with certain pollutant levels strengthen the conviction held by many experts in the field that these indicated relationships may be important leads to definitive knowledge—leads that should be vigorously pursued.

An integrated research effort, utilizing laboratory techniques, statistical methods, and the epidemiologic approach, along with intensified chemical, meteorological, physical, and engineering studies, provides the hope for a solution to these problems. Alone, no one method can hope to accomplish this aim.

Example 2

THE PROBLEM OF WATER POLLUTION BY INDUSTRIAL WASTES, INCLUDING RADIOACTIVITY

Organic Industrial Wastes

Studies and surveys by the Public Health Service in recent years indicate that the amount of organic industrial wastes (treated and untreated) now going into the Nation's watercourses is about double the amount of municipal wastes; that is, a "population equivalent" of 150 million persons.

The increase in organic industrial wastes since 1900 and estimated amounts in 1970 and 1980 are shown in the following table:

Increase in Organic Industrial Wastes

Year	Index of [1] industrial production	Population equivalent discharged (in millions)
1900	20	15
1920	40	49
1940	66	75
1950	113	100
1959	159	150
1970	[2] 246	[3] 210
		[4] 50
1980	[2] 367	[3] 310
		[4] 80

[1] Based on 1947–49 = 100; from Federal Reserve Board Index of Production, 1900–1959.

[2] Estimated by National Planning Board, "National Economic Projections," from annual growth rate of 4.1 percent.

[3] Assumes estimated percent rate of industrial waste treatment construction will continue.

[4] Assumes 80 percent removal of population equivalent by treatment will be obtained.

By 1975, industry is expected to more than double the production attained in 1950. This would indicate a possible doubling of present organic wastes by 1980 which may be tempered by certain technological and engineering developments, and the extent to which industry met its responsibilities for satisfactorily treating its own wastes.

These data show that substantial reductions in industrial organic pollution loads can be effected by waste treatment if industry can attain 80 percent removal of "population equivalents." Such reductions will require a greatly accelerated construction program and the development of new treatment processes, because fully effective measures have not yet been developed for many organic industrial wastes. The table also indicates the pollution situation that will exist if the present rate of treatment construction continues or if treatment processes are not found which can approach 80 percent removals.

Inorganic Industrial Wastes

There have been large increases also in the discharge of the "common" inorganic industrial wastes (principally of mineral and chemical origin). These wastes have polluting effects different from organic wastes and cannot be measured in terms equivalent to sewage.

Inorganic wastes originate from metal pickling, acid mine drainage, metal finishing, chrome tanning, and from the mining, processing, and manufacture of a wide variety of metal and chemical products. Also organic wastes often contain substantial amounts of inorganic constituents. Production figures for the industries discharging inorganic wastes show that the amounts are very large and the index of industrial production indicates they are increasing rapidly. Fully effective treatment processes have not yet been developed for many inorganic industrial wastes.

New Chemical Wastes

The chemical industry is the fastest-growing segment of American industry and some of its growth is reflected in the following table:

Leaders in Synthetic Organic Chemical Growth[1]

[Production in million pounds]

	1928	1938	1949	1958
Plastics	20	130	1,486	4,518
Synthetic rubbers	0	5	1,173	2,202
Synthetic detergents and other surface-active agents	---------	15	875	1,335
Nylon and other non-cellulosic fibers	0	0	66	480
Insecticides and other agricultural chemicals	0	8	97	589
Medicinals	4	13	43	101

[1] Source: *The Chemical Industry Facts Book 1960–61 Edition.*

Synthetic dyes, adhesives, surface coatings, solvents, and many other industrial, agricultural, and commercial products have also registered substantial production growth.

A major new water pollution problem has emerged with the growth of the synthetic chemical industry. Wastes from this industry are reaching watercourses in increasing numbers and amounts each year, both from the use of the manufactured products and from wastes produced during their manufacture. These chemicals reach the stream by way of municipal and industrial sewers, land drainage, or indirect application of chemicals to the stream, lake, or impoundment.

Wastes and products originating with the synthetic chemical industry are extremely complex in their composition and behavior. Some cause tastes and odors and a large number are highly toxic to fish and aquatic life. Many do not respond to biological treatment and persist in streams for long distances. We do not know how to detect most of these compounds in water, or how to treat them in waste effluents or remove them from water. Most important, we do not know the long-range toxic effects of these new synthetics on man.

The new synthetic wastes are present in low concentrations in most waters for the moment, but the industry is continuing its rapid growth. Each year we are finding increasing amounts of these wastes at our water supply intakes, and since neither our sewage nor our water treatment plants remove them, they are reaching the consumer in increasing amounts.

Radioactive Wastes

Still another new water pollution problem of serious potential has emerged in recent years from the growth of nuclear technology. The presence of radioactive materials in our streams is adding another new contaminant to the Nation's water supply that has serious health implications if not controlled.

Pollution by radioactive materials from nuclear weapons testing is well known. Waste products from mining and refining radioactive minerals, such as uranium or thorium, may be discharged into streams. Waste products from refined radioactive substances used in power reactors or for industrial, medical, or research purposes require adequate control measure to prevent dangerous concentrations from escaping to streams.

Radioactive materials are characteristic of a newly developing class of water pollutants that are subtle in effect and not detected by the usual stream pollution analyses. Even so, their control is a problem in principle no different than the control of the more common types of wastes, and in this instance the only practical means of protection against human exposure to radioactive wastes in water is treatment and control of such wastes at their source. Since radioactivity exposure effects are cumulative, these controls must be effected in light of total human exposure in the environment.

HEAT

"Heat pollution" is becoming an increasing matter of concern to water pollution control administrators and conservationists. Since 1900, electric power production has approximately doubled every 10 years and is expected to double again in 1970. Unless controls are effected, this could mean an increase in "heat pollution" of more than 100 percent in the next 10 years. This does not even take into account the increase in water temperatures that will accompany the increase in impoundments for hydropower, irrigation, navigation, flood control, and water-supply purposes.

In areas of population and industrial concentration, such an increase in "heat pollution" in lakes and streams could have a profound effect on the ability of the waters to assimilate even well-treated wastes, or to serve increasing demands for recreational and fishing opportunities.

The following example illustrates the potential of heat as a pollutant. In the Illinois River near Chicago, the effect of thermal pollution from steam-electric plants is reported to be equivalent to doubling the organic waste load from the Chicago area, that is, from the present "population equivalent" of more than 1 million to more than 2 million.

EVALUATING THE POLLUTIONAL EFFECTS OF WASTES

With increasing frequency, control agencies are faced with water-pollution problems that involve new types of wastes whose impact on water uses and on human health cannot now be fully evaluated. Toxicological and epidemiological studies are essential to assessment of the public health importance of new wastes, and a protocol of effective research must be established.

Predicting Toxic Effect of a Waste on Aquatic Life: Data on which to base the environmental requirements of aquatic life are needed and must be developed through research. These requirements, which include such items as temperature, dissolved oxygen, carbon dioxide, and pH, should be based on scientific fact so that reliable criteria can be developed for managing water quality to restore and maintain a suitable aquatic environment. These criteria may also prove valuable in managing water quality for other uses.

Predicting Impairment of Water Treatment Processes by a Waste: A waste may impair water treatment processes by retarding flocculation, increasing chlorine demand, or through other effects. Reliable predictive methodology for such effects should be developed to guide water purification practices.

Predicting Effect of a Waste on Palatability: Objectionable taste and odor of drinking water is the most common manifestation of industrial pollution which is difficult to identify and trace. Development of effective methods for predicting a waste's taste and odor potential, and for identifying and tracing the substance responsible is needed.

Epidemiological Studies: Current methods of disease reporting seem to indicate that waterborne infection is infrequent and not a major route of disease dissemination; yet there remain troublesome endemic occurrences of diarrheal diseases, infectious hepatitis, and poliomyelitis not explained by "contact" spread. More refined techniques must be developed to reveal the less obvious cause and effect relationships.

Few systematic appraisals of the health effects of pollutants have been made other than traditional investigations of infectious diseases. We need to know much more of the effects of mineral salts, organic compounds, domestic and industrial waste components, as well as the etiological agents of infectious disease; also, we need to know the effects of deficient trace elements, molybdenum, selenium, vanadium, nickel, zinc, and copper.

Evaluating Toxic Effect of a Waste on Humans: Many of the waste substances now entering water supplies are known to be toxic in sufficient concentrations, but there are many others of unknown toxicity. Detailed studies of the toxicologic effects of individual chemicals and mixtures of chemicals are time consuming and costly, and it is hazardous to predict toxicity potentials of mixtures on the basis of individual components, especially if they vary in specific biological, physical, and chemical properties. Increased attention must be directed to the development of rapid screening tests for waste materials which may carry toxicity hazards in the area of water supply. The fundamental studies in toxicology and the related sciences required by the development of such tests can probably be best conducted in concert with other programs having similar interests and competency.

Treatment of Wastes

The important need for the development of new methods for treating wastes more effectively and cheaply is not being adequately met. Also, since conventional treatment methods remove only 40–60 percent of pollutants in wastes, there is a real need to develop entirely new processes which will approach actual purification. This is becoming a particular requirement for large cities and in areas of population and industrial concentration where treated effluents are too great a burden on receiving streams, and where the same water must be used several times to meet needs.

Improvement of Biological Systems of Waste Treatment: Improvement of methods for selecting and rapidly adapting micro-organisms to metabolize new organic compounds will increase the effectiveness of present biological treatment systems. Whether organisms can metabolize a given compound or not will provide regulatory bodies and industry with information to determine whether a waste is acceptable in a waste treatment system and the receiving water.

Treatment of Wastes in Stabilization Ponds: The waste stabilization pond is a recent important low-cost treatment development. Pond design presently is on an empirical basis and understanding of the natural factors (solar energy, respiration, wind, etc.) involved in the stabilization processes is too fragmentary to properly evaluate their effect on design criteria. Additional knowledge is needed on effects of hydraulic loading and of waste character on pond efficiencies in removing pathogenic organisms.

The Application of Physical-Chemical Principles to Separation of Soluble Solids: In the face of a naturally fixed water supply, the growing needs of expanding population and industry are requiring that a given water supply be used more and more intensively. Eventually reuse will become an accepted and necessary practice in most densely populated areas. The development of satisfactory waste treatment techniques which will provide for repeated reuse of the receiving stream represents a major, challenging research problem.

Because present methods of waste treatment, stream sanitation, and water purification cannot remove many of the new pollutants and only a fraction of the older ones, a major research program has been undertaken to evaluate physical-chemical principles applicable to much more complete removal of contaminants from water. Some of the research areas of interest are: Adsorption, extraction, foam fractionation, freezing, ion exchange, oxidation, and various membrane processes. The major question will revolve about the eventual economic feasibility of such operations. Participation in this program by universities, research institutions, and industry is highly desirable.

Disposal of Waste Effluents

In disposal of waste effluents, the receiving water is seldom used effectively for maximum dilution. This raises pertinent questions regarding the adequacy of outfall design techniques. Effective techniques need to be developed to assure optimum use of all available receiving water, whether this be in a stream, the Great Lakes, or coastal marine waters.

The discharge into top soil of the liquid wastes from millions of homes and many industrial plants represents a potential, and often actual, nuisance and public health hazard. Discharging liquid industrial and radioactive wastes into very deep porous strata emphasizes the need for more information on this method of final disposal.

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QUALITY SURVEILLANCE

Until recently, few programs of water quality intelligence could present a realistic picture of changing quality conditions in a stream. The minimum criteria for effective quality surveillance are clear. An acceptable program must be based on stream data that accurately reflect the stream's condition. Sampling and analytical procedures must be dependable and inexpensive.

With increasing demands for water of good quality for all water uses, the demand for dependable and economical sampling and analytical techniques becomes more acute. Even the application of our most advanced laboratory methods would presently provide only a partial picture of water quality conditions. Because of the importance of such data in water quality management programs, considerable emphasis must be given to research directed to satisfying this need.

Improvement in Bacterial Indices of Fecal Contamination: The major research goal of sanitary microbiology is to develop simpler, more rapid and more specific procedures for identifying contamination by human wastes. Such procedures are important in health protection and are needed where questions of important regulatory action are involved.

Recovery, Identification, and Evaluation of Viruses: During the last 15 years more than 70 viruses have been detected in human feces. All may be present in sewage. Viruses pass through the sewage treatment plant, persist in contaminated waters, and may penetrate the water treatment plant. Numerous outbreaks of infectious hepatitis have been traced to contaminated drinking water. The occurrence of such incidents appears to be increasing.

An assessment of the significance of water in transmitting viruses will depend on the development of improved techniques. The development of an effective method of culturing the virus of infectious hepatitis represents the single most important task for research on waterborne viruses.

Use of Biota in Water Quality Surveillance: Changes in aquatic population reflect changes in water quality. A number of attempts have been made to employ aquatic life in water quality surveillance. No system has, however, been generally accepted as satisfactory by aquatic biologists. The potential value of employing aquatic biota in water quality surveillance should be determined by research.

Recovery and Identification of Chemical Contaminants: Increased production and widespread use of organic chemicals are introducing more new and highly complex chemicals into the water resource for which no methodology for detection and measurement exists.

The development of more effective methods for capturing, concentrating, identifying, and measuring organic contaminants represents an important need in water quality surveillance, and in development of controls. Improved, highly refined instrumentation for microchemical analysis must be developed for this purpose. It is clear that this will require evaluation and adaptation of the most advanced techniques of chemical separation and analysis.

Example 3

SOCIAL AND ECONOMIC ASPECTS OF ENVIRONMENTAL ENGINEERING

Environmental engineering concerns itself with the establishment and maintenance of a healthful environment, particularly in urban areas where the problems are most acute. This requires bringing together the social, biological, and physical sciences in dealing with the problems of the health and welfare aspects of man's relationship with his environment. These have been delineated by an American Public Health Association committee as follows:

1. Insuring the elements of simple survival.
2. Prevention of disease and poisoning.
3. Maintaining an environment suited to man's efficient performance.
4. Preservation of comfort and the enjoyment of living.

Environmental engineering, therefore, deals with safeguarding man's water, air, food, conveyances, structures for habitation and employment, and his recreational and work environments. It involves not only the control of the quality and quantity of basic necessities, but also, importantly, the control of the waste byproducts, whether solid, liquid, or gaseous. These byproducts, if uncontrolled or allowed to accumulate, would not only stifle existence but lead to widespread disease and physical impairment.

Increasing population and increasing concentrations of people into the urban areas of the United States have accentuated environmental problems in two important, related ways: (1) as our air, water, and land resources are fixed, increasing populations decrease the quantity of each of these basic necessities available to the individual; (2) with increasing amounts of waste products concentrated in areas with growing populations, the relative effects of these wastes on man are increasing at an ever-increasing rate. These threats are of an insidious nature, a form of creeping paralysis which, if not recognized and corrected, can lead to urban stagnation and death as surely as the most violent epidemic.

The solution of environmental engineering problems is viewed as dependent upon a recognition of these two factors and upon finding the ways for applying, successfully, technological advances already achieved. It is of course, also dependent upon the continuing search for new ways and means of controlling the environment.

The modern practice of environmental engineering, from the public health viewpoint, consists of obtaining cooperation between numerous, contiguous municipalities and this presents complex economic and social problems. It is, therefore, at this point that the engineering and social science professions become interdependent. Each has a vital contribution to make and it is doubtful if progress can be made without an attack on the problem by these combined forces. Some illustrations of these points are the following.

Socioeconomic Implications

Although engineers have traditionally endeavored to design the most economical as well as the most workable solution to a problem, economics in our context has a larger meaning. Involved is the need for evaluating the overall economic picture of a metropolitan complex for, say, the provision of an adequate water supply. In large metropolitan areas the provision of enlarged water supply facilities is sometimes hampered because of irrational rate structures. Solving such problems requires thorough economic studies of the water rates and instituting an equitable system overall. The importance of social factors is illustrated by the location of arterial highways without regard to social, economic, and health implications of these decisions. When this does occur, the completed road may create severe problems of neighborhood decay, inaccessibility to industrial complexes, or other undesirable "direction" of city growth.[1]

Metropolitan Approach to Planning

The metropolitan factor appears strongly to be the common denominator to most environmental engineering problems. The technical literature of the past 10 years abounds with references to the recognition of this fact. There are now 210 Standard Metropolitan Statistical Areas, and the number is growing each year. Of these, 27 are interstate. Still another pertinent statistic is that 70 percent of the U.S. population lives in urban areas. The growing interest in comprehensive metropolitan health planning is well illustrated by the recent appearance of an Environmental Health Planning Guide published by the Public Health Service. Designed for use by either technical or lay people, the guide emphasizes the evaluation of health related utilities and services which readily lend themselves to long-range planning.

Metropolitan Cooperation and Health

A study of an unsuccessful effort to create a county health department, and a more recent study of the social forces blocking State efforts to create countywide health departments, are examples of relevant social science research. The similar failures to secure public

[1] A pertinent discussion of social factors is appended to the Report of the Subcommittee on Environmental Engineering, q.v.

action on water fluoridation suggests the need for social science research into public attitudes as a basis for health action.

Most threats to environmental health cover geographic areas which are larger than the traditional political boundaries which constitute the basic State and local governmental system of this country. The problem of fragmented government is particularly acute in metropolitan areas, and it is in these areas that the problems of environmental health are most serious. Further, these health problems are no respecters of the boundaries which divide these areas into literally hundreds of semi-independent principalities. Air and water pollution, and radiation are hardly controllable unless the attack can be made on an areawide basis. The possibility of such areawide cooperation is a field which has been extensively researched by political scientists during the last decade. Most practical advances have been made through the use of the areawide functional special district. The employment of this and other governmental innovations may well fit the need of the public health function. Different problems are being created, however, by the mushrooming of these special districts. Some central function is going to play a coordinating role; health may be the logical function for this purpose.

Closely related in subject matter would be the study of interstate cooperation in health matters. Particularly in metropolitan areas, interstate cooperation has become an essential to an effective attack upon common problems. Today air pollution and water pollution are of special interest in this connection, but these are only two aspects of the problem. Recent social and legal research has produced an accumulation of knowledge in the field of interstate cooperation, and in the use and limits of the interstate compact which needs to be related to public health. What is suggested is studies of metropolitan health problems that would be comparable to those conducted in the mass transit field by the Transportation Center at Northwestern.

These examples are intended to indicate that the traditional areas of study in environmental health have underlying social causes to which social scientists can contribute insight.

Still another broad area of environmental engineering where social sciences play a part is that of standards formulation. In drafting criteria of performance in the environmental health field, it is important that the social factors of standards applications be carefully considered.

After three decades of increasing interest and work in the health aspects of housing, there is still little or no information on the effects on health of room size, noise, air conditioning, lighting, and other environmental factors.

In the area of metropolitan development, health-oriented standards are either nonexistent or empirical. Attempts have been made by some zoning authorities to set criteria. For example, New York and Chicago zoning authorities have set arbitrary limits on noise and vibrations from industrial sectors, but the problem of permissible noise levels in business and residential areas is not dealt with.

The setting of health standards for urban development is complicated by the subjective nature of the problem. Modern health concepts include mental health aspects. Much of how persons or large groups of people react to noise, vibration, light, and temperature is governed by attitudes. To research this area, the combined skills of social, psychological, physical, and medical scientists will be required.

Example 4

THE PROBLEM OF FOOD CONTAMINANTS

Microbiological Contaminants of Foods

The notable successes of the past 50 years in controlling botulism, typhoid fever, and other severe foodborne diseases, have tended to create an impression that technical knowledge in this area is adequate to prevent all infections and intoxications of microbial origin. However, the facts are that gastroenteric episodes continue to occur at a rate second only to respiratory infections, among the short-term illnesses suffered by middle-class American families. Current food sanitation practices have failed to reduce the high incidence of foodborne diseases during the past 8 years. Although the majority of outbreaks either go unrecognized by health authorities or are of undetermined etiology, a growing body of evidence indicates that hitherto unsuspected fungi, bacteria, viruses, rickettsiae, and protozoa may be partially responsible. For example, infectious hepatitis has been traced to consumption of polluted shellfish, first in Sweden, and on two more recent occasions in the United States. *Clostridium perfringens*, which has long been associated with foodborne gastroenteritis in Great Britain, is only now beginning to receive serious consideration in U.S. health departments. The first official reports of such outbreaks were received by the Public Health Service less than 2 years ago.

Well-known types of food poisoning organisms occur frequently in a variety of foods. Raw market milk supplies nearly always contain *Staphylococcus aureus*. Dried or frozen egg products are notable sources of *Salmonella* organisms. When these products are used for manufacturing purposes, they may cause serious contamination of the finished product, as happened in the case of commercially marketed hollandaise sauce. Outbreaks of *Salmonella typhimurium* were reported from Los Angeles, Calif., and St. Paul, Minn., in mid-June 1961. The hollandaise sauce withdrawn from the market was found to contain *S. typhimurium* in lots obtained in San Antonio, Tex., San

Francisco, Calif., Washington, D.C., and St. Paul, Minn. The product was manufactured in New York State.

There are in excess of 600 serotypes of *Salmonella* which may cause illness in man. A sharp increase in cases in the United States due to one, *S. reading*, rarely identified among *Salmonella* isolates from human or animal infections, began in September 1956. During the 12-month period following, 325 acute sporadic cases and 3 outbreaks due to *S. reading* were reported in widely scattered States from Alaska to New York. Obviously this widespread illness, due to a specific micro-organism, does not follow patterns of water or milk borne outbreaks but would be applicable to a processed contaminated food product in national distribution.

An example of spread of *Salmonella* infections from contaminated egg albumin was reported in England. Widely scattered cases were traced to certain bakeries where dust from American egg-albumin powder contaminated the finished bakery products.

From the above examples it may be seen that foodborne disease-producing micro-organisms are widely distributed in foods in national and international distribution, for which no protection of the public is afforded.

Recent field studies in a metropolitan area have shown (*a*) that *Salmonellae* were present in 17 percent of the raw market poultry, and (*b*) that staphylococci were found in 21 percent of the market Cheddar cheese. Direct evidence regarding possible effects of these contaminated foods on the health of consumers is not available, but similarly contaminated products have, on other occasions, been implicated in gastroenteric outbreaks.

The foregoing examples illustrate the complexity and magnitude of the microbiological problems of food protection, which require much increased research effort by the Public Health Service, in concert with other governmental agencies and industry. Potentially useful approaches to these problems include:

1. Methodological studies to improve techniques for the quantitative detection and identification of pathogenic foodborne micro-organisms and their toxic products.

2. Bacteriological, virological, mycological, and parasitological investigations to determine the kinds, prevalence, persistence, and public health significance of potential pathogens in specific foods. For example, the production of safe shellfish depends on a thorough knowledge of the microbiological condition of estuarial growing areas, as well as commercial harvesting, shucking, and packing operations, which are subject to contamination with various toxic dinoflagellates, enteric bacteria, and viruses.

3. Veterinary public health studies on epizootic diseases of food animals, which may be transmitted to man.

4. Ecological studies on the interrelated physical, chemical, and biological factors that affect the growth and survival of pathogenic micro-organisms in food.

5. Coordinated epidemiological, clinical, and laboratory investigations of foodborne diseases to establish cause-and-effect relationships, modes of contamination and transmission, extent and severity of illness, techniques for finding and reporting natural outbreaks, and means for prevention and control.

6. Consideration of the public health significance of alterations in the microflora of foods, which may be brought about by the newer methods of processing and marketing; e.g., freeze drying of products which may be reconstituted and sold at delicatessen counters or from vending machines.

7. Field studies in the community setting on practical approaches to the control of microbiological contamination of foods.

Foreign Chemicals in Foods

Increasing contact between foods and foreign chemicals is unavoidable in our technologically oriented economy. Without use of agricultural chemicals, food additives, sanitizing agents, chemically treated water, and synthetic packaging materials, the United States could not feed the urban population. It has been estimated that elimination of agricultural chemicals alone would reduce farm yields by 10 to 90 percent.

There is also growing concern about the radionuclide contamination of milk and other foods by fallout from nuclear explosions, byproducts of atomic reactors, and residues of radioactive wastes. About five-sixths of the strontium 90 taken into the human body is estimated to come from foods, especially dairy products. Accidental release of short half-lived radionuclides, such as iodine 131, from a reactor in another country has, on at least one occasion, necessitated withholding milk from the market until the level of radioactivity declined. Extensive studies, in close cooperation with radiological health and atomic energy experts, will be necessary to understand the progression of radionuclides through the food chain and their long-term effects on man.

As is brought out in the report of the Subcommittee on Milk and Food, "there are no harmless substances; there are only harmless ways of using substances." The determination of how and when chemicals may be used safely in relation to food is already a major public health problem, and it will become even more important in the future.

Some of the avenues by which the health implications of foreign chemicals in foods may be approached are as follows:

1. Methodological studies to develop and simplify analytical procedures for both the presumptive qualitative and quantitative determination of herbicide, insecticide, rodenticide, germicide, and other potentially harmful residues in foods. There are many new tools now available which should be studied with respect to their application in this field.

2. Toxicological and pharmacological investigation of animal and human responses to repeated low-level dietary exposures, using chemicals singly or in combinations which are typical of their occurrence in food.

3. Exploration of the correlations between long-term, chronic-toxicity testing and more rapid presumptive procedures, based on reactions of enzyme systems, tissue cultures, or micro-organisms, to chemical agents.

4. Radiochemical studies on the occurrence, measurement, intake, retention, and biological effects of radionuclides from foods and other environmental sources, including dietary means of minimizing human exposure and damage.

Example 5

PROBLEMS IN OCCUPATIONAL HEALTH

Occupational health is that portion of the total health effort which is closely associated with the individual's occupation. The occupational environment presents many special risks as well as opportunities for improving health, but effective programs must be based upon adequate and simultaneous attention to both the man and his environment.

The traditional emphasis in the study of occupational disease has been on specific, dramatic, and killing diseases apparently caused by single or small groups of environmental factors. The recognition and conquest of lead poisoning, mercury poisoning, tar cancer, phosphorus poisoning, radium poisoning, and silicosis are classical stories.

Occupational health today, however, must not only continue the application of conventional methods for the detection of new toxic agents, but must also extend its traditional concept in new dimensions. The problem confronting us today contains many elements that are new, but our methods of attack have been slow to adapt to the new challenges. The health of the worker is still far from optimal, and frank occupational disease also persists. Residual or slowly developing disease or dysfunction may not be detected by conventional clinical examinations or by conventional reports of death or disease. Some occupationally induced disease can easily be confounded with "normal" causes of progressive deterioration such as aging. The involvement of each individual may be less, but many more persons are involved. It has been estimated that of the more than 70 million members of the civilian labor force, probably more than half have some degree of physiological impairment which could be greatly reduced if adequate knowledge were available.

There is increasing evidence that impairments now being encountered are not produced by single, isolatable, and easily incriminated factors; rather that many are the result of multiple factors working together, each adding its own insult and helping others to add theirs. Only tentative beginnings have been made to answering such questions as the effects of high atmospheric pressures or thermal stress on the tolerable limits of toxic chemicals. Attempted solutions of some problems lead to new questions. For example, we may point to the paradox that has developed in the South African mines—dust, as it was known, has been largely suppressed and with it has disappeared the gross silicosis of old, but pneumoconiosis remains and resultant deterioration of pulmonary and cardiac functions continues.

This pneumoconiosis may at times even show a negative correlation with the environmental dust count as conventionally estimated. Again, with the decrease in heavy physical labor and the introduction of automation, the incidence of physical strain in industry can be expected to decrease, but the psychological stresses are obviously increasing at least in proportion and probably absolutely as well. For example, the problem of handling and interpreting masses of incoming information under pressure, in split-second fashion and often with very critical consequences, so dramatically seen in airport control rooms, is developing with increasing frequency in communication centers across the Nation, in plant control room and in emergency installations. In less intensive fashion the psychological and social concomitants of the job affect every worker, his relations with others, his productivity, his anxieties, and his health.

Recognition of the interrelationship of various environmental factors has perhaps been most evident in the heightened awareness of the effects of the growing chemical world surrounding us and of the consequences of exposures to radiation and other agents of technologic prowess. There is a widening gap between the new materials being created and an understanding of their effects on living systems. It should become axiomatic that these materials must be as well understood for their biological potentialities as well as for their physical and mechanical properties. It is in the in-plant environment where many of the toxic pollutants now threatening the air and water of communities throughout the Nation are first spawned. The industrial worker is first exposed to the chemicals that find their way into home use. Industry is the incubator for problems of more far-reaching consequence, and alert, scientifically sound, and unbiased investigations of occupational health problems can provide bases for later communitywide investigations. Also, without adequate knowledge and coordination of activities the elimination of a contaminant from a plant may well result in a community air- or water-pollution problem.

Over one-half of the industrial plants in this country lack basic industrial hygiene control measures. The most serious deficiency is in the provision of adequate preventive measures for workers in the small plants of less than 500 employees, which accounts for over two-thirds of the work force.

In several States the provision for the control of occupational environments is below the level considered adequate. Of the 584 persons employed full or part time in occupational health in State and local units in February 1961, 58 percent were in 6 States; the remaining States had either no programs or inadequate ones. Already serious, the manpower shortage in occupational health is expected to worsen.

Great benefits have come from advances in science and technology and from their application by our industries. These have not been gained, however, without certain costs in terms of human values. If we are to enjoy to the fullest extent the benefits from our modern industrial society, these costs have to be better recognized, evaluated, and reduced. The national effort in occupational health must be directed to this end. Accordingly, an occupational health program must have as its basic objectives:

1. Recognition of the influences and risks associated with occupations;
2. Evaluation of their effect upon human health and efficiency;
3. Development of preventive measures; and
4. Effective application of the knowledge so gained to industrial practice.

REPORTS OF SUBCOMMITTEES

Manpower Resources and Training

Applied Mathematics and Statistics

Pharmacology, Toxicology, Physiology, and Biochemistry

Analytical Methods and Instrumentation

Air Pollution

Environmental Engineering

Milk and Food

Occupational Health

Radiological Health

Water Supply and Pollution Control

REPORT OF THE SUBCOMMITTEE ON MANPOWER RESOURCES AND TRAINING

RECOMMENDATIONS

1. The divisional training program providing fellowships and traineeships to students and training grants to universities should be strengthened and augmented. In those instances where authority to undertake these programs does not exist, such authority should be sought by appropriate legislation.

2. A substantial program of environmental health institutional grants to support those universities engaged in programs of graduate education should be instituted.

3. Support for the training grant programs outlined in the foregoing two recommendations should be increased as quickly as possible to a level of $25 million.

4. There should be established, in the office of the Bureau Chief, a unit responsible for the formulation of overall policy and administration of the several training grants programs. This unit is essential to assure an orderly development of the total program.

5. Other Federal agencies engaged in training activities should take cognizance of the manpower demands which will be imposed upon them by the rapidly expanding field of environmental health and should adjust their programs to meet these new burdens.

MANPOWER REQUIREMENTS

The success of any human endeavor is closely related to the quality of the manpower which can be brought to bear therein. The effectiveness of the Public Health Service's programs in environmental health depends in no small measure on the availability of competent personnel in sufficient numbers to meet the tasks faced by the Service in this field.

Review of the several subcommittee reports which deal with the divisional programs of the Service's Bureau of Environmental Health indicate clearly that substantial deficiencies in manpower exist even now and that this situation will be aggravated in the years immediately ahead unless the training of additional personnel is vigorously promoted and prosecuted.

The types of personnel needed for a comprehensive attack on the problems of environmental health are delineated in the divisional subcommittee reports. They include a broad range of individuals with backgrounds in the physical and biomedical sciences, in mathematics, and in the social sciences. In the physical sciences, representation extends from classical physics and chemistry through meteorology, geophysics, and radiation physics to hydrology, oceanography, and sanitary engineering; in the biomedical sciences the personnel requirements extend from molecular biology, botany, and microbiology through biochemistry, pharmacology, and radiobiology to epidemiology, toxicology, and the several medical disciplines. In mathematics, representation is required from classical mathematics through biomathematics and statistics. And the very nature of the problems encountered in environmental health makes essential the availability of personnel with backgrounds in sociology, political science, anthropology, and psychology.

The intellectual resources upon which environmental health may be expected to draw are obviously extremely broad and extend well beyond those usually required in public health. Indeed, a large proportion of the personnel needed by the Bureau of Environmental Health in the years ahead must be sought outside of regular public health channels. Particular emphasis must be placed on this point because added burdens on the training programs of such agencies as the National Science Foundation and the National Institutes of Health may be expected in the near future. Hence, these agencies should prepare now to meet the extra demands which a rapidly expanding environmental health program will place upon them.

In table I are listed the current numbers of professional personnel in each of several scientific categories working in the field of environmental health in the Service and in the Nation at large. It is expected that, by 1970, more than twice these numbers will be required in most categories and triple in some.

TABLE I

Professional discipline [1]	Public Health Service	Nation
Physics	80	3,400
Chemistry	90	7,000
Biology	145	2,000
Medical	55	1,000
Engineering	420	8,500
Allied sciences	140	5,000
Total	930	26,900

[1] These are professional disciplines of all levels of training.

It is noteworthy that, at the present time, the total national pool of environmental health scientists is less than 2 percent of the sum of all scientists, engineers, and teachers of science in the United States. It may therefore be said that current environmental health programs place little drain on the scientific personnel resources of the Nation.

The requirements for additional environmental health personnel in the future do not change this picture substantially. Indeed, the growth of the total scientific manpower, projected by NSF,[1] in the next decade is similar to that outlined above for the field of environmental health.

To meet the substantial demands for trained personnel expected over the next decade, the subcommittee believes that the Public Health Service should take courageous leadership in the development of an extensive range of training programs which provide not only for the immediate technical needs of the Bureau of Environmental Health but for its broad requirements as well. It is recommended that the divisional training programs be augmented and strengthened as suggested in the divisional subcommittee reports. In addition, however, the Subcommittee strongly urges the Service to undertake a program of institutional grants in which support is given to universities to provide comprehensive training in environmental health. In such programs, each university would be expected to call upon its total resources in many departments to train a broad range of students for environmental health carriers.

The current training grant programs of the Public Health Service are tabulated in table II. The institutional grant program just referred to would be an important additional component of this series of programs.

TABLE II

Grants program	Where administered in PHS, presently [1]
Public Health Traineeship Program	Division of Community Health Practice, BSS.
Project Grants for Graduate Training in Public Health.	Division of Community Health Practice, BSS.
Formula Grants to Schools of Public Health	Division of Community Health Practice, BSS.
Air Pollution Traineeships	Division of Community Health Practice, and Division of Air Pollution, BSS.
Air Pollution Awards to Educational and Training Institutions.	Division of Community Health Practice and Division of Air Pollution, BSS.
Grants for Training in Radiological Health	Division of Radiological Health, BSS.
Water Supply and Pollution Control Training Grants.	Division of Water Supply and Pollution Control, BSS.
Graduate Training Grants	Division of General Medical Sciences (all 7 Institutes, NIH).
Regular Research Fellowships	Division of General Medical Sciences (all 7 Institutes, NIH).
Health Research Facilities Grants	Division of Research Grants, NIH.

[1] BSS, Bureau of State Services.
NIH, National Institutes of Health.

Presently the Public Health Service is spending approximately $8.5 million for training grants activities, including facilities, in environmental health. This support should be increased as rapidly as possible to a level of $27.5 million if the manpower requirements of

[1] Investing in Scientific Progress. National Science Foundation Report, NSF 61-27.

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the next 10 years are to be fulfilled. These funds should be expended in the form of institutional and departmental training grants and as stipends to students to assist them to defray tuition and living costs.

At present, the various training grant programs are administered differently and through a variety of organizational units. This has sometimes resulted in an imbalance in one program relative to another. It seems clear that coordinating mechanisms should be established to assure an orderly development of the total program, composed as it is of many interrelated parts.

When these mechanisms are set up, cognizance should be taken of the close relationships which exist between the various divisional programs and the types of personnel needed to be trained. These mechanisms should therefore strengthen the divisional training programs as well as promote their coordination. An example of one way, in which an orderly development of total program could be achieved, is the establishment of a training grant unit composed of the directors of the training grant operations in the Bureau and in each of the divisions to formulate overall policy on the administration of training grants in environmental health.

This unit could then intelligently take into account the relationships of these programs with outside professional and technical societies, the universities, and the scientific community in general. The various grant programs should not be in competition with one another. Therefore, overall coordination and administration of these programs is essential to achieve maximum impact with the money being spent.

SHORT-TERM TRAINING

In addition to the academic training at professional levels of specialists for work in environmental health, there is great need for updating those individuals already on the job. This is being accomplished by a variety of inservice training programs, with special emphasis on technical seminars and short courses ranging from 8 to 10 days to 12 weeks. Such updating and refinement of skills and competencies are essential for all who work in this field—in the Public Health Service, in State and local government, in industry, and in research.

Table III indicates present and estimated costs for inservice training of all types of environmental health personnel by the Public Health Service.

TABLE III

	1956–61 (inclusive)	1965 (estimated)
Number trained	14,200	10,000
Cost	$2,250,000	$2,500,000

GRADUATE TRAINING OF STAFF

In addition to the short-term inservice training activities, the Bureau should accelerate the formal academic outside-PHS graduate training of its personnel. This is necessary as part of career development and to further the professional competency of the staff. The graduate training of 185 employees (to the M.S. and doctorate level) over the last 7 years is noteworthy considering program levels. However, this effort must be increased to at least 3 to 5 percent (on a sliding scale) of operating budgets. This type of program will not only serve as a necessary training device but will attract new scientific disciplines into the field.

In table IV are listed the immediate requirements to fund the several training programs set forth above. As indicated heretofore, it is hoped that these programs may be vigorously promoted and prosecuted. Unless this is done, the Service will be in serious danger of failing to meet its responsibilities in environmental health.

TABLE IV

Program	Immediate need
Institutional grants	$5,000,000.
Training grants (faculty, facilities, and student support)	$20,000,000.
Short-term inservice training for all types environmental health personnel.	$2,500,000.
Graduate training (Public Health Service environmental health personnel).	3 percent of operating budget.

PERSONNEL RECRUITMENT

Although the training programs discussed in the foregoing paragraphs will go a long way to solve the manpower problems in environmental health, recruitment of these personnel into governmental public health programs, particularly at the State and local levels, may not be easy unless efforts are made to provide a better working climate for environmental health scientists. This involves (*a*) the development of an improved status for such scientists by greater recognition of their importance by society and (*b*) the provision of incomes more commensurate with their value to the health of the nation. The surgeon general should make every possible effort to promote those conditions which will bring about a better status and improved income levels for scientists working in environmental health.

Report of the Subcommittee on APPLIED MATHEMATICS AND STATISTICS

RECOMMENDATIONS

1. There should be a central facility to attack the problems of environmental health and to provide for services and activities needed in this area.

2. This central facility should include staff and research facilities to handle basic problems in environmental health and should provide for research activities designed to unify divisional interests where desirable, provide central services in the field of mathematics, statistics, and electronic data processing, and advise the Bureau chief and the Director of the Environmental Health Center with respect to the overall direction of research in environmental health.

3. This central facility should include:

a. An analysis group to review and conduct both laboratory and field studies of interdivisional concern and to advise the Bureau chief in long range program planning, priorities, and management. This analysis group should be provided with funding independent of divisional research budgets and should have both long and short range objectives and projects. It should report directly to an Environmental Health Center research director.

b. A consulting and research design group in the area of mathematics and statistics to provide guidance to categorical programs for the wide range of problems to be encountered and to insure that each of the Bureau programs receives the maximum possible benefit from activities in other parts of the Bureau and in other governmental units. Functions of this group should include the refinement and standardization of morbidity and other data relevant to environmental health so as to enable the identification of environmental health problems.

c. An electronic data processing group to service the Bureau and the Divisions and to insure that the most modern and efficient data processing procedures are followed throughout the Bureau.

4. There should be established an information storage and retrieval activity as part of a library and information center at the Bureau level. This information storage and retrieval facility should provide a service to environmental health activities in air, water, food, occupational health, etc., and should utilize consulting services and data-processing capabilities of the electronic data processing group and the staff of mathematicians and statisticians at the Bureau level.

INTRODUCTION

This subcommittee felt that its recommendations should cover an area described in the report of the Study Group on the Mission and Organization of the Public Health Service (June 1960) as Ecology and Systems Analysis. This activity involves the recognition of the multiple causation of disease and the fact that there are many environments which may interact to affect the health of man. As was stated in the reorganization report:

"Potentially toxic substances reach the population in intermittent, minute exposures from many sources. One division of BEH may assess the import of a given substance through one medium, another through another medium. A combination of skills in ecology, epidemiology, toxicology, biometrics, and electronic and other analytic systems is required to establish comprehensive, baseline data as a foundation for specific assessments."

Three groups are recommended for the Environmental Health Center. Their responsibilities will be as follows.

ANALYSIS GROUP

The primary purpose of this group is to engage in and develop studies designed to clarify the relationship between the environment and health and to explain the ecologic processes which affect the quality of man's environment. To define more clearly the broad nature of the environmental health research in which the members of this group will engage, the following examples are suggested:

1. Epidemiological study of the physiologic, economic, and social effects on urban population of multiple and simultaneous, low-level environmental exposures (e.g., oxidants in the air, industrial wastes in water supply, radioactivity in foods), including study of the way in which demographic and population factors either moderate or heighten the effect of environmental hazards.

2. Consideration of the criteria and systems which should be recognized by regional and metropolitan planning groups as necessary in the control of air, water, food, radiological and industrial environments within a metropolitan regional or topographic area to provide adequate utilization of natural and economic resources while safeguarding man's health.

3. Determination of the relationships between such variables as (*a*) the air transport of radioactivity to cattle forage or food growing areas, (*b*) the microclimate and general ecology of pastureland or cropland, (*c*) the accumulation of radionuclides in the milk of cattle or other foods, (*d*) the mechanism and effects of subsequent uptake and storage of such nuclides by man.

This group may also undertake, on request from the divisions, certain broad or theoretical research studies within the jurisdiction of a single division. An example of such a study might be quantitative and preferably mathematical definition of the importance of such factors as: (1) Domestic and industrial water quality requirements, (2) stream self-purification, (3) water treatment, (4) algal effects on dissolved oxygen, and (5) multiple use and reuse on the proper management of water resources. Similar studies might occur in occupational health, environmental engineering, and in other areas.

The analysis group will also include long-range planning of environmental health research and advising the Bureau chief with respect to the overall direction of research and field operations in the light of Bureau objectives and functions.

Although not the primary mission for this group, its members should be available on request for consultation with division representatives and with members of the Environmental Health Center consulting and research design group described below. It is important that the analysis group not be charged with day-today operating responsibilities and that it be allowed to view environmental health in the broadest possible perspective. To insure this and to insure continuity of studies and activities this group should be financed as a separate and distinct activity and not be dependent upon divisional research budgets. It should report directly to a Bureau level research director.

CONSULTING AND RESEARCH DESIGN GROUP

The basic effort for this group will be to provide consulting services to statisticians and other research workers in the various divisions. They will supply assistance and consultation with respect to the statistical design of laboratory and field studies and the effective use of electronic data processing equipment in statistical analysis. This group will also engage in mathematical statistical research, and deal with unsolved problems of the divisions. In addition, the members of this group may engage in such primarily mathematical research as, for example, the development of realistic mathematical representation of the processes of turbulent dispersion of pollutants in air, water, and body fluids.

The Consulting and Research Design Group must have responsibility for leadership in the development of uniform standards and criteria for the adequate reporting of sickness patterns related to environmental hazards by local, State, and Federal agencies. It will engage in the construction of morbidity indices, particularly those which would take advantage of existing hospital, industrial, and other records, to measure more accurately the effects of environmental hazards on man's health. This group must also assume responsibility for insuring the usability of environmental health data produced by other Federal agencies (e.g., Bureau of the Census, Bureau of Old Age and Survivors Insurance).

ELECTRONIC COMPUTING AND DATA PROCESSING FACILITY

This should be a large-scale facility to serve the data processing needs of divisional and Bureau activities. It will, in addition, keep abreast of latest developments in electronic computing equipment and programing, including the development of automatic recording instruments for laboratory and field investigations. This group will also maintain liaison with the information retrieval activities of the library and information center mentioned in Recommendation 4 of the Subcommittee.

The establishment of this facility should not preclude the maintenance at divisional level of mechanical data handling resources (e.g., keypunch, sorting, and tabulating equipment—commonly called EAM equipment) to meet small-scale immediate needs of the Division.

PROPOSED STAFFING AND BUDGET

Analysis Group

This group will require experienced competent professional investigators and adequate supporting staff in such areas as epidemiology, industrial medicine, industrial hygiene, toxicology, ecology, social sciences, mathematics and mathematical statistics, operations research and systems analysis, sanitary engineering, and physical chemistry. It should operate as several groups with project leaders in specific areas. Approximate initial staff requirements: 30 persons.

Consulting and Research Design Group

Staff for this group will include highly qualified individuals and supporting staff in the areas of mathematics, applied mathematics, mathematical statistics, biostatistics, records analysis and the social sciences, including demography and population analysis. Approximate initial staff: 10 persons.

Computing and Data Processing Facility

This group will include a director, assistant director and staff for overall supervision of the facility and particular responsibility in the areas of computer equipment and program development. The group will also include systems analysts in the areas of computer systems, information retrieval systems, statistical systems, and mathematical systems. To each of these systems, analysts and computer programers will be assigned as needed. In addition, adequate tabulating and supporting staff will be needed. Approximate initial staff: 45 persons.

Total Annual Budgetary Requirements

Personnel	$1,275,000
EDP and other equipment	900,000
Total	2,175,000

Report of the Subcommittee on PHARMACOLOGY, TOXICOLOGY, PHYSIOLOGY, AND BIOCHEMISTRY

RECOMMENDATIONS

1. Expansion of intramural and extramural research efforts utilizing the basic science disciplines of biochemistry, pharmacology, physiology, and toxicology is recommended because of the increasing importance of chemical agents and radiation as causative factors in environmental health problems.

2. A common denominator exists with respect to the basic science approach to environmental health problems arising from any type of exposure to chemical agents and radiation. It is, therefore, concluded that future progress in the solution of many of the environmental health problems can be made most efficiently and economically by consolidation of the major research activities within an environmental health center. It is recommended that each of the major divisions of the environmental health center contain the appropriate numbers of toxicologists, biochemists, pharmacologists, and physiologists attached to each division that are required for solution of immediate practical problems. In addition to strong representation of disciplines within each division or problem area, the personnel of individual disciplines should be brought together less formally but firmly on an interdivisional basis. It would then be possible to take full advantage, for example, of the contributions that a toxicologist or biochemist in air pollution can make toward problems in water pollution, occupational health, and radiobiology.

3. It is recommended that the environmental health center make provisions for basic research in toxicology and other basic science disciplines without reference to particular immediate problem areas. The center should strive for national leadership in environmental health, and to accomplish this objective it is essential that provisions be made for personnel and facilities beyond those required for service activities connected with the solution of specific immediate problems.

4. It is recommended that the environmental health center contain a centralized group for storage and retrieval of toxicological information as a service to the center itself, other public health laboratories, and the entire nation.

5. It is recommended that in consideration of any new field stations or regional laboratories for environmental health activities attempts should be made to locate them in close affiliation with universities to

facilitate acquisition of personnel and to enhance the training opportunities in this field.

6. The proposed expansion of Public Health Service facilities and activities in environmental health, together with the certain marked expansion of toxicological work in industry and other Government agencies as a result of existing and new legislation, makes it imperative that the training of professional personnel in the basic biological sciences be expanded. In connection with satisfying the increased personnel requirements in the aspects of environmental health that utilize the basic biological sciences during the next decade, the following recommendations are made:

a. Expansion of training grant programs in departments of biochemistry, pharmacology, and physiology in medical schools, schools of public health, and schools of veterinary medicine, particularly in those departments containing staff members who are competent and interested in some aspect of environmental health research.

b. Encouragement of selected schools of public health, medicine, and veterinary medicine to establish departments of toxicology as a direct method of increasing the output of professional toxicologists. Substantial Public Health Service support would be needed initially for facilities and staff and the support of predoctoral and postdoctoral students.

c. Expansion of research grant programs with long-term support for broad programs on the basic aspects of toxicity measurements, mode of action and treatment of poisoning. Research grant support to existing departments of biochemistry, pharmacology, physiology, entomology, and food technology in medical, public health and schools of agriculture will build effective research groups within universities and contribute substantially to the total environmental health research program and the training of scientists for careers in this field.

d. Maintenance of a substantial inservice training program in the environmental health center and regional laboratories for the training of postdoctorates and preprofessional personnel.

INTRODUCTION

During recent years marked changes have occurred in the nature of environmental health problems. In the past, communicable diseases were of principal concern, but a concentrated effort directed toward acquisition of knowledge about their cause and the development of effective control measures has led to a solution of most of these problems.

During the past few years unprecedented technological advances in the development and practical use of new chemical agents for a variety of purposes, and expansion of atomic energy developments, have necessitated radical changes in the approach to environmental health problems.

Progress in the control of communicable diseases required intensive efforts on the part of clinical investigators, with the supporting preclinical research contributed principally by the disciplines of microbiology, pharmacology, and biochemistry.

The different nature of present and future environmental health problems, which deal mainly with toxic chemical and physical agents, places heavier responsibilities on the preclinical biological sciences of toxicology, biochemistry, physiology, and pharmacology than at any time in the past.

The development of plans for progress in solving future problems in environmental health must take into account (*a*) an increasingly greater dependence upon basic biological sciences, (*b*) the inadequate supply of professionally trained personnel available for environmental health activities, and (*c*) the consequent necessity of markedly expanding the recruitment and training efforts in the Public Health Service and in university laboratories.

Many of the present environmental health problems involve exposure of man to potentially harmful chemical and physical agents. The exposures may occur as a result of air or water pollution, food contamination, occupational exposure, or from a combination of these sources. Although the source of exposure, the route of entrance of the substance into the body and the nature of the injurious material may differ, the underlying problem in each case is essentially the same, i.e., impairment of health through interference by chemicals or radiation with normal cellular functions. A common denominator thus exists for environmental health problems arising from any type of exposure to toxic chemicals and radiation. Environmental health research should, therefore, be organized on that basis.

In the field of occupational health there are many areas of research in which scientists from the basic science disciplines of toxicology, biochemistry, physiology, and pharmacology will in the future perform an important role. These problems include measurements of the toxicology of gases, vapors, and aerosols, the toxicology of materials acting upon or absorbed through the skin or absorbed from the gastrointestinal tract. The application of known techniques and the development of new methods for interpretation of animal reactions and for setting of tolerances for toxic substances must be given a great deal of attention.

In the field of water pollution the chronic toxicity of a large number of synthetic chemicals which reach surface waters must be determined to ascertain their long-term effects. Techniques for measuring the long-term harmful effects of individual water contaminants and combinations of these chemicals must be developed.

Environmental health problems in air pollution are closely related to those of water pollution and they demand a concerted effort toward identification of the toxic materials and measurements of their toxicity and physiological effects.

In the area of food protection, toxicological studies on pesticides, herbicides and other agricultural chemicals, on chemicals intentionally added to food, endogenous toxicants and natural poisons are needed.

In the field of radiological health, the long-term effects of low levels of radiation need much additional intensive study. Protective measures against radiation injury must be developed.

These examples represent only a few of the present and future problems in which the basic science disciplines of biology must assume an important role, and in which similar approaches at the laboratory level are equally applicable to the problems regardless of their environmental origin. Environmental health problems concerned with toxic chemical agents require laboratory investigations on experimental animals. Laboratory investigations together with clinical observations are essential for establishing the recommended conditions for elimination of health hazards. An interdisciplinary approach by the basic biological sciences is highly desirable for optimum progress.

TOXICOLOGY

Regardless of the source of the exposure or the type of toxic agent under study, the modern toxicological approach includes identification and analysis of chemical agents, detailed studies on the acute and chronic toxicity in laboratory animals and attempts to develop antidotal agents. The assistance of the toxicologists is also required in the interpretation of experimental findings in terms of hazards to man and in the establishment of tolerance levels. The present standard procedures for measuring the toxicity of chemicals are costly and laborious, and they require extensive facilities. However, there are no known substitutes for these tests with sufficient reliability to replace the conventional procedures.

The rapid development of new chemicals to the stage of practical application greatly outpaces the rate at which their toxicology can be investigated by all organizations engaged in this activity, and this trend is expected to continue. It is, therefore, essential to plan for intramural and extramural efforts in toxicology for at least the next decade. The plans for toxicology must also include basic research not necessarily related to immediate environmental health problems.

The development of new methods, instruments, and approaches to toxicological problems will require research, personnel, and facilities far in excess of the needs for immediate practical problems. Adequate provisions must be made for basic intramural and extramural research in toxicology. Planning for the future in this manner will result in developments of ultimate value to practical problems and, if conducted under appropriate leadership, the basic research program will contribute greatly toward stimulating the interest of competent scientists to enter this field.

BIOCHEMISTRY

An understanding of the deleterious actions of chemical agents and radiation hazards requires the knowledge and skills of the biochemist. Assessment of the potential health hazards of toxic agents to man is aided significantly by the availability of information on their storage, excretion, and metabolic fate. As part of an interdisciplinary approach to environmental health problems the potential contributions of biochemistry cannot be overemphasized.

Basic research on the precise mode of action of toxic agents can be expected to provide the soundest foundation for assessment of health hazards and for the development of specific methods of treatment. Biochemistry has already accomplished a great deal in explaining the mode of action of toxic agents on the basis of their interference with enzymatic reactions. Adequate provisions should be made for the use of this discipline in both intramural and extramural research activities because of its importance in solving practical problems and its great potential value for attracting personnel into training and careers in environmental health research.

PHYSIOLOGY AND PHARMACOLOGY

The nature of exposure of man to some chemical agents such as air pollutants, skin irritants and industrial airborne poisons demands the use of experimental methods of physiology and pharmacology for the assessment of health hazards.

Measurements of the actions of environmental chemicals on the function of intact organs and the general physiological functions of the intact animal constitute an essential step in the development of required information on toxic agents. Measurements that employ physiological and pharmacological techniques are essential to bridge the gap in information that sometimes occurs in understanding toxicological and biochemical findings as they relate to functional activity of the intact organism.

There are numerous environmental health problems that do not involve exposure to toxic chemical agents in which the techniques of physiology are required to properly assess the degree of hazard. Physiology plays an important role in gaining an understanding of the stressful effects of physical factors such as heat, light, noise, and work. A tremendous amount of additional effort is needed utilizing the techniques of experimental physiology to study the influence of these physical factors alone and in combination with one another and in combination with chemical agents on health and work performance.

The role which these disciplines have played in the training of personnel for careers in environmental health must also be considered in the long range plans. Provisions must, therefore, be made for sizable efforts in both of these disciplines in future plans for both intramural and extramural environmental health research activities.

FACILITIES AND TRAINING NEEDS

Satisfactory progress with the numerous problems in environmental health that involve the discipline of toxicology, biochemistry, pharmacology, and physiology requires a marked expansion and full coordination of facilities and manpower within the Public Health Service and development and material expansion of research and training in universities through strong extramural support.

The development of coordinated efforts in overlapping divisions of environmental health must be accomplished to utilize the basic biological sciences advantageously within the Public Health Service and in universities. Such developments could be accomplished by the following organizations and programs:

Public Health Service Environmental Health Center

As indicated above the problems of environmental health involving exposure to toxic chemicals have many similarities with respect to application of the disciplines of the basic biological sciences. Establishment of an environmental health center would bring together the problems and disciplines in such a manner that accelerated progress could be expected in all phases of environmental health. Toxicology, biochemistry, physiology, and pharmacology should all be appropriately recognized and represented in the center.

Provisions should be made for a strong toxicology unit to engage in toxicological examination of chemical compounds, and to perform analytical work and other services directly related to the immediate problems of each division. Development of a strong research component in toxicology is essential for new ideas and approachs to toxicological problems. If the center strives for national leadership in this field, its stature will be enhanced; an outstanding effort in toxicology would serve as a strong stimulus to outside institutions and attraction of competent personnel into the center for training and experience would be assured.

The organizational structure for toxicology within the center should involve attachment of toxicologists to each division for designation of their primary responsibilities. In addition, however, there should be some interdivisional organization of all personnel within the center into disciplinary groups for mutual benefit to the entire program and to the members of each discipline.

The center should have a toxicology information group for the storage and retrieval of data not only for the benefit of the center but also for use by other Public Health laboratories and institutions throughout the Nation.

The discipline of biochemistry should be represented in each major subdivision of the center. The solution of problems involving chemical analysis, and the tissue storage and fate of toxic agents will be greatly aided by appropriate activity of a biochemical nature. Furthermore, a strong biochemical research component will permit application of advances in biochemistry to investigations of the mode of action of toxic chemicals and to rational development of antidotal procedures. Basic research of this type will serve an important national need and will stimulate interest in problems of environmental health outside the center.

Physiology and pharmacology must also be considered as important disciplines for inclusion in all major units of the environmental health center. Adequate representation of these fields is essential to insure thorough studies on the influence of toxic agents and injurious physical factors on the physiological functions of intact animals. Basic research aimed at methods for elucidating toxic effects in intact animals and organ systems should be included in the plans for these disciplines.

Regional Environmental Health Laboratories

The environmental health center should maintain sufficient flexibility in its program and structure to permit a change in emphasis toward important new problems when they arise in order to exert a stimulating influence on environmental health activities throughout the Nation. It is anticipated that changes in emphasis will have to take place from time to time even though other problems are not yet completely solved.

The center should be supplemented by the creation of regional laboratories placed in geographical locations with special consideration for sites with longstanding environmental health problems. For example, in geographical areas where air or water pollution is a continuing problem, service functions such as analyses and some localized research activities could be transferred to the regional laboratory and thus free the staff and facilities of the center to undertake new problems of national importance.

In regional laboratories it would be expected that disciplines providing analytical chemists and toxicologists would generally be required, but the facilities and personnel requirements might vary considerably depending upon the particular problems under consideration and the amount of research to be included in the programs of these laboratories. Affiliation of these laboratories with, or in close juxtaposition to, universities should be considered whenever possible because of the value of such an arrangement in the recruiting of personnel, the possibility of attracting students into environmental health research, and the availability of consultation services.

University Research and Training Programs in Environmental Health

The present demand for professional personnel trained in the basic biological sciences with orientation toward careers in environmental health activities greatly exceeds the supply. This situation will continue to exist and to become more acute unless new mechanisms are instituted for increasing entrance of students into this field.

At the present time toxicologists are trained within the facilities and by the staff of other disciplines, usually in departments of pharmacology. However, a sizable number of departments of pharmacology in medical and veterinary schools have no graduate training programs of any type. In those departments which do have graduate programs the training and interests of the staff members are diversified and are often centered on activities quite far removed from environmental health research. As a result, relatively little space of effort is devoted to toxicology in the majority of the departments of pharmacology.

The output of trained toxicologists by other disciplines is sporadic and small in comparison with the needs. New mechanisms for the training of toxicologists are, therefore, urgently needed. Progress in this connection could be achieved by encouraging schools of medicine, public health, and veterinary medicine to recognize toxicology as an independent scientific discipline and, with the aid of extramural Public Health Service support, to provide facilities and staff for training and research programs in this field. Initially, the staffing of these departments would necessitate drawing upon the resources of biochemistry, physiology, and pharmacology until toxicology becomes self-sustaining.

A second mechanism for increasing the supply of toxicologists and personnel for the biochemical, physiological, and pharmacological aspects of environmental health could be the establishment of environmental health research and training programs or centers in universities. The centers should be organized in such a manner as to draw upon specialists from the various disciplines who would direct their efforts toward an integrated approach to environmental health research programs. They would contribute not only to the solution of important public health problems but also to the training of investigators for this field. They could readily be located in medical, veterinary, and schools of public health with financial support being provided by the Public Health Service to selected institutions.

Research Grants in Environmental Health

Continuous expansion of research grant programs in various aspects of environmental health is necessary. The encouragement of individuals in existing departments of pharmacology, biochemistry, physiology, food technology, and entomology to undertake research in the area of environmental health must be continued. The value of the efforts of individual scientists in furthering knowledge of toxic substances, developing improved methods of experimentation, and in the training of students in this field has been well established. Expansion of these efforts should be encouraged particularly when research of a basic nature is being conducted.

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Report of the Subcommittee on ANALYTICAL METHODS AND INSTRUMENTATION

RECOMMENDATIONS

The subcommittee recommends:

1. That the needs of the several categorical programs would best be served by the provision of a center within which the common analytical requirements could be housed and the associated operational staffs maintained. Not only would the individual divisional efforts be facilitated by assurance of maximal use-efficiency and maintenance of highly qualified operating staff, but the wise management of such a focal point would assure the interdivisional contact essential to effective consideration of the integrated environment on human health and welfare.

2. That the center be staffed with scientists and engineers of the best available competence to design analytical equipment and methods to meet the research and operational needs of the program, and to test, modify, and standardize the use of advanced instruments and methods evolved by others. The magnitude of such activity should be restricted, however, to that which is required to supplement and maintain close contact with, instrumentation development by industry, and to plan and direct intelligently a strong extramural contract program. To conduct the indicated operations well equipped instrument design and model shops, and machine, electronic, glassworking, and other fabrication facilities will be required. Such central capability would supplement, and in no sense limit, the development of divisonal capabilities for prosecuting assigned activities.

3. That the Center facilities be so organized and managed as to provide working tools for study of the integrated effects of simultaneous, or consecutive, multiple environmental impacts on health and welfare.

4. That the central environmental health facility be so designed as to provide for prompt and economical adjustment of analytical routines to the fluctuating requirements of research and program operations.

5. That field laboratories or operational centers be similarly designed for ease of adaptation to changing analytical technology. While the advantages of consolidation of instrumental and analytical facilities for the several programs in field stations are the same as those applicable to the national center, it seems likely that these advantages

will have to be compromised because appropriate locales for one type of activity will not always be appropriate to another; e.g., field operations in air pollution will not usually be geographically related to those required by water pollution.

6. That surveillance networks be developed to maintain knowledge of quality levels for air, water, and radiation. The emphasis should be on rugged, dependable automatic monitors reporting through normal communications circuits to field centers and to a national data processing and analysis center.

7. That a central training facility and appropriate regional centers for training be equipped with basic analytical instruments and laboratories necessary to provide instruction in the changing procedures of environmental health measurement and control operations.

8. That provision be made for the development and maintenance of a central bank of analytical reference standards pertinent to the several categorical programs of the Public Health Service, and that these standards be available to State and local agencies.

9. That procedures are needed for recognizing early biological damage resulting from single or multiple environmental exposure.

10. That the instrumental aspects and analytical facilities of the national center be developed progressively, first to strengthen and make more effective the respective divisional programs and subsequently to emphasize the concern with simultaneous multiple environmental impacts.

11. That the analytical and instrumental capability of the Service be strengthened by reliance on and close program coordination with other Federal agencies engaged in method standardization and the design and development of instrumentation, such as the National Bureau of Standards, the Department of Agriculture, and the Atomic Energy Commission.

INTRODUCTION

The effectiveness of research, surveillance, and preventive actions in all parts of the Environmental Health Program will be related to the adequacy, reliability, and speed of methods for measurement of environmental variables and biological responses thereto, and on the skill with which they are used. While such a conclusion is too obvious to require defense, its implications with respect to an integrated approach to environmental health are worthy of careful consideration.

The analytical needs of the several divisional programs differ substantially, yet have common elements which suggest the economy and efficiency of a unified, or closely coordinated, geographically centralized facility for methods development, evaluation, standardization, and demonstration, and for joint utilization of certain costly research implements. On the other hand, no consolidation of methods research, and no transfer of responsibility for such work should be so complete as to limit the fundamental responsibility of those concerned with the environmental problem. Such actions should supplement and facilitate the work of the problem oriented divisions; they should be available on demand but have no overriding functions.

FACILITY REQUIREMENTS OF THE PROGRAMS

Water Resources

Within the scope of current legislative authorizations, the Water Pollution and Water Supply Program of the Public Health Service has several identifiable functions involving analytical and instrumental needs:

a. Research and development.
b. Surveillance (the gathering and processing of basic data on water quality and water supply).
c. Field demonstrations.
d. Training.

This program involves emphasis on field facilities for decentralized research on problems unique to specified geographical areas and for regional surveillance, demonstration, and training activities. It also includes research of general applicability, training functions best performed at a central location, and technological support to headquarters operations including enforcement. The need for continuous surveillance of water qualities and quantities in relation to variable waste discharge and other factors requires a monitoring system capable of supplying measured values to a central data processing and analytical center. Similar or additional data developed by local, State, or other Federal agencies should also be transmitted to the central facility to provide the basis for interpretation and preventive action.

Air Pollution

In distinct contrast with the needs of the Water Supply and Pollution Control Program, the Air Pollution Program of the Public Health Service can best be prosecuted from a strongly centralized research, training, and technical support facility. Field functions will probably be served largely by contract or grant to academic and other non-Public Health Service agencies. Monitoring of air quality will require operation of a network of sampling and analytical facilities; some fraction of this should be the direct responsibility of the Public Health Service and be national in scope, although it is expected that detailed local reconnaissance will continue to be the responsibility of State and local governments. The latter will rely on the Service for guidance in choice of methods and instruments. Data from all sources will need to be processed promptly and meaningfully by a centralized facility in the interest of effective control action by responsible agencies.

Radiological Health

The Radiological Health Program of the Public Health Service is so intimately related to concurrent programs of the Atomic Energy Commission and other Federal agencies that a research training and program operating facility in close geographic and administrative relationship to these activities is indicated. In addition to a strong focal center, the program requires field facilities related to decentralized operations of the related agencies. These will not, in most cases, be located in proximity to field sites utilized by other divisions of the Environmental Health Program. Certain monitoring requirements may be met by sampling and measurement in coordination with similar air and water monitoring activities, but the program will have additional and quite independent needs for surveillance. Analytical and instrumental needs for radiological health training will differ substantially from those required by most other categorical programs. Even so, centralization with other elements of the Environmental Health Program could result in economies of manpower and money at least in the provision of basic maintenance and modification of services. Surveillance data should be reported to some central facility for interpretation and evaluation in terms of other environmental parameters and effects.

Milk and Food

This program will require a complete facility for the evaluation of the effects of technological processing on foodstuffs, from production to consumption, and for the development of quality analyses, determination of the physiological impact of food variables, epidemiological analyses, development and standardization of microbiological procedures, and for both basic and applied research aimed toward understanding and control of foodborne disease. The variety and temporal variability of the problems requires a well-equipped and flexible facility for attaching them as they occur, and provision for fluidity in surveillance rather than fixed or "regional" locations. In general, field laboratories should be of an ad hoc nature, e.g., for local study of shellfish pollution, or evaluation of local agricultural practices as related to foodborne toxic substances. Their best location will usually not coincide with the field facilities required by other Environmental Health Programs.

Occupational Health

This program differs in philosophical orientation from that of other divisional interests, in that it is concerned primarily with the health of workers and is therefore more dependent on facilities for the prosecution of work in the medical sciences. Its relationship to environmental health is, nevertheless, natural since the working environment is implicitly the etiological system with which the program is concerned.

Requirements for analytical and instrumental facilities will be closely parallel with those of other programs concerned with air, food, radiation exposure, sanitation, and other aspects of the occupational milieu. Beyond this there is a need for facilities usually associated with medical research, including provision for clinical studies.

The in-house functions of this program are well adapted to close coordination with cognate portions of the Environmental Health Program and would be benefited by close association in a National Center. Field functions, on the other hand, must be related to the existence of worker groups and epidemiological and clinical facilities, and will not normally be well served by integration into regional environmental health units.

ENVIRONMENTAL ENGINEERING

This program is responsible for several highly important areas of environmental health not yet assigned to divisional programs. As presently constituted, these activities will be served best by a centralized research, service, and training center providing close and comprehensive coordination with the categorical activities. Field operational bases may well be associated with field centers of other environmental health programs.

TYPES OF ANALYTICAL METHODS AND INSTRUMENTATION REQUIREMENTS

It is evident that each of the divisional programs has need for a focal facility for its own use, whether directly associated with the others or not. It is also apparent that the needs for analytical capability and instrumentation, while by no means identical, have large elements in common:

1. Organic and inorganic analysis, including a capability for determination of trace quantities, and for the analysis of large numbers of samples in a short time.

2. Radiation analysis, including a capability for low-level measurements and for determination of specific radionuclides rapidly and in large numbers.

3. Toxicologic and pharmacologic analyses; capability for tissue analyses, physiological measurements, biochemical analyses, behavioral analysis, and pathologic examinations including the structure analysis.

4. Data reception, processing and analysis; each national program will depend for its guidance on a capability for gathering, receiving, processing and analysis of information as to changes occurring in the environment.

5. Methods Development: each area requires a capability for development and standardization of analytical procedures to be used in its own program, and in the programs of State and local agencies.

6. Instrument Development and Maintenance: each program will have increasing need of a capability for in-house development, adaptation, and maintenance

of analytical instrumentation, including both research and field monitoring devices. Substantial competence and well-equipped shops will be required even though primary reliance for instrument development should be delegated to the scientific instrument industry. Effective coordination with the latter requires adequate in-house capability.

7. Supporting shops, drafting, art, printing and reproduction, and other technical services.

The many major areas of common need suggest immediately the establishment of a center for joint use to avoid duplication and to insure maximal efficiency in operation. Unquestionably such centralized supporting facility could yield substantial benefits in scope and quality of service rendered. The success of the aggregate would, however, depend more on the administrative skill with which it is managed than on the assemblage itself. If handled judiciously it could serve well the needs of the Nation; if permitted to function as a "center" not strictly subservient to the categorical programs, it could become just another ineffectual splinter related to the total effort.

Apart from the analytical and instrumentation needs common, in principle, to the divisions, there is an enormous diversity of requirement not directly relatable to the Center concept. Outstanding in this category are the following:

1. The research and development instrumentation required to prosecute individual study projects within each of the divisional areas of responsibility. These may be located within a Center, or at regional or field centers. They will be of great variety and will become obsolete and replaceable as related technology advances. Apart from the fact that their geographical juxtaposition would facilitate informational transfer among their operators, the location of the equipment would be of little consequence.

2. Monitoring Instrumentation: At least three of the divisional programs (water, air, radiological health) have a growing need for surveillance networks based on automatic or semiautomatic sampling, analytical, and recording devices. A reasonable expectation is that such monitors be telemetered to a central data processing facility.

The instruments themselves will, for the most part, have to be developed to a degree of dependability, service life, compactness, and low cost not now available. Wherever possible the design should contemplate multiple function units. Current technological trends suggest miniaturization, and the employment of solid state circuit components for prolonged reliability.

Radiation monitoring is a more advanced art than is the monitoring of material pollutants; in consequence a proportionately greater developmental capability will be required to place air pollution and water pollution monitors into field operation. Until they are developed and tested, data on these pollutants will have to be obtained less efficiently and at much greater cost by manual sampling and analysis.

3. Analytical Facilities and Instrumentation for Training: Instruction in analytical techniques and instrumentation, employed in environmental control programs, will require separate and distinctly different equipment for each categorical program whether the training is conducted centrally or at field sites.

REPORT OF THE SUBCOMMITTEE ON AIR POLLUTION

CONCLUSIONS AND RECOMMENDATIONS

FOREWORD

The need for a dynamic program in air pollution as a component part of a National Environmental Health Center is evident from a study of the magnitude and complexity of this problem. Development of a strong centralized program is believed to be a necessary prerequisite to the effective utilization of regional or local field stations by the Federal Government.

Air pollution affects the health and well-being, the productive effort, the convenience and happiness of millions of citizens in hundreds of communities throughout the country. Air pollution is not confined by political boundaries—and its chemical, medical, and physical complexities are as yet poorly defined. It is a problem involving gaseous emissions and mixtures of gases and particles of many kinds from many sources. Enough is known concerning the nature and seriousness of the problem in some urban centers to cause concern that it may be more important than is generally recognized and that it may be expected to become more serious with urban growth and the development of new technology. The urgency of this matter is further highlighted by the fact that the air-pollution problems of the next 25 to 50 years are being created by present urban construction and planning, by product development, and by present sociological trends.

A national network of observers and investigators, coordinated and directed from a highly specialized air-pollution research and operations center, is needed to detect and develop methods of controlling air pollution at its source, or, lacking preventive measures, to develop protective devices and systems for the protection of exposed populations. Research, surveillance, and training programs of the highest order and technical assistance to State and local governmental agencies are needed. Also needed is the development of strong research and training centers in universities.

The Subcommittee, in carrying out its responsibilities, discussed fully its findings and recommendations with the National Advisory Committee on Community Air Pollution. In addition, the Subcommittee reviewed the policies and proposals made by several national groups representing the public and governmental officials, including the Council of State Governments, the U.S. Conference of Mayors, the American Municipal Association, and the National Association of County Officials. These groups have formally proposed a centrally integrated air-pollution program by the Federal Government capable of exerting leadership and providing technical assistance and material and financial support to local governments in the solution of their air-pollution problems.

In the light of these considerations, and in order to meet the needs, the recommendations of the Subcommittee contemplate a central, integrated air-pollution program, equipped with adequate facilities of its own and utilizing, as required, existing supplemental resources throughout the country. This program should be capable of providing national leadership through the mechanism of research grants, contracts, and direct Public Health Service operations. These include:

a. The use of existing and the development of new university-based research and training resources assisted by research grants and contracts.

b. The use of other qualified public and private organizations through the same mechanism; and

c. The use of existing or future Public Health Service field stations for specific studies and operations where other solutions to the problems are not available.

The Subcommittee concludes that the Public Health Service, in order to fulfill its obligation of providing national leadership in the field of air pollution, requires a national air-pollution research, training, and operations center, located geographically close to the central administrative offices of the Service. It further concludes, since there are many elements scientifically and operationally common to the control of air pollution and other environmental health programs, that a National Environmental Health Center in which the various programs are closely associated geographically, scientifically, and administratively is an urgent necessity.

Specific Conclusions and Recommendations

1. The Subcommittee on Air Pollution takes cognizance of the research recommendations contained in the 1960 report of the Surgeon General's Task Group entitled "National Goals in Air Pollution Research" and concludes that this provides the basic plan of needed research and time phasing. The Subcommittee believes, however, that the level of support recommended in each of the areas outlined in that report is minimal, and concludes that among areas currently needing particular emphasis by the Public Health Service are the following:

a. Intensified studies of time and space variability of urban pollution levels under various source, topographic, and meteorologic conditions.

b. The specific interrelationships of air pollution and the social and economic development of communities in urban areas.

c. Increased emphasis on development of adequate automatic instrumentation and procedures for identification and measurement of air pollutants by the Public Health Service.

d. Extension and intensification of the studies of interreactions of pollutants in the atmosphere.

e. Increased studies on synergistic effects of pollutants on physical and biological systems.

2. The Subcommittee has inquired into the current facilities available to the Public Health Service for the conduct of its intramural research program in air pollution as outlined in "National Goals in Air Pollution Research" and supplemented above, and concludes that these are grossly inadequate to carry out the research program recommended. It further concludes that the present geographic separation of the central core research program from the operations and administrative elements is a handicap to the fulfillment of the mission of the Service in air-pollution control.

3. The Subcommittee concludes that there is a lack of sufficient numbers of trained personnel to carry on adequate air-pollution programs nationally and recommends that the Public Health Service devote increased attention to the training of research, technical, and administrative personnel. It is recommended that such training assistance continue to be both intramural and through training grants to universities and other qualified institutions. The Committee concludes that the existing intramural training program also suffers from inadequate facilities and from geographical separation from the administrative and operations parts of the program. It further concludes that the program could be made more effective by fuller association with the intramural training programs in other fields of environmental health. This association could be best achieved in the recommended National Environmental Health Center.

4. The Subcommittee has examined, in addition to the research and training functions, the present operational functions, including technical assistance, of the Public Health Service air-pollution program, and concludes that it is soundly conceived and, within the resources available, effectively executed. It concludes, however, that the program is handicapped by the lack of adequate physical facilities in which to operate and by the separation of the administrative and intramural research parts of the program.

5. The Subcommittee concludes that the attainment of the objective would be better assured by centralized interdisciplinary technical efforts as recommended for the National Environmental Health Center. The Subcommittee further concludes that greater emphasis should be placed on the application of existing knowledge in the control of air pollution and recommends that for this purpose the Public Health Service provide increased stimulation and assistance to State and local governments.

Among the areas in which the Public Health Service must provide leadership and technical and financial assistance are:

a. Appraisal of present and potential air-pollution levels in specific localities and their probable effects.

b. Stimulation of local participation in air-pollution abatement from the administrative, legal, and sociological points of view.

c. Provision of improved methods and instruments for recording emissions, atmospheric levels of pollutants, and effects of pollution.

d. Administrative procedures useful in combating interjurisdictional problems due to large-scale dispersion of pollutants.

e. Analysis of meteorological conditions in specific areas and relationships to border regions.

One of the means for the attainment of these objectives is grants for specific projects to stimulate the development, improvement, and extension of local air-pollution-control programs by State and community agencies.

6. The Subcommittee recommends that the Public Health Service assume the responsibility for the development of recommended air quality standards based on scientific information, to guide communities in the establishment and conduct of control programs.

7. The Subcommittee recommends that the Public Health Service assume the leadership in the development of standardized methods for sampling, analysis, and recording of air pollutants.

8. The Subcommittee concludes that the funds available to the Public Health Service in the past have been distributed so as to obtain a reasonable balance among research, training, and operations activities in the air-pollution program. In the Subcommittee's considered judgment, the further needed development of the air-pollution program will require the progressive increases in research, training, and operations, including technical assistance, as heretofore outlined and as tabulated below:

Millions of Dollars

Year	1956	1960	1962	1963 [1]	1966 [1]	1970 [1]
Research	1.52	4.56	7.82	12.0	16.0	16.0
Training [2]	.04	.25	.37	1.5	5.0	5.0
Operations	.17	.39	.61	[3] 4.0	[3] 12.0	[3] 15.0
Total	1.73	5.20	8.80	17.5	33.0	36.0

[1] Levels of expenditure recommended by the Subcommittee, with appropriate recognition of the recommendations of the Surgeon General's Committee on "National Goals in Air Pollution Research."

[2] Estimates of expenditures for training in 1963 and thereafter include costs for specialized training of research workers and teachers, for graduate training of persons in specific disciplines in control operations, and short-term training of field and technical personnel. The Subcommittee considers it important that the scheduling of the various types of training be coordinated with consideration of needs for various categories, lag time for curriculum development, and other factors.

[3] The increases reflect additional funds for grants-in-aid for the purpose of providing assistance in development, improvement, and extension of local air-pollution programs.

The Subcommittee feels strongly that there has been a marked imbalance in regard to facilities for this rapidly expanding program which has been faced with so many demands. No funds have been appropriated to the Service for air-pollution facilities, and such expansion as has been accomplished, through rental of quarters and temporary construction, has of necessity been at the expense of program operations and research activities. The advantages of such a facility are covered in greater detail hereafter.

9. The Subcommittee has examined the research, training, and operations programs of the Division of Air Pollution in relation to other environmental health programs of the Public Health Service and concludes that the coordination and integration of these various programs will:

a. Effect savings, promote the prevention of undesirable duplication, facilitate the sharing of knowledge and the exchange of ideas, and achieve a broader coverage of studies;

b. Make for a more productive research program and provide a more stimulating and effective training program; and

c. Provide for more efficient operations, all of which are designed to reduce the effect on humans and on the community of a wide variety of environmental pollutants in air, water, and food. The Committee concludes that among the additional benefits to the air-pollution program of such an association are the following:

(1) Increase in the likelihood of attracting and retaining personnel of outstanding ability who would be capable of evaluating all available information on air pollution and of acting as a focal point for the total national effort.

(2) Among the facets of environmental health related to air pollution now relatively underdeveloped that would be attacked more effectively by close association of the various programs are bioclimatology, meteorological factors in relation to air pollution, relationship of indoor to outdoor atmosphereic environment, and the role of natural resource use such as agriculture and forestry in relation to air pollution.

(3) Provision of centralized services and resources that would be beyond the reach of any single Division, such as centralized instrumentation and analysis functions, computer operations and data processing, public information services, graphic arts services, experimental animal supplies, and central administrative services.

The contemplated Center should be funded and staffed to permit the maximum stimulation and utilization of the total national resources for research, training, and operations in the solution of environmental health problems. The Center should be staffed with a core group of topflight personnel in the various disciplines, which would be engaged in activities of planning, stimulation, coordination, evaluation, provision of scientific leadership, and conduct of research, training, and operations programs of national relevance. The Subcommittee, at the same time, is cognizant that certain highly specialized functions and services would of necessity have to continue to be specific-program-oriented and directly associated with such programs.

10. The Subcommittee recommends that, in order to meet the growing need for Federal action to achieve the above objectives in the field of air-pollution control, there be established at the earliest possible time an air-pollution facility for research, training, and operations. Ideally, this facility would be part of a National Environmental Health Center provided this does not result in undue delay.

INTRODUCTION

Authority for Program

As an entity, the air-pollution program of the Public Health Service dates only from 1955. In that year, Public Law 159 was enacted by the 84th Congress. It directs the Public Health Service to engage in a program of research, technical assistance, and training in relation to air pollution. The Act authorizes direct activities by the Service and their support through grants and contracts; it directs the Service to cooperate with and assist public and private organizations and to collect and disseminate information relating to air pollution and its control.

A second Act passed by the Congress in 1960, Public Law 86–493, directs the Public Health Service to conduct a thorough study to determine the amounts and kinds of substances which, from the standpoint of human health, it is safe for motor vehicles to discharge to the atmosphere and to report thereon to the Congress not later than June 1962.

In addition to these two specific laws, there is authority for the conduct of air-pollution-program activity in the basic Public Health Service Act, particularly Section 301, which authorizes the conduct and support of research concerned with the diseases and impairments of man.

For reasons which will appear later, the Subcommittee believes that present authority is inadequate.

Scope, Philosophy, and Objectives of the Program

The Public Health Service air-pollution program to date has been based on the philosophy that the basic responsibility for the regulatory control of air pollution rests with the States and local governments, and that the Federal role should be a supporting one of research technical assistance to public and private organizations, and training of technical personnel.

The basic objectives of the program are threefold: (1) to improve the status of knowledge about the causes and effects of air pollution and about the means of controlling it within acceptable limits; (2) to apply our present and future knowledge to the actual control of air pollutants through technical assistance to States, communities, and industry; and (3) to stimulate all levels of government, industry, and the general public to devote increased attention and greater resources to the prevention and control of air pollution.

If present needs to cope with this problem are to be met, a significant expansion in the scope of the air-pollution program is urgently required.

NATURE AND EXTENT OF THE AIR POLLUTION PROBLEM

Air as a Natural Resource

The pollution of one of our most important natural resources—the air we breathe—has become a matter of national concern. Except for natural causes, polluted air is a product of industrialization, urbanization, and human mobility, all of which will continue to increase rapidly in the years ahead. The concern with air pollution in urban areas relates to the emission of a variety of gases and particles, often followed by secondary reactions in the air. The pollutants come from the fuels we burn in home and factory and in transporting ourselves and our goods, from the production and processing of materials in mine and factory, from our consumption of products, and from our disposal of unwanted waste materials.

The concentration of pollutants in the air at any time depends upon the interplay of many factors, such as the quantity being emitted, the vertical and horizontal dispersion of the pollutants from the sources, and the chemical and physical reactions that pollutants undergo before and after dispersion. Recent evidence has made clear that all metropolitan areas have limited air resources. Even in areas where the meteorological conditions are favorable, air resources are being heavily utilized, and in many cases acceptable concentration limits have been exceeded. The only recourse is source control. A combination of atmospheric capacity and the economic feasibility of control therefore will limit the air utilization and even the maximum size of a community.

In any specific area, the atmosphere has only limited capacity to dilute and disperse contaminants discharged to it before they can cause undesirable effects. Thus, the air must be regarded as an important and limited natural resource, whose quality must be conserved in the common interest.

Air Pollution and Health

That air pollutants can affect health has been demonstrated dramatically in several disasters in which many people were made ill and human deaths occurred. A growing body of circumstantial evidence testifies that long-term, low-level air pollution can contribute to and aggravate certain chronic diseases. Any evidence which points to differences in morbidity or mortality due to air pollution must be followed up in order, if possible, to relate specific health effects to specific pollutants or classes of pollutants.

The long-term effects of air pollution on man and other biologic systems must be quantitated accurately in order to establish the necessity, feasibility, and economic practicability of control measures designed to abate these effects. Research is still sorely handicapped by the lack of technics sensitive enough to detect minimal changes. To determine the levels of air pollutants above which biologic effects can be expected, extensive toxicologic, pharmacologic, and physiologic investigations will be needed.

Since the respiratory tract is the portal of entry for inhaled substances, an intense effort has been directed toward pulmonary function testing as an indicator of the physiologic status of exposed subjects. However, until pulmonary function testing is standardized, epidemiologic studies which rely on such measurements as an index of physiologic changes have little comparability.

The industrial threshold limits which have been set up for many of the individual compounds present in the outside air are probably in most cases too high for community residents, who include the most sensitive persons and who endure more or less constant exposure over a lifetime. Information is required about the toxicity, either acute or chronic, and the synergistic effects of pollutants in the various combinations in which they may occur in community air.

We know the acute lethal dose of ozone and the morbid pathology of chronic inhalation in various laboratory animals. But no one has studied human populations long exposed to small amounts of ozone.

In most cases earlier studies on air pollutants have been carried out on realistically high concentrations and have been concerned chiefly with lethal effects or extremely crude measurements on physiologic or psychologic consequences. This approach is of relatively little value and it is most urgent to extend laboratory studies of air pollution to meaningful levels using much more systematic and informative techniques for the evaluation of their effects. In many cases these diagnostic techniques themselves will need development.

Many air pollutants require such study in respect to the nitrogen oxides, for example. Little if anything has been ascertained about time-dose relationships or about the systemic changes from long exposures to low concentrations of nitrogen oxides, even in laboratory animals. Nitrogen oxide is said to have an affinity 300,000 times greater than oxygen and 1,000 times greater than carbon monoxide for hemoglobin; the significance of this for actual exposure needs study.

Decreased production of specific antibodies and decreased resistance to infectious disease were described many years ago in animals exposed to nitrogen oxides for prolonged periods, but such experiments need to be repeated with lower doses over longer periods, with an eye not to such gross changes as survival time and mortality rate, but to more elusive immunologic phenomena. Additive and even synergistic effects between nitrogen dioxide and carbon monoxide were shown more than a quarter of a century ago.

A well-established biologic effect of smog is eye irritation. We know that human panels exposed to irradiated mixtures of individual hydrocarbons and nitrogen dioxide experience eye irritation. Apparently a number of factors in the original mixture determine the occurrence and the degree of eye irritation, and the reaction products considered to be mainly responsible are formaldehyde, acrolein, and peroxyacyl nitrate.

Because a number of statistical studies have indicated a higher incidence of lung cancer in urban than in rural areas and because such well known experimental carcinogens as benzpyrene have been found in community air, the finger of suspicion has been pointing for some time to atmospheric benzpyrene and related aromatic polycyclic hydrocarbons as at least contributory etiologic agents in lung cancer. Certainly, it does not seem possible to attribute the alarming increase in its incidence to smoking alone. Besides the controversial statistical association, a growing body of experimental evidence incriminates atmospheric hydrocarbons. Benzpyrene, detected in significant quantities in the air of U.S. cities, is sufficiently stable in air to permit its being inhaled by community residents. In animals exposed to smog and then to soot, particles are precipitated and retained on the injured bronchial epithelium, allowing a high local concentration of hydrocarbons carried on soot. Although carcinogens are biologically ineffective while absorbed on soot, oxidants and human plasma are capable of eluting them from soot-laden lungs. All organic fractions of airborne particulate matter from U.S. cities are capable of producing local skin tumors after subcutaneous injection in mice, and chronic low-level exposures seems to be more injurious than brief heavy exposure. Animals exposed to both the virus of influenza and inhalation of ozonized gasoline develop true epidermoid cancers in the lung.

A causal relationship has also been suggested between air pollution and the group of chronic obstructive ventilatory diseases which appear to be increasing in incidence in this country as industrialization increases. Isolated research findings—that asthmatic attacks occur more frequently on days with smog damage to plants; that emphysema patients improve on breathing filtered air after severals days' exposure to smog; and that the daily course of patients with chronic obstructive respiratory disease fluctuates with certain pollutant levels—strengthen the conviction held by many experts in the field that these indicated relationships may be important leads to definitive knowledge, leads that should be vigorously pursued.

Current Status of Air Pollution Control

Our present knowledge about the health effects of air pollution and some of the steps needed to expand that knowledge were reviewed in the preceding section. In addition, air pollution's economic effects—damage to crops, animals, and structures—are manifest and we need

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to learn much more about these and to measure them much more accurately than we have so far attempted to do.

We can also greatly expand our knowledge of effective control methods. Nevertheless, the national application of what we now know about controlling air pollutants is unsatisfactory. Engineering procedures are known that can be used to control or prevent the emission of most pollutants, with some notable and important exceptions. The application of these procedures has been primarily pragmatic—based on judgments of what is technically and economically feasible. National expenditures for such controls, including operation and maintenance, are estimated to total $300–$400 million annually—a figure to be compared with the estimated annual economic damage of $7.5 billion, plus the unknown costs of effects upon health. Our surveys indicate that local government or regional regulatory control programs provide service to approximately 45 percent of the population resident in urban areas which have air-pollution problems. In many of these, however, the program is minimal. The average annual expenditure for these official programs amounts to about 10 cents per capita as compared to perhaps 40 cents for a reasonably comprehensive program.

Areas Needing Further Research

Identification and measurement of pollutants: Although some progress has been made in identifying and measuring general classes of pollutants, there is real need for intensive research into methods for identifying and measuring general classes of pollutants; there is real need for intensive research into methods for identifying and measuring the individual substances that make up these classes. Simpler and less expensive procedures are needed for this purpose.

Our knowledge is far from complete regarding air pollutants: their identity and quantity; the specific sources from which they derive; factors governing their dispersion and chemical and physical changes in the atmosphere; their effects, singly and in combination. Methods of measuring the physical state as well as the chemical composition of pollutants are needed.

Continuing source appraisals: We are concerned with pollution arising from domestic, municipal, and industrial sources. These pollutants in general are the end products of combustion, the products of incomplete combustion, and the emissions from various types of process industries. Technological development continually alters the types of emissions from chemical processing and from manufacturing and other industrial sources. The precise direction in which these changes will occur cannot be predicted, but the fact that they will occur is certain, emphasizing the need for continuing source appraisals.

The role of motor vehicles: One ubiquitous source of air pollution is the motor vehicle. In all urban areas, motor-vehicle emissions are in varying degrees already a significant source of pollution. Current trends in their use suggest that motor vehicles may become an even more significant source of pollution. The interrelationship between hydrocarbons and oxides of nitrogen when photochemical air pollution (smog) is produced in the presence of sunlight needs further elucidation. The role of particulates in the formation of smog and the mechanism by which smog irritates the eyes and causes damage to vegetation will require further research.

Photochemical smog: The formation of ozone and other oxidants characteristic of photochemical smog is known to result from reactions among gases at concentrations of a very low order, at which they are relatively innocuous. Control of such secondary reactions requires identification of the participating primary pollutants and determination of the relative importance of each in the photochemical processes. Changing technology necessitates fundamental studies in photochemistry. The identification of primary reactants associated with secondary toxicants will facilitate the development of more effective and less costly controls. Adequate knowledge of the intermediate and secondary products must be acquired before their biologic effects can be determined.

Meteorology: A fundamental scientific problem is that of establishing suitable relationships between meteorological parameters and dispersive capacities. These relationships are necessary to predict the three-dimensional distribution of airborne material, under a wide variety of weather conditions, emitted from sources of known characteristics. Objective determination of reasonable emission rates and the degree of control required for single sources in a given community are dependent to a considerable extent on this research.

Economic losses: Estimates of losses due to air pollution to date have been largely guesses, and studies are required that will provide a sound basis for future estimates of national losses from (1) damage to crops and livestock, horticultural products, and other types of vegetation; (2) corrosion of materials and soiling of surfaces; and (3) interference with ground and air transportation. Economic losses due to the expenses of illness and diminished productivity resulting from air pollution are completely unknown, as are the effects of pollution upon the general well-being of healthy individuals.

Studies are also required to identify specific causative agents of economic damage, their mechanisms and rates of action, their effective concentrations, and the costs of control, as a further basis for the development of adequate control measures and acceptable levels of pollutants in community air.

Control procedures: There are control methods available today for many of the known sources of pollution. In many cases, however, effective control methods are not yet economically feasible, either by process design and modification or through the installation of specific equipment. Considerable expansion of research on the fundamental aspects of control is needed, as well as on the development of applicable devices, so that the use of control methods will be more widespread and acceptable from an economic viewpoint.

Application of Existing Knowledge

Greater emphasis must be placed on the application of existing knowledge—and of new knowledge as it is developed—if research is to bear fruit in the form of control or abatement of air pollution. Toward this end, it has now become quite clear that the Federal program should provide greater stimulation and assistance to States and local governments in (1) appraising their air-pollution problem; (2) initiating or further developing their legislative authority; (3) organizing effective air-pollution-control agencies; and (4) developing "tailored" control programs to meet special needs. Plans have been developed for possible future Federal financial assistance to States and communities through a program of matching grants and expanded technical assistance activities to stimulate increased application of knowledge at the State and local levels.

If Federal stimulation of States and communities to control air pollution through regulation at the local level should fail to achieve the desired results, it may become necessary at a future date to seek some measure of direct Federal regulation.

Lastly, an expanded national research and application program will depend upon the availability of trained personnel to staff it. The numbers of such personnel are now woefully inadequate, and this lack will be accentuated as expansion occurs.

Technical Assistance Role of the Public Health Service

In a large majority of the jurisdictions which need control activity, State and local programs are nonexistent at present, or are grossly inadequate. Technical work in the field directed toward appraisal of problems and development of solutions is at a level far below that required for maintenance of an acceptable level of air quality. Over the next few years, the broad objectives of the technical assistance activity will be to assist States and communities in appraising overall problems and in developing "tailored" control programs, and to provide technical consultation on specialized problems. Cooperative Federal-State-local demonstration projects will be used to foster and facilitate program development and to provide some of the information upon which to base program design. In general, the Public Health Service activity will be directed toward helping initiate programs and toward providing tools and techniques in a form useful in attaining this end. Also, in order to provide a stimulus for this needed State and local control activity and render initial support in surveying problems and in operating control programs, provision would be made for Federal grants to State and local agencies for these purposes.

In the more distant future, as State and local programs develop, greater emphasis can be given to assistance in the more technical aspects of air pollution control.

Social Aspects

Among the areas which currently need special emphasis by the Public Health Service are the specific interrelationships of air pollution and the social and economic development of communities in urban areas.

In the structure of the American federal system of government, problems of intergovernmental relations are most marked, varied, and difficult in the large metropolitan areas, where the activities of all levels of government function in close proximity. Within such areas, Federal, State, county and municipal agencies, often supplemented by a host of special-purpose units of local government, must carry on their functions in close juxtaposition, subject to an extremely complicated framework of Federal, State, and local laws and administrative regulations. Obviously, it is the responsibility of government at all levels collectively to deal effectively with the problem of air pollution, which, unfortunately, does not respect lines of political jurisdiction.

We have a continuing concentration of population and economic activity in the metropolitan areas. As an example, it should be noted that the 1960 Census of Population found nearly two-thirds of the entire population of the United States residing within metropolitan areas—112.9 million persons of the nationwide total of 179.3 million. The 212 areas recognized as "metropolitan" in 1960 accounted for 84 percent of all the increase in the Nation's population during the 1950–60 decade. For these areas, the growth was 23.6 million persons, or 26 percent, while the population of the remainder of the country changed only from 62 to 66.4 million, an increase of 7 percent.

It is also in these growing metropolitan areas, of course, that most of the more serious air pollution problems arise. A question of some sociological importance is why many of these areas fail to provide adequate funds for the control of air pollution. It is doubtful that the citizens of our metropolitan areas have accepted air pollution as a desirable attribute of a high-density society. The desire for "clean air" is universal, but it is necessary to provide a focus for action to meet the problem. In this connection, the Division of Air Pollution now has on its staff a sociologist who, among other things, will attempt to determine the views of the citizens of various communities and the best mechanism to translate the individual latent wishes into desirable action for the general welfare.

ECONOMIC ASPECTS

The metropolitan areas of the United States account for the major portion of the country's economic activity. As of June 1960, metropolitan areas accounted for 78.6 percent of all bank deposits in the United States. In 1958, metropolitan areas accounted for more than three-fourths (76.8 percent) of the value added by manufacture, contained 67.2 percent of the country's manufacturing establishments, and accounted for 73.8 percent of the total number of industrial employees and 78.5 percent of all manufacturing payrolls. Of the total amount of value added by manufacture in that year, 55.2 percent was attributable to 40 major metropolitan areas, in which 52 percent of all industrial establishments were located, with 62.8 percent of industrial employees and 57.1 percent of the payrolls. Furthermore, a major portion of building activity in the Nation takes place in metropolitan areas. In 1959 and again in 1960, 69 percent of all "housing starts" occurred in these areas.

The Division of Air Pollution, recognizing the economic damage, estimated in excess of $7.5 billion annually, is interested in the development of technics and methodology to more accurately assess such costs. To meet this need, interest has been engendered in some academic institutions to undertake such investigations by applying for a research grant. Studies of the problem on a short-term basis to evaluate the nature and scope of the economic aspects of air pollution have been completed. There remains the need for further investigation of this aspect by employing the services of a full-time economist.

LEGISLATIVE ASPECTS

For a variety of reasons, the Division of Air Pollution must devote considerable attention to the consideration of the legal basis for local control problems. In many cases the existing legislation is antiquated and fails to provide for sound administration. Compounding this problem, many metropolitan territories are not within the limits of any one political unit of government. Many cross State boundary lines—and their polluted air, of course, crosses even more freely—so that adequate control requires interstate action.

Moreover, the problem may be simply too large for individual communities. Photochemical smog, for example, which results largely from motor vehicle emissions, is obviously a problem of nationwide importance. It is a present Federal responsibility to provide information which will enable communities to deal with this and other sources of pollutants, but this one cannot be dealt with in any one community. Ultimately, this is a problem of control and at present no Federal authority exists to take care of it.

The Division of Air Pollution has prepared and distributed digests of State laws and guiding principles for new legislation. There are many legislative needs to be met. Effective local action requires that the State governments permit greater flexibility and freedom of action for local units of government and provide for modification of responsibilities among such units in the best interests of the area as a whole. Most significant action by States would be legislation which provided, at least within the confines of metropolitan areas, for the joint exercise of common powers or for entering into contractual arrangements. In some cases the creation of functional authorities would be desirable.

Of considerable significance are the problems of financing and staffing local control agencies. Although about one-half of the core cities of metropolitan areas have specific air pollution legislation, repeated surveys have demonstrated that more than half of all funds now being expended by local governments on this account are within the single State of California.

On the national level, it appears essential that the State and local agencies of government receive financial as well as technical assistance to initiate or strengthen existing air pollution control programs. This would furnish an opportunity to provide Federal leadership at all levels of government. Legislation of this type has been under consideration and is now awaiting introductory and legislative actions.

The effective exercise of the various activities indicated here should be performed by the Division of Air Pollution. However, there are circumstances, particularly in relationships with outside organizations, where a coordinated approach would be desirable.

ROLES OF PUBLIC AGENCIES AND PRIVATE INSTITUTIONS AND ORGANIZATIONS

The respective roles of the Federal Government, the States and communities, and industry were clearly set forth by the Surgeon General 's Ad Hoc Task Group on Air Pollution Research Goals as follows:

> As to the nature and extent of the research to be funded, the Federal Government should be largely responsible for research of a broad nature and of general applicability throughout the country, and for the training of specialized personnel. In addition, the Federal Government should have primary responsibility for development of information required to establish air quality standards, and for the collection and distribution of information.
>
> The States and communities have a responsibility to support research on problems of primary interest to them, and to survey and evaluate continuously or intermittently the air pollution problems within their respective jurisdictions.
>
> Although industry's responsibility for research in air pollution extends in varying degree to all the goals, the major contribution to be expected of industry relates primarily to the development of adequate and economical control equipment and procedures. As used in this Report, industry is intended to include business, commercial, manufacturing, and other activities involved in the production and the exchange of goods. This definition would include agricultural, real estate (e.g., apartment houses), and Government agencies when these are sources

of air pollution. The control of contaminants at industrial sources is solely the responsibility of the industry concerned. It is reasonable to assume, therefore, that the cost of research involved in the development of control processes and equipment is largely the responsibility of industry. To realize the maximum return on industry's investment in air pollution research, perhaps even to qualify it as a contribution to the national effort, requires that the information obtained by industry be available for integration with the general fund of knowledge.

Funds from private sources such as research foundations and philanthropic organizations may also be available. A number of voluntary organizations, particularly those concerned with health research, have a real stake in this matter and should be encouraged to participate fully. The role of the universities and nonprofit research institutes will largely be confined to the conduct of research, the education and training of personnel, and the provision of consulting services. With the exception of some State-supported universities, these organizations cannot be expected to provide significant support for research on air pollution problems with their own funds.

Although this Report is concerned only with responsibilities for research, the committee is not unmindful that the full costs of enforcement will fall on the States and communities and that the entire cost of control of industrial sources must be borne by industry. On the other hand it must be realized that all such costs are ultimately borne by the public, so that in the final analysis it becomes a matter of how much society is willing to pay for research, control, and enforcement to maintain a clean and healthful environment.

PHS Research

As a result of increasing concern over air pollution and its effects on health, the Public Health Service recently conferred added strength and recognition upon its two existing Air Pollution Programs by combining them into a single unit with Division status. On September 1, 1960, the Air Pollution Medical Program and the Air Pollution Engineering Program were consolidated in a new Division of Air Pollution, consisting of five Branches: (1) Laboratory of Engineering and Physical Sciences, (2) Laboratory of Medical and Biological Sciences, (3) Field Studies Branch, (4) Technical Assistance Branch, and (5) Research and Training Grants Branch. Creation of this Division provides a sharp focus for activities both within and outside the Public Health Service and a more comprehensive, interdisciplinary approach in research, technical assistance, and training.

The nature and range of research projects conducted or sponsored by the Public Health Service can best be indicated by a brief review of some typical studies which were actually underway during fiscal year 1961.

Motor vehicle emissions: Following the approval, late in fiscal year 1960, of Public Law 86–493—which directs the Public Health Service to make a thorough study and report to Congress by June 1962 on the health effects of motor vehicle emissions—the Division of Air Pollution has sharply accelerated its research in this area.

In one group of studies, colonies of experimental animals are being exposed in the laboratory to irradiated and nonirradiated motor vehicle exhaust and to concentrations of auto exhaust pollutants as they occur in the ambient air on city streets.

In large cities, arrangements were completed for continuous measurement of exhaust-related gaseous pollutants to determine their ranges of concentration. In three cities, lead in the ambient air, and blood and urine levels of selected population groups, are being measured for correlation with traffic density and other parameters.

To help determine the pollutant contributions of gasoline- and diesel-powered trucks and buses, their operating modes are being surveyed in several cities. The particulate fraction of gasoline and diesel engine exhaust is also being analyzed for a variety of polynuclear hydrocarbons and oxygenates for correlation with analyses of potential carcinogens in emissions from other combustion sources. A cooperative survey is under way in Los Angeles to determine exhaust concentrations of hydrocarbons, carbon monoxides, carbon dioxide, and nitrogen oxides in a representative sample of registered motor vehicles under prescribed operating conditions.

Other research activities: In 50 stations of the National Air Sampling Network, gaseous pollutants such as sulfur dioxide and oxides of nitrogen are now being sampled. Formerly, only particulates were sampled.

Further advances were made in designing and improving instruments for sampling pollutants or assessing their effects; for example, a portable transistorized particle counter and size analyzer. For industrial-type installations, improved filter devices were developed. Chemical research was oriented toward analytic methods for aromatic and aliphatic hydrocarbons and inorganic gases.

A forecasting network throughout 36 States east of the Rockies was developed and research is in progress to provide a basis for extending the service to the Western States. A nationwide network has been set up to determine atmospheric turbidity. A program has been initiated whereby tetroons can be tracked by radar to indicate the trajectory of pollutant material. Further work was done on the chemical analysis of precipitation and on pollen sampling.

Special sampling for assay of potential cancer agents was conducted in six cities. The previously developed analytic technic for measuring certain potential carcinogens, particularly 3,4-benzpyrene, was applied to air samples of 103 cities and 28 nonurban sites; city levels averaged 16 times those found in nonurban areas. To further gage the potential carcinogenicity of polluted atmosphere, the geographic distribution of lung cancer according to the histological type of tumor is being studied to test the theory that the different cell types may result from different causative agents.

The following are typical of many field studies of air pollution's health effects. Tests in a large industrial firm indicated a relationship between absenteeism due to certain respiratory diseases and total sulfate pollution in the air. Further study of Nashville survey results disclosed a similar association between asthmatic attacks and airborne sulfates. In studies of two small towns, which differed only in the degree of air pollution prevalent, preliminary analysis of data suggests corresponding differences in the residents' lung function and breathing capacity.

Laboratory studies on health effects were also expanded. In further animal studies, conjugated nitroolefins were found to be potent irritants, with not only eyes and respiratory tracts affected but also circulatory and nervous systems. An especially significant study revealed that the resistance of mice to respiratory infection was markedly decreased after exposure to ozone, as demonstrated by increased mortality rate and lowered survival time. Pulmonary function tests revealed that human beings exposed under laboratory conditions to certain inhaled substances experienced reactions similar to those described in animals.

RESEARCH GRANTS

Nature and scope of current grants: Research grants which were supported during fiscal year 1961 can be grouped as to subject matter and cost, as follows:

Subject	Grants	Cost
Epidemiological and Other Studies Involving Human Beings	10	$405,159
Studies Involving Laboratory Animals, Protozoa, and Tissue Cultures	13	241,904
Studies Involving Plants, Including Algae and Fungi	8	288,107
Meteorology	4	64,839
Basic and Applied Chemistry of Air Pollution	18	426,640
Analysis and Identification of Air Pollutants	15	277,761
Control Devices	5	84,383
Totals	73	1,788,793

The present research grant program appears to be fairly well balanced and broad enough in scope to support research in the biomedical and physical sciences related to the physical environment. In the above areas, a stepped-up effort is indicated.

Other areas of research requiring grant support: The total needs of an adequate air pollution control program also include research activities in the social sciences (economics, sociology, and community planning) and the humanities (law). A general research grants program in these areas should be initiated consistent with program needs. There are in addition two general areas of need in the field of research grants which are of primary importance. The first is for a substantial increase and acceleration of program-oriented research, research directed toward solving specific practical problems. The second is for more basic research in areas which may provide fundamental information useful in the resolution of air pollution research problems.

The respective roles of the Bureau of Environmental Health and the National Institutes of Health: As long as the Division of Research Grants acts as the initial receipt and assignment office for Public Health Service research grant proposals, there should be a minimal overlap in the support of programs of the several Bureau of Environmental Health divisions and the National Institutes of Health institutes and divisions. Criteria of referral for research grant applications have been developed to delineate the program interests of these several organizations. Those related to environmental health are outlined in Public Health Service publication No. 870 entitled "Research Grants in Environmental Health." In those cases where a given grant may be supported by more than one program, it receives the ultimate program assignment after negotiations between program representatives concerned. This system should be continued as it appears to be most successful. In the environmental health programs, there should be constant communication between the Divisions and the Bureau office to determine areas of most needed emphasis.

Research Supported by Others

Other Federal agencies: Federal agencies other than the Public Health Service which have sponsored air pollution investigations in cooperation with the Service include the Atomic Energy Commission, the Bureau of Mines, the Bureau of Standards, the Department of Agriculture, the Library of Congress, the Department of Defense, and the Department of the Air Force.

States: Outside the Federal Government the State of California has been the largest supporter of medical research, with projects totaling approximately $250,000. These include population surveys in California, studies of lung function, and research relative to the setting of air quality standards. Cooperatively with the Service, medical research studies are under way with partial support from Erie County and New York State in the Buffalo area and from the State of New Jersey in Jersey City.

In general, activities engaged in by States and localities are more directly concerned with air sampling technics and control devices aimed at ameliorating local problems, although the effects upon agriculture are also being studied through State-supported research stations. If additional Research Grants and Contract funds become available there would undoubtedly be greater participation on the part of the States.

Industry: With a few exceptions research by industry has been primarily on control measures. A few industrial groups or individual companies have from time to time sponsored specific projects at a number of universities, institutes of technology, and research institutes, concerned largely with determining the smog-forming potential of their own operations and with developing economical methods of reducing emissions from these operations.

According to available information, the total research expenditures for the automobile industry have approximated $1 million annually, with the greater part devoted to research on auto exhaust control devices as a consequence of the acute problem in California.

Expenditures for the study of agricultural problems resulting from air pollution have been contributed by several directly interested industrial groups but, as far as can be ascertained, these appear to have been mainly for field monitoring in the vicinity of various plants rather than for fundamental research.

The American Petroleum Institute and the Automobile Manufacturers Association, through the Coordinating Research Council, undertook studies of automobile exhaust gases. The combined expenditures of API, Western Oil & Gas Association, and numerous individual companies for fundamental research are said to exceed $1 million annually.

In 1960 the petroleum industry announced a program for 1961 in research on new equipment aimed at the better combustion of fuel oil and distillates. Research projects supported by the petroleum industry include development of new tools and technics; air analysis programs; characterization of chemicals present in gasoline; research in photochemistry at the Franklin Institute; studies on the effect in photoatmospheric materials upon vegetation at the University of California, Riverside; and the development of specific devices for control of refinery emissions.

Very recently two manufacturers of lead additives for gasoline indicated their desire to support a cooperative project on the relation between atmospheric lead and auto exhaust to be conducted by the Kettering Laboratory in Cincinnati.

The fourth edition of "Guide to Research in Air Pollution," published recently by the American Society of Mechanical Engineers and developed jointly with the Division of Air Pollution is the most up to date (calendar year 1959) tabulation of Air Pollution research throughout the United States.

TRAINING

Intramural training: The Air Pollution Training Activities Section of the Division of Air Pollution participates in the overall training program at the Robert A. Taft Sanitary Engineering Center, Cincinnati, Ohio. This Section designs and presents short-term technical courses based on the needs of professional people at the point of practical application. In scope these courses cover the analytical, survey, control, medical, and meteorological aspects of air pollution. Field courses are given throughout the country to professional persons in the field of air pollution and to technical and nontechnical personnel from organizations which have need for a broad understanding of the current problems of community air pollution. This Section also offers consultation services to university staffs on the design and conduct of air pollution courses.

Current program: In fiscal year 1962, 13 residence courses are scheduled for presentation, with an expected enrollment of 260 professional personnel. The broad 2-week course, "Community Air Pollution," will be presented twice during the year. Other 2-week courses which will be offered include such highly specialized courses as "Atmospheric Survey," "Microscopic Analysis of Atmospheric Particulates," "Analysis of Atmospheric Organics," "Control of Particulate and Gaseous Pollutants," and "Particulate Pollutant Control." Courses of shorter duration will include "Sampling and Identification of Aeroallergens," "Medical and Biological Aspects of Air Pollution," "Radioactive Pollutants in Air," "Analysis of Atmospheric Inorganics," "Meteorological Aspects of Air Pollution," and "Source Sampling for Atmospheric Pollutants."

Also scheduled for fiscal year 1962 are two Summer Training Institutes: one on "Atmospheric Particulate Sampling" to be given at Rutgers, the second on "Control of Particulate Emissions" to be given at the California Institute of Technology. Also, an "Orientation in Air Pollution" is to be presented in Denver, Colo.

Additional needs: The number of short courses offered by the Public Health Service and the number of persons enrolled in the courses have shown a steady increase over the past several years. There is a need, however, for further amplification of this centralized training. This type of training also should be expanded on a decentralized, regional basis by the Public Health Service, and should be offered by universities in the form of extension-type curricula.

The existing intramural training program also suffers from inadequate facilities and from geographical separation from the administrative and operations parts of the program. The program could be made more effective by fuller association with the intramural training programs in other fields of Environmental Health. This association could be best achieved in the recommended National Environmental Health Center.

Training grants: Assuming satisfactory progress, the estimated needs for air pollution personnel by 1970 may be summarized as follows:

Activity	Total	Specially trained
Control agencies	7,500	2,000
Industry	7,500	2,000
Research	3,000	1,500
Teaching	100	100
Total	18,100	5,600

The above estimate of 1970 needs calls for the addition of approximately 4,000 specially-trained individuals to the number currently working in this field.

Personnel working in the fields of air pollution research and control must be drawn from a wide variety of disciplines. In some cases, individuals may enter air pollution activities with little specialized training in air pollution or merely an orientation to air pollution problems. In other cases, formal training in the methodology and techniques peculiar to air pollution activities will be required above and beyond initial disciplinary preparation.

Some 40 professional disciplines are currently represented—or listed among the needs—in air pollution research and control. They include 7 specialized areas in engineering, 4 in medicine, 6 in chemistry, and 2 in nursing, plus at least 20 more ranging from toxicology and genetics to economics and community planning. In the majority of these disciplines, additional specific training in air pollution applications is needed.

Current activities: In fiscal year 1962, $79,208 is being expended by the Division to provide training grants to 8 schools of engineering and public health for the support of graduate teaching to cover physical and engineering problems of air pollution. Approximately $25,000 more is being used to support trainees in some of these institutions. This training grant program falls far short of the needs for personnel outlined above. The entire biomedical and social science needs have been so far neglected.

General needs: In meeting these needs, it would be preferable for the Bureau to support training grant programs in the fundamental disciplines related to environmental health as a whole. To name a few, this could very well be done in toxicology, epidemiology, and the basis engineering disciplines. On the other hand, categorical training programs could be used to provide the formal training in methodology and techniques peculiar to air pollution activities which must be obtained above and beyond initial disciplinary preparation, or to provide specialized training for certain special purposes.

Special needs: In view of the many types of trained personnel needed to pursue air pollution research and control activities in the United States, it is evident that no one particular kind of grant program is completely suited to all these needs. It is, therefore, proposed that extramural support of training activities in universities and other institutions be developed toward four objectives: (1) training for research, (2) training for program needs, (3) individual traineeships, and (4) special training for top-level administrators.

(1) Training programs to meet special research needs would best be patterned after that currently in effect at the National Institutes of Health. There would be established in the Division three training committees: (*a*) for air pollution

biomedical sciences research training, (*b*) for air pollution engineering and physical sciences research training, and (*c*) for air pollution social sciences research training. Each committee would review for merit the applications assigned to it and make recommendations to be acted upon by the National Advisory Health Council.

(2) Training for program needs would be established in the Division under three training committees: (*a*) for air pollution biomedical sciences service training, (*b*) for air pollution engineering and physical sciences service training, and (*c*) for air pollution social sciences service training. Each committee would review for merit the applications assigned to it and make recommendations to the Division Chief. These recommendations could then be reviewed by the Bureau Chief and acted upon by the Surgeon General.

(3) As authorized by Public Law 84–159, the Division would establish a traineeship program for study at all academic levels. A standing advisory review committee would receive applications from candidates who wanted to study in any of the fields related to air pollution activities. Committee recommendations would be acted upon by the Division Chief.

(4) Special training for top-level air pollution control administrators would be instituted on only a very few university campuses. The chief control officer of a large air pollution control program must, above all, be a good public administrator. In order to arrive at intelligent decisions, he must have a knowledge of the needs of his program and an acquaintance with the relative contributions the several disciplines can make to it. He may have for his background training skills in one or more of some two-score professional disciplines. It is necessary therefore, that a training program for such an individual be tailored to his specific needs, in order to fill the gaps in his background and provide him with the skills of public administration.

The first requirement for such a program would be its establishment in a university center which contains departments and colleges which deal with all the background disciplines. There would have to be close cooperation between the departments under the general direction of the student's mentor to provide suitable training. There would probably be few, if any, formal course requirements but rather seminar and discussion sessions. The student who could best take advantage of this program would be a trained expert in his own field, and in addition would have senior level working experience in some phase of environmental health.

A single institution might be able to train two to five chief control officers per year. The training grant to such an institution should provide for the full support of one faculty member, who would organize and guide this program and maintain the necessary cooperative interdepartmental relationships.

Such a training grant program might be funded in the range of $75,000–$100,000 per year.

OPERATIONS

Introduction: Public Law 159 specifically states that control of air pollution sources is a State and local responsibility. At present, therefore, the "operations" portion of Federal activity encompasses no control activity as such. However, there are several problem areas in which the concept of control at the local level is less than realistic. Among these are the problems of automotive vehicle exhaust and interstate pollution. It is a reasonable prognostication that the operations portion of the Federal program eventually will include some control activity and will require development laboratories and testing facilities in support of such activity.

The operations portion of the Division of Air Pollution Program is not synonymous with Technical Assistance, but is much more inclusive, involving as it does Public Information, Monitoring, Forecasting, Standardization, Development, and Evaluation activities, in addition to those more specifically classified as Technical Assistance to State and local agencies.

If one defines as "operations" all phases of a national air pollution program other than research and training, then operations includes the entire area of the application of our accumulated know-how to the problem of air pollution control. Since control operates essentially at the local level, this phase must also encompass the communications channels to funnel information and assistance to the thousands of localities throughout the Nation. Let us therefore first examine these channels as to both their adequacy and their content.

Two sets of channels are needed: one carrying technical information and aid to the professional workers in the field, the other transmitting information to the lay public. The technical channel is closely related to the research and training functions of the program in that it is the means by which the results of the research are put to use and incorporated in training program curricula. It is obvious that dissemination of information does not, by itself, insure its application. Therefore a complete operations program includes not only the means for disseminating information but also the means for encouraging its application.

Technical assistance: A large part of the operations program of the Division of Air Pollution falls in the category of Technical Assistance to State and local agencies. These activities are characterized by the fact that in practically all cases the Division is required to work in a local community, with and for the local agency, and to provide services to support the local activity. Studies have indicated that all communities in the United States having a population greater than 50,000 and about 40 percent of the communities in the 2,500–50,000 bracket have air pollution problems. Thus about 6,000 communities are potential clients for some form of technical assistance.

The Division of Air Pollution has Air Pollution Program representatives in the New York, Chicago, and San Francisco regional offices to provide personal attention to local problems. More such representatives are needed in the several regions to which none are as yet assigned and in any particular State or city where the demands are very great.

There is a continuing demand for assistance to communities in the drafting of control legislation and of rules and regulations. To meet this need, the Division of Air Pollution has expended considerable effort in the assembly, codification, analysis, and publication of existing and proposed forms of legislation and regulations. As time goes by, increasing sophistication is being required in these matters; decisions are being faced such as whether or not to incorporate regulatory concepts based upon considerations of toxic levels, meteorological factors, topography, control technology, etc.

The survey has been the most common form of technical assistance provided by the Division to State and local agencies during the past 6 years. Many jurisdictions have as yet not been surveyed to delineate the extent of their air pollution problem and point out the means of its control. The newer, more sophisticated survey techniques yield more information than earlier surveys, but require more manpower and equipment per survey. Local agencies are in frequent need of assistance also in dealing with specific problems. Until each State agency is capable of handling these problems, many of them will be referred to the Division of Air Pollution.

The more deeply State and local agencies get involved in monitoring ambient air and air pollution sources, the more frequent will be the situation where the local agency lacks certain pieces of unique or costly laboratory or field equipment. In the former case, a solution is to send the sample to a fully equipped PHS laboratory for analyses; in the latter case, it makes sense to lend the needed field equipment from an equipment pool maintained by PHS for the purpose. The Division of Air Pollution presently provides both these types of service on a moderate scale, with indications that the scale will increase in the future.

Project and program grants: A tremendous buildup of State and local agency facilities and staff is needed if the desired decentralization of technical assistance is to be ultimately achieved. The surest way to reach this objective is to provide funds to State and local agencies through project and program grants. For the initial survey in a State or community, it is proposed that project grants cover the entire cost. For subsequent support of a State or local program after the completion of the survey and appraisal, it is proposed that the grants be on a matching basis on the order of $1 of Federal grant funds to $3 of State or local funds.

Investigation of interstate problems and intrastate problems of national significance: Under the present legislation the Division of Air Pollution lacks authority to gain access, on its own recognizance, to municipal, industrial, and commercial sources of air pollution for

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the purpose of assessing the nature and extent of emissions to the atmosphere and studying the means for their control. This makes it difficult to properly assist local agencies. The solution is legislative authority to PHS to investigate on its own initiative air pollution problems of national significance, with such authority spelled out to mean appropriate access to emission sources.

The identical problem arises where air pollution from one State adversely affects a neighboring State. Where the offending State has neither a compact on interstate air pollution with its neighbor nor a State control agency willing to intervene in behalf of its sister State, there should be authority vested in the Surgeon General of PHS to conduct an appropriate investigation on his own initiative, with rights of access to responsible or suspected sources assured by the enabling legislation.

Forecasting: Since August 1960, the Division of Air Pollution has operated an Air Pollution Potential Forecasting Service for the States east of the Rockies and is currently pilot testing a similar service for the western United States. The ultimate development of a really satisfactory local air pollution forecast system will have to await the establishment of a national network of stations to take vertical soundings of gradients between the ground and 5,000 feet.

Implicit in air pollution potential forecasting is the ability to spot the stagnation that lingers longer than expected, since this is the situation with disaster potential. A start is being made toward the development of procedures for Federal, State, or local action in the event the disaster potential situation should occur.

Monitoring: Most present air quality monitoring activity is to establish baseline data against which high values may be detected. More and more future monitoring will be for the purpose of comparison with baseline data to detect dangerous situations. Presently the Division of Air Pollution operates the National Air Sampling Network as the basic national air quality monitoring scheme. This network is not adequate to the air quality monitoring needs of the Nation. For instance, it provides continuous monitoring in only six cities and for only a limited number of pollutants. Permanent continuous monitoring stations need to be established in many more cities and in a few nonurban locations as control stations.

A number of State and local agencies operate local networks. An expansion of these and the stimulation of others would be in the national interest and would seem to be a proper use for air pollution project grant funds to States and cities.

Process and equipment development and evaluation: Since instrument development, control equipment application, and related activities are primarily undertaken by private industry, this area is one requiring extensive cooperation with industry, and one for which the Division needs appropriate laboratories, test facilities, and staff.

Standardization and certification: One important need of both control agencies and industry is in the general area of standardization—of equipment and process test procedures and of analytical methods. In American practice, professional and trade associations spearhead standardization activities. However, Federal agencies participate in such activities and frequently provide valuable supporting services. Standardization activities in the air polluton field are in their infancy. The future should see more participation on the part of the Division of Air Pollution with professional and trade associactions in these activities. The Division should plan to provide the laboratory facilities and staff for carrying on such activities.

Dissemination of technical information: A national air pollution agency has a major responsibility of providing a source of technical information for State and local use. However, even before satisfying the extramural need, a firm intramural technical information base must be provided to meet the needs of the technical staff of the Division of Air Pollution. Thus, the library, abstracting, translating, and other services discussed need to be readily accessible and available to the Division's staff.

A wide dissemination of abstracts of the pertinent technical literature is an essential need of the professional worker in the air pollution field. At present the Division of Air Pollution is supporting some abstracting service, but there is need for further extension and coordination of abstracting services.

Additional translating services, both from English to foreign language and from foreign languages to English, would be desirable.

To a larger extent than at present, the Division of Air Pollution should provide reprints of important air pollution literature which appears in reports of very limited initial distribution.

It would be desirable to publish and make available for wide distribution the series of course manuals already compiled by the Division of Air Pollution, and to prepare manuals in additional areas.

The professional air pollution worker in all except a few major cities lacks access to a comprehensive air pollution library. The Division of Air Pollution has a national responsibility to provide a National Air Pollution Library and Reference Service so that these workers may thereby have easier access to the technical literature in their field.

Dissemination of information to the general public: Although certain information activities do lend themselves to centralization, an effective public information program is important to the success of this Division's functional program and, for the reasons noted below, should be planned and carried out as an integral part of that program.

The objectives of the Federal program are not yet generally understood by the public nor accepted by the many groups which affect and are affected by the air pollution problem. Air pollution is far from being adequately controlled now. A long-continued public education program will be needed to bring about adequate control. Air pollution has major social and economic ramifications beyond those traditionally dealt with by the health professions. Since control depends upon cooperation among all levels of government and industry, its achievement depends to a high degree upon understanding on the part of all interest groups as well as the public. These groups include State and local governments, most industries, unions, schools, women's and civic clubs, professional associations, voluntary health organizations, and many more. Many of these have interests in conflict with the objectives of the Division and with each other, yet many can and do make concrete contributions toward better control of air pollution, provided they are kept well enough informed to be properly motivated.

The Division not only must continue its public relations program with magazines, newspapers, radio and television now largely geared to the Federal program—but should also provide professional guidance to State and local air pollution agencies and other local groups which seek to inform their local publics on local situations. There is also a need for development and publication of short informational brochures of the kind needed to explain aspects of the problem and program to the public. National conferences and regional demonstrations offer another means by which current problems and progress may be brought to public attention.

Strictly from the information viewpoint—apart from possible gains in economy or efficiency—the Division's activities could in many instances be expanded or its public impact be strengthened by cooperative action with other divisions concerned with environmental health. Some worthwhile activities can be better carried out jointly. For example, the Museum of Science and Industry in Chicago has offered an entire room for a permanent display on environmental health, but would not be interested in air pollution alone. A motion picture intended for lay audiences would have more impact, if it covered water pollution and radiological fallout, for example, rather than air pollution alone. The support of many organizations would be easier to enlist for the entire field of environmental health than for any one area of that field. A recruiting booklet for the environmental health field might be more appealing than one limited to air pollution—and more selective than one which covered the entire Public Health Service. In addition, there would be advantages in the location of all environmental activities in a centralized location for easier access by reporters, writers, and other visitors with information potentials.

There would be "overflow" from one division to another, from which all benefit.

INTEGRATION OF AIR POLLUTION WITH OTHER ENVIRONMENTAL HEALTH PROGRAMS

The proposed reorganization of the Public Health Service now presents all divisions of the proposed Bureau of Environmental Health with a timely opportunity to coordinate and integrate operations, to effect savings, to prevent undesirable duplication, to share knowledge, and to achieve broader coverage in studies of the total insult inflicted on humans by a wide variety of ubiquitous environmental pollutants in the air we breathe, the water we drink, and the food we eat.

Perhaps the most important benefit to be derived from the integration of the Division of Air Pollution with the other environmental health programs at a National Environmental Health Center would be the greater likelihood of attracting men of outstanding ability and national reputation, men capable of pulling together all available information on air pollution and of acting as a focal point for the total national effort. The cooperative efforts of recognized authorities in each of the programs, under the stimulation and guidance of a few topflight scientists acting as coordinators at the Bureau level, could bring about general recognition of the importance of environmental health problems and develop a reputation for the Center which would attract personnel to these programs.

Division Functions and Centralized Activities

There are certain functions presently carried out by the Division of Air Pollution which in the general interest of all environmental health programs could be performed as a centralized activity of the Bureau of Environmental Health. There are also some functions which could be carried out profitably either as a Bureau activity or as a cooperative activity by two or more program divisions. The Division of Air Pollution, however, should retain primary responsibility, in whole or in part, for much of the program in this field, due largely to the nature of its activities.

For example, research projects and technical assistance and training activities in the Division of Air Pollution are characterized by a high degree of interdisciplinary effort. One example of the need for close collaboration among many disciplines is the study of auto exhaust emissions and their effects on health. This study requires several research teams, each consisting of: Mechanical, chemical, electrical, and electronic engineers and instrumentation specialists to design and operate the unique facilities required; chemists and physicists to characterize the exhaust prior to and following complex photochemical reactions, and to identify a wide spectrum of organic and inorganic compounds, sometimes in the parts-per-billion range; toxicologists, physiologists, pathologists, veterinarians, microbiologists, biochemists, geneticists, and statisticians to conduct studies of effects on animals; and a similar variety of specialists to study the response of plants to auto exhaust.

Centralized bureau support of this interdisciplinary attack on program-related projects could provide comprehensive toxicological information services and such services as the care of animals, and could stimulate the exchange of information among scientists of the same or related disciplines in each of the divisions.

Special functions of an interdisciplinary nature at the bureau level might include: (1) Recognition of new environmental health problems not related to a specific program and initiation of action, by assignment of responsibility to one of the divisions or by other appropriate means; and (2) direction of broad investigations involving multiple environmental factors.

Specific program-related methodology and instrumentation required to carry out program functions also should remain the primary responsibility of the Division. Examples in the air pollution program include: (1) The development of equipment to measure respiratory function in humans and laboratory animals, and (2) the development of technics and instrumentation for laboratory and field sampling of air pollutants.

Centralized instrumentation and analysis functions, on the other hand, would be desirable in connection with the operation of a combined system of networks for the routine sampling of air, water, and food. Specialized networks required for short periods of time by the operating programs should remain the responsibility of the respective programs.

Computer operations and data processing should be centralized or pooled but not to the extent that it would discourage individual investigation. For example, programing should be a function of the organizational unit charged with responsibility for conducting a project.

Intramural training consisting of short, intensive courses for research, enforcement, and administrative personnel should be the responsibility of the operating program in so far as course content and staffing are concerned. Administrative coordination and operation of training facilities, on the other hand, should be part of a centralized activity.

Neglect or Underdevelopment Within the Field

Within the field of environmental health there are several areas which have not received much attention, due primarily to a lack of clear responsibility for division effort in these areas. Bioclimatology is an example of an area of relative neglect. The well-being of individuals, particularly those already suffering from physical impairment, is known to be affected by weather. Meteorological factors also have a significant effect on the frequency and severity of air pollution. The combined effects of weather and air pollution on human health and well-being need intensive study.

The relationship of air ions to air pollution and to public health also should be explored. The Division of Air Pollution has interest in this field.

The Division of Air Pollution is almost exclusively concerned with the outdoor environment, while the indoor environment, except for occupational problems, remains essentially neglected as an area of interest in environmental health. The inquiries concerning heating, cooling, cleaning, and deodorizing air in public and private buildings which this Division receives from occupants and representatives of industries engaged in various aspects of air treatment, seem to indicate an expectancy that the Public Health Service would be actively engaged in this area of environmental health.

RELATIVE EMPHASIS TO ACHIEVE BALANCED PROGRAM

Among Program Elements

The program elements—research, training, and technical assistance (operations)—are interrelated. Operational needs largely determine the nature and scope of the research program and the relative effort to be devoted to the various problems from time to time. The need to acquire new knowledge regarding air pollution has placed the greatest emphasis on research. Approximately 80 to 90 percent of program funds have been spent annually on research, and the remainder has been used to initiate token efforts in technical assistance and training. As additional funds become available, greater emphasis can be placed on technical assistance and training. The level of effort by the Federal program on research recommended in "National Goals in Air Pollution Research" will serve as a general guide in the allocation of funds to achieve a balanced program.

Just as the research program must be designed to meet the needs of control programs, so the training activities must be designed to meet the long-range and short-term requirements of the research and operating programs on a national scale. Thus a program attuned to the needs in air pollution includes what might be considered a built-in mechanism to achieve and maintain a balanced program, namely: (1) Federal, State and local, and industry operations; (2) research to meet the needs in (1); and (3) training to meet needs in (1) and (2).

The application of existing and new knowledge must be stimulated throughout the Nation in State and local agencies. The Public Health Service should provide the national stimulus and leadership in effecting this application. A mechanism which has proven successful in other public health fields has been the awarding of grants to State and local agencies to assist them in initiating or reinforcing their control programs. The Public Health Service now has authorization for the awarding of grants to State and local agencies for the appraisal of air pollution problems. Additional legislative authorization would have to be sought to permit the awarding of grants for control operations at the State and local levels. The Public Health Service should seek this additional authorization and should seek the funds to carry out the legislative provisions. If such authority and funding are realized, the relative emphasis of the various elements of a balanced program necessarily will be altered, with additional emphasis on the operations aspect of the total Division activity.

INTRAMURAL AND EXTRAMURAL

Intramural activities include the "in house" efforts of the Public Health Service and other Federal agencies, efforts supported by the award of contracts to private individuals or organizations, and such Federal efforts as the law permits in support of State and community activities. Extramural activities are those supported by grants to universities.

It does not seem feasible to arrive at a precise ratio of intramural and extramural activities. Certainly a strong central program is urgently needed to serve as a focus for the national effort. Beyond this it is considered highly desirable to expand the extramural effort at universities within the next 5 to 10 years to about five times the current level.

It is the opinion of this Committee that a proper balance between intramural and extramural activities and among the various elements of the air pollution program will be assured through recommendations and reviews by the National Advisory Committee on Community Air Pollution, and that the normal budgetary and legislative processes will further tend to ensure a program balanced in accordance with the needs.

REPORT OF THE SUBCOMMITTEE ON ENVIRONMENTAL ENGINEERING

RECOMMENDATIONS

The Subcommittee on Environmental Engineering at meetings held on August 31, September 21, and October 13, 1961, considered its responsibilities in the field of its subject. In accordance with the charge from the parent Committee, this Subcommittee has defined long-range research objectives in environmental engineering. It has also discussed the field of environmental engineering per se and has delineated relationships to that field of the Public Health Service, Division of Environmental Engineering and Food Protection, hereinafter often referred to as DEE&FP or as the Division.

The Subcommittee visualized the need for a greatly expanded research program in environmental engineering as defined herein. However, the difficulties of staffing led the Subcommittee to make conservative estimates of the magnitude of expenditures required. The Subcommittee presents the following recommendations.

1. It is recommended that there be developed, under the leadership of the Public Health Service, a more comprehensive program in environmental engineering, as discussed in this report, utilizing the combined and separate skills of physical, biological, and social scientists, at a level of expenditure which will assure the resources commensurate with the task.

2. That an Environmental Health Center be provided wherein a part of the environmental engineering program may be conducted by the Public Health Service.

3. That the research goals outlined in this report be used to guide the development of the environmental engineering research program. In addition to urgent research needs in established program areas the Subcommittee particularly recommends action to initiate investigation into new and unexplored phases of environmental engineering such as community noise, vibration, lighting, and open space requirements.

4. In establishing the Environmental Health Center that provision be made for centerwide programs as well as divisional programs and that separate funding be provided for each.

5. That research funds be apportioned on an extramural to intramural ratio of the order of 5 to 1. It is further recommended that basic research be largely done on an extramural basis.

6. That the levels of research grants and contract research in environmental engineering be increased from their present level of about $700,000 to a level at least of $10 million per year in 5 years.

7. That there be provided to DEE&FP resources which will permit it to meet its intramural research responsibilities in environmental engineering. It is recommended that funds to a level of $2 million per year in 5 years be appropriated.

8. That substantially greater emphasis be placed on research and development in the field of public water supply treatment and distribution, particularly from the standpoint of water quality, and that provisions be made for an identifiable, organizational unit within the DEE&FP to deal with these critical water supply problems.

9. The Committee recognized the importance of field studies and demonstration projects in the environmental engineering field especially pertaining to regional and metropolitan problems. It recomments that funds be made available to DEE&FP to support this work at a level of at least $3 million per year by the end of a 5-year period.

10. The Subcommittee recognized the metropolitan and regionwide character of most environmental engineering problems and recommends that the Public Health Service utilize its field study and research grants in such a way that this concept is observed.

11. That the level of research and nonresearch training grants be increased for environmental engineering. Future requirements for manpower are incorporated in the overall figures prescribed by the Subcommittee on Manpower Resources and Training.

12. That the Public Health Service take the lead in promulgating the criteria required by communities in the engineering area of environmental health.

13. That a review be made of the inadequacies of legislation whereunder the Division operates and that new legislation be promulgated to provide the Division an adequate framework to discharge its obligations in—

a. The control of noninfectious disease agents in relation to interstate carriers and interstate disease problems; and

b. Research and development pertaining to solid wastes; and

c. Research and development regarding health problems in intrastate metropolitan areas; and

d. Research and development regarding the health problems of housing.

14. That early steps be taken to establish high-level liaison and operating relationships between HEW–PHS and other appropriate Federal agencies (such as, but not limited to HHFA and the Department of Commerce, Bureau of Public Roads) in the area of urban development and metropolitan planning so as to promote the interests of environmental health.

15. The Subcommittee recognized that in order to carry out the programs recommended above, an expansion, proportionate to the new workload, of existing DEE&FP central, technical, and administrative staffs, will be required. It is recommended that provisions be made for

this. It is estimated that an increase of at least $500,000 per year at the end of 5 years will be required for this purpose.

NATURE OF THE PROBLEM

Environmental Engineering concerns itself with the establishment and maintenance of a healthful environment, particularly in urban areas where the problems are most acute. This requires bringing together the social, biological, and physical sciences in dealing with the problems of the health[1] aspects of man's relationships with his environment. This involves safeguarding man's water, air, food, conveyances, structures for habitation and employment, and his recreational and work environments. It involves not only the control of the quality and quantity of basic necessities, but also, importantly, the control of the waste byproducts, whether solid, liquid, or gaseous. These byproducts, if uncontrolled or allowed to accumulate, would not only stifle existence, but lead to widespread disease and physical impairment.

Increasing population and increasing concentrations of people into the urban areas of the United States have accentuated environmental problems in two important, related ways: (1) As our air, water, and land resources are fixed, increasing populations decrease the quantity of each of these basic necessities available to the individual; (2) with increasing amounts of waste products concentrated in areas with growing populations the relative effects of these wastes on man is increasing at an ever increasing rate. These threats are of an insidious nature, a form of creeping paralysis which, if not recognized and corrected, can lead to urban stagnation and death as surely as the most violent epidemic.

It is for this latter reason that the environmental health concept and an environmental health research center are of particular significance to the environmental engineering field—the recognition of the problem and the development of effective measures for correction and control depend more on a calm scientific appraisal of the overall problem than on public demand.

The Subcommittee recognized the importance of accidents and their relation to environmental engineering. We believe that there are many factors in the environment which contribute to accidents. These should not be disregarded but made the subject of research. The Subcommittee understands that accidents of all types are the concern of the PHS Division of Accident Prevention in which there is con-

[1] There are four basic levels of public health concern with the environment, as enunciated by the American Public Health Association (1):

1. Insuring the elements of simple survival;
2. Prevention of disease and poisoning;
3. Maintaining an environment suited to man's efficient performance;
4. Preservation of comfort and the enjoyment of living.

ducted a research program at the present level of about $2 million per year. As accidents fall within the purview of this Subcommittee in connection with metropolitan planning, housing and recreational areas, there should be coordinated efforts and funding between DEE&FP and the Division of Accident Prevention.

In order that the Public Health Service can take immediate steps to assure the quality of our urban environment, priority must be given to the following:

1. The application of the technical "know-how" that we already possess through more effective administration and organization, including metropolitan planning.

2. Research into all phases of the environmental engineering problem, including a more fundamental knowledge of the effect of wastes on man (both physically and sociologically); more economic methods of water supply collection, treatment, and distribution; more efficient and effective methods of sewage treatment (including onsite disposal), drainage, and the collection and disposal of garbage and refuse.

3. The development of health criteria or guidelines for use in planning and conducting programs involving water supply and sewage disposal, drainage, the disposal of garbage and refuse, housing, urban renewal, zoning, open space, and accident prevention.

TRENDS IN ENVIRONMENTAL ENGINEERING

The term environmental engineering is itself rather new. However, a close study of the definition given above shows that environmental engineering is the growth, or possible the sophistication, of what is known as sanitary engineering. To the fields of water supply, sewage, air pollution, and others, has been added a new dimension. It pertains to the practice of the profession, from the public health viewpoint, under urbanization. It is the large dimension of gaining acceptance of proposed environmental control projects by contiguous, diverse political groups. It is at this point that the engineering and social science professions became interdependent. Among the trends noted in "environmental engineering" the following are important.

Social and Economic Implications

Although engineers have traditionally endeavored to design the most economical as well as the most workable solution to a problem, economics in our context has a larger meaning. Involved is the need for evaluating the overall economic picture of a metropolitan complex for, say, the provision of an adequate water supply. In large metropolitan areas the provision of enlarged water supply facilities is sometimes hampered because of irrational rate structures. Solving such problems requires thorough economic studies of the water rates and instituting an equitable system overall. The importance of social factors is illustrated by the location of arterial highways without regard to social, economic, and health implications of these decisions. When this does occur, the completed road may create severe problems of neighborhood decay, inaccessibility to industrial complexes, or other undesirable "direction" of city growth. Appendix E of this report contains a pertinent discussion of social factors.

METROPOLITAN APPROACH TO PLANNING

The Subcommittee is convinced that the metropolitan factor is the common denominator to most environmental engineering problems. The technical literature of the past 10 years abounds with references to the recognition of this fact. There are now 210 Standard Metropolitan Statistical Areas (2) and the number is growing each year. Of these, 27 are interstate. Still another pertinent statistic is that 70 percent of the U.S. population lives in urban areas. The growing interest in comprehensive metropolitan health planning is well illustrated by the recent appearance of an Environmental Health Planning Guide (3) published by the Public Health Service. Designed for use by either technical or lay people, the guide emphasizes the evaluation of health related utilities and services which readily lend themselves to long-range planning.

NEW ENVIRONMENTAL HAZARDS

Until a few years ago the principal cleansing agent used in the U.S. was soap which when discharged in waste waters was changed by biological action to innocuous substances which disappeared. By 1958 the people of this country were consuming 3.8 billion pounds (4) of detergent which after use was discharged to the environment usually by way of drainage to surface or ground waters. Detergents resist biological decomposition and travel nearly unchanged for long distances to be picked up in municipal and individual water supplies. They pass readily through usual water treatment processes. What the long-range effects of detergents on health may be is not known.

Other chemical contaminants (5) found in drinking waters in recent years include DDT, aldrin, orthonitrochlorobenzene, diphenyl ether, tetralin, and acetophenone. The concern of the Public Health Service over these agents is expressed by the fact that the National Cancer Institute has begun studies of the carcinogenic properties of organic extracts from finished water supplies of several cities.

NATIONAL GOVERNMENT AND METROPOLITAN RELATIONSHIPS

From the cities themselves has come increasing pressure upon the Federal Government to provide direct assistance in solving their problems, many of which fall in the environmental field. The Council of Mayors at their annual Convention held in 1958 in Miami, Fla., requested Senator, now President, Kennedy (6) to speak on the subject, which he called "Time for an Urban Magna Carta." In the past few years several bills have been introduced in Congress providing for the establishment of a Department of Urban Affairs. Although this has not yet occurred, it is clear that direct relationships between the Federal Government and urban centers will grow. From the health viewpoint, an increasing demand by local government for environmental engineering standards is anticipated.

SYNERGISTIC EFFECTS

Synergism is defined as the "Cooperative action of discrete agencies such that the total effect is greater than the sum of the . . . effects taken independently." Little is known about the total effect of combined insults to man by his environment and major research should be directed toward this field as soon as possible. It is also here that the value of a central research center, where all facets of the environment are being simultaneously investigated, would be most apparent.

RESEARCH OBJECTIVES

This Subcommittee considered its scope of interest according to the broad definition given under Nature of the Problem. Although the term environmental engineering embraces air pollution, water pollution, milk and food, radiological and occupational health, these interests were excluded from consideration as other subcommittees were dealing with them. There remained a large area embracing the major part of the environment. The Subcommittee defined the major divisions of this area as given in Table I.

TABLE I
Major Divisions of Environmental Engineering

Housing and Occupied Space
Urban and Recreational Areas
Water Supply
Solid Wastes

In terms of program interests of the Public Health Service, Division of Environmental Engineering and Food Protection, various segments of the environment with which the Subcommittee concerned itself are listed in Table II.

TABLE II
Segments of the Environment of Interest to the Division of Environmental Engineering and Food Protection

Water Supply [1]
Metropolitan Development
Solid Wastes
Housing
Interstate Carriers
Plumbing
Emergency Sanitation
Individual Sewage Disposal
Individual Water Supply
Swimming Pools
Recreational Areas
Noise and Vibration
Air Conditioning
Environmental Aspects of Accident Control

[1] Public water supplies from water works intake to consumers tap.

An inspection of Table I shows that each element of the environment listed in Table II may be placed under one or more of the headings of Table I. The Subcommittee delineated three categories of research: Basic, operational (applied), and administrative. Research objectives [2] were then developed for each division of interest shown in Table I. The degree of priority as to when these projects should be initiated has been shown in terms of (I) immediate; (II) 2 to 5 years; (III) 5-10 years. A review of these is convincing as to the vast amount and scope of research which is required if environmental health is to keep pace with changing world conditions.

NEED FOR CRITERIA OR GUIDELINES

Environmental engineering guidelines, or criteria of performance, are viewed as an outstanding need by both professional workers and government officials at local, State, and National levels. Authoritative criteria require years of research and observation to develop, and when developed, must be reviewed at suitable, periodic intervals, changed and updated. Some problems of standards formulation are illustrated by the Public Health Service Drinking Water Standards. First issued in a very elemental form in 1914, they were revised in 1925, 1942, and lastly in 1961. In the latter work the Advisory Committee was unable to set firm requirements for limits on several important items, including viruses, because of the lack of basic research data.

Another example where much basic research is required is in the area of housing hygiene criteria. After three decades of increasing interest and work in the health aspects of housing there is still little or no information on the effects on health of room size, noise, air conditioning, lighting, and other environmental factors.

In the area of metropolitan development, health oriented standards are either nonexistent or empirical. Attempts have been made by some zoning authorities to set criteria. For example, New York and Chicago zoning authorities have set arbitrary limits on noise and vibrations from industrial sectors but the problem of permissible noise levels in business and residential areas is not dealt with.

The setting of health standards for urban development is complicated by the subjective nature of the problem. Modern health concepts include mental health aspects. Much of how persons or large groups of people react to noise, vibration, light, and temperature is governed by attitudes. To research this area the combined skills of social, psychological, physical, and medical scientists will be required. In summary, the following table lists selected, environmental engineering areas where, in the opinion of this Subcommittee, sound standards are required.

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[2] These are listed in Supplements A through D.

TABLE III

Areas in Which Environmental Engineering Criteria Are Needed

Housing and Occupied Space:
- Room Size
- Noise
- Vibration
- Lighting
- Ventilation
- Plumbing
- Mobile Homes
- Accident Prevention

Urban and Recreational Areas:
- Building Lot Size
- Population Density Standards for—
  - Water
  - Sewage
  - Waste Disposal
- Noise and Vibration by Type of Area
- Mobile Home Parks
- Accident Prevention

Water Supply:
- Drinking Water Standards
- Bathing Water Standards
- Recreational—Other Than Bathing

Solid Wastes:
- Collection
- Disposal
  - On Site
  - Community

LONG-RANGE OBJECTIVES

The Subcommittee reviewed long-range objectives in terms of the administrative, legislative, and financial arrangements required to accomplish research objectives in environmental engineering. An analysis of the Division's work indicates the need for strengthening in fiscal resources, manpower, and legislative authority some parts of its organization. Legal authority for the Division's activities is contained in the broad terms of the Public Health Service Act and amendments. The provisions of the Act should be carefully reviewed and further amended to provide a modern, legal framework within which the Division can operate to meet the problems of today's changing environment.

The Division is now staffed with a Research Grants Branch which administers the distribution of PHS research grants for projects related to its work. A review was made of the level and distribution of research grants of interest to the Division. In force, as of March 1, 1961 (7), there were 135 research grants of which only 25, or 18.5 percent, were in environmental engineering. The rest pertained to milk and food. Dollarwise, these projects were distributed $655,700 for environmental engineering and $2,214,600 for milk and food. The Subcommittee interprets these statistics to show two deficiencies. (1) Research grants, in terms of dollars, in the area of environmental engineering are grossly inadequate; and (2) the small number of applications shows a lack of interest or awareness on the part of investigators in universities and other research organizations as to requirements and opportunities for study in the environmental engineering field. The Subcommittee strongly urges that steps be taken to remedy both defects.

During the next 5 years the Research Grants Program should be expanded both in scope and funds. In addition to the present project grants, provision should be made for more broadly based support to institutions for programs of research, research facilities, and support for large-equipment items which may be used by more than one project or research program. Amounts of money required for this purpose are estimated to require progressive annual increases of $2 million so that in 5 years there will be an expansion of the program to the level of $10 million per year.

In addition, the Division, which currently has virtually no comprehensive organized research program, should be provided with resources to permit it to do research work both in its own facilities and by contract. It is estimated that an annual expenditure to the level of $2 million per year at the end of 5 years will be required.

Long-range planning to meet the research and operational goals must face the questions of manpower and training. The diverse disciplines required for conducting the work are well described by DEEFP in its "Areas of Specialization Required To Attain Long-Range Program Goals," a copy of which is appended to this report. The Subcommittee is in agreement with statements made therein. Estimates of the required numbers in the specific disciplines will be furnished by another subcommittee. It is clear, however, that environmental engineering must compete with other sciences and engineering professions, for young, technically minded persons. It is also clear that in the past the field of environmental engineering (sanitary engineering) has not been successful in attracting adequate numbers of young men to its practice. Part of this deficiency can be met by providing graduate-level training to engineers and scientists who were basically trained in related fields. This effort must be encouraged and research and traineeship grant programs by the PHS should be augmented.

LEVELS OF RESPONSIBILITY

The foregoing discussions have shown that any program of environmental engineering commensurate with the Nation's needs involves responsibilities at many levels.

Among the agencies and professional groups sharing the burden of providing a continuously healthful environment for U.S. citizens are the following: universities, foundations, health agencies, State and

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local governments, women's organizations, and medical and engineering and professional societies. Pertinent especially to this report, with its emphasis on research, is the role to be played by the university and the health agencies, particularly the Public Health Service.

In keeping with their traditions, it is expected that the universities will continue to have the responsibility for professional education and a major share of the responsibility for conducting much of the fundamental research.

The Public Health Service, with its long tradition of protecting the Nation's health, is in an established position where it may furnish leadership in aiding the States and localities in solving their environmental health problems. It should accomplish this by technical assistance, certain types of training, demonstration projects, and increased research activities, both intramural and extramural. The Subcommittee believes that the major part of the research program should continue to be extramural. It is also convinced that the Division of Environmental Engineering and Food Protection, having at present no organized, intramural research effort in environmental engineering, should institute such a program. The Subcommittee is convinced that adequate funds and facilities should be provided to enable DEEFP to discharge these responsibilities.

The Subcommittee also considered levels of responsibility or activity of other Federal agencies in the four areas of environmental engineering listed in table I. In the field of housing, the HHFA is the major Federal agency involved, but it does not presently conduct or sponsor major undertakings in health-oriented housing research. The area of urban or metropolitan development is a new identified entity. The Subcommittee noted little or no health-related research being done in this area at the present time. In the water-supply field extensive research is going on at the Engineer Research and Development Laboratory, Corps of Engineers, Fort Belvoir, Va. However, the thrust of this work is toward military and not civilian applications. Also, within the Department of the Interior, the Office of Saline Water has an extensive research program, but the prime objective is the augmentation of water resources through treatment of saline water. Within the PHS the Division of Water Supply and Pollution Control conducts water-supply research mainly related to raw water up to the waterworks intake. This Subcommittee has coordinated with theirs in the development of this area. No other Federal agency than the PHS undertakes solid-waste research and virtually none is being conducted at the present time.

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Supplement

RESEARCH GOALS IN ENVIRONMENTAL ENGINEERING

A. Housing and Occupied Space

B. Urban and Recreational Areas

C. Water Supply

D. Solid Wastes

E. Social Science and Environmental Health

F. Areas of Specialization Required: To Attain Long-Range Program Goals

A. *HOUSING AND OCCUPIED SPACE*

NOTE.—Occupied space includes, but is not limited to, institutional buildings, such as nurseries day-care centers, schools, colleges, and hospitals, offices, places of assembly, vessels, and aircraft.

Description of Research Area	*Category* [1]	*Priority* [2]
To formulate minimum standards for residences and occupied structures to satisfy the physical, physiological, and psychological needs of man, and to formulate desirable standards for residences and occupied structures to fulfill the desires of man and to provide efficiency and comfort of living; such minimum and desirable standards to include, but not limited to—	B	I

(*a*) Room sizes:
- (1) Floor area.
- (2) Room volume.
- (3) Limiting dimensions; e.g., ceiling heights.

(*b*) Thermal factors; including air temperature, radiant temperature, air movement and relative humidity:
- (1) For warmth.
- (2) For cooling.

CODE:

[1] *Category of Research:*
B—Basic.
O—Operational.
A—Administrative.

[2] *Recommended Priority:*
I—Undertake as soon as possible.
II—2 to 5 years.
III—5 to 10 years.

Description of Research Area	*Category* [1]	*Priority* [2]
(*c*) Ventilation:		
(1) Air cleanliness.		
(2) Removal of odors.		
(*d*) Illumination; quantity and quality standards:		
(1) Natural lighting.		
(2) Artificial lighting.		
(*e*) Noise; including that from internal and external sources:		
(1) Relationship to hearing.		
(2) As a disturbing factor of sleep.		
(*f*) Vibration; including that from internal and external sources.		
To formulate criteria for the design of neighborhoods for planners, developers, etc., to provide a healthful residential enviornment including, but not limited to	AO	II
(*a*) Basic requirements for site selection:		
(1) Physical characteristics of the site.		
(2) Proximity to hazards and nuisances.		
(3) Essential community facilities.		
(*b*) Utilities and services:		
(1) Water supply.		
(2) Sewage disposal.		
(3) Refuse and garbage disposal.		
(4) Telephone, electricity, and fuel.		
(*c*) Land use:		
(1) Housing and population densities.		
(2) Development of open space.		
(*d*) Vehicular and pedestrian facilities:		
(1) Roads and streets.		
(2) Vehicle parking.		
(3) Walkways.		
To evaluate the adequacy of present governmental controls to create and maintain a healthful residential environment and to propose amendments and/or supplements as necessary, including	AO	II
(*a*) Building codes.		
(*b*) Housing codes.		
(*c*) Fire and safety codes.		
(*d*) Zoning codes.		
(*e*) Subdivision regulations		
(*f*) Other administrative legal instruments.		
To determine the relationship of housing to health and to health and to identify the causative and contributing factors:		
(*a*) communicable disease	B	I
(*b*) mental illness	B	I
(*c*) chronic disease	B	I
(*d*) well-being	B	III

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[2] *Recommended Priority:*
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II—2 to 5 years.
III—5 to 10 years.

Description of Research Area	Category[1]	Priority[2]
To determine the role of the following in causing or contributing to home accidents:		
(a) Design	B	I
(1) Of the dwelling unit and structure.		
(2) Of the installed equipment and facilities.		
(3) Of furniture and household utensils.		
(4) Of the neighborhood.		
(b) Illumination	B	II
(c) Noise and vibration	B	II
(d) Toxic or irritating gases, dust and fumes	B	I
To determine the mechanism of the transmission of airborne disease organisms in dwellings and structures heated or cooled by circulating air	B	II
To evaluate the public health significance of exposure over long periods of time to low concentrations of toxic or irritant gases, fumes, dust, etc	B	I
(a) In the residential environment.		
(b) In other occupied space.		
To revise the American Public Health Association's Appraisal Method to Evaluate the Quality of Housing	AO	I
(a) To provide a technique for epidemiologists and others to use in studying housing and health.		
(b) To provide an instrument for redevelopment officials, planners, and others to determine areas of communities which need corrective action to provide a healthful environment and indicate the type of corrective action that is needed.		
(c) To develop a precise index of the hygiene quality of an individual dwelling unit or structure.		
To evaluate the role of housing in the transmission of virus diseases to man	BO	II
To determine if a relationship exists between juvenile delinquency and housing quality	B	II
To develop more effective and efficient methods of treating solid and liquid wastes on-site in residential areas, particularly in the suburbs and urban fringe areas	B	III
To develop effective means of protecting inhabitants of residences from radioactive substances including fallout	B	I
To develop criteria for the elderly and the handicapped to provide a healthful residential environment for them living independently to the maximum practical degree	BO	I
To determine adequacy of mobile homes as places of prolonged residence of families with and without children	O	III
To formulate design standards for mobile home parks to create a healthful residential environment	O	III
To define housing standards for itinerant workers	AO	III

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[2] *Recommended Priority:*
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II—2 to 5 years.
III—5 to 10 years.

B. URBAN AND RECREATIONAL AREAS

Description of Research Area	*Category* [1]	*Priority* [2]
To assess health problems related directly to metropolitanism	B	I
(a) To compare chronic disease rates in urban and rural populations	B	I
(b) To compare communicable disease rates in crowded urban areas versus sparsely populated areas	B	I
(c) To determine the effects on health of levels of community noise	B	I
(d) To evaluate health values of open spaces	B	I
To determine effects of environmental facilities on metropolitan development patterns, and vice versa; relationships to changing forms of metropolitan areas and patterns of land use	B, O, A	I, II, III
(a) To determine capacities, costs, operational characteristics, and space requirements of various types of sanitation facilities and services as related to the planning function	OA	II
(b) To determine the role and limitations of various types of sanitation systems and residential development, by general classification, in serving future land use plans and urban area	OA	II
(c) To determine the effects of change in form of sanitation services and facilities on urban development	B	II
(d) To determine the effects of land use patterns on sanitation and environmental health services (various patterns and levels of service)	B	II
(e) To determine the effects of various levels of user charges on operation and utilization of public and private sanitation and environmental health service and facilities; also the effects of different levels of charge on land use as well as on all utilization of systems	AB	I
(f) To determine theoretical limitations of possible degrees of substitutions for various types of services and facilities	AB	I
(g) To determine zones of influence of major trunklines of water and sewer facilities in terms of residential and industrial development	AB	II
(h) To develop concepts of points of diminishing returns and break-even points for sanitation and environmental health facilities, in relation to unit components	B	I
(i) To develop methods for projecting the range of possible future facility patterns within which we have choice	B	III

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A—Administrative.

[2] *Recommended Priority:*
I—Undertake as soon as possible.
II—2 to 5 years.
III—5 to 10 years.

Description of Research Area	*Category*[1]	*Priority*[2]
(*j*) To assess forces shaping urban areas	AB	I
(*k*) To determine restraints on change due to institutional, physical, or financial factors	AB	II
(*l*) To determine the relation of national, industrial, and population changes to urban environmental health projections	B	III
Criteria development—		
(*a*) To identify fundamental criteria for use in environmental health planning	B	I
(*b*) To develop methods for use of mathematical models, systems analysis, and computers for evaluation of interaction and effect of various criteria	B	I
(*c*) To research the methodology of sampling techniques, survey techniques, and other tools needed for studies	OB	I
Social values related to environmental health—		
(*a*) To determine the effects of various types and levels of environmental and sanitation services on individual and family life; also neighborhood relations	AB	II
(*b*) To assess the effects of open areas and recreational areas in relation to planning of residential development	O	III
(*c*) To determine the effects of social customs and ethnic tendencies on the use and effectiveness of environmental health measures	B	III
(*d*) To evaluate greater population mobility—short term and long term—in relation to environmental health planning	OB	II
(*e*) To identify and refine social criteria for decision making in environmental health planning	B	II
Economic development—industrial, commercial, transportation—		
(*a*) To determine the effect of industrial growth and development on planning for environmental health and sanitation requirements	A	III
(*b*) To determine the effect of changes, such as shift of commercial activity from central core to fringe areas, on environmental health facilities and services	A	III
(*c*) To measure and analyze costs and benefits of alternative interurban systems and services and their effects on location and growth of industrial and commercial areas	AB	II

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- A—Administrative.

[2] *Recommended Priority:*
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- III—5 to 10 years.

Description of Research Area	*Category* [1]	*Priority* [2]
Interrelationship between environmental health facilities and services and other programs such as urban renewal, urban highway, and airport programs—		
(*a*) To develop methods of collaboration among planners and program operators in different fields of activity	A	I
(*b*) To study the impacts of urban renewal, highway, and airport programs on environmental health and sanitation facilities and service programs	O	II
(*c*) To determine the effect of changing modes of transportation (i.e., to mass transit) on development of metropolitan sanitation services	O	II
Intergovernmental relationships, financing, and administration—		
(*a*) To evaluate various systems of laws and regulation to their effectiveness as environmental health controls	A	I
(*b*) To define conflicting governmental programs of public works or regulations as they affect environmental health	A	III
(*c*) To identify and evaluate trends in forms of government as they relate to environmental health	A	III
(*d*) To determine the effectiveness of various forms of financing sanitation facilities and services	A	II
(*e*) To determine the effect of different levels of government on administration and financing of environmental sanitation facilities and services	AO	I
(*f*) To evaluate the effectiveness of communication between government and citizenry on environmental health problems	AO	II
(*g*) To identify and analyze the decisionmaking process	B	II

C. *WATER SUPPLY*

To determine the future water supply needs—particularly of urban areas	AO	II
(*a*) Relationship of concentration of population in metro areas and availability of surface and underground water resources to those areas	AO	II
(*b*) Metro and municipal water supply planning and evaluation related to development of adequate water supplies	AO	II
(*c*) Alternate water supply sources for emergency needs	AO	I
(*d*) Water resources management	AO	III

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[2] *Recommended Priority:*
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II—2 to 5 years.
III—5 to 10 years.

Description of Research Area	Category [1]	Priority [2]
To determine efficient methods for water supply utilization, augmentation, and development	AO	I
(a) Conservation of surface waters	AO	I
(1) Better utilization of wasted flood waters.		
(2) Control of evaporation.		
(3) High rate recharge aquifers.		
(4) Prevention of silting of reservoirs and reclamation of silted reservoirs.		
(b) Conservation of ground waters	BOA	I
(1) Self-purification of ground waters and persistence of ground water contamination.		
(2) Depletion and recharge of underground reservoirs.		
(c) Water wastage control	AO	I
(1) Resources.		
(2) Plumbing design and installation.		
(3) Sociological factors.		
(d) Augmentation of water resources	BOA	I
(1) Development of marginal sources.		
(2) Conversion of sea water.		
(3) Extraction from atmosphere.		
(4) Reclamation of polluted water.		
To determine the relationship of water quality—for drinking, recreational, domestic, and food processing uses—to the health of man	BO	I
(a) Communicable and chronic diseases incidence related to water quality	BO	I
(b) Optimum and minimum physical, chemical, and biological standards for various water uses	B	II
(c) Standards for raw water quality related to intended usage and treatment available	B	II
(d) Beneficial effects of constituents in or added to water supplies—fluorides, etc	BO	II
(e) Criteria for public acceptability and economic factors of water supplies—taste, odor, color, hardness, etc	BO	II
(f) Effects of algae and other organisms on water quality	B	II
(g) Effects of gross and trace quantities of chemicals in water on humans	B	I
(h) Effects of viruses in water supplies on humans	BO	I
(i) Toxicological significance of organic chemicals in water fertilizers, insecticides, weedicides, and other agricultural poisons. What is the effect of chronic toxicity when combined with other environmental conditions?	BO	I
(j) Effect of antibiotics in water supplies	BO	I
(k) Effects of detergents in water supplies	B	I

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[2] *Recommended Priority:*
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II—2 to 5 years.
III—5 to 10 years.

Description of Research Area	*Category*[1]	*Priority*[2]
(*l*) Standards for temporary emergency supplies	B	I
(*m*) Relationship between risk of infection and bacterial standards—particularly tracer organisms—for drinking and swimming water	BO	I
(*n*) Effects of metals and salts of metals on humans (also organic compounds)	B	I
To develop, improve, and standardize laboratory quality control	B	I–II
(*a*) Methods for recovery, identification, and enumeration of viruses such as infectious hepatitis, etc	B	I
(*b*) Methods for accurate and rapid detection and determination of toxic chemicals in trace quantities, such as endrin, etc	B	I
(*c*) Methods for accurate and rapid determination of biological organisms	B	I
(*d*) Methods for determining specific radionuclides	B	II
(*e*) Automated quality determination and control	BO	II
To develop and improve systems for water treatment	BO	II
(*a*) Development of equipment and operational system design for more effective removal of harmful substances or less costly operation.		
(*b*) Particulate removal	B	I
(*c*) Removal of chemicals in solutions (heavy metals and salts of heavy metals) and synthetic chemicals (detergents, insecticides, antibiotics, etc.)	B	II
(*d*) Removal of viruses	B	II
(*e*) Coagulant aids	BO	II
(*f*) Automated treatment	O	III
(*g*) Hardness removal—central vs. individual and home treatment	AO	II
(*h*) Mechanisms for the removal or inactivation of sulfates, nitrates, and phosphates in waste waters used for ground water recharge	B	II
To determine and control water quality deterioration in distribution systems	O	II
(*a*) Decontamination of reservoirs and systems	O	II
(*b*) Control organisms and pests in water distribution systems and in reservoirs on the system	O	III
(*c*) Effectiveness of devices to prevent backflow or introduction of contamination into distribution system	O	I
(*d*) Programs for detection and control of distribution system hazards	A	I
(*e*) Toxicological determination of piping materials and other contact surfaces, such as plastic pipe or coatings	BO	II
(*f*) Performance of plumbing systems and devices and appliances	O	II

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[2] *Recommended Priority:*
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II—2 to 5 years.
III—5 to 10 years.

Description of Research Area	*Category* [1]	*Priority* [2]
(*g*) Pressure and flow problems in distribution system and plumbing	O	III
(*h*) Disinfection procedures	BO	II
(*i*) Corrosion control	BO	III
To determine related factors influencing water supply programs	A	I
(*a*) Develop health information	A	I
(*b*) Manpower requirements	A	I
(*c*) Training of operational personnel—especially the smaller plants	A	I
(*d*) Political, social, and economic factors in development-relationship between water supply and subdivision development	A	II
To determine health hazards associated with recreational water use and effective measures to control any hazards	O	II
(*a*) Determination of toxicological and physiological effects of such chemicals as iodine and isocyanine compounds	B	I
(*b*) Operational problems of backyard swimming pools	O	II
(*c*) Treatment and operation of swimming pools	O	II
(*d*) Effect of recreational use on water supply quality	O	II
(*e*) Evaluating chemicals proposed for use in swimming pool disinfection	B	II
(*f*) Determination of optimum design criteria for materials, shapes, depths, and bathing load of swimming pools for maximum safety and accident prevention	B	III
(*g*) Determination of required bacteriological quality standards for outdoor water sports and bathing waters	B	III
(*h*) Development of new practical and economical methods of maintaining satisfactory water quality for small backyard swimming pools	BO	III
(*i*) Communicable disease transmission factors in residential swimming pools	BO	II
To develop systems for dispensing safe drinking water from moving conveyances—ships, airplanes, trains, vehicles, etc.	O	III
(*a*) Water supply to conveyance	O	III
(*b*) Distribution system aboard conveyance	O	III
(*c*) Closed systems	O	III

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[2] *Recommended Priority:*
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II—2 to 5 years.
III—5 to 10 yeass.

D. AREAS OF NEEDED RESEARCH IN SOLID WASTES

Description of Research Area	*Category* [1]	*Priority* [2]
1. To determine the relationship between property value, or lot size, on the content and quantity of refuse produced per capita	B	III
2. To determine the effects of different provisions of laws and regulations governing refuse storage and collection practices; their effect on refuse production, on-site disposal practices, sanitation, and total cost of service	A	III
3. To develop "public education" measures which would increase efficiency and effectiveness of refuse collection operations	A	III
4. To develop criteria or guidelines for refuse storage, collection, and disposal to improve service, sanitation, and efficiency	A	II
5. To determine the economic feasibility of compressing and packaging refuse on the premises, or collection trucks, and at sanitary landfill sites	B	II
6. To determine if controls can be developed to assure the safe and satisfactory operation of home incinerators with mixed refuse and with rubbish	O	II
7. To determine the economic feasibility of using home incinerators instead of providing refuse collection service	O	II
8. To determine the economic feasibility and sanitation benefits of using disposable containers in refuse collection operations	O	II
9. To determine the feasibility and sanitation benefits of using chutes, moving belts, or other materials handling methods in the collection of refuse from apartment buildings and multiple family units	O	II
10. To determine the economic feasibility of using portable or truck-mounted incinerators for reducing the volume of refuse and demolition debris	O	III
11. To determine the characteristics of the end products of refuse disposal systems, their use, and market value, such as finding methods or ways to utilize metals found in incinerator residue	B	I
12. To determine the design criteria, and operation practices necessary to increase the efficiency of central municipal incinerators	B	III
13. To determine the effects of the changing contents of refuse on the various methods of disposal	O	III
14. To develop administrative and technical methods that can be used to secure the optimum use of manpower in refuse collection operations	A	II
15. To determine the rate of fly production of commonly encountered solid wastes	B	I

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[2] *Recommended Priority:*
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II—2 to 5 years.
III—5 to 10 years.

Description of Research Area	*Category* [1]	*Priority* [2]
16. To develop a method of field testing to measure the degree of soil compaction necessary to prevent the emergence of flies from sanitary landfills. Specifically, the study should correlate instrumentation to the emergence of adult flies from compacted soil	B	I
17. To determine the economic feasibility of composting as a method of solid waste disposal in communities of varying size, i.e., establish the market for compost in agriculture, home gardening, and nursery use as related to packaging and distribution costs	A	I
18. To determine the monetary value of compost to agriculture in terms of soil improvement or increases in plant germination, growth, or yield	B	I
19. To determine criteria or guidelines for the handling of demolition wastes	B	I
(*a*) Weight, volume, and character of wastes produced in metropolitan areas, based on population served	B	I
(*b*) Cost of on-site burning	B	I
(*c*) Cost of hauling and off-site burning—both burning at a central site and in tepee burners	B	I
(*d*) Cost of hauling and filling	B	I
(*e*) Cost of hauling and incineration	B	I
(*f*) Measurement of weight and volume of demolition wastes produced per square foot of floorspace of buildings being razed	B	I
20. To determine the contribution to air pollution of open burning of refuse	B	I
(*a*) Open dumps	B	I
(*b*) Controlled burning dumps—ramp burning or bank burning	B	I
(*c*) Backyard burning	B	I
(*d*) Agricultural burning	B	I
(*e*) Methods of laying fires to reduce air pollution	B	I
21. To determine the effects of refuse dumps and landfills on ground water, including operations receiving mixed refuse and operations receiving rubbish only	B	I
22. To develop a simple and reliable method of determining concentrations of particulate matter in stack discharges from incinerators by using the light refraction principle rather that the present colormetric method of analysis	B	I
23. To determine the effect of the mass installation of commercial and household garbage grinders on water consumption and on sewage treatment facilities	B	II

CODE:

[1] *Category of Research:*
B—Basic.
O—Operational.
A—Administrative.

[2] *Recommended Priority:*
I—Undertake as soon as possible.
II—2 to 5 years.
III—5 to 10 years.

Description of Research Area	*Category* [1]	*Priority* [2]
24. To determine the most economic operating characteristics of existing and commercially available municipal incinerators. This would enable these incinerators to be classified according to the range of calorific value of the refuse for which they are best suited	O	I

CODE:

Category of Research:
B—Basic.
O—Operational.
A—Mdministrative.

[2] *Recommended Priority:*
I—Undertake as soon as possible.
II—2 to 5 years.
III—5 to 10 years.

E. SOCIAL SCIENCE AND ENVIRONMENTAL HEALTH

COMMENTS ON SCOPE

The definition of environmental health which is suggested by the Subcommittee structure of the Main Committee excludes much of the environmental health area with which social scientists are concerned. For example, mental health, apart from occupational health, seems to be excluded. If so, the interests of the sociologist, anthropologist, psychiatrist, and many medical people in the metropolitan area as an environment for man in great measure are outside Committee concern. The functions suggested for the proposed new Bureau of Community Health by the Study Group on Mission and Organization of the Public Health Service, also include many of these aspects of health services in the urban area which are of basic concern to the social scientists. Thus the definition of environmental health with which we are working excludes much of the area of direct interest to social scientists.

The comments which follow assume these limitations on the definition of the field of environmental health.

PARTICIPATION BY SOCIAL SCIENCES IN ENVIRONMENTAL HEALTH RESEARCH

There is probably no aspect of environmental health, however narrowly or broadly defined, to which the social sciences cannot make a contribution. The environment in which man meets health challenges is inevitably social as well as physical.

Experience suggests that if social scientists are to make their maximum contribution, they should participate in at least two ways in program formulation and conduct.

The first grows out of exposure of social scientists to the engineers and natural scientists that are engaged in research in such program areas as water pollution, air pollution, radiological health, housing, food supply, etc. One or more social scientists participating in the deliverations of such groups can, at minimum, point out the existence of economic, social, and administrative considerations that influence the parameters of the physical problems under examination. For example, the newest health hazards come from radiation but the degree and nature of atomic energy and fissionable materials employed in industrial production are both technical and economic questions. The economist should, therefore, be a part of the team effort directed at understanding and eventually controlling the threat to environmental health caused by radiation. Similar technological changes lie behind the new or enlarged areas of environmental and occupational health and social scientists have a contribution to make to this understanding.

Also directly related to environmental health is urbanization and suburbanization of American society. The nature and trend of population concentration, the economic and social pattern of people living in the areas, their cultural traditions, the public and private social institutions in which they live and participate are a direct part of the environmental health problem, especially so when corrective action is the aim. For example, air pollution is related to commuting methods and patterns as well as to industrial location. Commuting patterns is an area where economists, political scientists, sociologists, and geographers have been paying increasing attention and can contribute significantly to research. The development of improved mass transit systems or the ending of those now in operation have a significant bearing on air pollution. The Los Angeles studies estimated that 69 percent of the hydrocarbons deposited in the air each day came from automobiles, trucks, and buses. Thus, individual driving habits, future trends, and their relationship to road patterns, industrial and recreational locations, are aspects of the problem of air pollution which can be usefully studied by economists, geographers, and other social scientists.

These examples are intended to indicate that the traditional areas of study in environmental health have underlying social causes to which social scientists can contribute insight, especially when the objective is to develop standards for use in systems of social control.

The second kind of participation by social scientists in environmental health studies may perhaps be best undertaken without continuous exposure to the work of the physical, life, and engineering sciences directed at the more specific health problems. At least it is suggested that a small group of social and other scientists could usefully be engaged in focusing on the complex administrative and intergovernmental relation of the traditional program areas.

Such a group should also look at the multidimensional character of the concepts of health and environment, and the complex behavior patterns which compose the modern metropolitan area. This need is also suggested by the fact that the Public Health Service shares its concern with environmental problems with many other Federal departments and agencies. The impact of the multiple Federal programs at the local government level, when not coordinated can be devisive and not effective.

If Public Health Service programs are to be relevant and influential at the metropolitan level, this condition needs to be reflected in Administration in Washington, the State capitals, as well as at the local level.

A multidisciplinary team set to work on the health environment as a total system would perhaps open up new doors for health researchers. For example, such a team might select one or a few metropolitan communities as case studies for testing such techniques. What is suggested here is an enlargement of the work proposed for the Division of Environmental Economics and Organization, in the report of the Study Group on Mission and Organization of the Public Health Service.

An ideal setting for the work of such a group would be the proposed environmental health center.

SOME EXAMPLES OF METROPOLITAN AREA PROBLEMS IMPORTANT TO THE IMPROVING OF ENVIRONMENTAL HEALTH

Improvement in environmental health is possible only to the degree that its hazards can be eliminated or mitigated or to the extent that man's behavior can be altered in ways which will reduce his susceptibility to the hazards. Again, staying within the usual fields included in environmental health, the social scientist has a great deal to contribute.

Most threats to environmental health cover geographic areas which are larger than the traditional political boundaries which constitute the basic State and local governmental system of this country. The problem of fragmented government is particularly acute in metropolitan areas and it is in these areas that the problems of environmental health are most serious. Further, these health problems are no respecters of the boundaries which divide these areas into literally hundreds of semiindependent principalities. Air and water pollution, and radiation are hardly controllable unless the attach can be made on an areawide basis. The possibility of such areawide cooperation is a field which has been extensively researched by political scientists during the last decade. Most practical advances have been made through the use of the areawide functional special district. The employment of this and other governmental innovations may well fit the need of the public health function. Different problems are being created, however, by the mushrooming of these special districts. Some central function is going to play a coordinating role; health may be the logical function for this purpose.

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There is also need for more specific research projects: looking to ways and means of meeting area environmental health problems, within the framework of the existing governmental structures.

Health programs also cost money—usually tax money. Can a local community afford to conduct the kind of programs which may be necessary to alleviate certain health hazards? Measuring community resources, particularly in metropolitan areas, is a complex problem. A whole metropolitan area, for example, may have sufficient fiscal capacity to carry out an extensive health improvement program; yet many of the governmental units which constitute the area may lack the necessary resources. Or a program may require interstate cooperation—many metropolitan areas cross State lines—and such cooperation may present legal and constitutional barriers that only experts in law understand. A critical evaluation of interstate compacts might prove valuable in this connection.

Health programs often involve extensive regulatory activity by government. Programs in the environmental health field are likely to require a type of regulation which reflects the highly scientific content of the standards and their probable highly restrictive intent. Do local and State governments possess the type of personnel which such programs will require? If not, what kind of training will be needed to produce them? The best designed program has no possibility of success unless it is carried into the field by personnel capable of applying it. Further, the regulated publics will have to be educated to a level of understanding in order to secure compliance, which is required in few fields today.

Environmental health is also more closely related to overall physical and social planning than any other part of the health field. How are environmental health needs going to be integrated into the planning process? Population density, for example, is inevitably related to environmental health, yet densities are more often determined by economic and political than by health considerations. Environmental health programs dependent on particular population densities are not likely to succeed unless coordinated with actual densities. The need here is twofold. First, research in environmental health to be meaningful must take into consideration the kind of densities likely and, second, health considerations should in some way be integrated into overall planning in order to provide the densities least harmful to good environmental health. Further, many private economic decisions uncontrolled by the public planning agency may adversely affect the community health and should therefore be brought into the planning purview. Here the planners need improved measurements and standards to guide their decision, and these can best be derived by the doctors, physical scientists, life scientists, and engineers working together on these problems.

In all of these applied areas, the social and natural scientists working in environmental health complement each other. In order to develop programs which are realistic and in order to understand better what is necessary to get the programs adopted and correctly administered requires a team effort.

A few more specific illustrations may serve to demonstrate the viability of a metropolitan perspective in research on environmental health problems.

Pollution Control

One field is the problem of administration of pollution regulations. A significant part of the recent Delaware Valley Project dealt with this subject and points to the need to view enforcement problems in the context of a total river system and of the multipurpose use of its water. Similar comprehensive studies need to be made of enforcement practices and experience in air pollution and in the control of food and milk moving in metropolitan areas. While many small studies have been made, few have been directed toward a concern for developing national enforcement standards and methods.

Metropolitan Cooperation and Health

A study of an unsuccessful effort to create a county health department, and a more recent study of the social forces blocking State efforts to create countywide health departments are examples of relevant social science research. The similar failures to secure public action on water fluoridation suggests the need for social science research into public attitudes as a basis for health action.

Closely related in subject matter would be the study of interstate cooperation in health matters. Particularly in metropolitan areas interstate cooperation has become an essential to an effective attack upon common problems. Today air pollution and water pollution are of special interest in this connection, but these are only two aspects of the problem. Recent social and legal research has produced an accumulation of knowledge in the field of interstate cooperation and in the use and limits of the interstate compact which needs to be related to public health. What is suggested is studies of metropolitan health problems that would be comparable to those conducted in the mass transit field by the Transportation Center at Northwestern.

Code Development and Enforcement

Research projects concerned with housing problems, with the Government's regulation of private housing, with zoning as a land planning tool are all relevant to environmental health in cities. The use of standards and their acceptability in the light of political, economic, and cultural factors is of importance to gain acceptance for research results. The fact that such standards are of local origin and use, gives rise to economic and health problems of national concern by imposing standards unrelated to the most up-to-date knowledge in the public health fields.

Ethnic Minorities and Public Health

Increasingly society's contact with new groups of immigrants in our metropolitan centers occurs through the five partners of the minister, teacher, policeman, welfare official, and public health officer. The first two have always been a part of the assimilation process in the United States, but the latter two are relatively new on the scene and partly have served to take the place of the professional machine politician. This alternation in roles might be examined from any one of a variety of angles: (1) The problems facing the public health officer in enforcing regulations that are not understood by the minority groups involved; (2) the development of a consistent policy toward the minority group that can be used to provide directives for such professional personnel. The New York City Puerto Rican population would be an obvious subject of study in such an inquiry.

Suburban Schools and Gray Area Schools as Health Problems

Among the problems produced by high density of population combined with administrative separation from the central city are the development of health programs and health standards for the suburban and rural school systems. As the upper and middle income group move from the central core of the city, the children who remain also present a special health problem and a special opportunity for effective health action programs addressed to improving living conditions in general.

Local Finance and Public Health

Research in what is often described as the community power structure is currently extremely fashionable in social science. Numerous attempts have been made to explicate the process by which decisions are made in the local community and to classify the variations. One of the questions still largely left unanswered is the extent to which the local community leaders are free to make decisions and the extent to which decisions are forced upon them by circumstances inherent in their environment. Thus, Robert Wood's study of the New York metropolitan area governments has generated the suggestion that the greater part of the variation in local government expenditures can be explained by variations in population, tax resources, etc.; little leeway is left in the form of unexplained variance for the operation of local community decisionmaking. One of the first detailed explorations of the subject is currently underway as part of the Carnegie program of research in educational problems. Economists, sociologists, and political scientists have joined in a statistical study of variations in local government spending on schools. A comparable study of local government health expenditures might profit from the methodological advances made, contribute to the knowledge of the public health profession as to its fiscal environment, and provide useful comparative data for the student of local government finance.

Other aspects of the study of community power structure would also be relevant to the overall research theme proposed. One of the pioneer comparative studies in this area was Paul A. Miller's "Community Health Action," a study of initiation of hospital construction applications under the Hill-Burton Act. Charles Wille has published a similar study of the conflict surrounding a proposal to build a community hospital in "Patients, Physicians, and Illness: A Source Book in Behavioral Science and Medicine." The methods involved in these studies are relevant to studies needed to secure action in areas of environmental health.

Health Professionals and Community Decisionmaking

One of the principal methodological contributions of metropolitan leadership studies has been the formulation of a procedure to determine the degree of overlap among the community participants in decisionmaking in the various functional fields; e.g., do the same men who determine who is nominated for the city council also appoint school superintendents, etc.? Research employing these same procedures might be used to identify the character of public participation in decisionmaking affecting health and to fix the position of the health professionals in relation to them.

Metropolitan Reorganization and the Private Health Agencies

Usually the problem of metropolitan reorganization is presented in terms of public instrumentalities; it exists, however, for private agencies that are structured around separate communities as well. What happens when a previously separate community is absorbed into the metropolitan areas as a suburb; how freely do the suburban private health agencies accept incorporation into metropolitan-level organizations? These and related questions might also be explored.

Safety and the Automobile as a Public Health Problem

The car, the driver, the highway, the manufacturer, the police, and the lawmakers represent a system. This is the system that produces the automobile accident—4,888,000 injuries in 1957 reported by the U.S. Public Health Service. This environmental health problem cannot be left to the highway engineers, or even the automobile engineers. It is a logical system for the epidemiologist to study together with social scientists and engineers.

F. *AREAS OF SPECIALIZATION REQUIRED TO ATTAIN LONG-RANGE PROGRAM GOALS*

The Division's diverse responsibilities in providing protection and improvement of public health in the areas of environmental engineering and food protection require numerous areas of professional specialization. There are three basic objectives to be met for each individual program goal:

1. The identification, measure, and assessment of problems;
2. The development of standards, criteria, and practices necessary to solve these problems;
3. The application of the most current standards and techniques toward the solution of problem situations and the enforcement of regulations under legislative responsibilities.

There is a need for expanding basic and applied research, technical assistance competency, standards development, training activities, and interstate control procedures.

The professional resources required to attain the Division objectives are described below under four categorical headings reflecting the overall development which each specialized area is expected to attain within the coming 5 years. The status of these specialties will change progressively as new problems appear and additional techniques or pertinent knowledge becomes available. New specialties will undoubtedly need to be added and the emphasis on existing areas of competence will require adjustments to meet the changing problems in environmental public health.

INDEPENDENT RESOURCES

The areas of specialization in this category form the core of the professional resources required to meet the Division's research, technical consultation, training, and related responsibilities. Each area will be developed in depth to serve the principal day-to-day needs of the Division.

ENGINEERS

Sanitary engineers with competence in water treatment, sewage disposal, solid-waste methodology, and applied radiological health. Also included are sanitary engineers with special orientation to metropolitan planning and development problems and techniques. Sanitary engineers will be available for consultation and technical assistance at the local levels or at the operational level as well as lending their specialized knowledge in developing research information.

Chemical engineers with competence in research evaluation of food-processing techniques, water purification, and swimming pool equipment and operation.

Mechanical engineers equipped to investigate problems relative to the design, construction, and operation of food equipment; control of time-temperature operations; ultra-high-temperature pasteurization; dehydro-freezing; and hydraulics and pneumatics for application to plumbing and water-supply systems.

Marine engineers for vessel construction and facility review at operational level; competence in nuclear powerplant installation and shielding will supplement the basic marine engineering skills.

PHYSICAL SCIENCES

Chemists with competence in inorganic, organic, and biochemistry for application to problems in enzymology, metabolism, nutrition, immunology, and other subspecialties related to the study of natural food products. Strong support will be needed in physical, organic, inorganic, and analytical chemistry to deal with the increasing problems of hazardous chemical contamination of foods. Radiochemistry will be essential component of this area, because of special significance of foods as sources of environmental radioactivity and the importance of tracer techniques in research. Special competence in water flocculation and treatment, water-supply-quality evaluation, and sewage-treatment techniques would also be required.

Physicists: The application of engineering physics to the research areas in sound, light, vibration, and other preceptory phenomena will be required. Physicists with special competence in health physics will be utilized at the field level for problems involving radiation hazards.

LIFE SCIENCES

Microbiology: Specialists in bacteriology, virology, mycology, and parasitology will be required to investigate the causative agents of food infection or intoxication and to develop control measures. Orientation to microbial physiology, genetics, and serology, as well as to medical, veterinary, sanitary, dairy, and marine microbiology, will be necessary to investigate the public health implication of microbial food contamination, develop sanitation standards, and devise preventive measure applicable to the preparation and serving of foods. Special competence in water microbiology will supplement the chemical and engineering skills also applied to this problem area.

Sanitarians and health service officers: Specialist in the application of research information and techniques in the areas of microbiology, entymology, and zoology in carrier sanitation and vector control and for each class of highly perishable foods such as milk, shellfish, meat, and poultry products will be required at the field level to conduct studies and demonstration projects and perform surveillance operations.

METROPOLITAN PLANNING AND DEVELOPMENT SPECIALISTS

Political-economic disciplines: Political scientists, economists, and attorneys with special orientation of their skills toward assessing and solving metropolitan planning problems in such categories as local and State political structures, public utility financing, community economic base studies, enabling legislation at local, State, and regional levels.

City planners to perform studies and demonstration projects and furnish technical assistance to local, State, and regional units.

HEALTH EDUCATORS AND TECHNICAL INFORMATION SPECIALISTS

This group will have the prime responsibility of—

(*a*) Enlisting community participation in study areas and demonstration projects; and

(*b*) Insuring that all research information submitted be available to the scientific community for application to existing problems and to prevent duplication in research investigations and the application of research information to operational programs.

DEPENDENT RESOURCES

Included in this category are areas of specialization for which the Division must have the competence to meet its ordinary needs, but will also require the support of other groups with respect to fundamental or theoretical research and unusual equipment or professional talent.

PHYSICAL SCIENCES

Toxicologists: The Division will need the services of chemists, pharmacologists, and pathologists to evaluate experimentally and judgmentally the health hazards of foreign chemicals and natural constituents found in foods. Recommendation of safe practices and control measures will be a part of their responsibilities. Toxicologists will be needed to evaluate materials proposed in construction of equipment having public health significance and such special problems as insecticide residues in food products and stored-water supplies. This competence would be shared with such elements as the Division of Water Supply and Pollution Control and the Division of Air Pollution.

Physicists: Specialists capable of utilizing complex physical instrumentation and interpreting the results will be needed to characterize foods and their significant components or contaminants. The orientation of the work will be primarily to biophysics, but knowledge of both radiation physics and the classical physics of heat and pressure will also be required. In recognition of the very high degrees of specialization within this area and the large investment required for proper instrumentation, the Division will also need the support of other groups with related competences. Quite probably a central facility will best serve the needs for the most costly items which are infrequently used by any division.

Statisticians: In this area, a distinction is made between statistical design and analysis of data, on the one hand, and the broader areas of systems analysis, data retrieval, and operations research which are considered in the Category III, "Pooled Resources." The Division will require a statistical staff and facilities sufficient to develop sound protocols for research, evaluate technical data, and record information in forms which can be subjected to more sophisticated statistical treatment. Although the Division will need machines and staff for coding, sorting, and collating statistical information, it will depend on others for computer services and the development of mathematical statistics to meet its needs.

LIFE SCIENCES

Hydrography: The special problems associated with production, harvesting, and processing of raw shellfish and other seafoods requires the attention of specialists in marine biology and oceanography to complement the chemical and microbiological work on sanitation of these products. Because of the allied interests of the Division of Water Supply and Pollution Control, coordination of work in this area is contemplated.

MEDICAL SCIENCES

Physiologists will be required to evaluate physical effects of preceptory phenomena such as excessive levels of vibration, sound, temperature and related environmental factors encountered in the urban environment.

Epidemiologists: Both "classical" and "experimental" epidemiologists will be needed to investigate the occurrence, causes, and circumstances associated with illness as attributed to foods. Field studies with human populations, as well as experiments with animal populations, will be conducted in this area to examine critically and perhaps extend the precepts of epidemiology with respect to the impact of both food contaminants and food itself on health. Such specialists will also determine sources and dissemination of communicable diseases through food-service operations on interstate carriers, such recreational media as swimming pools and bathing places, and vector borne disease problems stemming from faulty waste-disposal practices.

BEHAVIORAL SCIENCES

Psychologists and sociologists will be required for community studies to determine the effect of urban environmental problems on the individual, the family structure, and the overall community social framework. The effects of changing environmental factors on the populations of our urban centers must be evaluated in the sociological and psychological aspects which will then be supplemented by whatever data of a physiological nature can be obtained. This total picture of deleterious effects of urban problems on our social structure will provide positive guidelines not presently available for recommending and implementing expanded community services and environmental health measures.

TRAINING

Training officers and specialists will insure that survey and evaluation techniques, developed in the research area, are made available to field personnel and that the latest and best techniques devised in the research community are made available to the regional staffs. They must be capable of recognizing, interpreting, and communicating technical information of value in public health practice. They will need the support of other professional staff members and consultants, as well as certain training facilities available to the Center as a whole.

ADMINISTRATION AND MANAGEMENT

In order to work effectively within the administrative framework of the Bureau, DEEFP will need the full-time services of specialists in personnel, fiscal management, procurement, management, and bibliographic services, as well as skilled illustrators, draftsmen, shopworkers, janitors, and emergency maintenance personnel. This group will be heavily dependent on the central management and service groups available to the Center as a whole.

POOLED RESOURCES

Areas of specilization in this category will be supported in common with others using divisions at a single location. DEEFP will employ ancillary specialists who have some knowledge of these fields, but will depend on the central organization for facilities and additional talent. Areas included here differ from those in category II with respect to the degree of internal development required to meet the needs of the Division.

ADPS UNIT

Systems analysis: As noted above, DEEFP has need for supporting resources which will bring to bear advanced mathematical theory and data processing equipment on the public health surveillance of the environment. These resources will supplement the internal statistical competence of the Division if a central facility is provided.

Physical Sciences

Mathematicians to develop mathematical models for solving aspects of environmental programs in community development and planning on a predictive basis wherever possible.

Climatologists: Rainfall, temperature, day length, and other climatic factors are well known to affect the composition of food crops. In order to assess the role of these factors in the uptake of radionuclides, agricultural chemicals, and soil constituents, climatologic studies will be required. Studies may also be needed on the relation of climate to human nutrition.

Life Sciences

Ecologists: Understanding of the health problems associated with foods requires knowledge of food chains and the factors that determine the dietary habits of man. These important components of human ecology can best be investigated in broad studies, but are of special interest to DEEFP.

Radiation and Reactor Technology

These specialists will represent a very high degree of competence in the specialized aspects of radiological health and nuclear reactor technology. DEEFP has direct interests in (*a*) the possible contribution of reactors to radionuclide contamination of foods, and (*b*) the utilization of high-energy sources as tools for research on radiation sterilization and neutron activation analysis. Because of the high costs involved, the Division would prefer to utilize a central facility which might be constructed and operated by the Division of Radiological Health. In addition, such projects as the evaluation of radiochemical constituents in water supplies and specialized problems in nuclear powerplant units on ships would be investigated by these specialists.

UNDEVELOPED RESOURCES

This includes categories to be drawn upon intermittently for special projects or problem application and will consist primarily in professional competencies retained under contract or by consultant appointments. Other elements of the Service are also included which would not be found within the projected Bureau structure.

Clinical and Medical Disciplines

Specialists in such fields as geriatrics, pediatrics, radiology, allergy, dentistry, and internal medicine may be needed to undertake specific studies or provide advice on responses of man and animals to food constituents and dietary regimens.

Other Areas

Even within the areas where the Division has considerable competence, situations will almost certainly arise which require the help of additional specialists in such fields as spectroscopy, organic synthesis, chemotherapy, electron microscopy, and the like. The full range of possibilities cannot be clearly defined in advance, but ample provision should be made for the temporary employment of such individuals on a basis that will be mutually acceptable to them and to the Government.

REPORT OF THE SUBCOMMITTEE ON MILK AND FOOD

CONCLUSIONS AND RECOMMENDATIONS

The principal conclusions and recommendations of the Milk and Food Subcommittee, regarding the food-protection aspects of environmental health, are summarized below.

CONCLUSIONS

1. Food is a major component of man's environment, which exerts important multiple effects on human physiology and psychology. Food may also serve as a carrier of chemical and biological contaminants acquired from soil, air, water, food handlers, equipment, and many other sources. Much useful information is at hand concerning the impact of diet and food contaminants on health, but the more subtle relationships are not yet clearly understood. Enough is known, however, to suggest that food, alone or in concert with other factors, may affect man's response to nearly all environmental stresses.

2. There is an enormous and rapidly increasing disparity between the rate at which new public health problems are arising, due to growth and technological changes in the food field and the level of effort being directed toward their solution. The food industries and governmental enforcement agencies are actively engaged in the commercial application of new processes and in determining compliance of finished products with existing standards. They urgently need the active participation and leadership of the Public Health Service in a national program to develop additional information, methods, and criteria applicable to new products which may be used to protect the health and welfare of the consumer.

3. It is necessary that the Public Health Service program in food protection include aspects of the problem not now being studied. In areas of common interest, collaboration with other governmental agencies will be required. Among the major problems of public health concern are the following:

a. Prevention and control of foodborne-disease outbreaks caused by microorganisms or their toxic products, which represent one of the more common categories of nonfatal illness in the United States.

b. Determination of the health effects of foreign chemicals occurring in food as residues, additives, or fallout.

c. Assessment of the physiological significance of the complex chemical and physical changes resulting from novel methods of processing, packaging, storing, and marketing convenience foods.

d. Development of criteria and methods for determining food safety.

e. Surveillance of the consumer food supply with respect to sanitary quality.

f. Evaluation of food equipment and processes from the public health viewpoint.

g. Improvement of control techniques used by health agencies in the field of food protection.

4. The current Milk and Food Program of the Public Health Service is making valuable contributions in the areas of milk, shellfish, and food service sanitation, which fortify, rather than duplicate, the work of industry and other governmental agencies in these areas. The intramural and extramural phases of its research, training, and technical assistance activities are severely handicapped by inadequate funds, manpower, facilities, legislative authority, and organizational status. The Program cannot be expected to cope with the rapid changes occurring in our $80 billion food industry, or to be an effective participant in a comprehensive environmental health program, unless its support is increased substantially over the $5 million appropriated in fiscal year 1962 for grants, laboratory construction, and internal operations.

5. Inclusion of a Food Protection Program in the proposed environmental health center is essential to its effective development and for the ultimate solution of problems involving multiple environmental stresses on man. Among the specific advantages are:

a. "Cross-fertilization" of the research staff by association with professional counterparts in other fields.

b. Common use of special equipment, such as high-energy radiation sources and climatological facilities, which may be accessible in other parts of the Center.

c. Capitalization of talent by creating a community of scientific culture which will attract, hold, and develop capable people.

d. Participation in a program to determine the total impact on health of substances acquired, not only from food, but other environmental sources, including air, water, and occupational exposure.

e. Exploration of the part played by environmental factors in determining the varied responses of man to ingestion of certain bacteria and other potential causes of foodborne illness.

f. Guidance of research studies involving health hazards of foods so that the results will be more readily useful to industry and community health agencies.

RECOMMENDATIONS

1. The Public Health Service is recommended as the focal point for research, surveillance, and standards necessary to maintain and improve the quality of the food supply as it affects the health and welfare of the consumer and for the stimulation of research application. The Service has worked for many years with States and localities as well as other Federal agencies and industry, and is in a key position to integrate the interests of the producers, processors, distributors, and consumers of food. Such preventive action is essential to the main-

tenance of our high health status in the face of revolutionary changes in food technology and eating habits of the population. The proposed overall mission is to improve and protect the public health and welfare as they may be affected by foods and beverages, alone, or in combination with other environmental stresses. The primary objectives include:

a. Detection, assessment, and control of microbiological, chemical and nutritional health hazards which have been and will continue to be introduced as the result of changes in food production, procurement, processing, packaging, marketing, and serving.

b. Reappraisal of food protection measures now in use, as they are affected by changes in technology and food handling practices.

c. Surveillance of developments in science and technology as they may potentially affect food protection.

d. Development and maintenance of a basic-data program on trends of public health hazards associated with food production, processing, and distribution.

e. Investigation and development of methods to prevent or reduce health-hazard problems confronting the food industries.

f. Application of the accumulated knowledge to improve public health practice.

2. The pressing need for competent manpower, to staff both food research and operational programs, warrants a major expansion of training activities, including the following:

a. Development of interest among potential candidates for employment by offering career inducements, beginning at the high school level.

b. Creation of greater opportunities for basic scientific training, at both the undergraduate and graduate levels, by means of grants to colleges and universities as well as fellowships for the support of individual students.

c. Reinforcement of technical knowledge among industry, State, and municipal health workers concerned with foods, by organizing and presenting intensive specialized courses in the various phases of food protection.

3. The increasing occurrence of foodborne illnesses, and the dearth of information about potential health hazards associated with recent technological developments in the food field, are compelling reasons for fostering a broad program of research on food protection, including:

a. Rapid expansion of the research grants program in scope and funds during the next 5 years.

b. Establishment of a central research and technical-service facility, supported by regional laboratories designed to deal with the special problems of each area.

c. Utilization of the existing PHS Milk and Food Program as a nucleus around which to build a multidiscipline organization that has greatly increased capacity and resources for experimental work, technical leadership, and conversion of research to practical food protection programs.

d. Development of contractural relations and interagency agreements for projects of mutual interest to the Public Health Service and other governmental or private organizations.

4. The Committee notes that the Public Health Service Act, as amended, does not refer explicitly to food protection, but covers this area only by implication. The Service is, therefore, urged to seek legislation that will specifically authorize and support a national program in the food field along the lines recommended above. Enactment of such legislation would serve to delineate Service responsibilities, generate public awareness, and establish a basis for the working relationships with other organizations, on which the program depends for its continued development. In this connection, the Committee believes that planned improvements in the Milk and Food Program, including the construction and operation of two new shellfish research laboratories, are so much needed that they should proceed independently of further legislative proposals or administrative determinations relating to longer range developments in the field of environmental health.

5. A five- to six-fold increase in the scope and intensity of both the intramural and extramural food-protection activities of the Public Health Service is recommended during the next 5 years, in order to overcome the evident deficiencies and to keep pace with new developments in the food field. The Service should plan to acquire an additional 250 professional staff members,[1] about 500 more supporting personnel, a new central research facility, and an annual operating budget of approximately $8 to $10 million by fiscal year 1967. It is estimated that an additional $15 to $20 million will be needed to provide support for extramural research, training and facilities grants, contracts, and interagency agreements, thus bringing the total support for the Program to roughly $25 to $30 million within 5 years. A further three- or four-fold expansion should be anticipated by fiscal year 1972.

INTRODUCTION

Food protection is defined, for the purposes of this report, to include: (*a*) The prevention and control of contamination with biological, chemical, or physical agents which, alone or in combination with other environmental insults, adversely affect man's health; and (*b*) the maintenance or improvement of those dietary, sensory, and other qualities which contribute to human welfare. The important multiple effects of foods on health and welfare and influenced, in large measure, by the environmental conditions under which the foods are produced, processed, packaged, and made available to the consumer. They, in turn, affect man's physical and mental responses to other stresses, which together make up the complex termed environmetal health. (1)

When foods come into contact with air, water, soil, and the byproducts of civilization, they acquire a variety of microbial and chemical

[1] See Supplement for types of professional specialists required.

contaminants which may be passed on to the consumer. Food processing may remove or destroy some agents, but it may also allow further exposure to environmental contamination. The complexities arising from multiple ingredients, processes, and types of contamination, make food protection a peculiarly difficult area of public health. Much of the needed research in this area requires an interdisciplinary team approach.

In contrast to air and water, for which availability and purity are the principal considerations, food, even when plentiful and uncontaminated, exerts profound physiological effects on the consumer. Although man's basic nutritional requirements have been defined (18), much remains to be learned about the more elusive, yet important, sensory properties of foods, and the more subtle dietary relationships to physical vigor, mental alertness, longevity, resistance to infection, and the onset of degenerative diseases. In any event, enough is already known to suggest that man's response to almost any environment stress may be affected by the food he eats.

Food also differs from air and water in being the private property of individuals and business enterprises, whose economic interests do not necessarily coincide with the needs of public health. Public pressure has led to a profusion of laws related to food (27), which sometimes result in the misuse of public health regulations to erect economic barriers.

Trends

The store of Abraham Lincoln's day sold less than a hundred food items, consisting mainly of dried staples and produce from nearby farms (37). Meals were generally eaten at home, where they were prepared daily from the basic ingredients. Perishable foods, such as milk and meat, were used as quickly as possible or were converted to butter, cheese, sausage, etc., which would keep longer. Neither the causes of foodborne diseases nor the means of preventing them were clearly understood, and the quality of food products was determined largely by the odors, tastes, and appearances associated with spoilage.

About the turn of the century, notable changes began to appear in the traditional pattern, based on the development of farm machinery, commercial canning, long distance transportation by railroads, and mechanical refrigeration of storage warehouses. Concurrently scientific studies were begun which, over the years, have led to a succession of remarkable advances in the production, manufacturing, distribution, and serving of foods. For example, bacteriological and epidemiological studies on the role of milk and other foods in the spread of infectious diseases, such as typhoid fever, dysentery, tuberculosis, and

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septic sore throat, led to the establishment of sanitation programs involving pasteurization of milk, veterinary examination of dairy and food animals, inspection of restaurants, and education of food handlers in hygienic practices. Botulism was found to be caused by the toxins of spore-forming bacteria that could grow in foods without air. As a result, commercial canning practices were radically revised to incorporate adequate heat-processing for the destruction of these spores.

Biochemical research laid the foundation for modern concepts of human nutrition and toxicology. Prevention of deficiency diseases was made possible by supplementation with vitamins and minerals. Addition of vitamin D to milk, thiamine to flour, and iodine to table salt are well-known examples. Possible carcinogenic and other harmful effects resulting from improper use of certain food additives were considered, and legislation has been promulgated to control the commercial application of chemical preservatives, artificial colors, and the like, in order to prevent a potential problem from actually occurring (17).

In the agricultural field, tremendous strides have been made in the development and application of chemicals, such as fertilizers, weed-killers, insecticides, fungicides, and feed supplements; these have resulted in an increased food output per acre. Selection and hybridization have also increased the productivity of crop plants and domestic animals. With the aid of power-driven machinery, the American farmer now produces 10 times as much food per acre with less man-hours than his Indian or African counterparts (32).

The technology of food processing, packaging, and distribution has also undergone dramatic changes since World War II. The major trend is toward centralized processing and widespread distribution of commercially prepared convenience foods which minimize or eliminate culinary work in the preparation of meals. Among these foods are dried, precooked, and frozen products which are not sterile. The consequences of improper storage, shipment, or marketing are obvious. Because of the consumer demand for convenience products, modern foods are no longer simple commodities; they are compounds and blends of products, obtained from worldwide sources and subjected to multiple processes, which may introduce unrecognized health hazards.

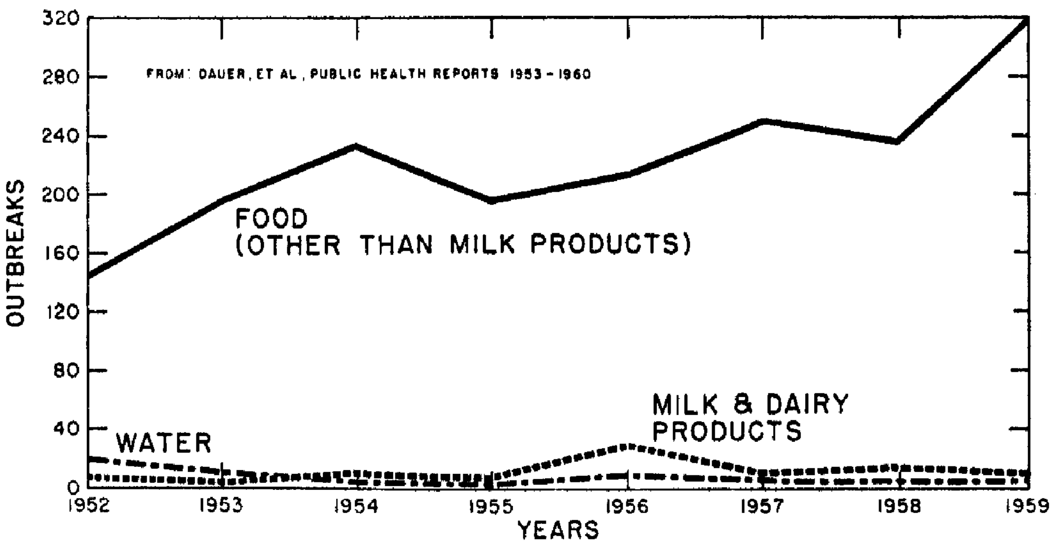
Food processing is becoming increasingly complex and often involves elaborate electronic control of high-speed continuous operations. In some instances, momentary temperature fluctuations may result in failure to protect large amounts of the product, without the knowledge of the operator. High-temperature short-time processing, freezing, vacuum dehydration, and radiation sterilization may be applied singly or in combination to those products. Certain of these new methods involve increased handling after cooking or other treatment; therefore, the skin and fecal microflora, including bacteria, viruses, fungi, and parasites, may contaminate the final product. Continuing changes in processing techniques may be expected to introduce a variety of new problems in the future.

In addition to the usual glass and metal containers, foods are now being packed in treated papers, plastics, laminated foils, flexible tubes and pressurized cans. The time-honored method of canning involved heat sterilization, but today packaged foods may be only partially sterilized and held in the refrigerated or frozen state until marketed. Certain packaging techniques, for example, by excluding oxygen may prevent molds from developing; however, at the same time, such techniques may contribute to the less apparent, though more important, health hazards involving the growth of toxigenic bacteria.

More than 8,000 food items are available for sale in supermarkets, and new products are being offered to the consumer at the rate of about 2 dozen per day (11). Further evidence of the rapid rate of change in this field is provided by the fact that two-thirds of these convenience items either did not exist in 1946 or have been radically changed since that time.

Comparable developments have occurred in the food service industries. Today practically all urban wage earners and students eat at least one meal a day away from home. In addition to spending about $1 billion per month in restaurants, the American public is giving ever increasing patronage to commercial catering and delicatessen operations. The development of automatic vending machines, which deliver individual hot or cold foods and even complete meals, is also progressing rapidly. The automatic food dispensing business has increased from $10 million in 1954 to move than $200 million in 1960 (5). In the future it may be expected to receive an even greater share of business now going to restaurants and grocery stores.

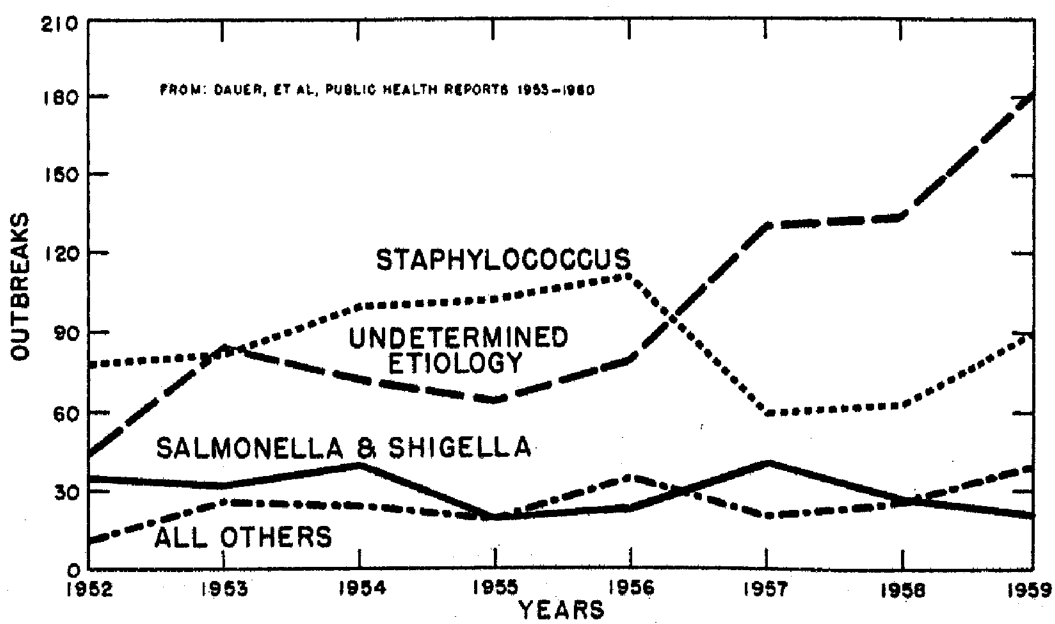
The retail value of the U.S. food supply now stands at approximately $80 billion per year (11), and it will continue to expand as the population grows (26). At present, industry is spending more than $100 million per year on new product developments, all of which, a priori, involve a wide assortment of food safety problems (21). Too often such technological changes are equated with improvements in quality, without discriminating between changes which actually reduce health hazards and those introduced primarily for reasons of convenience or economic advantage. Unquestionably many improvements have been made in both directions, but public health agencies have been unable to keep pace with the overwhelming number of new problems that continue to arise as the technological revolution in the food industry progresses (33, 47).



FOOD, MILK, AND WATERBORNE DISEASE OUTBREAKS REPORTED IN U.S.A. 1952-59

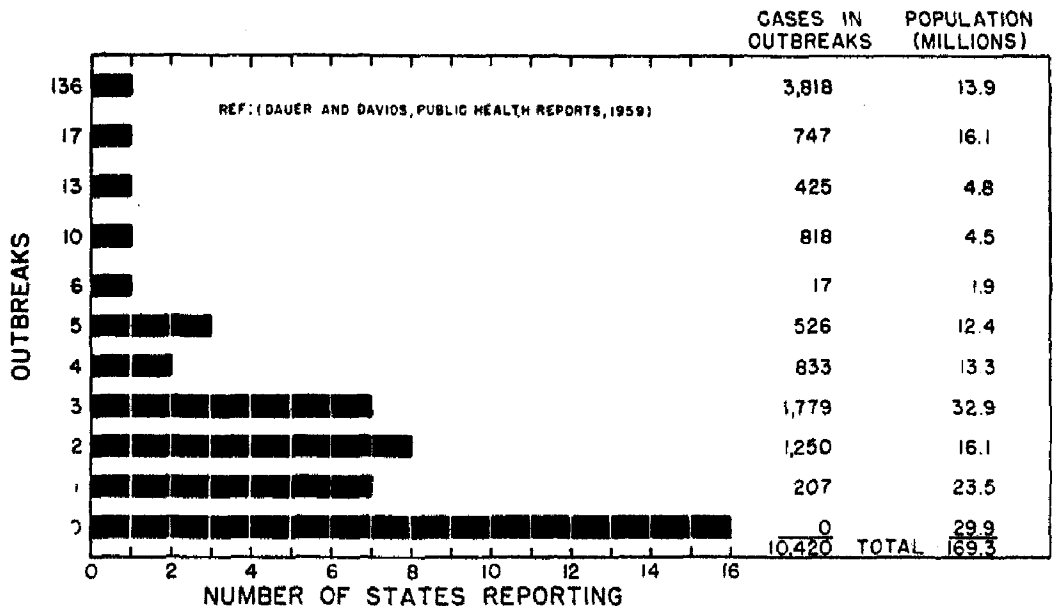
Fig. 1

An estimated 1 million cases of food poisoning occur annually in the United States (14). This estimate is probably too low because scarcely any individual escapes an occasional intestinal upset. The number of reported outbreaks has approximately doubled since 1952 (see Figs. 1 and 2) and the majority of these outbreaks are of undetermined etiology and scope. Staphylococcal food poisoning and salmonella infections are among the most commonly reported forms of gastroenteritis, but investigation and reporting of foodborne illness are so grossly inadequate that a real evaluation of the impact of contaminated food on health cannot be made at the present time (see Figs. 3 and 4).



TYPES OF FOODBORNE DISEASE OUTBREAKS REPORTED IN U.S.A. 1952-59

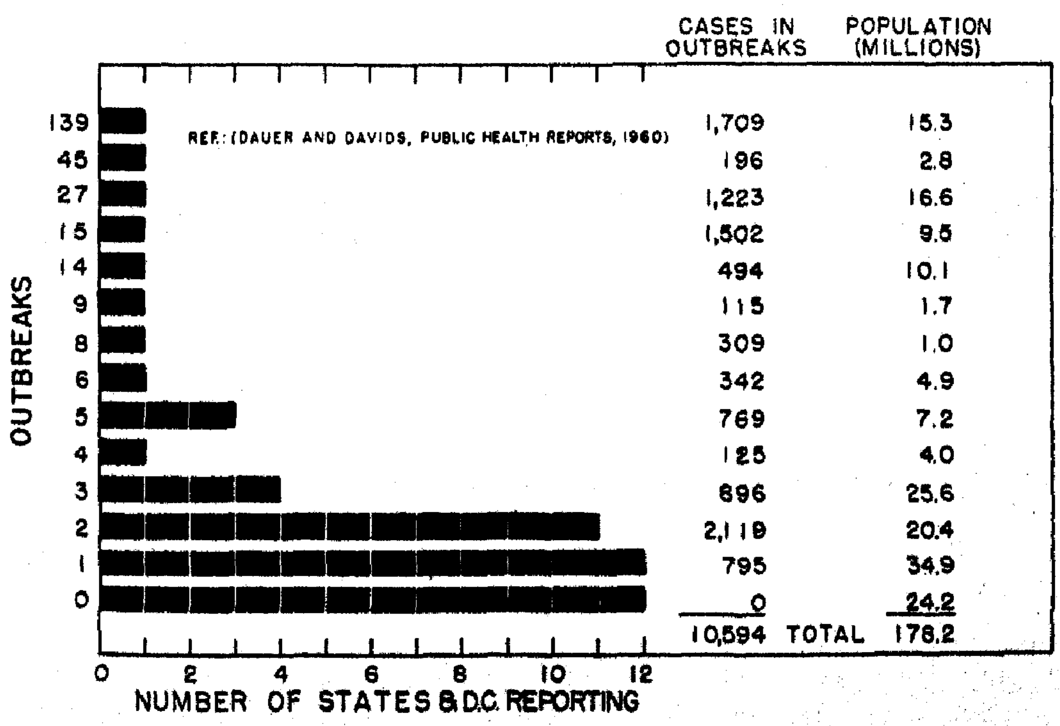
Fig. 2



DISPARITY BETWEEN REPORTED FOODBORNE DISEASE AND POPULATION OF REPORTING AREAS – 1958

FIG. 3

Acute illnesses represent but one facet of the total problem. To this should be added other difficulties introduced through direct and indirect addition of chemicals which may have long-term effects on health (41). These may be introduced at different stages; e.g., during production (residues of insecticides, growth regulators in plants, hormones in animals, etc.) during processing (detergents or



DISPARITY BETWEEN REPORTED FOODBORNE DISEASE AND POPULATION OF REPORTING AREAS – 1959

FIG. 4

other contaminants of the water supply, dust and fumes from the air, and additives used in formulation), during storage (via leaching from containers) and during preparation for serving (contact with faulty utensils, and residues of cleaners or sanitizing agents). In addition, the human body may suffer other stresses of a psychological or physical nature, which should be integrated with those of food origin.

Study of the cumulative effects from repeated exposures to small amounts of food contaminants has only begun, and knowledge of the interrelationships between dietary factors and other elements of the environment is essentially lacking. Recent research has begun to indicate that the main nutrition problems of the future may well be concerned with the sensory properties of foods, such as flavor, odor, texture, etc.—how these are affected by processing, and their mediation via the central nervous system (42). All of this must be integrated with the above cited physical, chemical, and microbiological problems in respect to the whole human being.

Positive action is needed to stem the trend toward obsolescence of the food protection program in public health agencies, and thus keep pace with the developments in food science and technology. In contrast to the notable progress made in food sanitation during the first half of the 20th century, this area of Government activity has now become the weakest link in the protection of the Nation's food supply.

Current Responsibilities of the Public Health Service and Its Relationships With Other Governmental Agencies

The Milk and Food Program derives its statutory authority from the Public Health Service Act of 1944, as amended, particularly Sections 301, 311, 314, and 361 of Public Law 410 (42 U.S.C. 241, 243, 246, 264). This broad authorization provides for the Public Health Service to assist states and localities and to carry out interstate quarantine activities, primarily directed at the control of communicable diseases. Public Law 410 does not specifically direct the Service to conduct programs related to food protection in relation to infectious disease control nor does it address itself to the problems of nonliving disease-producing agents. Under its mandate, the Service is now engaged in milk, shellfish, and food service activities designed to assist the States and local authorities in the development, operation, and maintenance of programs for the prevention and control of foodborne diseases. To implement this role and to provide national leadership in this area, the Milk and Food Program (*a*) conducts research and field investigations, (*b*) evaluates the public health significance of new processes, techniques, and equipment, (*c*) develops recommended sanitation standards, technical procedures, and program guides for State and municipal adoption, (*d*) provides technical and advisory assistance to governmental agencies and food industries on food sanitation, (*e*) conducts specialized training courses for public health workers and industry personnel engaged in sanitary control of milk, shellfish, and food service operations, and (*f*) participates with the States in cooperative programs for the certification of interstate milk shippers and interstate shellfish shippers.

In this program, working relationships and agreements are maintained not only with the States, but with elements of the Public Health Service, other Federal agencies, and various domestic and foreign organizations having responsibilities for the U.S. food supply. A review of these numerous relationships indicates that they are mutually beneficial, and do not lead to duplication of effort. At present, the Milk and Food Program is heavily dependent on the Communicable Disease Center at Atlanta for epidemiological investigation of disease outbreaks, and when these occur on interstate carriers, both groups frequently assist the Interstate Carrier Program with studies necessary to enforce the Interstate Quarantine Regulations. Research and surveillance related to radionuclides in milk and other foods are coordinated closely with the Division of Radiological Health, which, in fact, provides fiscal support for the activities of the Milk and Food Program in this field.

In 1959, a document, entitled *Shellfish, Milk and Food Service Sanitation Activities of the Public Health Service and the Food and Drug Administration*, was developed jointly by the two agencies and the Office of the Secretary of the Department of Health, Education, and Welfare (44). It identifies and compares the activities of these agencies, and in addition, summarizes the cooperative agreements, understandings, and working relationships between PHS and FDA in the areas of milk, food, and shellfish sanitation. A similar document was developed in 1961, *Public Health Service and Food and Drug Administration Activities Concerned with Pesticide Hazards* (38). These analyses indicate that the enforcement efforts of FDA against adulteration and misbranding of foods in interstate commerce are, in fact, strengthened by the collateral efforts of PHS to support intrastate and local food protection programs (25). The differences in responsibilities and objectives of the two agencies are effective deterrents to duplication, even in research, where both frequently work on different facets of the same problem to the mutual advantage of all concerned. Additional work is necessary (*a*) to make these relationships more effective in areas of food safety above and beyond the present scope of the Milk and Food Program, (*b*) to keep pace with the rapid developments in food science and technology which have been and are continuing to be made, and (*c*) to keep abreast of the needs, requirements, and desires of the American people.

The Public Health Service also has a memorandum of agreement (2) with the Fish and Wildlife Service of the Department of Interior relative to the certification of interstate shellfish shippers, as well as a bilateral agreement with Canada (15) on the sanitary control of shellfish. These are supplemented by informal liaison and collaborative research efforts. All of this is cited to illustrate the cooperative and integrated effort undertaken for the protection of the American people in this portion of their food supply. It is an extremely important one from the food protection point of view, since so much of our shellfish is consumed raw.

Working relationships with the U.S. Department of Agriculture are concerned principally with protection of dairy and poultry products. Currently the Service is a participant with the U.S. Atomic Energy Commission and the U.S. Department of Agriculture in cooperative research on the development of a feasible process for the removal of radioactive contamination from milk (39). The present successful method of treatment with ion-exchange resins to remove radionuclides was devised by the Milk and Food Research staff of the Public Health Service (34), and pilot plant operations are in progress at the Beltsville laboratories of the Agricultural Research Service.

A variety of relationships is maintained with the Department of Defense, which range from individual consultation to formal agreements. For example, Milk and Food Research receives support for investigation of properties of paralytic shellfish poison under an interagency agreement with the U.S. Army Chemical Corps. These two agencies are also cooperating informally with several other groups, including the Food and Drug Administration and the Food Research Institute of the University of Chicago, to study staphylococcal enterotoxin, which is the most commonly reported cause of food poisoning in the United States. Rather intermittent and casual relationships are maintained with other components of the Department of Defense, including the Armed Forces Food and Container Institute of the Quartermaster Corps.

Industry Contributions to Food Protection

In addition to the development of new products and processes, the food industry is making noteworthy contributions to public health, particularly in those areas which directly affect sales or where governmental agencies have taken the initiative. The competitive nature of private enterprise is a barrier to acceptance by industry of full responsibility for food protection, but it willingly cooperates with health agencies to protect the consumer from any foreseeable hazard.

For example, industry participates with public health agencies in the 3A Sanitary Standards organization for the design of dairy equipment. Similar voluntary standards are being developed by industrial groups concerned with bakery equipment, restaurant equipment, vending machines, pickles, olives, mayonnaise, confections, and the like. These and other groups may also provide engineering and microbiological data for common use in the development of new processes.

The food industry frequently supports projects in universities and privately owned laboratories on problems relating to health and welfare, such as sanitary requirements, foodborne diseases, nutrition, engineering performance of processes, chemical composition, microbiological content, toxicology of additives, and consumer acceptance of new products. The findings are generally published in the technical periodicals of professional and trade associations, which industry also assists in supporting.

Most firms recognize the importance of inhouse sanitation and quality control programs; however, the smaller manufacturers, in particular, frequently lack the technical knowledge and resources to determine their needs in this area. It is, therefore, essential for protection of the consumer to provide reliable sources of such information. At present, many local health agencies are unable to render this service, and the industry is, understandably, reluctant to reveal its difficulties to enforcement agencies. The manufacturer often depends on advice from the technical representatives of other firms which sell sanitizing agents or equipment. Although the contributions of the latter groups to food protection are invaluable, experience has shown that they cannot cope with the total problem. This situation presents a challenging opportunity for collaboration between industry and government, in which the Public Health Service is well suited to extend its leadership along the lines already developed with the dairy and shellfish industries.

Examples of work which needs to be done in this area are:

1. Development of standards of sanitary quality for procurement, processing, and distribution of foods comparable to those contained in the various PHS recommended ordinances, codes, and guides dealing with milk, shellfish, and restaurant sanitation.

2. Reevaluation of existing standards in terms of (*a*) their application to products produced by new procedures or processes and (*b*) possible simplification or improvement on the basis of new scientific knowledge.

3. Evaluation of engineering limits to performance precision of food process equipment as it relates to (*a*) control of microbiological contaminants, (*b*) maintenance of desired temperatures, pressures, flow-rates, and other physical conditions.

4. Formulation of requirements for the quality of air and water used in food processing.

5. Establishment of design and construction criteria for food equipment which minimize handling of the product, opportunity for contamination, growth of micro-organisms, and difficulty of cleaning.

6. Development of precise simple methods for examination of foods with respect to their sanitary quality, which may be applied uniformly by both industry and health agencies.

PROBLEM AREAS AND GOALS

Industry, enforcement agencies, and the public need the assistance of a national organization primarily concerned with health problems, which can work and be the focal point of leadership in a lattice of other governmental and private organizations to provide the inspiration, information, guidelines and resources necessary for food protection (27). The Public Health Service has an obligation to meet this need in such a way that it will engender the confidence and cooperation of all concerned. It must avoid, on the one hand, a fragmentary approach which cannot give adequate and timely answers to new problems being evolved or, on the other hand, an overly comprehensive program that tends to duplicate and infringe on the primary responsibilities of other organizations. Particular attention should be given to health-related problems which require the participation of a public agency for the protection of the consumer's interest and to those areas of environmental health where food indirectly may play a decisive role in human welfare.

The proposed overall mission is to improve and protect the public health and welfare as they may be affected by foods and beverages, alone or in combination with other environmental stresses. The primary objectives include:

1. Detection of microbiological, chemical, and nutritional health hazards which have been and will continue to be introduced as the result of changes in food production, procurement, processing, packaging, marketing, and serving.
2. Reappraisal of food-protection measures now in use as they are affected by changes in technology and food-handling practices.
3. Surveillance of developments in science and technology as they may potentially affect food protection.
4. Development and maintenance of a basic-data program on trends of public health hazards associated with food production, processing, and distribution.
5. Investigation and development of methods to prevent or reduce health-hazard problems confronting the food industries.
6. Application of the accumulated knowledge to improve public health practice.

Major problem areas, which are expected to be of continuing importance during the next decade or longer, are noted below, together with comments on their significance and some suggested approaches to their solution.

Microbiological Contaminants of Foods

The notable successes of the past 50 years in controlling botulism, typhoid fever, and other severe foodborne diseases, have tended to create an impression that technical knowledge in this area is adequate to prevent all infections and intoxications of microbial origin. However, the facts are that gastroenteric episodes continue to occur at a rate second only to respiratory infections, among the short-term illnesses suffered by middle-class American families. Current food sanitation practices have failed to reduce the high incidence of foodborne diseases during the past 8 years (14). Although the majority of outbreaks either go unrecognized by health authorities or are of undetermined etiology, a growing body of evidence indicates that hitherto unsuspected fungi, bacteria, viruses, rickettsiae, and protozoa may be partially responsible (20). For example, infectious hepatitis has been traced to consumption of polluted shellfish, first in Sweden (40), and on two more recent occasions in the United States (29, 30). *Clostridium perfringens*, which has long been associated with foodborne gastroenteritis in Great Britain (24), is only now beginning to receive serious consideration in U.S. health departments. The first official reports of such outbreaks were received by the Public Health Service less than 2 years ago (14).

Well-known types of food-poisoning organisms occur frequently in a variety of foods. Raw market milk supplies nearly always contain *Staphylococcus aureus.* Dried or frozen egg products are notable sources of *Salmonella* organisms (12). When these products are used for manufacturing purposes, they may cause serious contamination of the finished product, as happened in the case of commercially marketed hollandaise sauce. Outbreaks of *Salmonella typhimurium* were reported from Los Angeles, Calif., and St. Paul, Minn., in mid-June 1961 (31). The hollandaise sauce withdrawn from the market was found to contain *S. typhimurium* in lots obtained in San Antonio, Tex., San Francisco, Calif., Washington, D.C., and St. Paul, Minn. The product was manufactured in New York State.

There are in excess of 600 serotypes of *Salmonella* which may cause illness in man. A sharp increase in cases in the United States due to one, *S. reading*, rarely identified among *Salmonella* isolates from human or animal infections, began in September 1956 (28). During the 12-month period following, 325 acute sporadic cases and 3 outbreaks due to *S. reading* were reported in widely scattered states from Alaska to New York. Obviously, this widespread illness, due to a specific micro-organism, does not follow patterns of water- or milk-borne outbreaks but would be applicable to a processed contaminated food product in national distribution.

An example of spread of *Salmonella* infections from contaminated egg albumin was reported in England (45). Widely scattered cases were traced to certain bakeries where dust from American egg-albumin powder contaminated the finished bakery products.

From the above examples it may be seen that foodborne disease-producing micro-organisms are widely distributed in foods in national and international distribution, for which no protection of the public is afforded.

Recent field studies in a metropolitan area have shown (*a*) that *Salmonellae* were present in 17 percent of the raw market poultry (48), and (*b*) that *Staphylococci* were found in 21 percent of the market Cheddar cheese (16). Direct evidence regarding possible effects of these contaminated foods on the health of consumers is not available, but similarly contaminated products have, on other occasions, been implicated in gastroenteric outbreaks (3, 23, 46).

The foregoing examples illustrate the complexity and magnitude of the microbiological problems of food protection, which require much increased research efforts by the Public Health Service, in concert with other governmental agencies and industry. Potentially useful approaches to these problems include:

a. Methodological studies to improve techniques for the quantitative detection and identification of pathogenic foodborne micro-organisms and their toxic products.

b. Bacteriological, virological, mycological, and parasitological investigations to determine the kinds, prevalance, persistence, and public health significance of potential pathogens in specific foods. For example, the production of safe shellfish depends on a thorough knowledge of the microbiological condition of estuarial growing areas, as well as commercial harvesting, shucking, and packing operations, which are subject to contamination with various toxic dinoflagellates, enteric bacteria, and viruses.

c. Veterinary public health studies on epizootic diseases of food animals, which may be transmitted to man.

d. Ecological studies on the interrelated physical, chemical, and biological factors that affect the growth and survival of pathogenic micro-organisms in foods.

e. Coordinated epidemiological, clinical, and laboratory investigations of foodborne diseases to establish cause-and-effect relationships, modes of contamination and transmission, extent and severity of illness, techniques for finding and reporting natural outbreaks, and means for prevention and control.

f. Consideration of the public health significance of alterations in the microflora of foods, which may be brought about by the newer methods of processing and marketing; e.g., freeze-drying of products which may be reconstituted and sold at delicatessen counters or from vending machines.

g. Field studies in the community setting on practical approaches to the control of microbiological contamination of foods.

Foreign Chemicals in Foods

Increasing contact between foods and foreign chemicals is unavoidable in our technologically oriented economy. Without use of agricultural chemicals, food additives, sanitizing agents, chemically treated water, and synthetic packaging materials, the United States could not feed the urban population (17, 19, 36). It has been estimated that elimination of agricultural chemicals alone would reduce farm yields by 10 to 90 precent (32).

There is also growing concern about the radionuclide contamination of milk and other foods by fallout from nuclear explosions, byproducts of atomic reactors, and residues of radioactive wastes. Campbell et al. (7) have estimated that about five-sixths of the strontium 90 taken into the human body comes from foods, especially dairy products. Accidental release of short half-lived radionuclide, such as iodine 131, from a reactor in another country has, on at least one occasion, necessitated withholding milk from the market until the level of radioactivity declined (43). Extensive studies, in close cooperation with radiological health and atomic energy experts, will be necessary to understand the progression of radionuclides through the food chain and their long-term effects on man.

In a recent address, "Foods, History and Problems," Mrak (32) has noted that "there are no harmless substances; there are only harmless ways of using substances." The determination of how and when chemicals may be used safely in relation to food is already a major public health problem, and it will become even more important in the future (9).

Some of the avenues by which the health implications of foreign chemicals in foods may be approached are as follows:

a. Methodological studies to develop and simplify analytical procedures for both the presumptive qualitative and quantitative determination of herbicide, insecticide, rodenticide, germicide, and other potentially harmful residues in food. There are many new tools now available which should be studied with respect to their application in this field.

b. Toxicological and pharmacological investigation of animal and human responses to repeated low-level dietary exposures, using chemicals singly or in combinations which are typical of their occurrence in food.

c. Exploration of the correlations between long-term, chronic-toxicity testing and more rapid presumptive procedures, based on reactions of enzyme systems, tissue cultures, or micro-organisms, to chemical agents.

d. Radiochemical studies on the occurrence, measurement, intake, retention, and biological effects of radionuclides from foods and other environmental sources, including dietary means of minimizing human exposure and damage.

Nutritional Quality of Market Foods

The newer types of food processing, packaging, and storage provide many opportunities for the addition, removal, modification, and interaction of substances which are physiologically important (4, 22). For example, high temperatures may destroy heat-labile vitamins and amino acids, and they may also affect the availability of calcium or other mineral components. Efforts to compensate for such losses by supplementation may lead to imbalances and excesses in the total diet. Blending and reprocessing of products may bring about changes of possible health significance which would not otherwise be encountered.

Undigestible materials, such as alginate, pectin, or modified cellulose, are often substituted for normal food ingredients in an effort to improve texture and keeping qualities or to lower calorie value and cost. If carried to excess, such modifications may have serious nutritional consequences to certain segments of the population. There are, in fact, hundreds of other artificial substances being used in the manufacture of foods to improve texture, flavor, color, and stability (17, 19). Apart from their intended uses, these substances have physiological potentials which are, in many instances, incompletely explored at the present time.

In addition to recognizing and avoiding undesirable changes in food, there is the problem of learning how to promote good health by dietary means. The potential for increased resistance to infection, lengthened life, greater vigor, and retardation of degenerative diseases is now recognized, but not enough is yet known in these areas to take advantage of the possibilities in public health practice.

In assessing the physiological significance of the complex changes which occur in foods as they move from farm to factory and thence to the family dinner table, the following approaches may be useful:

a. Comparisons of the dietary effects of different processing methods as applied to a common food, such as raw, pasteurized, evaporated, and dried milk.

b. Assessment of nutritional changes resulting from new processes such as ion-exchange treatment of milk, ultra-high-temperature pasteurization, freeze-drying, dehydro-freezing, microwave cooking, or radiation sterilization.

c. Evaluation of safety with respect to unusual levels and combinations of food ingredients.

d. Biochemical investigation of reactions among food ingredients, with special reference to the formation of compounds which may influence the metabolism of mammals.

e. Controlled long-term studies on animal and human populations to identify and investigate the interrelationships between diet and other environmental factors such as temperature, exercise, radiation, or the pollutants of air and water.

Criteria and Methods of Determining Food Safety

Public confidence in commercially distributed foods depends on the maintenance of high sanitary quality. The buyer, whether he realizes it or not, depends entirely on the industry's awareness of food-hazard problems and the integrity of industrial and governmental controls to insure the safety and wholesomeness of food items purchased in retail markets or public eating places (6). When these foods are produced and/or processed at locations remote from consumer areas, local health agencies cannot inspect the sanitary conditions to which these products may have been exposed prior to their arrival in the local market. The trend toward centralized manufacturing and widespread distribution of refrigerated, nonsterile, convenience foods has created a need for the development of standard methods and uniform criteria by which the sanitary quality of these products may be determined (8, 13). Even more, there is vital need to identify the nature and extent of the potential public health hazards.

A substantial beginning has already been made in this area with respect to the interstate shipment of milk and shellfish. The voluntary programs between the States and the Public Health Service in these areas are based on:

1. Employment of sanitation, administration, and evaluation standards recommended by the Public Health Service.
2. Utilization of laboratory methods recommended by the American Public Health Association and the Association of Official Agricultural Chemists.
3. Uniform application of these methods and criteria by the responsible government agencies in both producing and receiving areas; and
4. Self-imposed compliance of the dairy and shellfish industries with the established criteria of sanitary quality.

On the basis of the experience gained in these programs, the Public Health Service is not only in an excellent position to accept leadership in the extension of these concepts to other foods, but must do so at the earliest possible time, since technological progress in the food industries is expanding rapidly. Acceptance of this responsibility will require a continuing effort on each type of food for which the potential public health hazard has been carefully studied, proper practices established, and enforcible sanitary standards adopted. Present knowledge does not permit the use of identical procedures and criteria for different categories of foods. Because of the difficulties in detecting and identifying specific etiological agents, development of feasible sanitary standards will depend upon the application of indirect tests for indicator organisms and chemicals, which reflect the past history and present quality of the product in question. Activities which will contribute to the development of this area include the following:

a. Study of the microflora, typical of selected foods, and the changes it may undergo during various stages of production, processing, storage, distribution, and preparation for serving.
b. Develop analytical schema for determining chemicals in foods of unknown composition.
c. Develop and evaluate biological, chemical, and physical tests, which may be routinely applied to the examination of foods.
d. Conduct collaborative studies to determine the practical feasibility of selected sampling and analytical procedures.

Surveillance of the Consumer Food Supply

Development of national leadership in the field of food protection depends heavily on the availability of factual evidence about the sanitary quality of the food supply. Much useful information of this type is obtained regularly by a wide assortment of public and private organizations, but no mechanism presently exists for the collection, processing, and analysis of these data. By developing in the food field a cooperative basic-data program, analogous to the existing air, water, and radiation networks, the Public Health Service can become the focal point of comparative data on the microbiological, chemical, nutritional, toxicological, and related qualities of key food items. Such information will serve to identify potentially hazardous products, provide leads for research, and guide both public and private agencies in planning effective control programs.

Because of the magnitude and complexity of the surveillance program, gradual development over the next 5 years is suggested along the following lines:

a. Establish surveillance programs on milk, shellfish, and the food services of interstate carriers, with which the Service already has much experience and numerous contacts in both control agencies and industry.

b. Determine the variety and utility of information obtainable about additional foods from other sources.

c. Formulate plans for regular collection and analyses of samples from key stations located in different areas and, if possible, at sites being used by other networks.

d. Devise methods for coding, statistical analysis, and reporting.

e. Develop techniques for utilization of reported findings by industry and government.

Evaluation of Food Equipment and Processes from the Public Health Viewpoint

The design, construction, and operation of milk and food equipment determines, to a large extent, the sanitary condition of finished products. Study of the operational characteristics, reliability of control devices, feasibility of cleaning and sanitizing, resistance to corrosion, and protection against product contamination are essential to the development of sound public health performance criteria.

For competitive reasons, the food-equipment industry cannot assume full responsibility in this area, but it has willingly cooperated with public health agencies to the extent that the latter could specify commercially feasible sanitary requirements. The 3–A Sanitary Standards for dairy equipment represent a notable example of such cooperation.

A substantial increase in public health activity in this area is needed to cope with the wide variety of new equipment being applied to the mechanical processing, packaging, and serving of foods (10.35). For example, ultra-high-temperature pasteurization of milk involves complex problems of heat transfer, vapor pressure, fluid flow, and electronic control on which the success and reliability of the process depends. Intimate knowledge of these problems is essential to the definition of the public health requirements, and can only be obtained by use of experimental devices and testing of commercial-scale equipment. The service is now constructing temporary facilities in which to conduct engineering and microbiological studies along these lines.

Other important areas in which evaluative studies are needed include:

a. Purification of shellfish taken from substandard growing waters.

b. In-transit food services of airlines, trains, buses, and ships.

c. Automatic vending of meals.

d. Mechanical dish washing.

e. In-place cleaning and sanitizing operations.

f. Freezing, drying, and related processes such as dehydro-freezing, vacuum drying, and multistage evaporation.

g. Cooking and pasteurization processes intended to prolong shelf life, such as heating with infrared or microwaves, high-energy ionizing radiation, or ultraviolet radiation of surfaces.

h. Possible chemical contamination from new types of packaging and equipment materials.

OPERATIONAL TECHNIQUES OF FOOD PROTECTION

The traditional food sanitation programs of health departments already utilize a large segment of the available funds and manpower. Generally speaking, funds have not been appropriated at a rate commensurate with the new responsibilities resulting from advances in food technology, changing eating habits, and population growth. So many new problems have arisen that many departments are no longer capable of providing adequate food protection (6). There is urgent need to reverse this trend toward obsolescence by the introduction of new administrative and operational techniques which will make more efficient use of the available resources.

In order to guide the State and local agencies in this direction the Public Health Service needs to extend its operations along the following lines:

a. Provide reference laboratory services for the investigation of unusual problems and assessment of routine laboratory performance.

b. Develop recommended ordinances and codes, guides, administrative manuals, and information suitable for distribution to the public.

c. Sponsor field studies and demonstrations to show in practice how new research findings may be applied to local problems.

d. Conduct specialized training courses for the benefit of laboratory, field, and administrative personnel employed by industry and government in the food-protection field, and foster university training programs for professional specialists.

e. Investigate procedures for sharing the responsibility for inspection and laboratory control between government agencies and industry.

f. Promote cooperative research and development projects on food protection problems with the industries involved, utilizing industry facilities whenever feasible.

g. Expansion of program activities related to certification of interstate milk and shellfish shippers, and to the approval of sources of milk, frozen desserts, and perishable foods served on interstate carriers.

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IMPLEMENTATION

Substantial expansion of extramural research grants and contracts, as well as intramural research, surveillance, training, and technical assistance activities, is needed to meet the Public Health Service's responsibilities for food protection outlined above. The Milk and Food Program has a nucleus of professional staff around whom these activities can be increased rapidly, but it lacks many of the specific competencies and facilities which will be required for the enlarged program. Its research and training staff are presently composed mainly of bacteriologists, biochemists, and food technologists, about half of whom are housed in temporary laboratories at Cincinnati, Ohio, and Purdy, Wash. The headquarters and regional office staffs are largely sanitary engineers and sanitarians, whose workload is so heavy that a consistent effort cannot be placed on any facet of the technical assistance activities. The program has supplemented its budget with funds from outside sources, such as the Division of Radiological Health and the Army Chemical Corps, in an effort to broaden its operations. Dependence on such funds tends to create an air of instability, especially in research, which now receives about one-third of its support from outside sources.

Several NIH Study Sections have approved research grants related to food protection, but coverage of the major problem areas is uneven, and the total effort is inadequate to develop the basic information needed by public health agencies. There is no program of institutional grants for research or training purposes specifically associated with food protection.

In the light of the disparity between the existing program and the present-day need for food protection, an order-of-magnitude increase in both intramural and extramural activities seems indicated over the next 5 to 10 years.

Intramural Program

The Milk and Food Program is currently limited to milk, shellfish, and food service sanitation. The total resources available for its support in fiscal year 1962 amount to approximately 160 positions and $3 million, of which 45 positions and $1,700,000 are for the establishment of 2 new regional shellfish laboratories. Of the remainder, about 60 positions and $600,000 are allocated for research and training at the Sanitary Engineering Center, while the rest is utilized by headquarters and regional offices for technical assistance and administration.

The two regional shellfish laboratories will partially fill research needs of long standing. These special-purpose facilities, which must be located in coastal areas, are now urgently needed to undertake research on the survival of enteroviruses and other pathogenic agents in estuarine areas and to investigate practical shellfish purification processes. The establishment of these facilities will enable the Public Health Service to meet research needs in the New England, west coast, and gulf areas; however, a need will remain for a similar facility in the important Chesapeake Bay area, and for additional marine laboratories to study the neglected public health problems associated with other seafoods.

The program needs to acquire professional specialists and research facilities with which to activate projects related to all its long-range goals. Technical competence will be required in each area of responsibility in order to utilize the scientific output of the extramural program, provide timely answers to practical problems, and give responsible leadership to cooperative programs. The Supplement to this report, entitled "Areas of Specialization Required To Attain Food Protection Goals," suggests the kinds of professional personnel required and the appropriate depth of competence.

Within the next 5 years, the program should plan to acquire an additional 250 professional staff members, about 500 more supporting personnel, a new central research facility, and an annual operating budget of approximately $8 to $10 million. In the following 5 years, a further threefold expansion is recommended, including the establishment of additional special-purpose regional laboratories.

EXTRAMURAL PROGRAM

In fiscal year 1962 a program of research grants was initiated in the Division of Environmental Engineering and Food Protection. Appropriations in the amount of $3,310,000 are provided for this purpose. Of this amount present obligations for food-related research approximate $2 million. The full amount to be expended for food research will depend upon approval and priority allocation to applications reviewed at November and March meetings of the National Advisory Health Council.

Contracts are limited to the construction of laboratories and provision of services, such as the collection of specimens for laboratory use. The anticipated cost of these contracts is about $1,800,000 in fiscal year 1962.

Support of professional education in universities is limited to the advanced training of one to two employees annually. Quite obviously, this level of support is inadequate to meet the food-protection problems associated with an $80 billion industry that spends at least 1 percent of its income on research to develop new products, most of which present health agencies with problems of food safety that they are presently unable to consider.

During the next 5 years the Research Grants Program should be expanded both in scope and funds. In addition to the present project grants, provision should be made for more broadly based support to institutions for programs of research, research facilities, and support for large-equipment items which may be used by more than one project or research program. Amounts of money required for this purpose are estimated to require progressive increases in annual amounts ranging from $2 to $5 million during the 5-year period. Comparable increases in contract funds for applied research field studies and surveillance operations will also be needed to support interagency agreements and collaborative studies with industry.

Special effort should be made to initiate, as soon as possible, a program of institutional grants to help train the scientists, engineers, and other professional personnel needed to strengthen food protection throughout the United States. Continuing support of interdepartmental programs in colleges and universities with strong graduate training programs will be necessary. On this basis, it is estimated that the total funds devoted to the extramural program of food protection may reach $15 to $20 million by fiscal year 1967 and should undergo a further threefold or fourfold expansion by fiscal year 1972.

ADMINISTRATION

The Milk and Food Program is included in the newly organized Division of Environmental Engineering and Food Protection. The Committee notes with satisfaction that, in this title, food protection is given divisional recognition for the first time in the Public Health Service. The Division is concentrating its efforts on the several environmental problems typically facing health agencies in large urban areas.

The food supply for metropolitan centers presents an increasing number and variety of public health problems, based on the potential hazards associated with technological changes, the continuing widespread occurrence of foodborne illnesses, rapidly changing economics and pattern of distribution, and the influence foods may have on man's response to environmental stresses. An effective national effort in this area will require an organization that is considerably more complex than the current Milk and Food Program. Inasmuch as food protection is the keystone of environmental health, the organization should be given status and support comparable to that of other major components of this field.

LEGISLATION

Although the Public Health Service Act provides the basic authority for undertaking a national program of food protection, more specific legislation is needed to delineate Service responsibilities, generate public recognition and awareness, and establish the working relationships with other organizations on which the program depends for its continued development. Federal legislation relating to the certification of interstate milk and shellfish shippers embodying the principles of the present voluntary State-PHS programs, is very much needed. Additional authority should be sought which will make the Public Health Service the focal point of research, surveillance, and standards necessary to maintain and improve the quality of the food supply as it may affect the health and welfare of the consumer. Such legislation should also include provisions for strengthening the extramural program with respect to training, long-term cooperative activities, and categorical research.

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Supplement

AREAS OF SPECIALIZATION REQUIRED TO ATTAIN FOOD PROTECTION GOALS

The professional resources needed within the Division of Environmental Engineering and Food Protection to attain the objectives of food protection are described below under four categories according to degree of development which each area of specialization is expected to attain within the next 5 years. The status of these specialties will undoubtedly change progressively as new problems appear, additional techniques or other pertinent knowledge become available, and novel food protection measures are developed. Presumably new subspecialties will need to be added, and the emphasis on existing areas of competence will require adjustment to meet the food sanitation problems of the next decade.

INDEPENDENT RESOURCES

Areas of specialization in this category form the core of the professional resources required to meet the Division's research, technical consultation, training, and related responsibilities for food protection. Each area will be developed in depth to serve the principal day-to-day needs of the Division as well as the lesser related needs of other divisions.

Food Microbiology

Specialists in bacteriology, virology, mycology, and parasitology will be required to investigate the causative agents of food infection or intoxication and to develop control measures. Orientation of microbial physiology, genetics, and serology, as well as to medical, veterinary, sanitary, dairy and marine microbiology, will be necessary to investigate the public health implication of microbial food contamination, develop sanitation standards, and devise preventive measures applicable to the preparation and serving of foods.

Food Chemistry

Primary emphasis on biochemistry will be required to supply competence in enzymology, metabolism, nutrition, immunology, and other subspecialties related to the study of natural food products. Strong support will be needed in physical, organic, inorganic, and analytical chemistry to deal with the increasing problems of hazardous chemical contamination of foods. Radiochemistry will be an essential component of this area, because of special significance of foods as sources of environmental radioactivity and the importance of tracer techniques in research.

Food Engineering

Specialists in sanitary, chemical, mechanical, and electrical engineering will be needed to evaluate problems related to (1) the sanitary design, construction and operation of food equipment, (2) procedures of producing, harvesting, processing, storing, shipping, and serving of perishable foods, and (3) criteria and requirements for inplace cleaning and germicidal treatment, automatic control of time-temperature dependent operations, and preservation of foods by novel processes such as dehydro freezing, radiation sterilization, ultra-high-temperature pasteurization or so-called natural purification of shellfish.

Food Technology

Technologists will be needed with special knowledge of each class of highly perishable foods, such as milk, shellfish, meat, and poultry products, which may serve as vectors of hazardous contaminants. These specialists will conduct field studies, surveillance operations, and demonstrations related to food sanitation.

DEPENDENT RESOURCES

Included in this category are areas of specialization for which the Division must have the competence to meet its ordinary needs, but will also require the support of other groups with respect to fundamental or theoretical research and unusual equipment or professional talent.

Statistics

In this area, a distinction is made between statistical design and analysis of data, on the one hand, and the broader areas of systems analysis, data retrieval, and operations research which are considered in the category III, Pooled Resources. The Division will require a statistical staff and facilities sufficient to develop sound protocols for research, evaluate technical data, and record information in forms which can be subjected to more sophisticated statistical treatment. Although the Division will need machines and staff for coding, sorting, and collecting statistical information, it will depend on others for computer services and the development of mathematical statistics to meet its needs.

Epidemiology

Both "classical" and experimental epidemiologists will be needed to investigate the occurrence, causes, and circumstances associated with illness as attributed to foods. Field studies with human populations, as well as experiments with animal populations will be conducted in this area to examine critically and perhaps extend the precepts of epidemiology with respect to the impact of both food contaminants and food itself on health. No doubt other divisions will have similar interests in the epidemiological investigation of air- and water-borne illnesses as well as those attributed to environmental radiation and occupational hazards; therefore, close cooperation among these groups seems desirable.

TOXICOLOGY

Specialization in this area is usually achieved by experience rather than formal training. The Division will need the services of chemists, pharmacologists, and pathologists to evaluate experimentally and judgmentally the health hazards of foreign chemicals and natural constituents found in foods. Recommendation of safe practices and control measure will be a part of their responsibilities. However, the Division will need the help of a toxicological group with broader orientation to assess the role of foods in the total exposure of man to hazardous materials from the environment.

PHYSICS

Specialists capable of utilizing new complex physical instrumentation and interpreting the results will be needed to characterize foods and their significant components or contaminants. The orientation of the work will be primarily to biophysics, but knowledge of both radiation physics, and the classical physics of heat, light, pressure, etc., will also be required. In recognition of the very high degrees of specialization within this area and the large investment required for proper instrumentation, the Division will also need the support of other groups with related competences. Quite probably a control facility will best serve the needs for the more costly items which are infrequently used by any division.

OCEANOGRAPHY

The special problems associated with production, harvesting, and processing of raw shellfish and other seafoods require the attention of specialists in marine biology and oceanography to complement the sanitary engineering, chemical, and microbiological work on sanitation of these products. Because of the allied interests of the Division of Water Supply and Pollution Control, coordination of work in this area is contemplated. It is recommended that representatives of other departments, both in and out of the Public Health Service, having allied interests in this area, serve on an interdepartmental oceanography committee, to assure a high degree of coordination in this activity.

TRAINING

Instructors with basic scientific and public health backgrounds will be required to organize and present specialized courses on food sanitation to health workers. They must be capable of recognizing, interpreting, and communicating technical information of value in public health practice. They will need the support of other professional staff members and consultants, as well as certain training facilities available to the Center as a whole.

ADMINISTRATION

In order to work effectively within the administrative framework of the Bureau, DEEFP will need the full-time services of specialists in personnel, fiscal, procurement, management, and bibliographic services, as well as skilled illustrators, draftsmen, shopworkers, janitors, and emergency maintenance personnel. This group will be heavily dependent on the central management and service groups available to the Center as a whole.

POOLED RESOURCES

Areas of specialization in this category will be supported in common with others using divisions at a single location. DEEFP will employ ancillary specialists who have some knowledge of these fields, but will depend on the central organization for facilities and additional talent. Areas included here differ from those in category II with respect to the degree of internal development required to meet the needs of the Division.

CLIMATOLOGY

Rainfall, temperature, day length, and other climatic factors are well known to affect the composition of food crops. In order to assess the role of these factors in the uptake of radionuclides, agricultural chemicals, and soil constituents, climatologic studies will be required. Studies may also be needed on the relation of climate to human nutrition.

ECOLOGY

Understanding of the health problems associated with foods requires knowledge of food chains and the factors that determine the dietary habits of man. These important components of human ecology can best be investigated in broad studies, but are of special interest to DEEFP.

REACTOR TECHNOLOGY

DEEFP has direct interests in (*a*) the possible contribution of reactors to radionuclide contamination of foods and (*b*) the utilization of high energy sources as tools for research on radiation sterilization, neutron activation analysis, and the like. Because of the high costs involved, the Division would prefer to utilize a central facility which might be constructed and operated by the Division of Radiological Health.

Systems Analysis

As noted above, DEEFP has need for supporting resources which will bring to bear advanced mathematical theory and data processing equipment on the public health surveillance of the food supply. These resources will supplement the internal statistical competence of the Division if a central facility is provided.

UNDEVELOPED RESOURCES

The DEEFP will have intermittent use for several areas of specialization which can be obtained from contractors or consultants, but may not be available within the Bureau. In the field of food protection, the following are presented as examples.

Social Sciences

For the understanding of dietary preferences and nutritional problems, the assistance of psychologists, sociologists, and economists will, on occasion, be needed, but the Division does not now foresee a continuing workload in these areas which would justify internal development of those specialties.

Medical Sciences

Although physicians and veterinarians with specialized training are included in several areas covered under categories I and II above, additional clinical specialists, in such fields as geriatrics, pediatrics, radiology, allergy, dentistry, and internal medicine, may be needed to undertake specific studies or provide advice on responses of man and animals to food constituents or dietary regimens.

Other Areas

Even within the areas where the Division has considerable competence, situations will almost certainly arise which require the help of additional specialists in such fields as spectroscopy, organic synthesis, chemotherapy, electrons microscopy, and the like. The full range of possibilities can not be clearly defined in advance, but ample provision should be made for the temporary employment of such individuals on a basis that will be mutually acceptable to them and the Government.

Report of the Subcommittee on OCCUPATIONAL HEALTH

RECOMMENDATIONS

1. Major strengthening of the PHS program in occupational health is recommended to secure and maintain the health and well-being of the gainfully employed of the Nation at the highest possible level, so that they may realize their full potential as members of society and the Nation may enjoy, in fullest degree, the benefits from our industrial effort. The PHS must assume primary leadership in the advancement of the total national effort in occupational health.

2. To meet the foregoing, we recommend acceptance of the objectives, specific goals, and plan of action outlined in the accompanying proposal as a "charter" for the U.S. Public Health Service to follow.

3. Administrative organization and operation of the occupational health program within the Environmental Health Center is recommended as a means of insuring a strong position for occupational health within the Public Health Service structure and in order to gain strength from close association with other activities having certain common interest in the field of environmental health. The Subcommittee wishes, however, to sound a note of caution. Care should be taken to avoid compartmentalizing environmental health activities by scientific disciplines and/or professions with consequent loss of identity of the separate problem areas. The potential strength of the Center should develop by interdivisional collaboration and mutual attack upon problems of common interest, with encouragement of interdisciplinary development, rather than by administrative predetermination of specific research areas.

4. As an essential part of the national effort in occupational health, university research must be encouraged and expanded. To meet these needs, financial support through the PHS has to be increased. In addition to the present scheme of support for specific research projects, we particularly recommend that the PHS be authorized to support long-term university research programs in broader problem areas in occupational health, so that effective research groups can be built up within the universities with better chances of drawing well-trained research scientists into this field. We also recommended that such research undertakings be employed as a means of training scientists for work in important areas of occupational health.

5. Support of specific training programs in occupational health in appropriate universities, and provision of fellowships for student support, are recommended.

6. A program of inservice training is recommended, to be operated within and by the staff of the Division of Occupational Health, to meet two major needs in technical training: (*a*) for certain Division personnel; and (*b*) for personnel in State and local health services. In addition to the short-term training provided under (*a*) above, the Bureau should intensify the program of formal academic postgraduate out-of-service training for suitable personnel in the Division of Occupational Health.

7. To meet the manpower requirements for the proposed program, an increase in personnel, as set out in table 1 of this report, is recommended over the next 5 years. It is anticipated that the staff needs for 1971 will exceed those shown for 1966 by approximately 50 percent.

TABLE 1. *Estimated Technical Manpower Requirements*

Professional discipline	1961	1966
Engineering	12	40
Physics	7	20
Chemistry	37	130
Biology	8	40
Medical and paramedical	36	80
Allied Sciences	8	40
Total	108	350

8. The sums of money set forth in table 2 of this report are recommended for the support of the proposed program over the next 5 years. It is anticipated and recommended that the budget for 1971 exceed that of 1966 by a factor of approximately 2.

TABLE 2. *Estimated Fiscal Requirements*

[Millions of dollars]

Use	1961	1962	1963	1964	1965	1966
Grants						
Research grants	1.4	4	5	7	8	11
Project training grants				1	4	7
Other grants and fellowships		.5	1	1	2	3
Total, grants	1.4	4.5	6	9	14	21
Direct operations						
Research	1.0	1.2	2.5	3	4	5
Training	.2	.2	.4	1	1	1,5
Technical assistance	.7	.7	1.1	2	3	3,5
Total, direct operations	1.9	2.1	4	6	8	10
Total, occupational health	3.3	6.6	10	15	22	31

INTRODUCTION

The Subcommittee met with representatives of the Division of Occupational Health on September 10 and the Chairman had a further conference on September 19. In the course of these meetings, the mission of the Subcommittee was reviewed and the overall objectives, present operation of the Division, and needs for continuation and expansion of the national program of occupational health were examined in a preliminary way. The Division staff were asked to prepare a working paper, setting forth in more specific detail a statement of the present and future problems in occupational health; the objectives and specific goals as developed in the Subcommittee-staff discussion; and an outline of the programs, organization, and facilities needed to meet these goals. In the preparation of this paper, the staff was particularly requested to examine the subject in relation to the central questions confronting the committee on environmental health, having to do with meeting the scientific and professional manpower requirements, provision of the necessary organization and physical facilities for the conduct of essential research, both in the laboratory and in the industries, proper coordination and balance between the PHS and non-Federal agencies in respect to research and training of scientific and professional personnel, and between PHS and other Federal agencies having personnel and research facilities and responsibilities in the areas of occupational health. These questions, in turn, center around the main question respecting the need for an organic Environmental Health Center designed to bring together for mutual strengthening and to give a central purpose to the several major problem areas of public health arising out of environmental challenges to man's health.

The staff working paper was reviewed by the Subcommittee and consultants on September 27 and is attached as a supplement to the Subcommittee report. It reflects the Subcommittee views and provides essential foundation material in support of the conclusions and recommendations of this report.

NEEDS FOR A STRONG PROGRAM IN OCCUPATIONAL HEALTH

The need for a strong national effort to secure and maintain maximum health among the gainfully employed men and women of America requires no particular justification. The need is obvious. They must be given the same protection against ill health as is enjoyed by other members of our society but, in addition, they require special protection against the peculiar health hazards that arise out of and in the course of their work. As individuals, too, and from the standpoint of total national welfare, both economic and in terms of deeper human values, every opportunity must be taken to raise their level of health in a positive sense, over and above the mere elimination of negative health factors. Great benefits have come from advances in science and technology and from their application by our industries. These have not been gained, however, without certain costs in terms of human values. If we are to enjoy to the fullest extent the benefits from our modern industrial society, these costs have to be better recognized, evaluated, and reduced. The national effort in occupational health must be directed to this end. All of the costs, of course, are not to be measured in terms of ill health, but it is in this area that we can especially expect clear-cut returns. The remarkable successes from organized, scientific public health effort of the past assure this, and success will be limited only by the extent of our effort to define the problems, identify significant cause-and-effect relationships, and devise and apply corrective measures. These broad principles and methods of operation—the basic, time-tested procedures of public health—are spelled out for particular application to occupational health in the accompanying program.

The specific problems of occupational health are many and varied and, owing to the dynamic nature of American industry, it is impossible to anticipate the exact nature of future problems. Hence, an occupational health program must be flexible, anticipating new problems in broad categories and not making rigid commitments to particular areas of research, development, and operation. The Subcommittee accepts and recommends this program as a broadly conceived, sound, and essential "charter" to meet the particular responsibilities of the Federal Public Health Service within the total national effort to secure and maintain the health of the gainfully employed.

It is significant to note that the total cost of the current program in occupational health amounts to 5 cents per worker, per year, and that the estimated cost of the fully expanded program for 1970 would amount to not more than 70 cents per worker, per year. On the basis of past accomplishments, the returns to the Nation would more than offset these expenditures.

RESPONSIBILITY OF THE PUBLIC HEALTH SERVICE IN OCCUPATIONAL HEALTH

The direct operation of services to protect the health of employed people has to be done by the industries themselves, and direct governmental assistance in such efforts is carred out by State and local public health agencies. The esssential role of the U.S. Public Health Service is one of leadership and advisory assistance, supported by a dynamic research program designed to provide the necessary scientific and technical knowledge on which to base effective control measures. Because the health problems of industry are so varied and involve so many different man-environment relationships—physical, chemical, biological, and social—and because the health problems of the gainfully employed cannot be divorced from nor dealt with altogether separately from those of the general public, it is evident that the research programs, scientific and professional staff, research facilities and means for undertaking field studies and operation must be broadly based. It must draw upon scientific skills in all branches of the physical, biological, behavioral, and social sciences, and their counterparts in applied science and professional practice, medicine, engineering, etc. Individuals from these many areas must be brought together to work *jointly* upon problems of common concern. Thus, organized effort in occupational health has to be problem oriented rather than by disciplines or professions. It cannot be compartmentalized by disease categories nor by classes of stress agents, nor can it be viewed solely as an area of environmental health in the sense that common denominators of the environment dominate the different problems. Primary importance is given to man-environment relationships that may disturb health, but from one situation to another the environmental stress factors range over the whole gamut of physical, chemical, biological, and social relationships to man, and the relative importance of man and of environment in the quation shifts from one problem to another. Problems are solved in one case mainly by correcting the environment and in others by working with people.

OCCUPATIONAL HEALTH WITHIN A BUREAU OF ENVIRONMENTAL HEALTH

In order best to serve the national needs in occupational health, the Federal program must be organized within the Public Health Service in such a way as to draw maximum strength from the other activities, staff, and facilities of the Service. It was with this point in mind that the Subcommittee examined the question of the place of the Division of Occupational Health within the Bureau of Environmental Health, and, physically, within the Environmental Health Center. The following points are made:

1. The nature, magnitude, and national importance of a Federal program in occupational health are such that the program must occupy a strong position and at a high level within the Service to insure its essential support.

2. The structure of the Occupational Health Division, its staff and facilities, must be sufficient, up to a point, to insure its independent capacity to perform its mission. Since this is not an isolated area of concern, it should be organized, both conceptually and administratively, with those other PHS activities from which it will particularly gain strength.

3. Occupational health has many important and obvious interrelations with other areas within the proposed grouping of environmental health activities. Problems of radiologic health, air pollution, and water pollution are inevitably associated with industry. General sanitary controls, food protection, and other such environmental problems are encountered in the industries as well as in the surrounding communities. Basic approaches and the kinds of scientific

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and professional skills needed in the several areas have much in common, and close association will give mutual strength to the several divisional programs.

4. Administrative compactness, efficiency, and economy of operations, avoidance of unnecessary duplication of scientific staff and research facilities, and the convenience of certain common services are further important advantages to be gained from operation within the Center.

5. There are some important common areas of interest in basic research which can be properly shared, as well as common scientific and technical services. In both basic research and high-level services the cost of separate provision would be prohibitive. There is greater chance, too, of recruiting first-quality scientists into the larger and broader Center.

In view of the foregoing points, the Subcommittee believes that the Division of Occupational Health will gain material strength by administrative organization within the Environmental Health Center. In doing so, however, it must have its own integral organization, including a staff drawn from all the necessary areas of science and the professions to insure its effective operation. Thus, for example, it must have its own research program in industrial toxicology, its own competence in epidemiological research, etc. The Subcommittee believes, as matter of administrative policy, that the common scientific effort of the Center should be developed and maintained by bringing together appropriate individuals from the several divisions for common study of problems, rather than by setting up in advance permanent groups to carry out basic research in separate underlying disciplines.

MANPOWER NEEDS, TRAINING AND NON-FEDERAL RESEARCH

With respect to special charges to the Committee on Environmental Health concerning manpower needs, Federal and non-Federal research and inter-Federal coordination of activities in environmental health, the accompanying working paper sets forth the needs within the Occupational Health Division, we believe, in a reasonable manner. Manpower requirements—for the Division itself—as presented in the tables are not of great magnitude; they represent about a fourfold increase over present staff within 10 years. New personnel are to be drawn from many areas of science and the professions, and the numbers from each are not large. For the country as a whole, the estimates of needs are much bigger, but it must be pointed out that these are ideal figures for a fully developed program. Actual demands will be much more dependent upon the success with which real needs are met. We believe that the well-defined needs can be met without unreasonable expansion of existing university-training programs, in either the underlying disciplines and professions or in schools of public health or other university departments devoted to training of occupational health specialists.

An important point to be noted is that much of the staff training for the Division can be done through inservice programs and, with respect to training of personnel for State health services, major dependence has to be on such intensive training within the Division. This has worked very well in the past and will in the future. This means a continuing training program must be made a part of the operation of the Division. For convenience and efficiency, such inservice training activities may share a common administrative setup within the Center with the other divisions, but we believe that the actual planning and conduct of training courses should be carried on within and by the staff of the Division to insure close integration within its own problem area. Training has to be oriented around the health problems of the industries and not by disciplines or professions or in terms of general environmental health.

The Subcommittee agreed that the universities must be encouraged and supported in a greater research effort in problems of occupational health, for three reasons: first, proper training of occupational health specialists (especially research workers) can be done most effectively by a faculty who are, themselves, deeply involved in solving occupational health problems; second, there are certain areas of research that can best be done in the university, free of the government-private industry relationship; third, such university programs multiply in a major way the number of research workers throughout the country who are involved in and committed to this important area of research. The Subcommitteee was not able to draw any sharp lines between Federal and non-Federal research activities, in respect to either the nature or magnitude of effort. Given strong leadership within the Public Health Service, we believe these questions are best left to be answered as the program develops.

In respect to questions of inter-Federal relationships and coordination of efforts in occupational health, the Subcommittee found no problems of immediate concern and does not feel that this matter has particular application to the present question of how best to organize occupational health activities within PHS.

Supplement

PHS PROGRAM IN OCCUPATIONAL HEALTH

DEFINITIONS

The general objective of health programs may be defined, not merely as maximizing the length of life of the individual but also as permitting him to realize his full potential as a member of society. Mere length of life is not enough; the effectiveness of the individual throughout that life is just as important.

The pattern of bodily functions which determines maximum expression, or health, is the result of interactions between the characteristics of the individual, on the one hand (such as bodily conformation, physiological reactions, psychomotor functions, psychological patterns, and immunities); and the environmental conditions surrounding him (such as physical factors, chemical contacts, electrical conditions, radiation, infective and allergenic agents, psychological stresses, socioeconomic conditions, etc.), on the other. From whence it follows that health can be understood and preserved only by adequate and simultaneous attention to both the man and the environment.

The term "Occupational Health" signifies that part of the total health picture which is closely associated with the individual's occupation. While it needs to be viewed in relation to the individual's total life, this segment calls for special consideration because: (*a*) it presents certain special environmental influences or risks; (*b*) the worker's life centers around his work; (*c*) it brings persons together into defined groups which can be studied not only as regards specific occupational diseases but also in respect to disturbances affecting the population at large; (*d*) health enters in an important way into the relationships between employer and employee; and (*e*) the products of industry in turn affect the life of people in general. The term "occupational" should be taken in the wide sense of including all types of occupation, and the term "industry" should be taken in a similarly wide sense of any department or branch of art, occupation, or business; especially one which employs much labor and capital and is a distinct branch of trade. Agricultural, educational, and service work and workers, for example, would be included as well as those of the mechanical and chemical industries.

The basic objectives of any occupational health program can be very simply stated: (*a*) recognition of the influences and risks; (*b*) evaluation of their effect upon human health and efficiency; (*c*) development of preventive measures, and (*d*) effective application of the knowledge so gained to industrial practice.

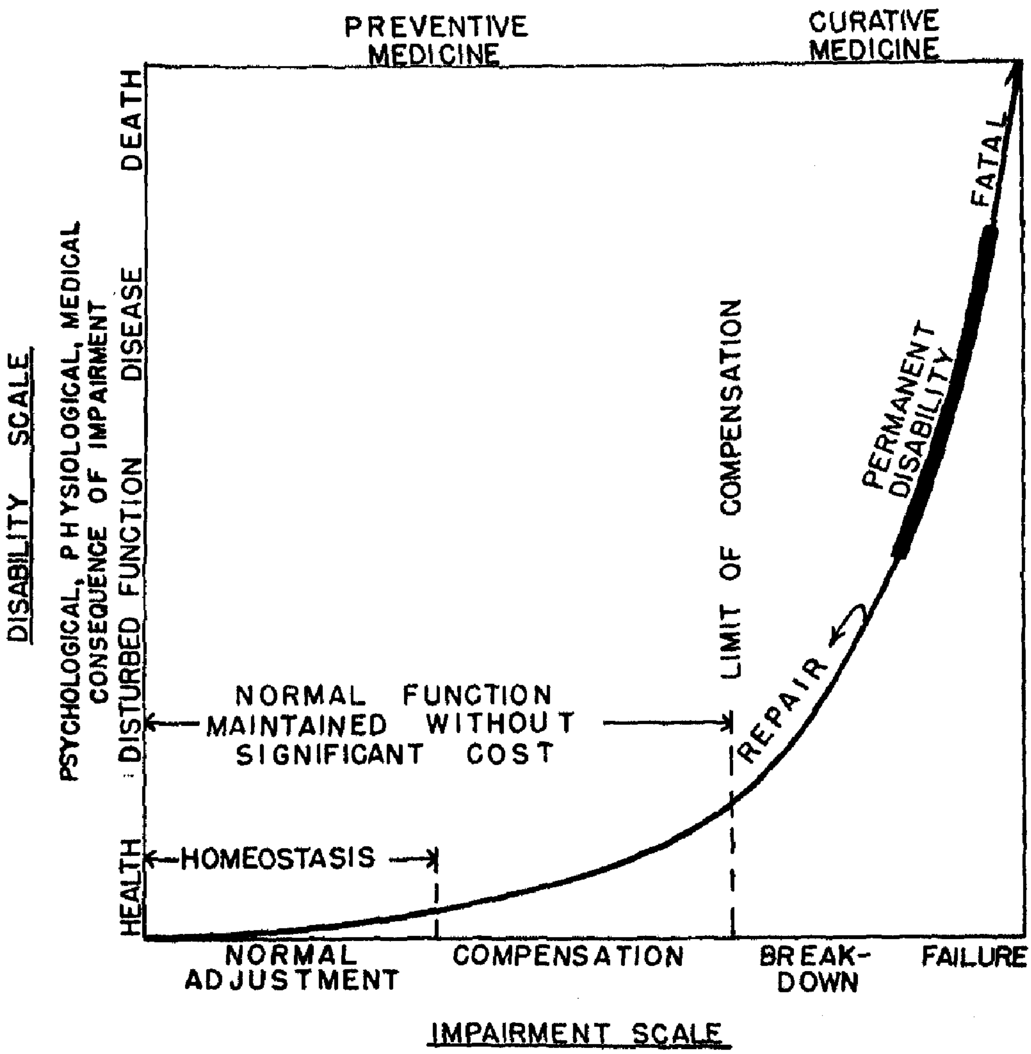
HISTORICAL

The traditional emphasis in the study of occupational disease has been on specific, dramatic, and killing diseases apparently caused by single or small groups of environmental factors. Medical history from Agricola (mid-16th century) to McCord (early 20th century) affords eloquent testimony to the success of this approach, but occupational medicine today suffers to a certain extent by that very success. The recognition and conquest of such killing and disabling diseases as lead poisoning, mercury poisoning, tar cancer, phosphorus poisoning, radium poisoning, and silico-tuberculosis, is a classical story. Such cases as still develop are nearly always traceable to failure in the application of knowledge rather than to lack of knowledge. New industrial materials will produce new hazards requiring careful detective work before the exact agent or mode of action is incriminated, and to which the classical approach can be applied, but the principles are known and the work can proceed along what are now fairly conventional lines.

Occupational health today, however, must not only continue the application of conventional methods to the detection of new agents, but also extend its traditional concept in new dimensions. The problem confronting us today contains many elements that are new, but our methods of attack have been slow to adapt to the new challenges. In spite of the attention given to the single dramatically killing and disabling factors, the health of the worker is far from optimal, and frank occupational disease also persists. Some of this is due to newer and as yet imperfectly defined agents, but much of it cannot be explained upon this basis. Much of this residual disease and disablement may not be apparent to the casual observer, especially if he relies upon the classical approach using the conventional examination procedures of clinical medicine, and conventional records of death and reported disease. This residual disease and disablement may not be dramatic, it may not kill (or not obviously), and much of the disablement that it produces is apt to be subtle, of slow development, and easily confounded with "normal" causes of progressive deterioration such as aging. The involvement of the individual may be less, but more persons are involved. Of the 70 members of the civilian labor force, probably more than half have some degree of physiological impairment which could be greatly reduced if adequate knowledge were available. Furthermore, the impairment is not produced by single, isolatable, easily incriminated factors; rather it is the result of multiple factors working together, each adding its own insult and helping others to add theirs.

By way of example, we may point to the paradox that has developed in the South African mines—dust, as it was known, has been largely suppressed, and with it has disappeared the gross silicosis of old; but pneumoconiosis remains, and resultant deterioration of pulmonary and cardiac function continues. This pneumoconiosis may at times even show a negative correlation with the environmental dust count, at least as conventionally estimated. Again, with the decrease in emphasis upon heavy physical labor, and the introduction of automation, the incidence of physical strain in industry can be expected to decrease; but the psychological stresses are obviously increasing at least in proportion, and probably absolutely as well. For example, the problem of handling and interpreting masses of incoming information, under pressure, in split-second fashion, and often with very critical consequences, so dramatically seen in airport control rooms, is developing with increasing frequency in communication centers across the Nation, in plant control rooms, and in emergency installations. Modern man shows remarkable ingenuity in the acquisition of information, but much poorer ability in digesting it when he has it. In less intensive fashion the psychological and social concomitants of the job affect every worker, his relations with others, his productivity, his anxieties, and his health—that is, the lifetime sum of his realization as a member of society.

The traditional concept of occupational health as dealing with the man-environment relationship, as it applies to the job, still holds and can be as successful in the future as in the past in revealing the true nature of the relationship, its significance for health, and the measures that are necessary to optimize that health; but it must be exploited in the new terms. The interrelated operation of multiple factors, the existence of new factors, the importance of hitherto neglected classes of factors, the aging of the population exposed, and the variability of the human material must be taken into proper account; the less marked, more slowly developing, less easily defined responses of man to these factors must become the prime object of examination; and the significance of total stress as well as individual stresses must be assessed. The relationship of disability to physiological status illustrated in the accompanying diagram remains the same; but whereas we have hitherto concerned ourselves with the uppor portion of the curve, applicable to only a small proportion of persons, we must now give proper attention as well to the middle portion of the curve which applies to the majority of employees over an extended potentially rewarding lifespan. This is largely *terra incognita*, over which the deteriorative and reparative processes fight out a fluctuating battle for man's health; we must discover the rules of this warfare, and devise means for influencing the result in favor of man.



IMPAIRMENT —
1. INCREASES WITH AGING
2. INCREASED AS RESIDUAL OF ILLNESS
3. INCREASED BY EXCESSIVE ENVIRONMENTAL STRESS

TIME SCALE: "ACUTE"— SHORT TIME FROM CAUSE TO EFFECT. "CHRONIC"— DELAYED EFFECT. DETECTION AND MEASUREMENT OF IMPAIRMENT MOST IMPORTANT FOR DEVELOPMENT OF PREVENTIVE MEASUREMENT

For completeness, this historical conspectus should draw attention to changes which can be seen in the legal setting in which practical occupational health programs must operate. Whereas in the early years of this century corrective action tended to be taken only after a direct causal relationship had been established between an environmental factor and major disease, industry today is more and more adopting the policy of instituting preventive measures, if not before the event, at least as soon as the risk is recognized. The role of Federal and State health agencies is correspondingly becoming one of advising and helping industry to help itself; there is a growing demand being placed upon public health authorities for information, research, and leadership as a supplement to and eventually, it is hoped, a replacement for purely regulatory control. On the other hand, there appears to be a growing tendency for the party at risk to resort to litigation and claims for compensation, and a tendency on the part of some jurists to liberalize the basis for granting compensation. Occupational health programs will necessarily need to temper their practices to the varying legal winds that blow about them.

THE ROLE OF THE PUBLIC HEALTH SERVICE

The health of the worker is a national asset calling for protection and conservation at all levels, Federal and State, academy and agency, management and labor, economic and humanitarian. While it would be unwise to define too exactly the role of any one group in the total effort to maximize human health, for fear of restricting individual freedom in the striving for betterment, the general role of the Public Health Service can be delineated.

In essence, the function of the Public Health Service is to provide those opportunities for combined or coordinated action which are unlikely to develop from the independent action and responsibilities of the multitudinous individual activities across the Nation. It provides the technical means for discharging those functions which are adjudged at the governmental level to be a Federal responsibility or opportunity; it provides a set of facilities for such research and investigation as is not easily developed by individual organizations: it may sometimes permit review of a problem in a detached fashion not always possible to those engaged in the daily flux of events; it provides a link between the more basic sciences and the severely practical demands of immediate industrial operations; it furnishes a mechanism for supporting those segments of the national effort which have not developed sufficiently to meet national needs; and in all that it does it has the opportunity of setting an example of devotion to the national needs and aspirations. It does not and should not seek to substitute its efforts for those that are the province of or are being adequately discharged by individual groups; it does not and should not undertake routine activities unrelated to its primary mission, or which can be adequately carried out by others; and however much it may assist others in the development of their own roles, it cannot and should not take away from them their rightful initiative in the discharge of those roles.

As was indicated earlier, the basic objectives of an occupational health program can be simply stated as: (1) recognition of the influences and risks associated with occupations; (2) evaluation of their effect upon human health and efficiency; (3) development of preventive measures; and (4) effective application of the knowledge so gained to industrial practice. The program operated by the Public Health Service should provide for all of these, not only by its internal operations but also by proper support of State, industrial, and academic organizations engaged in relevant activities.

It is desirable that these objectives be examined in more detail before proceeding to a specific program. Here, as elsewhere, knowledge cannot be divided into mutually exclusive compartments, so that there will be a certain overlap between the categories described; but in general the description will proceed from the acquisition of information to its application, and from the more fundamental aspects to their practical significance.

1. Recognition and Definition of Occupational Influences and Risks

An outstanding characteristic of modern industry is change. It would be unrealistic to rely upon past knowledge and experience to predict or prepare for the future to say nothing of information concerning those influences which were not previously recognized as significant. The acquisition of detailed knowledge concerning the existence, nature, and mode of operation of all significant factors is essential to the design and prosecution of any worthwhile effort in occupational health. Practice cannot be adequate unless this information is extensive, representative, accurate, and projective.

a. Nature and trends of industrial processes: Except with the most toxic materials or most damaging conditions, there is necessarily a timelag between the introduction of a new material or process and the recognition of deleterious effects in operating personnel. The timelag is large enough where one is content with preventing frank disease or disability; but it is apt to be much greater still where the effects are subtle nonspecific deteriorations of general health and efficiency. It is very important, therefore, that information on industrial processes and materials not only be kept current over a wide section of industry, but that it include projections of the materials and processes that are scheduled or even proposed for introduction over the following several years. Had those concerned with public health been fully aware beforehand, for example, of the proposed development of epoxy resins, agents for foaming plastics, or plastic materials for machining, and in a position to study them, the effects of these substances and the derivatives formed in processing could have been predicted, precautionary measures devised, and a considerable amount of disability saved. The rather fortuitous fact that health experts were consulted early in the newly introduced plasma torch operations, with the consequent recommendation of protective measures, could become the rule rather than the exception. The institution of an adequate information-collecting scheme is not easy, but it is as important to the rational practice of occupational health as a sampling network is to an air pollution program. The difficulties, though considerable, are not insurmountable if attacked with quiet and tactful determination.

b. Mechanisms of human responses to environmental conditions: In terms of the new dimensions cited earlier, occupational health has as its goal, not merely the prevention of additional cases of recognized disability but the prevention of any cases at all. It is concerned, not only with the immediate effects of occupational conditions but also with the interaction between them and the various other vicissitudes of the employee's life. It implies knowing enough about all possible causes and their mode of operation upon the body to recognize and eliminate them before they have opportunity to be effective. To give an example, one would not wait until pulmonary distress focused attention upon a new substance X, or emotional outbreaks raised questions of sensory overloading, before inquiring into the cause and devising preventive measures; one would have established the probable toxicity of X-like substances and the probable consequences of sensory overloading beforehand, drawn attention to their possible occurrence, and devised measures to eliminate the stress before breakdowns occurred. Similarly with the operation of multiple environmental factors in the impairment of health, whether frank or insidious, the significant patterns of combined operation would have been established, the probable consequences worked out, and appropriate preventive measures developed.

As of now, this would be a counsel of perfection indeed; but nevertheless this is the goal toward which the new occupational health must work. It envisages: (*a*) careful systematic review of all the environmental factors that may affect human functions; (*b*) establishment of their mode of operation on the body singly and in combination; and (*c*) the development of methods whereby their effects upon health, used in its widest sense, can be systematically examined. In this section we are concerned with the more fundamental aspects of this picture; the resolution of specific problems will be taken up in the next section.

To meet these needs a comprehensive occupational health program must provide: (*a*) mechanisms of keeping thoroughly abreast of currently available knowledge in the field; (*b*) support for those extramural groups who have the ability but not the resources to develop the areas of inadequate knowledge; (*c*) internal resources to develop those areas of inadequate knowledge not otherwise being prosecuted; and (*d*) a continuing review and synthesis of emergent knowledge with subsequent reevaluation of its efforts in the preceding categories.

It must pursue its inquiries wherever they may lead, not duplicating activities and facilities available elsewhere, but certainly not being inhibited in acquiring competence in techniques hitherto characteristic of some other group or academic field but necessary for the job. Much of the work can be expected to lie at a fairly basic or fundamental level, and one of its characteristics will be the search for early and sensitive indices of bodily response to environmental stresses.

As has been implied in the foregoing pages, recognition of this pursuit as fundamental and essential to occupational health has been slow to develop, with the result that such information as has accumulated is still scattered and unorganized. Just how much really new effort will be necessary, and along what lines it is most needed, will not be clear until some systematization has been attempted. History suggests, however, that many more questions will be revealed than answered in the process. Certainly this type of fundamental and systematic inquiry is the foundation upon which any adequate occupational health program of the future must be erected.

c. Consideration of the total worker in a total environment: While much of the scientific study of human responses to environmental factors must necessarily consider the components one at a time, the ultimate fact must be kept in mind throughout that it is the total man, operating in a total environment, with whom the program is concerned. The necessity for ultimate synthesis of the emergent information must be considered both in experimental design and in the interpretation of results. Methods, disciplines, and approaches not now common in studies of occupational health must be introduced. Psychology, sociology, and economics must enter, not only into the implementation of preventive measures but also into the basic study of how man—the total man—reacts to environmental stresses, and how his reactions affect his realization as a member of society.

The techniques for obtaining a total view of the man-environment picture are far from complete. Considerable attention must be given to the techniques of synthesis even before there is much in the way of information to synthesize. A forward-looking program will place this item very early in its development, since progress is likely to be slow and arduous. In general, two types of procedure can be envisaged. Certain types of information, particularly of a quantitative nature, can be integrated by mathematical techniques sometimes called operational analysis. Other types of information are best synthesized by the roundtable technique—the repeated matching and attempted intellectual integration of information into a more meaningful whole, separated by periods in which the individual contributors have the chance to rework or expand their evidence in terms of the last discussion.

As an example of the necessity for considering the combined action of environmental variables, one may cite the current belief that the progress of chronic degenerative diseases is influenced, not merely by diet, or workload, or psychological pressures, or past infective diseases, or genetic constitution, or age, but by all of these things acting together. The contribution of the occupational situation to the progress of a degenerative disease in a given individual, or in a group of employees, can be properly evaluated only in the light of the nonwork factors. The significance of noise on work efficiency must similarly be seen against a background of numerous other physical, psychological, and social factors affecting efficiency. When we depart from the killing or grossly disabling consequences of specific occupational conditions, we find ourselves increasingly handicapped by lack of knowledge on how the total man responds to all of the various stresses inherent in his total environment. This deficiency must be remedied.

2. Evaluation of Effects on Human Health and Efficiency

In the previous subsection we were concerned with the basic nature of human responses to the spectrum of environmental influences operating singly and in combination, and the establishment of methods for assessing the significance of these reactions for human health. In this subsection we will be concerned with the more specific objectives of evaluating stated environmental conditions for stated groups of people. Many of the methods to be described here as necessary to specific evaluations are applicable as well to the more basic studies already described.

a. Evaluation from general principles: As the more generalized knowledge discussed in the preceding subsection advances, and as the data obtained in specific studies accumulate, it becomes progressively possible to make some types of evaluation solely upon the basis of those principles and data. It is possible now, for example, to make some predictions about the reactions of workers to very hot environments, the length of time that they can work efficiently, and the probable rate-of-performance deterioration if work is continued. As knowledge grows, the opportunities for this type of evaluation can be expected to increase, and programs must make corresponding provisions for its use.

b. Field studies: Examination of employees in their normal occupational environment, where the relevant environmental conditions are known or can be simultaneously measured, has the advantage of providing information under realistic conditions, and usually on large numbers of persons. The disadvantages introduced by the operation of numerous uncontrolled or even unrecognized factors can be offset to a certain extent by adequate statistical procedures. As a standard method of public health inquiry, it has yielded very valuable information in the past on the status of metal miners, diatomite workers, and granite cutters. It has established the essential causative relation ship between uranium mining and an increased incidence of lung cancer. It needs to be continued and applied to those industries which are amenable to it. But new and more sensitive methods of detecting early deviations from normal function, such as blood enzyme profiles, need to be added to the more conventional clinical survey techniques as they emerge from the more basic studies.

c. *Experimental studies—human:* These, by contrast with the previous studies, examine the reactions of selected subjects to the operation of graded stresses, singly or in small combinations, under conditions that are otherwise controlled. They yield information on the precise and quantitative effects of specified environmental factors, but usually on comparatively few subjects and under necessarily artificial conditions. The resultant information needs to be carefully matched with that obtained by the previous method, and discrepancies subjected to further examination. This, the classical method of scientific investigation, must continue to constitute an important part of any research program. It has yielded valuable, sometimes critical, information in the past on the operation of such environmental factors as heat, sound, vibration, and workload. It must be extended and applied to the operation on multiple factors, including the psychological.

d. *Experimental studies—animal:* It is virtually impossible to expose human subjects deliberately to many of the potentially injurious environmental conditions that need to be studied, at least with intensities and for periods that will give significant results. Much of our knowledge concerning the toxic properties of chemical substances, ionizing radiation, and physical agents has necessarily come from animal experiments. Such experiments have the great advantage, also, that large numbers can be exposed, and proper statistical account taken of variability. Unfortunately, animals by no means always react to environmental conditions in the same way as man; in fact, different species of animals may react in markedly different ways from each other. Animal experimentation must continue, perhaps on an even bigger scale, especially with primates, but provision must be made for very careful comparison of the results so obtained with what can be learned about human reactions, and final interpretation made in conjoint terms. The growing use of experimental animals for investigation of psychological situations will extend both the use and the significance of this type of evaluation. As more is learned about the techniques of animal care, and the importance of standardizing the nonexperimental aspects of their environment, the facilities will necessarily become more elaborate and the supervision call for more specialized professional care.

e. *Clinical studies:* Medical examination of persons suffering from diseases believed to be associated with occupation was, of course, the original method of investigation, and it will continue as long as employees get sick. It is still an important weapon in the armamentarium, and adequate facilities for its prosecution are essential. But it is now increasingly supplemented by the other lines of inquiry described here, and its own methodology is becoming increasingly complex, to the point that it may be hard to distinguish at times between clinical and other types of injuiry. Here, as in field studies, there is a continuing search for more and more sensitive indices of altered physiological function, which can be applied to their detection at earlier stages of displacement.

f. Epidemiological studies: Review of statistical information on the incidence of death or disease has been one of the standard methods of determining the existence, extent, progress, and possible causes of disease in given populations. The basic data may be gleaned from published vital statistics, hospital or clinic records, field studies, special census, or insurance returns. It necessarily deals with events that have already taken place, are recognized as such, and have been recorded. It cannot take account of the undeveloped, the unrecognized, or the unrecorded. Nevertheless, it will continue to be a major tool in the investigation of occupational health, and provision must be made in any comprehensive program for its increasing use as the volume of recorded data increases, better methods of detection are devised, and quantitative information is derived from more and more fundamental aspects of the disease (or nonhealth) process.

g. Economic evaluation: The real cost to the individual, the industry, the community, and the Nation must be known if public health resources are to be allocated in optimal fashion, attention focused on the economically important problems, and the most economically effective control measures selected. Techniques for adequate analysis are still in the developmental stage, and much remains to be discovered about the guiding principles. Nevertheless, progress is substantial, so that a realistic program for the future must include provision for very significant activity in this respect.

3. Development of Preventive Measures

a. Determination of standards of acceptability: It would be unrealistic to demand that all traces of all potentially deleterious influences be removed from occupational situations, or to insist on control measures that cannot be economically sustained, unless the threat to health were grave indeed. Some levels of intensity which are acceptable must be set, and control procedures developed to meet those levels. In many cases more than one level may need to be set for a given environmental conditions, depending upon the duration and frequency of exposure, other coincident and influential environmental conditions, age and sex of persons exposed, national necessity etc. Much work has been done in the setting of limits for the gases, vapors, and fumes encountered in industry, and for certain dusts developed in mining and kindred trades. But close examination shows many inadequacies in both the determination and the application of such standards. For example, the data derived from animal experiments are not usually backed by any substantial body of information derived from human reactions, the effect of rate of work on the toxicity of inhaled material is seldom taken into account, the methods used for determining air concentrations are not always well adapted to the particular material, and the evidence upon which to base decisions is sometimes very scanty. Much the same sort of criticism can be made about current standards for such things as tolerable hot conditions, noise levels, illumination qualities such as glare, vibration, and other physical factors in the environment. Virtually no standards have been devised for acceptable psychological conditions. An adequate program in occupational health must provide for marked improvement of standard setting, and extension of this process over a much wider range of environmental conditions. The high dependence upon animal reactions needs to be offset by careful examination of human evidence; and the various conditions such as work stress, heat, age, prior exposure, and simultaneous exposure which may markedly affect tolerance must be much more carefully defined.

b. Development of engineering control methods: Engineering procedures such as ventilation, directed airflows, noise suppression, heating and cooling devices, air filtration and precipitation, and regulation of illumination will probably continue to be the mainstay of environment control practice. They will, however, need frequent revision to meet the changing needs of industrial situations, and to incorporate the benefits of technological advance. Associated with this more classical type of engineering are the newer techniques often termed "human engineering," in which the design of tools, machines, procedures, and installations is adapted to the characteristics and capabilities of the man who operates them, to maximize his effectiveness and minimize the stress placed upon him. Both classical and human engineering must find a prominent place in both the principles and practice of industrial engineering.

c. Pharmacological methods of control: As we get to know the detailed ways in which bodily processes respond to or are affected by environmental stresses, we begin to see how they may be helped or protected by the administration of substances having specific pharmacological action. To take a simple example, if it is demonstrated that a particular substance owes its toxicological properties to the fact that it blocks the transmision of impulses from nerve to muscle, then a rational method of treatment and perhaps of prevention would be to administer a substance which facilitates the transmission, or some substances that would lock with the toxic material and prevent its action at the junction. Or again, less drastic vasodilators than nitroglycerin might very well be used to counteract the weekend effects of temporary deprivation experienced by nitroglycerin workers.

d. Organizational methods of control: In spite of the general tendency to rely more and more on automatic detection devices and regulators, prevention, in the final analysis, arises from a human desire and by human decision. A great deal can be done, by so arranging layout that employees are placed in positions of least hazard, by explaining to employees the toxic potentialities of the materials they handle, by inculcating an appreciation of control measures, and by inducing a rational organization of the work regime. Insufficient attention has been given to a study of the personal factors involved in requiring, devising, operating, and monitoring control procedures, or in training employees in proper attitudes toward prevention. Some place must be found for this type of study in a developing occupational health program.

4. Practical Applications

Knowledge must come first, but knowledge alone is not enough. The employee's health will not be improved unless the knowledge is applied with appreciation, understanding, and patience. It is essential to the practice of occupational health that there be a strong, active, informed, and smoothly coordinated machine for putting knowledge to work at all levels of responsibility through Federal, State, county, city, and industrial organizations. At each level several modes of operation are necessary, and all must find proper representation in the program.

a. Investigative and advisory services: A public health service, by definition, must be ready to provide service to the Nation in accordance with the current state of the art, and on a scale commensurate with the significance for the national interest of the problems presented. This may take the form of a direct service by PHS personnel, assistance to State or local health authorities, support of the same authorities, or collaborative activities with them in varying proportions. Labor and industrial organizations will have similar claims upon PHS service, although policy may dictate that such service be given through or with the consent of the State and local authorities. The individual taxpayer has some claim to consideration also, and some provision should be made for answering, or at least directing, such inquiries into appropriate State or local channels. The service to be rendered may range from simple answers to specific queries, through short-term investigations of trouble spots, to long-range studies of unresolved problems affecting a wide section of the Nation. While some such services can be integrated with on-going deliberate research, others may present a competition for available personnel. Nevertheless, the program and the organization set up to conduct the program must make adequate provisions for such services, and their use should be encouraged. This is one of the major delivery points of the system, and everything must be done to make it effective. At the present time this service is not as highly developed as it might be, partly because of limited resources, and a reluctance to promote requests that may have to be denied; but partly also because of a lack of appreciation by those who could be helped of their needs and opportunities.

b. Elaboration of codes and guides: The translation of scientific and technical information into practical action is often hampered by the difference between the ways of thinking customary to the two groups involved. A very important step in such translation is the development of illustrative codes or guides for the control of undesirable situations, which can be used by the health authorities, industrial health programs, safety associations, etc., as a basis for drawing up specific regulations or instructions for local use. PHS personnel are in a particularly advantageous position to assist in this essential translation, if they can be assured of sufficient freedom from other duties.

c. Technical instruction: The provision of trained and informed personnel to meet the national needs in occupational health is a matter which will be taken up in a later section of this report; but mention should be made at this stage of the provision that a PHS program must make for technical instruction in its normal operating program. There are certain types of instruction, particularly of the short-course, technical type, which universities are unwilling or even unsuited to undertake. Intensive training in dust counting, lead analysis, ventilation control, thermal assessment, air-sampling techniques, and kindred severely practical procedures are illustrative of the training that PHS facilities can very well provide. More fundamental instruction in areas of specialization in which individual PHS officers happen to be authorities constitutes another field in which training might be offered with advantage. Beyond these, there are areas in which PHS personnel may well cooperate with universities in conjoint instruction, either because of special knowledge or equipment, or in the development of courses which would afterward be handled by the universities alone. During the period of growth in occupational health activities, considerable demand can be expected for this type of training. At a later date the demand may settle down to a steady, but still very significant level. These demands must be foreseen and adequate provisions made in any definitive program.

d. Publication: The national belief in the importance of the printed word is certainly as well justified in the application of public health knowledge as in other fields. Both as a means of dissemination, and as a record of what was actually reported or advocated, publication

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stands supreme. Proper provision is essential in every occupational health program for the preparation, printing, and dissemination of information of various types: research and professional papers, monographs, technical bulletins, statistical tables, technical reports, and instructions, popular articles, handbooks, and exhortative leaflets, to name only a few. The common tendency to leave the preparation of material to odd moments reluctantly snatched from "real" work, and to provide insufficient resources for the costly business of reproduction, must be corrected if a program is to be adequately known, appreciated, and used by the potential beneficiaries across the Nation.

e. *Public information service:* The individual, as well as the involved groups, has a claim to know the current events and beliefs in this field, not only through his right as a taxpayer but also as a member of that mainstay of democracy, an informed public. While it would be impossible for a service to deal with a hundred million individual inquiries, it can and should provide mass educational material for public information. This, too, costs money and effort, for which adequate provision must be made in a comprehensive program.

SPECIFIC PUBLIC HEALTH SERVICE PROGRAM

The preceding section presented the broad objectives of a realistic, forward-looking Public Health Service program. This section will be concerned with formulating such a program in specific terms. The program items will take the order: intelligence (1), research (2–7), services (8, 9), technical training, (10), grants (11), and ecology (12). Item 11 will deal with the support of research and training by universities and other appropriate institutions or groups. The remaining items will deal with direct operations by DOH and work done under contract by external organizations or individuals.

1. Evaluation of Trends in Occupational Health

Background: The planning of research, the rational allocation of resources, and the evaluation of preventive efforts demand that the information be constantly available as to new or potential environmental hazards, the patterns of illness or death as related to occupation or industry, and the resources available for the study and control of hazards in the work environment.

Present status: Information on current industrial practices is obtained only from incidental contacts in the course of investigations, and a rather unsystematic examination of industrial literature. There is no organized network for the acquisition of information on current trends, let alone ideas scheduled for development, and thus little or no foreknowledge of situations which may be created by new materials or processes. Vital statistics of a routine character are obtained from the Bureau of Old-Age and Survivors Insurance (BOASI) and census returns, and some special information can be obtained by arrangement with these agencies. Data are beginning to come in from the recent addition of occupational information to the National Health Survey. Information on relevant articles published in foreign countries is beginning to come in through the recently established CIS plan.

Five-year goals:

a. Completion of the analysis of preliminary data obtained as a result of adding occupational information to the National Health Survey.

b. Application of Bureau of Old-Age and Survivors Insurance cohort analyses to studies of mortality and disability in four or five specific industrial groups.

c. Coding and storage for retrieval of pertinent information on old and new industrial chemicals and physical agents now being filed in the Occupational Health Information Exchange.

d. Completion of cooperative pilot study of one or more major health plans in which occupational information and health experience of subscribers will be surveyed.

e. Development of an effective method for the international exchange of information on occupational health hazards and studies.

f. Development of an effective file of information on medical care programs and environmental health research programs of all major American industries.

g. Development of trial surveillance procedures for the recognition of new or potential problems in selected industry.

Ten-year goals:

a. Publication annually of statistics on occupational relationship in BOASI mortality and morbidity records.

b. Incorporation of occupational data in reports of major medical care plans.

c. Assignment of an individual trained and experienced in occupational health intelligence surveillance in every region.

d. Institution of surveillance network in selected industry to provide information on the appearance of new or potential problems.

2. Clinical and Epidemiological Studies of Occupational Disease

Background: Disease, disability, and impairment must be studied to the extent that they are revealed by vital statistics, case records, or clinical examination as identifiable entities, and by persons who are in constant touch with clinical realities, to whom the data represent something more than a set of statistics, although statistical methods will be employed to the limit of their usefulness. The results of such studies need, in turn, to be linked with other types of evidence, and further studies of a similar nature, in the attempt to complete our understanding of the incidence, severity, progress, causation, and prevention of the disturbances examined.

Present status: While such studies have classically constituted the primary mode of attack on problems of recognizing occupational diseases, modern data processing methods have greatly extended the scope of the information that may be extracted from the data, and the ease of handling large masses of data and of establishing correlations between events. At the same time, increased understanding of the fundamental nature of the disturbances of function set up by environmental conditions has increased the range of phenomena on which data can be obtained and analyzed by these techniques.

Five-year goals:

a. The development of teams trained and competent in a number of specialized areas of occupational health, prepared to participate actively in clinical research and in epidemiological studies. Examples of areas where competence will be needed include:

(1) Occupational dermatology.

(2) Occupational pulmonary diseases, with plans for the systematic study of selected groups exposed to industrial dusts, irritant gases, mists, or fumes, to obtain quantitative data on the long-term effects of such exposures upon the lungs. Concern here is not only with the pneumoconioses, but also obstructive emphysema, chronic bronchitis, and aggravating effects on other chronic disease. Specific occupational groups needing study include workers exposed to cotton and other vegetable fibers, to coal dust, and to asbestos.

(3) Systemic disease, dealing with the systemic effects of environmental conditions and substances resulting in clinical disease.

b. The initiation of surveys of major occupational or industrial groups to define potential areas of risk to health, current and projected preventive health programs. Each survey, in cooperation with industry, would lead to a monograph containing practical information useful to engineers, physicians, and other health personnel.

c. Development of clinical facilities, preferably in a Public Health hospital, for the study of problem cases selected for special study or referred for evaluation from a Federal agency.

d. Constant availability of a medical and industrial hygiene team for prompt and effective study of suspected outbreaks of occupational diseases.

Ten-year goals:

a. Continued development of clinical and laboratory groups oriented toward specialized areas of occupational health.

b. Expansion of clinical facilities, with provision for regular rotation of clinical staff members.

TOXICOLOGIC STUDIES IN LABORATORY AND FIELD

Background: It is imperative that PHS be in a position to evaluate critically all available information on the toxicity of substances and materials to which workers may be exposed, to carry out impartial laboratory and field studies where indicated, to resolve conflicting evidence, to evaluate the risks of submitting familiar materials to new processes, to develop techniques for the early recognition of deleterious effects in man, and to apply this information precisely and quickly to the formulation of standards and the issuance of advice on preventive measures. When multiple exposures, concomitant physical agents, infectious agents, and inherited metabolic derangements are considered, the permutations which require consideration are almost infinite.

Present status: Considerable activity has been maintained, as evidenced by recent studies on the toxicology of vanadium, ozone, nitrogen peroxide, and fluoride, and by current studies on oil mists, toluene diisocyanate, and intermetallic compounds. Increased attention has been given more recently to an investigation of the basic mechanisms by which substances produce toxic effects and by which bodily tissues respond. But there is no systematic survey of new materials. The larger chemical firms do a considerable amount of work toward establishing the toxicity of new substances before they are released to the public, but this is not so well done in the case of the smaller companies. Substances with toxic potential which get on to the market without adequate screening come up for examination only after deleterious effects have been produced.

Five-year goals:

a. An expanded program both in toxicologic evaluation and in studying mechanisms of action. Emphasis will be placed on combinations of chemical agents or of chemical and physical agents known to occur in industry.

b. Development of techniques which will facilitate the interpretation of animal behavioral reactions for the estimation of human reactions to and tolerances for toxic substances.

c. Exploitation of promising leads to determine the usefulness of biochemical criteria, including enzyme patterns, as early indicators of toxic reaction in animals and man.

d. Studies on the effects of fatigue and other body strains upon a susceptibility to toxic actions.

e. Strengthening of mechanisms for the coordination of laboratory toxicology and studies of exposed employees.

Ten-year goals:

a. Continued development along the same lines, with techniques employed dependent upon results of earlier programs and substances to be tested dependent upon current industrial practices, number of persons exposed, character of observed reactions and criticality of the process.

b. Increased attention to development of methods for determining in advance unusually susceptible individuals, which may be found dependent upon now unsuspected genetic differences.

4. Ergonomics and Stress Evaluation

Background: The physiological processes of the body constitute the essential mechanism on which environmental stresses operate to produce the disturbances that eventually lead to the departure from normal that is termed disease. Every stress evokes both deteriorative and compensatory reactions. The conditions which determine the balance between them must be known, measures for measuring the net balance devised, and the ultimate significance for the individual determined. Understanding of these processes and their reaction to environmental conditions is basic to occupational health studies such as toxicology and occupational medicine.

Present status: Much is known about the major physiological responses to the more important environmental factors considered singly, or in very limited combinations, but little is known about their operation in multiple patterns. Studies of the responses to stress have been largely confined to rather crude measures of general reactions, or to the behavior of the endocrine system as judged by relatively indirect measures. Recent research has greatly increased the opportunities of studying the responses of the body cells, but this has not yet been applied to assessment of the strain developed in man as a result of environmental conditions.

Five-year goals:

a. Initiation of studies on the nature and incidence of impaired pulmonary function in various workers, in collaboration with clinical staff, as related both to environmental and constitutional factors.

b. Preliminary investigation into the effect of thermal stresses upon tolerance to chemicals, susceptibility to infection, response to allergens, and capacity to perform physical and mental work.

c. Definitive studies on neurophysiological responses to noise and vibration.

d. Evaluation of the relative effects of environmental factors upon work capacity and efficiency, with emphasis upon alertness and responsiveness.

e. Study of bioclimatological aspects of occupational environments as indicated in recent reports to the Interdepartmental Committee on Atmospheric Sciences.

f. Formulation of indices for the evaluation of environment involving more than one mode of stress.

Ten-year goals:

a. Further development of the above.

b. Active participation in the ecological program (item 12).

5. Study of the Impact of Psychological, Social, and Economic Factors Upon the Health and Efficiency of Workers

Background: As the impact of major toxic and physical factors in the work environment is reduced, and automated procedures are introduced, the significance of psychological and social factors not only becomes more apparent but increases in absolute value. For the assessment of the effect of the total environment upon the total man, not only must these influences be understood and taken into account but the effects produced by their operation must be integrated with the effects produced by the other environmental factors into a composite picture.

Present status: No more than isolated and somewhat specialized attempts have been made to study the impact of the psychological and social factors on workers, and these have mostly been in relation to the more dramatic instances, such as very busy communication and control centers, and have followed the pattern developed in military studies. There is a very wide scope here for studies ranging all the way from the basic aspects of motivation to specific problems of psychological breakdown. The techniques are far from frozen, and in the matter of synthesis have still largely to be worked out. Goals can be pointed out, but the method of attainment will largely have to be developed as the studies proceed.

Five-year goals:

a. Psychomotor studies, particularly directed at effective information-response sequences.

b. Studies of motivational psychology, directed especially to the role of motivation in worker satisfaction and control.

c. Anthropological investigations of man-machine relationship in the causation of impaired health or efficiency.

d. Sociological studies designed to elucidate the significance of extra-occupational conditions in occupational health.

e. Economic evaluations of impairments caused by occupational factors and of proposed control measures.

Ten-year goals:

a. An increase in activities along the foregoing lines.

b. Active participation in the ecological program (item 12).

6. Methods of Environmental Evaluation and Control

Background: The central objective of an occupational health program is the prevention of disease and disability, or, more positively, the preservation of health. Knowledge needs to be translated into practical methods for achieving these ends. This, in turn, depends in part upon the adequacy and sensitivity of instruments for detecting and measuring the intensity of relevant environmental conditions, and on the full use of the technological arts in the suppression or removal of those conditions which are judged deleterious.

Present status: Good use is made of current technology in the selection, design, and use of detecting and measuring equipment, to the extent that the judgment of the PHS personnel is frequently sought in the selection of equipment. Industry designs control apparatus, but PHS maintains a watching brief on the adequacy of the systems devised and makes known practices which are considered inadequate.

Five-year goals:

a. Initiation of a critical review of current dust sampling and counting techniques, and development of the outline for a definitive manual of recommended practices.

b. Development and maintenance of reference standards for materials and substances of importance in occupational health investigations.

c. Continued development of techniques for the analysis of multiple samples to replace long and complicated methods, without undue loss of precision and sensitivity.

d. Development or modification of existing instruments for monitoring various aspects of the physical environment, such as radiant heat, vibration, noise, and pressure, and their evaluation for industrial hygiene purposes.

e. Development and application of techniques as needed for epidemiologic or clinical studies.

Ten-year goals:

a. Completion of review of dust sampling and counting techniques and publication of manual of recommended practices.

b. Continuation and expansion of program set as 5-year goal, with further development of concepts of preventive engineering, such as inclusion of essential controls in the actual design of industrial equipment.

7. Research on Types of Occupational Health Program for State and Plant Use

Background: Serious practical difficulties are often encountered in translating knowledge and principles of prevention into actual health programs at the State, local, or plant level. Objective study is required of the factors which affect this translation, of methods for overcoming the difficulties, and of the economic aspects. The problem is akin to some that are encountered in operations research.

Present status: The most serious deficiency is in the provision of adequate preventive measures for workers in the small plants of less than 500 employees, which account for over two-thirds of the work force. In several States the provision for the control of occupational environments is below the level considered adequate for a variety of economic, professional, and operational reasons. Of the 584 persons employed full or part time in occupational health in State and local units in February 1961, 58 percent were in 6 States; the remaining States had either no programs or inadequate ones.

Five-year goals:

a. Establishment of the factors which militate against the development of occupational health services.

b. Analysis of the economic aspects of occupational health services.

c. Development of model programs and the setting up of pilot projects under contract with research supervision.

Ten-year goals: Completion of the research aspects of occupational health program establishment.

8. Development of Standards for the Work Environment

Background: Determination of the environmental conditions which can be tolerated, or, better still, of the environmental conditions which are to be recommended for optimal health, productivity, and performance, is basic to the operation of an effective occupational health program. Without this, every move to control environmental conditions is apt to be met with demands for proof as to why the particular value taken was chosen, and not some other value more favorable to the party posing the question.

Present status: Organizations and groups such as the American Conference of Governmental Industrial Hygienists, the American Standards Association, and the American Industrial Hygiene Association engaged in setting standards look to the PHS for advice, assistance, and support; but the resources to meet these demands are meager.

There are now no agreed standards for the work environment with respect to allergens, substances absorbed through the skin, or carcinogens. The same thing applies to psychological conditions. The current standards for noise, vibration, heat, and cold are unsatisfactory. Those used for toxic substances cover only a limited number of substances, and are too often based on evidence of a rather tenuous character.

Five-year goals:

a. To work with the organizations named above and with other divisions with responsibilities in environmental health in a critical reevaluation of the philosophy, criteria, and applications of current standards for the occupational environment, with the definition of areas of needed information and the provision of specific staff and other assistance as needed. Special attention will be given to revising and strengthening the bases of threshold limits and maximum acceptable concentrations (MAC) at present in wide use.

b. To develop mechanisms for effective and sustained international cooperation and interchange of information in the field of standards for the occupational environment, such as an expansion of the present cooperative activity with CIS.

Ten-year goal: In cooperation with appropriate committees or organizations, to develop standards for the work environment in areas not now covered.

9. TECHNICAL SERVICES AND ASSISTANCE

Background: PHS has 50 potential clients in the States, and several more in the various Federal departments and agencies. Few of these have sufficient resources or sufficient need to set up full-scale technical organizations capable of making all the investigations and solving all the problems of occupational health that may develop in their respective spheres. Even where the resources exist, individual institutions of any magnitude would lead to unnecessary overlapping, and and unwarranted drain on the national resources, especially of expert manpower. A central research and investigation facility, at this stage of development, can maintain a wider range of expertise, and provide a greater variety of services rather than several smaller institutions, and keep those services in close contact with research developments across the Nation. Beyond the State and Federal agencies lies the mass of industry itself, and beyond it the general public, who also desire service and assistance in matters of occupational health.

Present status: From its current resources, DOH furnishes three types of service: (*a*) technical information and advice; (*b*) problem-solving teams; and (*c*) assistance to States in the building up of their own programs. These resources are, however, limited. The technical information service relies on a manual storage and retrieval system of relatively small bulk; requests for visits by problem-solving teams may have to wait several months before the required personnel are free from prior commitments: and only two officers are currently assigned to States for program assistance.

Five-year goals:

a. The installation of at least a semiautomated information storage and retrieval system, for the provision of technical information to States, industry, and the public on environmental hazards associated with occupations.

b. The provision of sufficient skilled personnel to be able to maintain two teams of four technologists in the field at all times for problem investigation.

c. The assignment of a physician, engineer, or nurse, trained in occupational health, to at least 20 of the 50 States, on a basis of need, opportunity, and evidence of adequate support.

d. The fiscal support of an occupational health program in each State.

e. The continued development of effective working relationships with industry, labor unions, local agencies, and appropriate Federal agencies aimed at the fair and equitable attainment of recommended environmental standards in both large and small industry.

f. The development of a trained and experienced staff for consultation in the development of the health aspects of union contracts.

g. The development and use of effective methods of educating workers and the general public in the possibilities of and necessity for sound occupational health practices.

Ten-year goal:

Complete development of the above goals, and particularly the establishment of an effective occupational health unit in each State, with close collaboration with PHS.

10. Direct Technical Training

Background: The pursuit of studies or the implementation of programs in occupational health require many techniques, items of information, points of view, or specialized knowledge, which are seldom acquired in the course of routine professional training for engineers, physicians, nurses, or scientists. It is essential that there be some organization which can provide this training, in conjunction with the regular professional training, as a postgraduate course, or on the job.

Present status: A few universities offer postgraduate course in industrial medicine, occupational health, or industrial hygiene; but these require one or more academic terms of full-time instruction, and are not sought by many students. DOH provides 1- or 2-week technical courses for industrial hygienists, industrial engineers, safety engineers, and plant medical officers, which are usually oversubscribed. There is an obvious need for providing still further short-term classes, and for cooperation with universities in attracting more students to the long-term professional courses.

Five-year goals:

a. Increased activity in the presentation of short-term courses for physicians, chemists, engineers, nurses, and other health workers in general and specialized aspects of occupational health.

b. An expanded educational program for health practitioners in the diagnosis, treatment, and prevention of occupational disease.

c. Continued education of workers and the general public in the importance and methods of preventing occupational disease.

d. An expanded program of cooperation with universities in promoting graduate courses in occupational health.

Ten-year goal: Extension of the same.

11. Grants

Background: Universities, nonprofit research organizations, technical institutions, and some private groups are actively engaged in both research and training relevant to the advancement of occupational health. This is the foundation upon which the PHS helps to build an adequate national activity in occupational health. In keeping with the role ascribed to it, the PHS must encourage them in meeting the national needs, especially in relation to the more basic aspects of occupational health problems and activities, and must render substantial support to these activities.

Present status: The award of grants for research in occupational health have come under the purview of DOH in the last year, and a substantial increase in funds has been made available for this fiscal year. As this is a relatively new departure, it remains to be seen to what extent the national pool of talent can effectively use these funds. For the research as well as for the proposed increased occupational health activities in Federal, State, local, and industrial agencies, a much larger number of trained persons will be required than are at present in sight. It is doubly important, therefore, that immediate action be taken to attract a larger number of good personnel into training, not only for occupational health itself, but also for the sciences and technologies upon which it is based. The DOH is concerned, however, primarily with those courses which relate directly to occupational health activities, depending upon the National Institutes of Health and others for the support of the training in the contributory disciplines, for whom this field will be one of many competing employers.

Five-year goals:

a. The support of research in fields relevant to occupational health to be conducted in universities, technical institutions, nonprofit organizations, and appropriate private groups, to the extent that worthwhile projects can be conducted by the available talent.

b. The introduction of research training grants and fellowships to encourage and support capable personnel according to their needs during the period of training in research.

c. The introduction of training grants to similar organizations for the development and conduct of courses in subjects relevant to occupational health, for physicians, engineers, scientists, industrial hygienists, and nurses.

d. The introduction of traineeships to encourage and support capable personnel according to their needs during the period of training in occupational health science and technology.

Ten-year goal: Development of the above in accordance with the available talent.

12. Development of Ecological Picture of Occupational Health

Background: As with most fields, the tendency has been to concentrate on the pursuit and conquest of the more easily recognized, isolated, and urgent problems to the exclusion of adequate efforts toward maintaining a unified conspectus of the field. This tendency has been accentuated by the absence of well-defined procedures for integrating independent observations on the simultaneous operation of multiple factors. In spite of the difficulties, however, such an integration is vitally necessary, since the worker, who is the prime object of concern, is and reacts as a whole man, and not as an isolated system responding to stimuli one at a time. Such a conspectus is necessary not only for the completion of an intellectually satisfying concept of the object of study, but also for the organization of activities within DOH in a manner best suited to the overall purposes of the organization. The development of this ecological viewpoint is the more essential as attention passes from the dramatic effects of single environmental conditions to the more subtle but more far-reaching effects of multiple coincident factors.

Present status: Very little attempt is made at the present to derive an integrated picture of the total worker in a total environment, beyond the intuitive and almost casual picture that any keen administrator develops in his own mind. Two kinds of techniques are available, although in still rather undeveloped form: (*a*) mathematical procedures based on probabilities such as factorial analysis, symbolic logic, and game theory; and (*b*) roundtable integration, in which experts from various fields meet periodically to attempt dialectic synthesis, with progressively penetrating review of the evidence between sessions.

Five-year goals:

a. Development of a pilot system whereby an ecological picture may be established of the total worker in his total environment from the information available in the several contributory diciplines.

b. Determination of ways in which this activity can be linked with corresponding activities in other Divisions and at Bureau level.

c. Development of methods by which the ecological information may be applied to DOH program operations.

Ten-year goal: Establishment of definitive activities in the above, related to the Center type of conjoint activity.

IMPLICATIONS FOR ORGANIZATION AND RESOURCES

While many of the activities described in the preceding Section are to be found in the current operations of DOH, the scope of each is less than the level which is adequate to the national needs, and some are hardly represented at all. The resources currently available for the occupational health program fall far short of supporting the desirable level of effort. The program which has been described will need considerably more in the way of fiscal support, facilities, and manpower than are at present employed. The implications of the recommended program expansion for organization and resources are indicated in this Section.

Organization

Occupational health, being centered around a well-defined group of people with rather specific environmental stresses, has a unity of purpose that is quite marked and should not be disturbed. Intelligence, research, prevention, and service must work together and be viewed together. The ecological conspectus can emerge only if the process can draw intimately upon the contributing groups. Administration should be closely related to the ecology which provides the integrated viewpoint and to the groups whose actions it directs. An important item for attention in setting up and operating an expanded program is the preservation of this unity in spite of increased numbers and activities. It is strongly recommended that the organization be so designed that interaction and communication between various disciplines and operations is an inherent part of the structure. This would require that all functional segments of the Division be physically located together, that personnel have laboratories and offices in closely interlinked groups, and that the work load be focused on problem areas with personnel from different organizational segments cooperating in their solution. (The "problem" may equally be one in fairly fundamental research, as in prevention of a specific disturbance.)

In the association between DOH and other Divisions engaged in environmental health activities, provision should be made for persons of similar technical competence or working on related problems to meet and work together in such a way that between them they bring to bear ideas and capabilities not available to the Divisions acting in isolation. This, however, should be done in such a way that their parent field is not deprived of their services, and new barriers created as the old ones are removed.

In the course of its activities DOH depends in many instances upon other agencies or organizations, both within and without PHS, for advice and assistance. Some illustrations are given in table 1.

Manpower Requirements

a. With DOH: In table 2 are given by various categories the projected manpower requirements within DOH for the conduct of the program indicated in Section III, in the years 1966 and 1970, together with those actually employed in 1961, as at 30 June, for contrast. The degree of training required specifically in occupational health, in

TABLE 1. *Association with Other Organizations*

FACILITIES AND COMPETENCE SHARED WITH OTHER ELEMENTS:

Item	Shared with—
Statistics on O.H.	National Health Survey, BOASI, etc.
Cohort analyses	BOASI.
Pilot study of health plans	Selected States, industries, insurance companies.
International O.H. information exchange	Labor Department, CSI.
O.H. consultants	Regional offices, States.
Environmental standards	ACGIH.
Applied research	Universities, etc., through contracts.
Clinical studies of specific occupational diseases	Universities and clinicians through grants and contracts.
Ecological synthesis of total man in total environment	Bureau Office of Ecology and Systems Analysis.
Economic evaluation of occupational disease and its control.	Bureau Office of Ecology and Systems Analysis.
Training programs for industrial hygienists, industrial chemists, safety engineers, industrial physicians, and nurses.	Training Branch, SEC; universities.
Compilation, storage and dissemination of toxicologic information.	Other Divisions and Bureau Office of Toxicology Intelligence.

RELIANCE UPON FACILITIES AND COMPETENCIES ENJOYED BY OTHERS:

Item	Look to—
Toxicology of insecticides	CDC.
Bacteriological and other infective complications of toxic exposures	CDC: NIH.
Reporting of disturbances in health of workers	National Health Survey; States; BOASI.
Air pollution and water pollution as background to occupational disturbances.	Respective Divisions of BSS.
Special techniques and assistance in radiological aspects of occupation.	DRH.
Special techniques and assistance in psychological aspects of occupation.	NIMH.
Basic research	Universities through grants.
Special techniques and assistance in cancer	NCI.

addition to the normal professional training, can be gauged from table 3. The proportion of Ph. D/M.S./A.B. desired is given in table 4.

It is evident from these tables that the manpower requirements of DOH for internal activities are not great, and that a relatively small proportion will require orientation to or training in occupational health aspects before being proficient on the job. Of the latter, some can be given the requisite orientation after taking up duty. The heavy demand is upon persons with professional competence in the supporting fields of chemistry and other sciences, in whom specific occupational health orientation is a minor requirement which can certainly be acquired on the job.

b. National needs: In the matter of national needs, the estimated supply and requirements of personnel in certain professional categories, trained in occupational health, are given in table 5.

TABLE 2. *Categories of Personnel Required by DOH*

Categories	Numbers of personnel		
	1961	1966	1970
Engineers	12	35	57
Industrial Hygienists	10	20	32
Physicians	14	33	46
Nurses	3	8	12
Physiologists	2	10	14
Statisticians	3	11	15
Toxicologists	3	12	19
Pharmacologists	7	14	17
Physicists	3	6	10
Chemists	20	65	91
Pathologists	2	6	10
Phychologists	....	13	17
Mathematicians	....	4	4
Veterinarians	....	3	4
Radiochemists	4	11	13
Electronic Engineers	....	2	4
Health Analysts	5	16	24
Public Information Specialists	4	7	10
Science Aides	20	78	110
Clerical and Administrative	48	118	170
Labor	8	24	32
Total	168	494	711

These figures are based on estimates made by eminent persons in the field, having regard to the expected growth of the work force, and the institution of that degree of supervision and care that would adequately apply existing knowledge.

c. Training: It is clear, therefore, that although the demands for personnel for direct DOH operations is small, the national requirements are quite large. It would appear from these figures that there is already a large deficiency that must be made up. This deficiency, however, is in number of people who would be necessary to run an adequate program. It does not follow that the same number could be employed if they became immediately available. It would take a great deal of educational effort and time to persuade industry, for example, that such people should be employed. By 1970, however, much of this slack should be taken up if the educational aspects of the recommended program are fully implemented.

The burden of training the required personnel will certainly fall upon the universities, both in providing the basic professional competence, and in giving the orientation and training in occupational health required by certain categories. As regards the latter the effort of the 9 schools now having recognized industrial health curricula,

TABLE 3. *Degrees of Orientation Required in Occupational Health*

Classification	1961	1966	1970
With strong orientation	47	124	190
With some orientation	8	38	53
Scientific but no orientation	57	192	266
Clerical and labor	56	140	202
Effective total	168	494	711

TABLE 4. *Degree Status Required*

Degree	1961	1966	1970
Ph. D. or M.D	37	111	160
M.S	35	165	239
A.B	20	78	110
Total	112	354	509

giving advanced degrees in occupational health to approximately 25 physicians, 3 nurses, and 21 hygienists each year, will certainly need considerable supplementation. This could be by encouragement and support of trainees and research trainees, by support of program development, or by the creation of training centers. All except the last named activity are envisioned under item "11. Grants" in the proposed program of Section III. The need for training of personnel in the contributory disciplines should be brought to the attention of other appropriate bodies such as the National Institutes of Health and the National Science Foundation for inclusion in their efforts for promotion of general science training.

FACILITIES

The DOH now occupies (or will before the end of 1961) about 75,000 square feet of gross floor space; 63,000 in a converted ware-

TABLE 5. *National Needs of Personnel*

Personnel	Present (1957-60)	Projected (1970
Industrial physicians:		
Available	2,300	2,900
Needed	4,800	6,000
Industrial nurses:		
Available	16,000	19,000
Needed	30,000	35,000
Industrial scientists:		
Available	1,300	1,600
Needed	8,000	9,600

house building in Cincinnati, and the rest in HEW South Building, Washington. These facilities are not adequate for or encouraging to the current program, and fall far short of those required for that proposed in the preceding Section. Table 6 sets out the net space requirements envisioned by DOH for operations other than field stations and clinical facilities in 1970. The corresponding gross space requirements would be approximately 300,000 square feet. In terms of the activities to be carried out and the number of personnel involved in the proposed program, this estimate appears to be modest.

TABLE 6. *Total Estimated Net Space Requirements*

Element	Office	Laboratory	Exposure	Housing	Other	Total
Division [1]	9,46–	3,080			1,540	14,080
SS Branch	4,000					4,000
R &TS Branch	2,200					2,200
Toxicology Section	5,500	36,080	6,600	22,600		70,780
Occupational Medicine Section Dermatology Section	10,340	12,540		5,280		28,160
Physical and Chemical Analysis	4,840	14,300			660	19,800
Engineering Section	4,180	8,580			1,320	14,080
Physiology Section	2,200	6,600			440	9,240
Ecology Section	1,320	4,180				5,500
Training Branch	1,980					1,980
Requirements Analysis Section	3,080					3,080
Training Operation Section	2,640	1,540			2,860	7,040
Training Methods Section	2,200				2,420	4,620
Technical Information Section	3,300				1,320	4,620
Totals	57,240	86,900	6,600	27,880	10,560	189,180

1 Includes facilities common to several sections.

The point has been made earlier in this Section that all of the activities of DOH should be physically located together. It remains here to point out the further advantages that would accrue to the activities of DOH if it were physically associated with the other Divisions in Environmental Health. Undoubtedly the economy of service-type operations that could be expected from joint facilities are significant, but over and above this is the more basic advantage, or even necessity, that through the close proximity and cooperation of the other Divisions the picture of the total man in the total environment would be still further advanced. The importance of this for occupational health has been stressed; the importance of extending it still further to cover the remaining aspects of man's environment is obvious. The close relationship of industrial exposures to air pollution, of work in radioactive environments to radiological health, of industrial hygiene to food quality in general, and of industrial environment control to environmental control in general, including water quality control, are self-evident. It is strongly recommended that DOH be brought into close contact and collaboration with the other Divisions, not merely by contiguity of buildings, but also by arrangement of space and common living facilities in such a way that frequent meetings inevitably occur between men whose activities are convergent and knowledge mutually beneficial. It is very desirable that individuals concerned with matters of interest to several problems be able to work together without losing sight of the problems.

The DOH Field Station at Salt Lake City is certainly very useful in the conduct of the current studies on uranium miners, and in providing technical services to the western region. The continuation of this field station and the creation of others are matters that management will have to judge in terms of requirements as the program unfolds. It is hoped, however, that field stations have quarters more adequate to their responsibilities than those now available to the one at Salt Lake City.

For the conduct of clinical studies, access is required to hospital facilities in which selected cases can be retained for special, continued, or controlled studies. It is estimated that a total of 10 available beds, with an average of 5 occupied, would meet the needs. While they would almost certainly be part of a larger clinical installation, it is highly desirable that they be contiguous to the facilities occupied by the clinical portion of the DOH program.

If the universities are to take up the increased scope of training indicated earlier in this Section, larger and better equipped facilities will probably be needed. Whether these increased facilities should be provided in concentrated form at one or two places, or scattered amongst several schools, is a matter that will have to be carefully considered.

Fiscal Requirements

In Table 7 are set out the fiscal requirements estimated by DOH for the implementation of the program proposed.

It is considered that the figures shown for direct operations are a reasonable projection of the program advocated. The figures shown for Grants represent the amounts that will be necessary for the implementation of an adequate national program, provided that the talent can be found and attracted to this type of work. The Division has at present no evidence to guide it in estimating if the talent will in fact be available.

The high rise in Project Training Grants is largely due to the necessity of training the large numbers of industrial physicians, nurses and scientists shown in Table 5, as necessary to meet national needs. The late placing of the rise in support, after 1966, is due to the need for prior educational efforts in alerting the State and industrial organizations to the need for utilizing such personnel, and for the prior strengthening of the staff in schools in which such training will be undertaken.

TABLE 7. *Estimated Fiscal Requirements of DOH (Thousands)*

	Actual 1961	Estimated					
		1962	1963	1964	1965	1966	1970
Grants (total)	$1,410	$4,334	$5,900	$9,000	$14,250	$20,880	$55,200
Research grants (existing)	1,410	3,884	5,000	6,500	8,500	11,000	25,000
Research training grants and fellowships:							
a. Existing (fellowships)	0	450	900	1,400	1,900	2,400	4,500
b. Proposed	0	0	0	0	0	0	0
Project training grants:							
a. Existing (General Health)	0	0	0	0	0	0	0
b. Proposed	0	0	0	1,000	3,500	6,800	23,700
Traineeship:							
a. Existing (General Health)	0	0	0	0	0	0	0
b. Proposed	0	0	0	100	350	680	2,000
Direct operations (total)	1,923	2,097	4,050	5,700	8,000	9,900	12,000
1. Research:							
a. Direct	948	988	1,819	1,900	2,900	3,100	3,600
b. Contract	115	200	700	800	1,000	1,500	1,800
2. Training	181	194	402	800	1,000	1,300	1,800
3. Technical assistance and control operations	679	715	1,129	2,200	3,100	4,000	4,800
Grand total	3,300	6,431	9,950	14,700	22,250	30,780	67,200

Report of the Subcommittee on RADIOLOGICAL HEALTH

RECOMMENDATIONS

1. The Public Health Service should assume primary responsibility for the development of a sound radiological health program in the United States. Particular attention should be directed to—

a. research on radiation protection standards;

b. the continued development of a comprehensive surveillance network for the measurement of environmental radiation levels; and

c. the development and application of appropriate countermeasures where radiation hazards exist.

2. The Service should carry out this responsibility through its Division of Radiological Health. This Division should be provided with (*a*) a scientific staff of high competence and (*b*) facilities which include central administrative and laboratory units and a series of regional field stations wherein the technical operations and suitable portions of the research and training programs of the Division may be conducted. The central units might well be developed as part of a PHS Center for Environmental Health although delay in the development of such a center must not be allowed to hold up the construction of additional facilities for the Division. Estimates for facilities needed immediately are $10 million of which $7 million are for central administrative and laboratory units and $3 million are for additional regional laboratories. Substantial additional funds will be needed in the not-distant future to meet the rapidly expanding demands being placed upon the Division of Radiological Health.

3. The Division of Radiological Health should give increasing attention to its programs to support university research through grants and contracts. The current extramural research program of the Division is far behind the schedule laid out by the National Advisory Committee on Radiation 2 years ago and strong efforts should be made to bring this program to its proper place in the activities of the Division.

4. The program of the Division of Radiological Health to promote and support training programs for radiation health specialists and radiation technicians within universities and public health agencies should also be substantially increased. Annual support at a level of $5 million is needed immediately to meet the anticipated demands for radiological health personnel over the next 10 years.

5. The Division of Radiological Health in the development of its programs should place special emphasis on problems arising from the use of medical and industrial radiation sources and should pay particular attention to regional problems that transcend State and local authority. The measurement of environmental levels of radioactivity and the application of appropriate countermeasures where excessive levels are found to exist constitute one set of such problems.

6. A Radiation Hazards Research Liaison Committee should be established between the Public Health Service and the Atomic Energy Commission, to give direction and coordination to the radiation hazards research programs of the two agencies.

7. Finally, the growth of the budget of the Division of Radiological Health should be allowed to proceed at the pace outlined in the 1959 report of the National Advisory Committee on Radiation. This calls for an annual budget of $50 million by 1964. Currently this growth is behind schedule, a circumstance that should not be allowed to continue in view of the rapidly increasing responsibilities of the Division in today's troubled world.

HISTORY OF RADIOLOGICAL HEALTH

The biological effects of ionizing radiation were first observed by the physicians who used X-rays in medical practice soon after Roentgen's discovery in 1895. Early X-ray apparatus was erratic in its operation and it rapidly became common practice for a physician to test his equipment each day by holding his hands in the X-ray beam and observing the clarity of the image appearing on a fluoroscopic screen. In a few years, pathological changes appeared in the skin of the hands of these physicians. In many cases, the changes progressed until cancerous degeneration took place.

The cause and effect between X-ray exposure and biological damage was immediately recognized and steps were begun to establish criteria of safe operating procedure for physicians using X-ray apparatus. In the late 1920's these criteria were given formal status through a series of statements issued by the Advisory Committee on X-ray and Radium Protection, a non-Government group of outstanding physicians and scientists who came together to examine critically the problems of protection standards in medical X-ray practice. This committee, since renamed the National Committee on Radiation Protection has, through the years, recommended an increasingly broad range of radiation protection standards as the problems of radiation exposure in the population increased.

Until recent years, the Public Health Service has not been strongly active in the field of radiological health. Instead, as nuclear science expanded rapidly with the creation of the Manhattan District during World War II, concern for the control of ionizing radiation was largely confined to those associated with the District. After the war, this concern continued to reside mainly among those working in nuclear science through the programs of the Atomic Energy Commission with only minor interest in the subject developing in the Public Health Service. Not until a report of the National Academy of Sciences in 1957 pointed out that exposure to ionizing radiation in the United States was becoming an important health problem, did the radiological activities of the Public Health Service take on substantial proportions. In 1958, the Surgeon General created a Division of Radiological Health and appointed the National Advisory Committee on Radiation to advise him in all matters pertaining to the hazards of ionizing radiation. This committee recommended that the Service embark upon a strong and rapidly expanding program involving radiobiological research, training of radiation health specialists and a series of control operations closely coordinated with State and local health departments.

As the Public Health Service took an increasingly active position in the field of radiological health, many uncertainties arose concerning the respective roles of the Atomic Energy Commission and of the Service in matters pertaining to radiation regulation and safety. There were many persons who did not believe that the Atomic Energy Commission, an agency with substantial responsibility for the promotion of atomic energy as a social and military instrument, should also have major jurisdiction over the health and safety aspects of ionizing radiation. On the other hand, there were those who feared the placement of total regulatory authority over radiation exposure in the Public Health Service since the Service is a Government agency primarily concerned with health risks and hence might establish regulations which are excessively restrictive and which would substantially curtail the growth of nuclear science.

It soon was recognized that there was need in the federal establishment for an organization of high authority, independent of the AEC and PHS, to serve as a quasi-judicial body in the resolution of problems in radiation safety and protection. In 1959, there was therefore created, first by presidential order and then by legislative statute, the Federal Radiation Council, to advise the President on all matters which involve a balancing of the benefits and risks of radiation exposure. The Council is currently composed of the Secretaries of Health, Education, and Welfare, of Defense, of Commerce, and of Labor, and the Chairman of the Atomic Energy Commission, with the Secretary of HEW acting as Council chairman. One of the first actions taken by the FRC has been a review of radiation protection standards. It has now published two reports which henceforth will serve as a basis for its own judgments and as guides to all who work with ionizing radiation.

TASKS OF THE DIVISION OF RADIOLOGICAL HEALTH

Radiation Protection Standards

The establishment of the Federal Radiation Council has clarified many of the responsibilities of the AEC and the PHS. Since the AEC is primarily concerned with the promotional aspects of atomic energy, it has been suggested that the Commission be the agency to bear major responsibility for providing the Council with data on the benefits of nuclear science. Concurrently, it has been suggested that the Public Health Service be the agency to provide the Council with data on the risk side of the equation. One of the prime tasks of the Public Health Service, therefore, is the development of basic data on the biological effects of ionizing radiation to support the Council in the formulation of its radiation protection guides. This is not to say that the Service must itself generate all of these data. Indeed, an evaluation of the research needed to provide the information required by the Council in the foreseeable future is of such magnitude that such a task would be quite impossible for a single agency. Instead, the Service must utilize all of the resources available to it both inside and outside of Government. These include the resources of the Atomic Energy Commission as well as those of the universities and other laboratories of the Nation. It should be pointed out, however, that since this research must focus on the fulfillment of specific needs, for which the Service is responsible, its direction must rest in the Service and must be supported by a highly competent group of scientists who are provided with adequate facilities and resources.

Surveillance and Interpretation of Radiation Exposure Levels

The formulation of radiation protection standards constitutes, of course only one phase of a radiation control program. There is also need for mechanisms to determine the extent to which radiation-producing equipment and materials and those using such equipment and materials comply with these standards. This involves the regular and systematic measurement of environmental radiation levels through a broad range of circumstances and the wise interpretation of the resulting data to insure the institution of those countermeasures which may be necessary when hazardous conditions are found to exist. These functions of surveillance and interpretation of data fall logically within the purview of the Public Health Service and have been so noted in the presidential directive creating the Federal Radiation Council.

To carry out its surveillance and interpretive functions, the Service should draw heavily on all available resources. Much surveillance data can and should be collected by State and local health departments. The sharing of data gathered by other Federal agencies should be promoted. University centers, under contract or through research grants, may be expected to perform a valuable supporting role. However, since primary responsibility for these functions lies in the Public Health Service, overall direction of them must be a Service task.

In this regard, the Subcommittee believes the Service should place special emphasis on problems arising from the use of medical and industrial X-ray radiation sources. No other agency has these problems under study at this time. It should also pay particular attention to regional problems of population exposure which transcend State and local authority. An example of one such problem, rapidly increasing in magnitude, is the widespread exposure of the population from the fallout of the present series of Russian nuclear bomb tests.

The surveillance and interpretive responsibilities of the Service are extensive. They should be met with vigor. On them depends the effectiveness with which the radiation control measures are carried out.

Development and Use of Countermeasures for Radiation Protection

The third element of a radiation control program is the development and application of those measures needed to maintain a safe environment or to restore it when radiation hazards are found to exist. The Subcommittee believes that the Public Health Service has an obligation to take leadership in this aspect of the radiation control problem. It should maintain an active program of research for the development of methods and techniques by which radiation exposure may be reduced. Such efforts should encompass a broad range of activity, extending from the investigation of methods of food decontamination to the development of techniques to reduce medical X-ray exposure.

The inevitable corollary to the development of control measures is the promotion of programs for their effective use. In most areas of public health, regulatory responsibility properly belongs with State and local government, with the PHS limited to a dual role of promoting such programs and furnishing technical assistance. In the field of radiological health, the Service should continue and strengthen this role, but at the same time must recognize that the character of the hazard is often not limited by State boundaries. If the public is to be given adequate protection, the Service, through its Division of Radiological Health, must therefore take a more active and positive role than has, in the past, characterized some parts of its activities in the regulation of environmental health hazards. It cannot passively wait for requests for assistance, but must actively stimulate the development and conduct of radiological health programs and, because of the technical nature of these programs, must be prepared to give a higher degree of technical assistance. An even higher degree of authority to regulate interstate hazards is also essential.

To carry out the foregoing mission, the Service should utilize all available resources. Those associated with State and local health departments should be particularly valuable. At the Federal level, the resources of such agencies as the Atomic Energy Commission and the Food and Drug Administration should be fully utilized. However, the Subcommittee would like to emphasize once again that in view of the importance of the health problems created by excessive radiation exposure, the primary responsibility for coordination of effort and the provision of technical assistance where needed should reside with the Public Health Service.

DEVELOPMENT OF THE DIVISION OF RADIOLOGICAL HEALTH

To perform the tasks set forth in the preceding section, the Division of Radiological Health requires an organizational structure which includes technical operations, training, and research. In addition, means must be provided whereby the Division's programs may grow in an orderly and well conceived manner. This requires the establishment of a divisional structure for planning and development which operates continuously to determine the courses of action which the Division should follow. It is proposed that this structure consist of a divisional advisory board composed of the Division Chiefs, his several Branch Chiefs and other appropriate personnel. Such a board should have the responsibility to determine Division policy and to plan those actions needed for the Division to meet its responsibilities.

Technical Operations

The comprehensive measurement of environmental radiation levels and the application of appropriate countermeasures where radiation hazards are found to exist constitute the principal operational functions of the Division of Radiological Health. To perform these tasks effectively, the Division requires an organization which includes a central administrative and laboratory group intimately linked to a series of regional field stations. The central group is needed to give overall direction to the Division's technical programs, and to provide the basic scientific competence for problems of national scope. The field station complex is required to meet the many problems which have a strongly regional character. For example, the control of radiation hazards in mines can usually best be maintained through the close surveillance provided by a technical staff operating from a nearby field station. The subcommittee believes that the Division of Radiological Health should have at least one field station with administrative and laboratory facilities in each of the nine districts of the United States. Each station should be developed in close affiliation with a State health department to increase and strengthen the effort which may be brought to bear on the problems encountered.

During the past 2 years, the Division of Radiological Health, with the resources available to it, has undertaken responsibility for the development of a series of surveillance networks by which the radiation levels of air, water, and food may be monitored on a continuing basis. Although this activity has by no means reached the comprehensive level needed, the Subcommittee wishes to commend the Division for the progress it has been able to make in this field.

The National Advisory Committee on Radiation, in studies with the Division of Radiological Health, believes that by the year 1964, a minimum of $18 million will be needed to operate the central and regional programs of the Division. This figure includes funds for the support of State and local health department laboratories. By 1970, these costs may well rise to a level of $24 million.

TRAINING

It has been estimated by the National Advisory Committee on Radiation in its report of 1959 that approximately 1,200 radiation specialists and 4,000 radiation technicians will be needed by 1970 to meet the personnel requirements of the Nation in the field of radiological health. The subcommittee finds no reason to alter these estimates. To reach them, the Subcommittee believes that the training program already underway in the Division of Radiological Health should be substantially and rapidly strengthened until it approaches a level of not less than $5 million annually. These funds should be made available to support university programs in radiological health and to provide fellowships for suitable students. The specialist training should be developed principally at the postgraduate level and should provide at least 2 years of training in most cases. The training for technicians should be directed principally toward the undergraduate level of instruction with utilization of the facilities of the regional field stations where appropriate.

At the present time, the support for training in the Division of Radiological Health is at a level of $1 million per annum. This is quite inadequate to meet the needs set forth in the foregoing paragraph, and the Subcommittee must be critical of the Service for not having taken greater leadership in promoting such an important part of its program as the training of radiation health specialists and radiation technicians. Because of the great need for qualified personnel, it is hoped that the efforts of the Division may be greater in the future.

It should be pointed out that there is no overlapping between the foregoing programs and those of the AEC. Training supported by the latter agency is designed primarily to develop men who will direct the health and safety operations of AEC and related installations. The PHS training program has been planned on the other hand, to develop personnel who can serve effectively in public health operations at the Federal, State, and local levels. Here, emphasis is placed on biomedical instruction as well as on work in the physical and engineering sciences.

The subcommittee would like to say a word now on the administration of the training grant funds available in radiological health. Although these funds should be provided on a categorical basis, it is recommended that they be administered, along with similar categorical training funds of other divisions of the Bureau of Environmental Health, in a central office of the Director of the Bureau. Such administrative centralization will do much to assure an orderly development of the training program in radiological health as well as those of the other divisions of the Bureau.

RESEARCH

The success of the programs of the Divisions of Radiological Health in surveillance, data interpretation, counter measures, and control depends to a great extent upon the ability of the Division to develop sound programs of research. Indeed, so intimate is the relationship between research and operation success that research laboratories should be an integral part of the central and field station organization of the Division.

It has already been pointed out that the research requirements for the Division's programs are so extensive that one cannot expect the Division to perform more than a small fraction of them within its own facilities. There is, therefore, a need to develop a strong extramural program of research grants and contracts with universities. There is also need to develop close working relationships with other government agencies having resources which may be used by the Division.

The National Advisory Committee on Radiation has proposed that the research activities of the Division of Radiological Health reach a level of $27 million per year by 1964. This subcommittee finds this estimate reasonable and endorses it. Of this amount, the Subcommittee finds it difficult to make recommendations concerning the fractions which should be devoted to intramural and extramural research. It calls attention to the fact that the relationships here are likely to be different from those which prevail in other agencies due to the fact that the Division is required to direct its attention to problems of a highly specific nature. Hence, its research programs are likely to have a stronger intramural emphasis than is the case in such agencies as the National Institutes of Health.

Like the training program in radiological health, the research programs of the Division have not, during the past 2 years, received the emphasis recommended by the National Advisory Committee on Radiation. The Subcommittee is concerned about this and asks that greater effort be made by the Service to provide adequately for the research of the Division.

Although many of the problems which the Division of Radiological Health is likely to encounter are of a strictly categorical nature, and hence may be attacked entirely within the limits of the Division's resources, there are many which are more complex and require the application of disciplines found elsewhere. The Bureau of Environmental Health should recognize this need for interdisciplinary research and should undertake those measures necessary to assure its provision.

Relationships of the Division of Radiological Health to the Atomic Energy Commission

The Subcommittee would like to speak now of the relationship of the Division of Radiological Health to the Atomic Energy Commission. Worry has been expressed in a number of quarters lest there be unnecessary duplication in the effort of the two agencies, worry which incidentally is shared by this Subcommittee. The Subcommittee believes that this problem should be dealt with, as soon as possible, by the creation of a Radiation Hazards Research Liaison Committee composed of the Chief of the Division of Radiological Health, PHS, an appropriate representative of the Atomic Energy Commission, and such other personnel from the two agencies as may be needed. This Committee should meet at frequent intervals to review PHS and AEC radiation research programs and to plan and devise ways and means whereby the resources of one agency may be used fully to advance the programs of the other. This Committee should review budgetary proposals in all areas of common interest before annual budgets are submitted for consideration to the Bureau of the Budget. Although a Radiation Hazards Research Liaison Committee of the type set forth here may not resolve all of the questions of program duplication, the subcommittee believes that it will go a long way to resolve misunderstandings concerning the content of AEC and PHS programs in radiological health and will assure Congress that the full resources of both agencies are being brought to bear on the radiological problems of the Nation.

CURRENT AND FUTURE NEEDS FOR RADIOLOGICAL HEALTH FACILITIES

The Division of Radiological Health currently operates from facilities located in Washington, D.C., Rockville, Md., Las Vegas, Nev., and Montgomery, Ala. The Washington and Rockville facilities house the Division's central administrative and laboratory operations respectively; the Las Vegas and Montgomery installations are regional field stations. A third field station will be opened this year in Winchester, Mass.

During the past year, the foregoing facilities have become quite inadequate for the rapidly expanding responsibilities of the Division of Radiological Health. The resumption of nuclear bomb testing has placed great demands on the Division to increase its surveillance network operations. The programs for the development and application of countermeasures to reduce medical and environmental exposure levels have lagged far behind because space is not available for them. Research on radiation protection standards has been curtailed for similar reasons.

The Subcommittee believes that the urgency to today's radiological health problems require immediate action to expand the facilities available to the Division. Indeed, this expansion should proceed regardless of the creation of an Environmental Health Center, although if such a center is built the expansion would desirably take place as a part of the center's development.

After an examination of the current tasks of the Division of Radiological Health, the Subcommittee believes that the Division has an immediate need for additional facilities having a value of approximately $10 million. Of this $7 million is required to provide new and enlarged administrative and laboratory units at headquarters. These units should be located together preferably in the Washington area. The remaining $3 million are needed to enlarge the Division's field station complex. These are the current needs the subcommittee visualizes. It is anticipated that substantial additional facilities will be required in the future and these should be allowed to develop in an orderly manner as need arises.

REPORT OF THE SUBCOMMITTEE ON
WATER SUPPLY AND POLLUTION CONTROL

CONCLUSIONS

The Subcommittee on Water Supply and Pollution Control concludes that:

1. The United States is faced with a national water resources problem of increasingly serious proportions of which water pollution is a major part.

2. The rate of national population and industrial growth, and technological advances have created water supply and pollution problems national in scope, and that treatment works constructions, knowledge, manpower, and funds required to solve these problems have not kept pace with needs.

3. The rapidly increasing demands for water for all purposes, adequate in quantity and quality, can be met largely by an effective national water quality management program which will permit use of the same waters over and over as streams flow from their source to the sea.

4. The Federal Water Pollution Control Act, as amended, assigns a major Federal water resources role to the Department of Health, Education, and Welfare in which it is responsible for controlling water pollution to conserve water for all uses—propagation of fish and aquatic life and wildlife, recreation, industrial and agricultural water supplies, and other legitimate purposes, as well as for public water supplies and protection of the public health.

5. The Public Health Service has made substantial progress in developing and administering the Federal program authorized by the Federal Water Pollution Control Act and is providing effective national leadership.

6. The Federal program requires further expansion to meet its legislated responsibilities which will require additional budget, facilities for headquarters staff, research activities and field programs, and manpower in a wide variety of engineering and scientific disciplines. Studies and advance planning indicate manpower needs of 2,200 and a direct operations budget of $22 million in 1965; by 1970 these figures will be about 2,700 and $39 million respectively.

7. The expanding Federal program has urgent need for a national water quality center for the conduct of basic and applied research on water resource problems of national significance, and for the regional laboratories authorized in Public Law 87–88 to support Federal field programs and provide for the specialized research and service needs

of the individual geographical regions, including those of other Federal agencies, State agencies, and local governments.

8. National manpower needs for water supply and pollution control programs—Federal, State, local, and university—are especially urgent, and there is adequate authority to train the numbers and kinds of disciplines required for development of the national program. These programs need to be adequately supported and expanded as rapidly as practicable.

9. Water supply and pollution control problems are becoming increasingly diverse and complex, and the development of knowledge has not kept up. As a result there is a large backlog of urgently needed research relating to the whole broad spectrum of water quality management and to human health. The Federal research program needs to be expanded and extended by full use of grant-supported extramural research programs.

RECOMMENDATIONS

The Subcommittee on Water Supply and Pollution Control recommends that:

1. Since concern has been expressed that the health orientation of the Public Health Service limits its effectiveness in dealing with water resources problems, actions be taken to assure Congress and the public of the Service's full capacity for dealing with all aspects of the Federal water quality program, and that its program is an activity of major proportions which deals with water quality management for all water uses.

2. Responsibilities for all water supply and pollution control activities of the Public Health Service should be vested in one organizational unit, in a manner to give clear and separate identification to this program, with level of personnel status and resources commensurate with the importance of the program.

3. The Headquarters staff of the water supply and pollution control program be augmented to include sufficient specialists in the engineering and scientific disciplines, including economic and social sciences, to provide program direction, for budget preparation, to develop legislative materials, and to do planning.

4. The presently authorized regional laboratories be built and staffed to provide field services and to meet the specialized needs of individual geographical regions, and these be located on the basis of carefully developed criteria.[1] These should provide space, equipment, and staff adequate to give technical support to States within regions on request, provide technical training, provide for the data collection needs of the Public Health Service, demonstrate new procedures and

[1] Criteria recommended by the Subcommittee are presented as a Supplement following this report.

processes, and provide for research on problems unique to the region and for the conduct of field surveys. They should provide support to regional and State water quality programs, but in no sense substitute for adequate State laboratory facilities.

5. Authorization be obtained for a national water quality center in which can be conducted programs of basic and applied research on water resource problems of national significance, with financing to follow completion of the regional laboratories. The national water quality center does not necessarily need to be contiguous with Headquarters.

6. During the period of constructing and staffing the regional laboratories, a comprehensive study be made of the research and data processing needs which can best be met in a water quality center, and that the conclusions of this study be used to define in detail the type and size of central facility needed.

7. Certain technological and informational activities be located at the national water quality facility and be organizationally oriented to serve national program needs. Examples are: (*a*) Data processing and computation facilities; (*b*) highly specialized training at levels not likely to be justified in geographic regions; (*c*) development of uniform procedures for field sampling and analysis.

8. Adequate staff and facilities be provided to conduct toxicologic and pharmacologic studies needed to assess the impact of waterborne substances on plants and animals, including man.

9. Existing authorizations for training grants, facilities grants, fellowships, and research grants be utilized and supported to the fullest possible extent to accelerate the training of scientists and engineers required for development of the national program.

10. The intramural research program be amplified and extended by the expansion of grant-supported extramural research activities, with an ultimate ratio intramural to extramural of approximately 1 to 4. The extramural effort should include some support of long-term projects to university research programs.

11. That greater emphasis be placed on the application of existing knowledge in the control of water pollution, and that stimulation and assistance to States be given through a combination of increased program grants and technical assistance from the Public Health Service.

These recommendations are related to the necessity to prosecute an independent water resources program. It is recognized that some elements could be incorporated into the environmental health concept but such integration is not essential to the successful prosecution of the water resources program by itself.

There is strong evidence that the water resources program will be elevated in organizational status, to a position superior to that of other segments of the proposed Bureau of Environmental Health. Arguments have been advanced for separate Bureau status, or for removal to a level outside the responsibility of the Surgeon General. While organizational repositioning of the water resources program would not affect the cogency of the above recommendations, attention is invited to the probable disruptive consequences of such administrative detachment of the water program from the concept of an integrated environmental health program.

WATER, THE NO. 1 NATURAL RESOURCES PROBLEM

Water has become the Nation's No. 1 natural resources problem—a direct result of rapid population and industrial growth and changing technologies. We can no longer afford the widespread illusion that our water supplies are drawn from a limitless source. We must take comprehensive steps now to conserve and protect our water resources in order to insure the country's continued growth, prosperity, and security.

The Nation is not running out of water; there is just as much water falling on this country now as there ever was. But, there is a limit to our developable dependable water supply, and water needs are approaching or exceeding this limit in many parts of the country. If this limited supply is to serve all the purposes for which it is needed, the same waters must be used over and over. This will require effective water resources management, both quantity and quality.

Since World War II, the Nation's water resources have been the subject of important discussions by an impressive number of Federal committees and commissions set up by the executive and legislative branches of the Government. Also, most of the States have completed, have underway, or have authorized comprehensive studies of the water resources within their jurisdictions. These studies, both Federal and State, up to now have been concerned primarily with the conservation and development of water resources for power, flood control, irrigation, and navigation. Most of the planning effort up to now has been directed toward increasing and conserving the *amount* of water available for use. Far too little attention has been given to the all-important need of planning for the *cleanliness* of water. It is now generally accepted that water quality management must have the highest priority in water resources developments.

Oversimplifying a very complex situation: The water resources problem confronting the United States from now on is one of making its relatively fixed supply meet a rapidly increasing demand by providing the right quantity of water of the right quality where it is needed.

To meet needs we must develop our capturable water resources up to their maximum dependable amounts and pursue an aggressive, effective program of pollution prevention and control that will maintain a high level of water quality in the ground, lakes, and streams across the country—the Nation's fresh water supply. We must do the same with respect to our valuable estuarine and coastal water resources.

Most of our present water pollution problems have resulted from too little attention in the past. Many States have not been provided with program resources commensurate with their pollution problems and their role of primary responsibility in dealing with pollution. The Federal Government has dealt with the problem only in recent years and then on a small scale.

Many municipalities and industries have resisted constructing needed waste treatment works, regarding them as a benefit only to someone else downstream, and as an unnecessary or unbearable financial burden. The public has been allowed to retain too much of the outmoded "water purifies itself every 7 miles" philosophy. It has been oversold on the cheapness and plentifulness of water and undersold on the value and necessity for pollution control. The engineer has relied on the stream to do much of the waste treatment job rather than tailoring treatment to keep the stream as clean as possible.

The problems of water pollution have been brought into sharp focus by the speed of our population and industrial growths, a new and changing technology, new agricultural practices, and new contributions to a continually rising standard of living. These developments have caught us relatively unprepared to deal with the resulting pollution problems sociologically, economically, legally, or technically. The water pollution control administrators are attempting to manage the new, complex problems of today with tools that were designed for the problems of yesteryear. The Nation is entering a critical water supply and pollution control situation that requires immediate attention if it is to continue to move forward.

NATURE OF THE NATIONAL WATER POLLUTION PROBLEM

In the past, pollution control authorities dealt largely with problems caused by sewage, industrial wastes of known toxicity and behavior, and natural organics. Pollution control was aimed principally toward protecting downstream public water supplies, abatement of local nuisance conditions, and protection of fish and aquatic life. For the most part, dilution provided by streams was adequate to prevent serious pollution; waste treatment plants, where provided, were designed to take full advantage of the self-purifying capacity of the stream; and the water purification plant provided the safety barrier for the water-consuming public. Pollution problems were principally local in extent and their control a local matter.

National growth and change have altered this picture in recent years. Population and industrial growth have figuratively and literally moved waste outfalls closer together and increased their number. Urbanization, increased living standards, and encirclement of industry by the municipality have increased the volumes and strengths of municipal wastes. In some instances treated effluents today have polluting effects approaching and sometimes greater than the raw sewage discharges of 30 years ago.

Increased production of goods have greatly increased the amounts of "common" industrial wastes. New technologies are producing complex, new wastes and products that defy our current ability to treat or control them, or even detect their presence in water. The increased application of commercial fertilizers and the development and widespread use of a vast array of new pesticides are resulting in a host of new pollution problems from land drainage. The growth of the nuclear energy field and use of radioactive materials foreshadow still another complicating and potentially serious water pollution situation.

Stream pollution is no longer a local affair. Long stretches of both intrastate and interstate streams are subjected to pollution which adversely affects their use for many purposes. Conventional biological waste treatment processes are hard pressed to hold the pollution line and for a growing number of our larger cities, these processes are not adequate. There is growing concern over the ability of our water purification plants to adequately protect the public against the sheer mass of biological and chemical pollutants entering plant intakes.

Ground water pollution is still a local affair, although it is often an intermunicipal and sometimes interstate matter. Our exploding population is concentrating in urban areas and constantly moving outward from the central cities into suburbia and exurbia. Sewerage construction has not matched either this growth rate or its movements. As a result, a large share (an estimated 23 million in 1960) of our population must rely on individual septic tanks for its waste disposal. In an increasing number of places, this is resulting in serious pollution of ground waters which often must serve the same population with water supply. Few metropolitan areas are escaping this serious public health problem, and it plagues many smaller communities.

Sea water intrusion is a growing ground water pollution problem in coastal areas. It is caused by excessive pumping of the fresh ground water which lowers the water table, allowing salt water to flow into the ground water aquifers. Already a widespread problem, it is now of particular significance in California, Maryland, New Jersey, Texas, and Long Island, New York. Oil field brine disposal practices also are causing salt pollution of ground waters, particularly seepage from so-called "evaporation" pits. This is a particular problem in the oil fields of the Midwest and Southwest.

Sewage and industrial waste oxidation ponds, and waste storage lagoons are often responsible for ground water pollution, especially when improperly located in permeable soils.

Although the practice is not yet in extensive use except for oil field brines, industry is beginning to look to underground strata as the answer to the problems of disposing of highly toxic and/or untreatable wastes. This practice should not be pursued until much more is known of the geology and hydrology involved, and of the procedures which will insure that pollution of ground water aquifers at any time and any distance from the disposal site will not result with particular hazard to public health.

Twenty-three States border on the ocean and their estuarine and coastal waters have been subject to serious and increasing pollution for many years. Many of our large cities and industries are located along the coasts and discharge their wastes, treated and untreated, into adjacent estuaries, bays, harbors, and coastal waters. These waters are also subject to significant pollution from inland areas, transported into them by the drainage basins of the country.

THE EXTENT OF SEWAGE POLLUTION

Since 1900 the number of communities served by sewers has increased from 950 to more than 11,000. Over 7,500 of these municipalities have constructed sewage treatment works to serve 80 million people. At the same time, the amount of municipal pollution has increased because of growing population, obsolescence of older treatment plants, failure to construct needed sewage treatment plants, increased interception of industrial wastes by municipal sewers, and increased number of water-using services in the home (multiple baths, garbage grinders, automatic laundries, etc.).

The following table shows the growth in the sewered population and the increase in municipal sewage pollution, also future conditions if the present rate of treatment works construction is maintained and if secondary treatment is provided by all communities by 1980. Projections are based on estimated urban growth rates and assumption that municipalities will continue to intercept acceptable industrial wastes.

Population Served by Sewers and Sewage Treatment (1900–1980) [1]

[In millions]

Year	Sewered population	Served by treatment	Discharging raw sewage	Population equivalent discharged
1900	24.5	1.0	23.5	24.0
1920	47.5	9.5	38.0	40.0
1935	69.5	28.5	41.0	51.0
1950	80.0	54.0	26.0	60.0
1960	105.0	80.0	25.0	75.0
1970	(145.0)	[2] (130.0)	[2] (15.0)	[2] (76.0)
		[3] (110.0)	[3] (35.0)	[3] (84.0)
1980	(210.0)	[4] (210.0)	[4] (None)	[4] (74.0)
		[5] (140.0)	[5] (70.0)	[5] (150.0)

[1] Data taken or extrapolated from "Modern Sewage Disposal," Federation of Sewage Works Association, 1938; 1957 Inventory of Municipal and Industrial Waste Facilities, USPHS; and unpublished data from Basic Data Branch, DWSPC, USPHS.

[2] Assumes that progress toward secondary treatment for all municipal wastes by 1980 will be made; a per capita population equivalent (P.E.) of 1.6; and 80 percent removal of P.E. by secondary treatment.

[3] Same as (2) except assumes present rate of sewage treatment construction will continue.

[4] Assumes that all sewered population will be served by secondary sewage treatment by 1980; a per capita population equivalent (P.E.) of 1.75; and 80 percent removal of P.E. by secondary treatment.

[5] Same as (4) except assumes present rate of sewage treatment construction will continue.

This table shows that even if we provide secondary treatment by present methods for all the sewered population by 1980, the amount of pollution reaching watercourses in 1970 and 1980 will be substantially the same as today. More importantly, it shows what is likely to happen if apathy toward constructing needed municipal sewage treatment continues; intolerable water pollution situations will exist in many places before 1970 and will be a nationwide situation long before 1980.

The urban waste problem: The concentration of population and industry in urban areas is already creating serious water pollution problems. Such concentrations produce vast quantities of complex wastes which usually must be discharged into a single and often relatively small watercourse. We can look forward to many serious pollution situations below these large centers of population and industry because the pollution load imposed by high volumes of treated effluents will result in low water quality in the receiving stream.

The situation at Chicago is a classic example of the profound economic, social, technical, and legal difficulties inherent in the growing metropolitan sewage disposal problems already with us and certain to increase in number rather rapidly in the years to come. Although Chicago provides the best treatment available, the city pours into the Illinois waterway each day an effluent equivalent to the sewage from 1 million persons and containing solid wastes, suspended and in solution, amounting to 1,800 tons.

Municipal waste treatment processes in use today were designed for the wastes of 40 years ago and no essentially new or more effective process has been developed since. These processes will be effective for many smaller cities for some time, but for a growing number of larger cities, they are proving to be entirely inadequate.

It is clear that a major water pollution need is to develop new municipal waste treatment processes that will remove much more of the contaminants than is now possible. These new treatment methods will probably be based on entirely different principles and concepts than the mechanical and biological processes now in use.

The septic tank problem: Associated with urban growth but not confined to urban areas is the septic tank problem of ground water pollution. Population movement into suburbs has outraced sewer systems extensions and planning officials. The table below shows the growth in metropolitan populations served by septic tanks which implies the magnitude of the problem.

Septic Tank Installations in Metropolitan Areas

[In millions]

	1945	1950	1955	1960	1970
Metropolitan population	75	84	94	109	134
Served by septic tanks	6.7	10	15	23	32

Septic tank pollution is particularly a problem where the ground water is used for domestic and municipal supply. It is nationwide and involves large and small cities alike. The health hazards are obvious and much more attention must be given to providing adequate water and sewer services to suburban populations by developers, planning officials, health agencies, and regulatory agencies.

THE EXTENT OF INDUSTRIAL WASTES POLLUTION

Organic industrial wastes: Studies and surveys by the U.S. Public Health Service in recent years indicate that the amount of organic industrial wastes (treated and untreated) now going into the Nation's watercourses is about double the amount of municipal wastes; that is, a population equivalent to 150 million persons.

By 1975, industry is expected to more than double the production attained in 1950. This would indicate a possible doubling of present organic wastes by 1980 which may be tempered by certain technological and engineering developments, and the extent to which industry meets is responsibilities for satisfactorily treating its own wastes. The increase in organic industrial wastes since 1900 and estimated amounts in 1970 and 1980 are shown in the following table.

Increase in Organic Industrial Wastes

Year	Index of industrial production [1]	Population equivalent discharged (in millions)
1900	20	15
1920	40	49
1940	66	75
1950	113	100
1959	159	150
1970	[2] 246	[3] 210
		[4] 50
1980	[2] 367	[3] 310
		[4] 80

[1] Based on 1947–49 = 100; from Federal Reserve Board Index of Production 1900–59.
[2] Estimated by National Planning Board, "National Economic Projections," from annual growth rate of 4.1 percent.
[3] Assumes estimated percent rate of industrial waste treatment construction will continue.
[4] Assumes 80 percent removal of population equivalent by treatment will be obtained.

These data show that substantial reductions in industrial organic pollution loads can be effected by waste treatment if industry can attain 80 percent removal of population equivalents. Such reductions will require a greatly accelerated construction program and the development of new treatment processes, because fully effective measures have not yet been developed for many organic industrial wastes. The table also indicates the pollution situation that will exist if the present rate of treatment construction continues or if treatment processes are not found which can approach 80 percent removals.

Inorganic indusrial wastes: There have been large increases also in the discharge of the "common" inorganic industrial wastes (principally of mineral and chemical origin). These wastes have polluting effects different from organic wastes and cannot be measured in terms equivalent to sewage. Inorganic wastes originate from metal pickling, acid mine drainage, metal finishing, chrome tanning, and from the mining, processing, and manufacture of a wide variety of metal and chemical products. Also organic wastes often containing substantial amounts of inorganic wastes show that the amounts are very large and the index of industrial production indicates they are increasing rapidly. Fully effective treatment processes have not yet been developed for many inorganic industrial wastes.

New chemical wastes: The chemical industry is the fastest growing segment of American industry and some of its growth is reflected in the table below.

Leaders in Synthetic Organic Chemical Growth [1]
Production in million pounds]

	1928	1938	1949	1958
Plastics	20	130	1,486	4,518
Synthetic rubbers	0	5	1,173	2,202
Synthetic detergents and other surface-active agents		15	375	1,335
Nylon and other non-cellulosic fibers	0	0	66	489
Insecticides and other agricultural chemicals	0	8	97	539
Medicinals	4	13	43	101

Source: ***The Chemical Industry Facts Book*** **1960–61 Edition.**

Synthetic dyes, adhesives, surface coatings, solvents, and many other industrial, agricultural, and commercial products have also registered substantial production growth.

A major new water pollution problem has emerged with the growth of the synthetic chemical industry. Wastes from this industry are reaching watercourses in increasing numbers and amounts each year, both from the use of the manufactured products and from wastes produced during their manufacture. These chemicals reach the stream by way of municipal and industrial sewers, land drainage, or direct application of chemicals to the stream, lake, or impoundment.

Wastes and products originating with the synthetic chemical industry are extremely complex in their composition and behavior. Some cause tastes and odors, and a large number are highly toxic to fish and aquatic life. Many do not respond to biological treatment and persist in streams for long distances. We do not know how to detect most of these compounds in water, or how to treat them in waste effluents or remove them from water. Most important, we do not know their long-range toxic effects of these new synthetics on man.

The new synthetic wastes are present in low concentrations in most waters for the moment, but the industry is continuing its rapid growth. Each year we are finding increasing amounts of these wastes at our water supply intakes and since neither our sewage nor our water treatment plants remove them, they are reaching the consumer in increasing amounts.

Radioactive wastes: Still another new water pollution problem of serious potential has emerged in recent years from the growth of nuclear technology. The presence of radioactive materials in our streams is adding another new contaminant to the Nation's water supply that has serious health implications if not controlled.

Pollution by radioactive materials from nuclear weapons testing is well known. Waste products from mining and refining radioactive minerals, such as uranium or thorium, may wash or be discharged into streams. Waste products from refined radioactive substances used in power reactors or for industrial, medical, or research purposes require adequate control measures to prevent dangerous concentrations from escaping to streams.

Radioactive materials are characteristic of a newly developing class of water pollutants that are subtle in effects and not detected by the usual stream pollution analyses. Even so, their control is a problem in principle no different than the control of the more common types of wastes, and in this instance the only practical means of protection against human exposure to radioactive wastes in water is treatment and control of such wastes at their source. Since radioactivity is cumulative, these controls must be effected in light of total human exposure in the environment.

Heat: Heat pollution is becoming an increasing matter of concern to water pollution control administrators and conservationists. Since 1900, electric power production has approximately doubled every 10 years and is expected to double again by 1970. Unless controls are effected, this could mean an increase in heat pollution of more than 100 percent in the next 10 years. This does not even take into account the increase in water temperatures that will accompany the increase in impoundments for hydropower, irrigation, navigation, flood control, and water supply purposes.

In areas of population and industrial concentration, such an increase in heat pollution in lakes and streams could have a profound effect on the ability of the waters to assimilate even well-treated wastes, or to serve increasing demands for recreational and fishing opportunities. The following example illustrates the potential of heat as a pollutant: In the Illinois River near Chicago, the effect of thermal pollution from steam-electric plants is reported to be equivalent to doubling the organic waste load from the Chicago area; that is, from the present population equivalent of more than 1 million to more than 2 million.

THE EXTENT OF LAND DRAINAGE WASTES

Silt: Up to now silt pollution has largely resulted from erosion of agricultural lands and streambanks. Two examples illustrate the magnitude of the silt problem. The annual silt load carried by the Potomac River amounts to as much as 40 million cubic feet. The Corps of Engineers has estimated the sediment load in the Mississippi Basin above the delta to be about 500 million tons per year. The growth of "suburbia" has created a "new" siltation problem. Housing developers have completely denuded large areas of land of all vegetative cover, exposing the raw land to severe erosion with resulting heavy silt pollution of streams. Serious local pollution problems are resulting from such practices, and pollution control agencies are turning their attention to them.

Brush and forest fires: With the increasing need for water, particularly in water-short areas, brush and forest fires are a matter of serious concern. Such fires destroy the vegetative land cover, increasing erosion and stream siltation, causing rapid runoff of needed waters, and creating tastes and odors from leaching of burned materials.

Irrigation return flows: Irrigation return flows have been a major water pollution problem in the 17 Western States for many years which has increased as more land has been put under irrigation. As irrigation waters percolate through the soil, they dissolve important amounts of minerals and other substances. The same waters are used over and over, with the result that there are repeated additions of minerals. Evaporation losses are high and this further adds to the concentration of pollutants. In many instances, irrigation return flows render streams unfit for further use, including irrigation, until some dilution of their mineral content is provided. With population and industry moving steadily westward, even into these water-short areas, the competition for the available water for public and industrial purposes is rising. The problems this will generate for the water pollution control administrator are imposing.

Urban land drainage: Each year additional millions of acres of land are withdrawn for use for streets, highways, airports, housing, and other buildings. The runoff from these hard-surfaced areas is nearly 100 percent, and with it all of the accumulated deposits—oils, organic matter, trash, soil and industrial dusts, other air pollutants, fertilizers and pesticides used on yards and parks. In addition, municipalities with combined sewers are bypassing increasing amounts of storm water sewage as hard-surfaced areas increase. Only recently have pollution control agencies looked into the matter of urban land drainage and have found its pollution potential to be highly significant.

Agricultural pesticides and fertilizers: Perhaps the most important and emerging land drainage problem involves the tremendous increase in the use of agricultural pesticides and fertilizers. Production of synthetic pesticides in 1958 amounted to more than 500 million pounds, and most of this production was used by U.S. farmers. Each new pesticide introduced on the market is generally more toxic than its predecessor.

More than 30 million acres of cultivated cropland are sprayed one or more times annually in the United States. Aerial spraying is increasing. The treatment of pasturelands and noncroplands, such as highway rights-of-way, is adding to the total use of pesticides. Also, the chemical control of rough fish, aquatic vegetation, and nuisance plants such as mesquite is increasing. Urban dwellers account for a small but significant share of the growing pesticide market.

With some 500 million pounds of highly toxic chemicals being broadcast over the land, it is inevitable that some of it will reach our watercourses. They may be applied directly to the water, they may drift into water during the treatment of adjacent areas, or they may be washed in from treated areas of the entire watershed. Many of these materials have a long residual toxicity in the soil. Numerous fish kills have been traced to pesticides. In other situations, aquatic life, both animal and plant, making up the food chain of fishes have been wiped out.

Most pesticides are not removed by ordinary water treatment processes. While the concentrations found thus far have no apparent acute toxicity to humans as drinking water contaminants, they are approaching levels toxic to fish under continous exposure. As the use of these chemicals continues, the chronic effects of long-term ingestion may well be of greater significance than acute toxicity.

Some indication of the magnitude of the problem in the immediate years ahead has been given by Mr. Wayne R. Yoder, manager of American Cyanamid's pesticides products department, who has predicted a ten-fold increase in pesticide output in the next 20 years. This could mean in 1980, pesticide production amounting to more than 5 billion pounds annually.

As scientific farming progresses, the U.S. farmer is using more and more chemical fertilizers. This practice will undoubtedly increase as new lands are put into use and as more intensive farming practices become profitable. Fertilizers applied to agricultural lands find their way into natural waters principally during runoff and from soil leachings. Their significant pollutional effect thus far appears to be the adding of nutrients to the water environment, although as their use increases there may be other effects such as increased hardness and mineralization.

These added nutrients are capable of supporting and often do support heavy aquatic growths, bacterial, algal, vegetation, and others, particularly in impoundments. Many of these forms of aquatic growths improve the fishing environment, but usually this proves to be a more serious detriment than benefit because such growths often cause serious tastes and odors in water supplies that are difficult and expensive to remove. Stream pollution from agricultural fertilizers, supplemented by the increasing amounts of nutrients from municipal and industrial wastes, is becoming a water pollution problem that may reach national significance. A widespread increase in the growth of nuisance organisms and plants would have serious degrading effects on water quality and use.

Nonwithdrawal Water Uses

Recreation: Recreational use of waters—swimming, water skiing, and boating—can cause measurable pollution. The pollution resulting from water contact sports is principally bacterial. The very large increase in recreational boating and water skiing is resulting in increased pollution. Most recreational craft do not have waste-disposal facilities, and galley and toilet wastes are discharged directly into the water. These kinds of pollution create particular problems when recreational watercraft are clustered together in anchorages, both in fresh waters and coastal salt waters.

A new and perhaps serious problem of pollution is resulting from the growth of outboard motor boating and water skiing, particularly on lakes and reservoirs. Public Health Service studies are showing significant concentrations in such waters of oil, lead, and combustion products from outboard motor exhaust. These wastes have been shown to cause tastes and odors, taint fish flesh, and in sufficient concentration to be toxic to fish and aquatic life.

Navigation: Navigation is an old and continuing source of water pollution in estuaries, habors, and coastal waters. With the opening of the St. Lawrence Seaway, it is a growing problem in the Great Lakes that is creating concern. Ship pollution consists of bilge waters, sanitary sewage, garbage (including cargo spoilage), oils, and whatever can be thrown overboard. Accidental spills in pumping liquid cargoes to shore occasionally cause serious problems as do navigation accidents. Few ships afloat today, even those of recent design, have any facilities for the collection, treatment, or disposal of shipboard wastes.

The St. Lawrence Seaway has opened the Great Lakes to 90 percent of the world's commercial vessels and to possible increases in vessel pollution, a matter of considerable concern in the Great Lakes, involving water supplies, recreational beaches, and real estate values. The discharge of shipboard sewage near public water supply intakes is of special concern since many of these intakes are in or near present port areas or those being planned for development. With ships from all parts of the world entering and harboring in waters adjacent to public water supply intakes, the chances are greatly enhanced for waterborne disease transmission, and particularly those diseases from other countries which have long been gone from the American scene or never have gotten a foothold here.

ECONOMICS OF WATER POLLUTION

The application of basic economics is needed to develop valid yardsticks by which reliable dollar measurements can be made of the costs of water pollution and benefits from its control. With such data, water resources can be accomplished on a more sound basis. Achievement of this goal will require measurements for the value of each water use. These may well differ according to the region or situation involved. New measurement devices which take into account social and public values will need to be developed.

Because of the magnitudes of investments required to achieve water quality control and because of the extensive ramifications throughout the economy of polluted waters, more economists are scrutinizing the situation. The increased attention acts as a stimulus to technical experts already involved and to scholars, public administrators, and others. It is imperative that the intensity of this pace be increased, for adverse economic effect on human welfare is too great for correction to be left to chance or the sporadic attention of the general public.

APPROACHES TO SOLUTION OF THE NATIONAL PROBLEM

Public Awareness

Related to all the elements in water quality management is the need for a much better public understanding of the water pollution situation and greater public support for what needs to be done.

Very important water resources decisions are being made and will continue to be made in the years ahead. The public should have a voice in these decisions and it should be an informed voice. For example, any changes in water rights legislation would have a profound effect on water use and the public should be heard on such issues. Further, it is the public which must pay for water resources developments, including water supply and pollution control, and these programs will not go forward unless the bond issues are passed.

To have the force of public opinion behind water quality management, the facts must be presented to the public through well-thought-out programs. Public support will make it possible to meet needs for adequate legislation and appropriations, and for planning, construction, and the other elements of a successful national water quality management program.

Legislation

The law is the basic framework within which organized society carries out its public functions, including water pollution control. Effective pollution control programs must be supported by effective legislation, tailored to meet the specific problems and needs. As these change, the supporting legislation should be reviewed and changed accordingly.

Many States have reasonably comprehensive pollution control legislation, but all should have it. Legislation is needed for metropolitan areas which will permit communities in the urban fringe to work more effectively and equitably with the central cities on an integrated regional approach to common water and waste problems, including interstate cooperation where necessary. A very pressing need is improvement in State laws for the public financing of waste treatment works. Although most States have liberalized and clarified their public financing laws since the 1930's, improvements are still needed. It may be necessary for the States to consider legislation dealing with the financing of industrial waste treatment works as some have already done.

The need to manage our water resources effectively and efficiently is making it increasingly necessary to provide legislation for integrated river basin and regional water resource developments participated in by all local, State, and Federal interests concerned.

APPLICATION OF ABATEMENT MEASURES

Construction of treatment works: A great deal of water pollution abatement could be achieved now if present knowledge were applied, and the needed sewage and industrial waste treatment works were constructed and properly operated and maintained. A large backlog of sewage and industrial waste treatment construction has accumulated through the years. Last year, the Conference of State Sanitary Engineers completed a comprehensive survey of municipal waste treatment needs as of December 31, 1960, which is summarized as follows.

National Summary, Backlog of Municipal Waste Treatment Needs

Type of need	Number of communities	Population served
New plants	4,136	22,997,547
Enlargements	560	12,729,981
Additional treatment	431	6,513,197
Total	5,127	42,240,725

The estimated cost of the above municipal waste treatment needs is $2 billion. Elimination of this backlog in 10 years, together with needs imposed by population growth and obsolescence of existing works during this period, will require an average annual expenditure of $600 million, 40 percent higher than is being spent by municipalities now.

Information on industry's waste treatment construction needs is not nearly as complete as those for municipalities. This is one of the serious gaps in basic data collection that must be filled. However, surveys by the Public Health Service in 1950 and 1954, information in the 1957 Inventory, and industry's waste treatment record since indicate that more than 6,000 construction projects are needed for industrial wastes. To eliminate this backlog of needed industrial waste treatment and control measures, and to provide for new needs of a rapidly expanding industry, industry will need to spend an average of $575–$600 million a year for the next 10 years to meet its pollution control obligations.

We cannot afford to continue to lose ground to water pollution by failing to construct needed municipal and industrial waste treatment works. Where there are adequate treatment processes available, and there are no problems of organizing and financing treatment works, construction should be required without delay, invoking enforcement when necessary. Where reasonable and effective treatment methods are not available, adequate research programs should be pursued. Where there are problems or organzing and/or financing, the necessary legislation, incentives, and other mechanisms should be provided so that construction can proceed.

Efficient operation and maintenance of waste treatment works: It is not enough merely to construct waste treatments works—they must be efficiently operated and maintained thereafter. This responsibility rests directly on the municipality or other public agency, and on the industries which own the treatment facilities. The regulatory agency responsibility belongs to the State.

Municipalities and industries should be strongly urged to employ the most qualified supervisory, operating, and maintenance personnel possible. Much more attention needs to be given to training programs for both professional and subprofessional operating personnel. States need more staff and funds to properly supervise operation and maintenance of municipal and industrial waste treatment plants. The degree of efficient operation of a waste treatment plant is usually the difference between satisfactory and unsatisfactory pollution conditions downstream. Proper maintenance improves plant efficiency and protects an important economic investment. If all the existing waste treatment plants were operated and maintained at a high level of efficiency, it would result in a very substantial additional reduction in present pollution of the Nation's waters.

Enforcement: Most States prefer to use persuasion in getting municipalities and industries to construct needed waste treatment facilities. However, when reasonable efforts at persuasion have failed, all States should vigorously apply their own enforcement measures.

In 1959 a survey of the States was made to assess tangibly the utilization of enforcement procedures by the State water pollution control agencies. An analysis of replies submitted by the 42 States which reported showed that, of the 37 having authority to issue administrative orders, 8 had issued none, 17 less than 50 orders, and 12 had issued 50 or more. All States have authority to take court action, and the survey showed that 17 States have never brought a court action, 5 have brought only 1 each, 10 had brought from 1 to 5 each, 6 from 5 to 15 each, and 3 States have instituted more than 15 actions each (1 State did not specify any number).

Since Public Law 660 was enacted in 1956, Federal enforcement action has been taken in 15 interstate pollution situations. The 2 most recent cases are in the conference stage, but in the other 13 agreements reached as a result of conferences and the findings of public hearings, facilities costing about $500 million are to be constructed. When completed and in operation, these will eliminate the interstate pollution situations and upgrade the water quality of 4,000 miles of streams.

Enforcement actions will undoubtedly need to be invoked more frequently in the future if further ground is not to be lost to pollution. The States need to be more aggressive in this area, not only to get the job done for which they are primarily responsible but to retain the responsibility.

Improvement of watershed management practices: Many activities on watersheds adversely affect the quality of water draining from them. Poor agricultural practices which contribute to soil erosion, injudicious applications of fertilizers, lumbering activities, unwise use of economic poisons, and construction which lays bare large areas of land are examples of poor watershed management practices which contribute to water pollution.

Since land drainage wastes cannot be collected and treated as can sewage and industrial wastes, their control requires good land management practices. The application of such practices would result in substantial improvement in the quality of many waters. Water pollution control administrators need to give much more attention to land drainage pollution, especially to the development of controls through good practices.

In-plant control of industrial wastes: The reduction or elimination of materials from the liquid effluents of industrial plants by process changes, equipment modifications, careful housekeeping, and other in-plant measures can significantly reduce the waste load to be treated and which eventually reaches the stream. Many industries are reluctant to institute in-plant waste controls unless this results in profitable savings. They have overlooked the substantial savings in waste treatment costs and the beneficial effect on the receiving stream from reduced effluent loads.

Improved management of nonwithdrawal water uses: The use of water supply reservoirs for bathing and other water sports has become a matter of increasing concern for water works officials. Where recreation use is permitted, a barrier of distance, the maximum reasonably enforceable, should be maintained around the intake. Adequate and properly maintained sanitary facilities should be provided.

The discharge of untreated toilet wastes and garbage from ships and pleasure craft should be prohibited. Rigid controls are needed to provide a barrier of distance to protect public water supply intakes.

Studies are needed to determine the effect of the underwater discharge of outboard motor exhaust emissions to provide a basis for control. Proposals to apply chemical poisons to water to destroy undesirable fish, weeds, insect larvae, algae, and other nuisance aquatic life should be approved by the State water pollution control agency.

COLLECTION AND EVALUATION OF BASIC DATA

Basic data in water quality management are the counterparts of inventories and bookkeeping in business. Water is big business today,

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and reliable basic data are necessary to orderly and efficient development and administration of river basin water quality management programs.

In pollution control, basic data consist principally of information on the sources, kinds and amounts of pollution; the causes of pollution and its effects on water quality and uses; the present and future intended uses of waters; the pollution prevention and control measures required to accommodate the planned water uses; the kinds, costs, and efficiencies of remedial treatment works; and the costs and benefits associated with pollution and its control.

The dearth of reliable basic data on water resources has been specifically pointed out by the Presidential Advisory Committee on Water Resources Policy, the Senate Select Committee on National Water Resources, and by the 1960 National Conference on Water Pollution.

Basic water pollution data need to be collected, evaluated, and distributed on a cooperative basis among the water resources agencies concerned. To make these data more reliable, they need to be collected on a continuing basis in all the river basins; to make them more usable they need to be made available widely. We need to know where and why we are gaining or losing ground in controlling pollution, and to maintain a water intelligence that will detect pollution situations as they arise before they become major problems. Progress has been made, but basic data collection and evaluation programs still need to be greatly accelerated by all water pollution control agencies—local, State, interstate, and Federal. Most agencies require increased appropriations before this can be done.

Technical Services

For nearly 50 years, the Public Health Service has been providing technical services to State and interstate agencies, other Federal agencies, and to municipalities and industries. The solution of many problems requires scientific and specialized personnel which the State and interstate agencies cannot justify on a full-time basis.

Technical services have been and will be an increasingly effective tool in the Federal-State-local cooperative approach to water pollution problems. As problems become more complex and demands increase, a much greater resource and variety of skilled manpower and facilities will be required. The State agencies have a major responsibility to provide technical services to local agencies, municipalities, and industrial plants. As problems multiply and more treatment works are placed in operation, the need for technical assistance will increase.

Research and Development

The problems to which research and development must be directed encompass all phases of the fate of a waste, from its point of origin to the point of water use. Because of the water quality implications of water conservation measures, this area of concern is included. The major problem areas are (1) sources of waste, (2) evaluation of pollutional effects of wastes, (3) treatment of wastes, (4) disposal of treated waste effluent, (5) water quality surveillance, (6) water treatment, and (7) conservation and water quality. Each of these is presented in terms of its major research needs.

Special consideration is given to certain activities which may be most advantageously conducted through pooling program resources at a central research facility. These needs include fundamental studies in toxicology, ecology and systems analysis, and instrumentation.

SOURCES OF WASTE

Our ability to account for pollution in the water resource is unsatisfactory. This shortcoming is twofold: the pollutional impacts of several important sources of waste have not been well defined and methods for determining important characterstics of waste are inadequate. On the one hand, therefore, certain significant sources of waste have been largely ignored (as for example, land drainage), and on the other, control of wastes has been incomplete (as for example, alkyl benzene sulfonate in sewage). Only recently have these defects in accounting for pollution been recognized.

Four major sources of pollution have now been described: sewage, industrial wastes, land drainage, and nonwithdrawal water uses. Each presents difficulties in measurement and characterization.

Sewage: Sewage is assuming new and important chemical characteristics. For example, organic chemicals of industrial origin may be undetected and unsuspected components of sewage. Satisfactory control of sewage requires improvement of analytical methodology to detect and measure substances of industrial origin as a first step in their evaluation and control.

Industrial wastes: The "traditional" industrial wastes are still major problems. However, new and even more troublesome wastes are being encountered, such as radioactive wastes, thermal pollution, and a vast complex of waste substances discharged by the chemical industries. The gap in knowledge of the quality and character of such wastes is a problem of fundamental importance in the protection of water quality.

Thermal pollution: **An increase in stream temperature caused by industrial use may hinder the stream's ability to assimilate wastes, impair valuable aquatic life, reduce the value of the water for further cooling use, and promote the growth of objectionable slime or aquatic weeds. No reliable data are yet available for determining the rate at which a stream will dissipate excess heat, or on which to base effective controls.**

Radioactive wastes: Research is required to determine the behavior and fate of radioactive materials in sewage treatment processes and in the aquatic environment (both fresh and salt water), develop treatment processes for wastes from major nuclear industries, and develop relatively rapid physical-analytical methods for determining the specific radioactivity of aquatic media.

Chemical wastes: Wastes from the modern chemical industries are inadequately described by conventional yardsticks of waste strength and character. Chemical characterization of waste effluents is most difficult and their control requires the availability of analytical procedures that can reliaby reflect the waste's composition and pollution character.

Land drainage: The pollutional impact of land drainage, excepting siltation, is relatively recent but highly significant. There is increasing evidence that most land uses result in a deterioration of water quality.

Urban runoff: Drainage from urban areas is now regarded to be an important factor in pollution. Determination of the chemical, physical, and biological character of these wastes is a necessary preliminary to the development of effective methods for their capture and treatment.

Agricultural chemicals: The large increase in use of agricultural chemicals, particularly the new synthetics, has created a new water pollution problem from land drainage. It has been stated, for example, if the 466 million pounds of pesticide sold in the United States in 1958 were diluted by the average annual runoff of all streams, the resulting concentration would be about 0.13 ppm, and for ammonia it would be 3 ppm. Research is needed to develop effective methods for capturing, identifying, and controlling land drainage wastes.

Irrigation return flows: The value of water used for irrigation is seriously limited by the increase in inorganic salts leached from the soil following each application. No practicable control measures have been developed.

Nonwithdrawal water use as a pollutional factor: Increasing recreational use of impounded waters is raising questions of considerable importance, such as the survival of pathogens in relation to use for drinking purposes, the pollutional effect of outboard motor exhausts, and the growing use of organic poisons to destroy nuisance water vegetation, insect larvae, and undesirable fish. The problem of pollution by wastes from vessels and pleasurecraft using the Great Lakes and other inland waters has not been adequately studied. The optimum multiple use of impounded waters requires examination of the physical, chemical, and biological character of contaminants associated with each use.

EVALUATION OF POLLUTIONAL EFFECTS OF WASTES

With increasing frequency, control agencies are faced with water pollution problems that involve new types of wastes whose impact on water uses and on human health cannot now be fully evaluated. Toxicological and epidemiological studies are essential to assessment of the public health importance of new wastes, and a protocol of effective research must be established.

Predicting toxic effect of a waste on aquatic life: Data on which to base the environmental requirements of aquatic life are needed, and must be developed through research. These requirements, which include such items as temperature, dissolved oxygen, carbon dioxide, and pH, should be based on scientific fact so that reliable criteria can be developed for managing water quality to restore and maintain a suitable aquatic environment. These criteria may also prove valuable in managing water quality for other uses.

Predicting impairment of water treatment processes by a waste: A waste may impair water treatment processes by retarding flocculation, increasing chlorine demand, or other effect. Reliable predictive methodology for such effects should be developed to guide water purification practices.

Predicting effect of a waste on palatability: Objectionable taste and odor in drinking water is the most common manifestation of industrial pollution which is difficult to identify and trace. Development of effective methods for predicting a waste's taste and odor potential, and for identifying and tracing the responsible substance is needed.

Epidemiological studies: Current methods of disease reporting indicate that waterborne infection is infrequent and not a major route of dissemination; yet there remain troublesome endemic occurrences of diarrheal diseases, infectious hepatitis, and poliomyelitis not explained by "contact" spread. More refined techniques must be developed to reveal the relationships of less obvious cause and effect.

Few systematic appraisals of the health effects of pollutants have been made other than traditional investigations of infectious diseases. We need to know much more of the effects of mineral salts, organic compounds, domestic and industrial waste components, as well as the etiological agents of infectious disease; also, we need to know the effects of deficient trace elements, molybdenum, selenium, vanadium, nickel, zinc, and copper.

Evaluating toxic effect of a waste on humans: Many of the waste substances now entering water supplies are known to be toxic in sufficient concentrations, but there are many others of which toxicity is unknown. Detailed studies of the toxicologic effects of individual chemicals and mixtures of chemicals are time consuming and costly, and it is hazardous to predict toxicity potentials of mixtures on the basis of individual components, especially if they vary in specific biological, physical, and chemical properties. Increased attention must be directed to the development of rapid screening tests for waste materials which may carry toxicity hazards in the area of water supply. The fundamental studies in toxicology and the related sciences required by the development of such tests can probably be best conducted in concert with other programs having similar interests and competency.

TREATMENT OF WASTES

The important need for the development of new methods for treating wastes more effectively and cheaply is not being adequately met. Also, since conventional treatment methods remove only 40–60 percent of pollutants in wastes, there is a real need to develop entirely new processes which will approach actual purification. This is becoming a particular requirement for large cities and in areas of population and industrial concentration where treated effluents are too great a burden on receiving streams, and where the same water must be used several times to meet needs.

Improvement of biological systems of waste treatment: Improvement of methods for selecting and rapidly adapting micro-organisms to metabolize new organic compounds will increase the effectiveness of present biological treatment systems. Whether organisms can metabolize a given compound or not will provide regulatory bodies and industry with information to determine whether a waste is acceptable in a waste treatment system and the receiving water.

Treatment of wastes in stabilization ponds: The waste stabilization pond is a recent important low-cost treatment development. Pond design presently is on an empirical basis and understanding of the natural forces (solar energy, respiration, wind, etc.) involved in the stabilization processes is too fragmentary to properly evaluate their effect on design criteria. Additional knowledge is needed on effects of hydraulic loading and of waste character on pond efficiencies in removing pathogenic organisms.

The application of physical-chemical principles to separation of soluble solids (The Advanced Waste Treatment Research Program): In the face of a naturally fixed water supply, the growing needs of expanding population and industry is requiring that a given water source be used more and more intensively. Eventually reuse will become an accepted and necessary practice in most densely populated areas. The development of satisfactory waste treatment techniques which will provide for repeated reuse of the receiving stream represents a major, challenging research problem.

Because present methods of waste treatment, stream sanitation, and water purification cannot remove many of the new pollutants and only a fraction of the older ones, a major research program has been undertaken to evaluate physical-chemical principles applicable to much more complete removal of contaminants from water. Some of the research areas of interest are: adsorption, extraction, foam fractionation, freezing, ion exchange, oxidation, and various membrane processes. The major question will revolve about the eventual economic feasibility of such operations. Participation in this program by universities, research institutions, and industry is highly desirable.

DISPOSAL OF WASTE EFFLUENTS

In disposal of waste effluents, the receiving water is seldom used effectively for maximum dilution which raises pertinent questions regarding the adequacy of outfall design techniques. Effective techniques need to be developed to assure optimum use of all available receiving water, whether this be in a stream, the Great Lakes, or coastal marine waters.

The discharge into top soil of the liquid wastes from millions of homes and many industrial plants represents a potential, and often actual, nuisance and public health hazard. Discharging liquid industrial and radioactive wastes into very deep porous strata emphasizes the need for more information on this method of final disposal.

WATER QUALITY SURVEILLANCE

Until recently, few programs of water quality intelligence could present a realistic picture of changing quality conditions in a stream. The minimum criteria for effective quality surveillance are clear. An acceptable program must be based on stream data that accurately reflect the stream's condition. Sampling and analytical procedures must be dependable and inexpensive.

With increasing demands for water of good quality for all water uses, the demand for dependable and economical sampling and analytical techniques becomes more acute. Even the application of our most advanced laboratory methods would presently provide only a partial picture of water quality conditions. Because of the importance of such data in water quality management programs, considerable emphasis must be given to research directed to satisfying this need.

Improvement in bacterial indices of fecal contamination: The major research goal of sanitary microbiology is to develop simpler, more rapid and more specific procedures for identifying contamination by human wastes. Such procedures are important in health protection and are needed where questions of important regulatory action are involved.

Recovery, identification and evaluation of viruses: During the last 15 years more than 70 viruses have been detected in human feces. All may be present in sewage. Viruses pass through the sewage treatment plant, persist in contaminated waters, and may penetrate the water treatment plant. Numerous outbreaks of infectious hepatitis have been traced to contaminated drinking water. The occurrence of such incidents appears to be increasing. An assessment of the significance of water in transmitting viruses will depend on the development of improved techniques. The development of an effective method for culturing the virus of infectious hepatitis represents the single most important task for research on waterborne viruses.

Use of biota in water quality surveillance: Changes in aquatic population reflect changes in water quality. A number of attempts have been made to employ aquatic life in water quality surveillance. No system has, however, been generally accepted as satisfactory by acquatic biologists. The potential value of employing acquatic biota in water quality surveillance should be determined by research.

Recovery and identification of chemical contaminants: Increased production and widespread use of organic chemicals are introducing more new and highly complex chemicals into the water resource for which no methodology for their detection and measurement exist. The development of more effective methods for capturing, concentrating, identifying, and measuring organic contaminants represents an important need in water quality surveillance, and in development of controls. Improved, highly refined instrumentation for microchemical analysis must be developed for this purpose. It is clear that this will require evaluation and adaptation of the most advanced techniques of chemical separation and analysis.

WATER TREATMENT

The modern water purification plant represents a solution to the treatment problems of a generation ago. Its main function then, as it is now, was to remove particles suspended in the water and to destroy micro-organisms that manage to survive flocculation and filtration procedures. A well operated modern water treatment plant still performs this function efficiently.

However, the modern water treatment plant does not remove dissolved impurities efficiently and is unable to handle satisfactorily problems involving soluble organics. This situation will become progressively worse as the challenge increases. Where taste and odor are objectionable, carbon is usually applied, but carbon is selective in its action, and sometimes ineffective.

To increase the efficiency and economy of water treatment, it is necessary to develop a fundamental understanding of physical-chemical principles applicable to the removal of foreign substances in water, soluble and colloidal as well as in particulate form.

Improved separation of suspended solids: Although it has been in use for some 50 years, the mechanism by which the filter component functions has not been well defined. Because the filters represent the most expensive part of the plant, an improved understanding of filter function and performance is essential to a reduction of water production costs. Although current research is directed to water purification, it should also be applied to suspended solids separation in waste treatment.

Improved separation of dissolved substances: The growing taste and odor problem in drinking water taken from streams subject to chemical wastes is evidence of the inefficiency of modern conventional water purification plants in removing chemical contaminants. Research on improving separation procedures is needed and would be mutually complementary with the Advanced Waste Treatment Research Program. Developments in this program can be applied to water purification. This potential benefit to the quality of municipal water supplies supports the need for the Advanced Waste Treatment Research Program.

Disinfection: Chlorine, the disinfectant used almost universally in safeguarding water, is not effective against all micro-organisms in the concentrations of chlorine normally used in water works systems. Certain viruses, the cysts of Endamoeba histolytica, nematodes, and slime bacteria are resistant or invulnerable to chlorine in the amounts generally applied. Research on new and more effective disinfectants should be supported.

CONSERVATION AND WATER QUALITY

The need of our growing population, industry, and agriculture make it essential that practicable ways be found to conserve for use and reuse, waters now being lost or wasted. Phases of present effort include impoundment of water, desalination of brackish and salt water, weather modifications, long distance piping, recharge of ground water and evaporation control. Many of these phases present special problems requiring research effort on methods of protecting water quality.

TOXICOLOGY

The time and expense required to evaluate the long-term toxicity of a substance by classic methods preclude such determinations as a routine procedure in the water supply field. An important need exists for a presumptive test or a screening procedure which would permit the identification of chemicals of real significance, a difficult and expensive research task. Toxicologists, biochemists, pharmacologists, physiologists, and other scientists allied to toxicology, capable of undertaking fundamental work in physiological response to subtle chemical challenges, would be required for toxicology research. Because this need is probably general in all environmental health phases such research should be conducted through pooling of resources in a central facility.

ECOLOGY AND SYSTEMS ANALYSIS

The Federal water supply and pollution control program has initiated epidemiological investigations on the relationship, if any, between drinking waters of differing chemical character and the illness experience in communities using these waters. The project must be conducted independently because an important condition is the specific geographical area served by the water supply of concern.

Supraprogram considerations are involved, however, where a chemical of critical interest occurs simultaneously in several environmental phases. For example, specific cancer promoting chemicals encountered coincidentally in water, food, and air. In this case, it is doubtful that classical epidemiology could resolve satisfactorily the relative importance of each of the several environmental phases. More sophisticated techniques based on analysis of the total system must be employed.

The most complicated situation would be a concurrent challenge by diverse environmental stresses, each of which may be insignificant by itself. This might conceivably involve a simultaneous exposure to toxic chemicals in trace concentrations in food, water, and air, a pathogen in low concentration in food, radiation slightly above background, and, say unusually high ambient temperature. This kind of situation probably is a frequent occurrence and is actually concerned with human ecology. An evaluation of the public health problem presented is not believed to be within the present capability of modern analytical techniques. Research on "human ecology and systems analysis" might, however, produce analytical procedures for the evaluation of the public health significance of multiple environmental stresses occurring simultaneously. Such research could probably be carried on best by a team having competency in mathematics, physics, analytical chemistry, microbiology, biometrics, and epidemiology working at a central facility.

INSTRUMENTATION

Certain basic analytical methods and their required equipment, because of their wide applicability, costliness, complexity, or need for scarce high-level personnel, are best made available as service facilities for use across the lines of individual programs at a central facility. These activities would also involve the development and/or application of highly precise and difficult analytical methods and instruments to research procedures.

Dissemination of Knowledge

A basic approach to the solution of the national water pollution problem is in effective dissemination of the knowledge needed to do the job. This need reaches from the operator of the waste treatment works upward through the highest policymaking levels. There is, of course, dissemination of knowledge now through professional meetings, seminars, conferences, and publications but a much more concerted program is needed. There is a great deal of valuable information available in files across the country and in the experiences of many competent persons which is not available to others. An effective program is needed to: (1) Result in the rapid translation of the findings of research and studies into practical application to existing problems; (2) improve professional competencies through the sharing of experiences and information; (3) prevent unnecessary duplication of effort; (4) point up gaps in needed information; and (5) encourage new ideas and approaches for solving problems. A great deal could be accomplished through use of a wide variety of publications, technical training, demonstration projects, conferences and seminars on subjects of special interest, and establishment of a national data retrieval service.

COMPREHENSIVE PROGRAMS

For nearly 30 years the Nation has been moving toward basinwide and regional water resources planning. The need for this type of comprehensive water resources management is accelerating as competition for the available water increases and as problems of water pollution multiply.

Since the economic and social structures of whole regions often depend upon the available water resources, and how these are developed and used, comprehensive pollution control plans need to be integrated with all other land and water resources planning for a river basin or a region. The growing requirement for multiple water reuse to meet water demands makes integrated water quality management planning a matter of highest priority.

Research or systems analysis for application to comprehensive program planning for pollution abatement is needed to produce a rational basis for management of water quality. A typical river basin may include multiple sources of pollution, multiple water uses, and multiple possibilities for reservoir development for streamflow augmentation. There may be several possible methods of treatment available for certain wastes. In addition, there are natural variables such as rainfall and runoff patterns. With such an assortment of interrelated variables, the choice of the best water quality management decision under any given situation and time will require the development and application of methods of systems analysis.

SCOPE OF FEDERAL WATER SUPPLY AND POLLUTION CONTROL PROGRAM

RESPONSIBILITY

Four major points need to be considered in reviewing the broad scope of the program contained in the Federal Water Pollution Control Act as amended, and the responsibility of the Secretary of Health, Education, and Welfare for conserving and improving water quality for all uses:

1. The Act makes it clear that there is to be a strong Federal role in water pollution control;

2. The provisions of the Act make it mandatory that the Secretary carry out the specified programs;

3. The Act provides for broad water quality control responsibilities for *all* water uses; and

4. The Act assigns to the Department the primary Federal responsibilities for water pollution control and in so doing, assigned it the role of a major Federal water resources agency.

The Federal Water Pollution Control Act goes beyond the usual public health legislation in that it assigns to the Department the responsibility for controlling water pollution to conserve and improve water for all uses—propagation of fish and aquatic life and wildlife, recreation purposes, industrial and agricultural (including irrigation) supplies, and other legitimate purposes, as well as public water supplies and protection of the public health.

Legislated Responsibilities

The programs authorized and directed to be carried out by the Act provide a broad base for dealing with both the water resources and the health aspects of water pollution prevention and control. Specifically, the Secretary is:

1. Directed to encourage cooperative activities by the States in—
   a. Prevention and control of interstate pollution.
   b. Enactment of improved laws to control water pollution.
   c. Establishment of interstate compacts.

2. Authorized to make grants to State and interstate agencies to assist them in meeting costs of water pollution control programs ($5 million annually through fiscal year 1968).

3. Authorized to make grants to municipalities for the construction of waste treatment works ($80 million in fiscal year 1962, $90 million in 1963, and $100 million annually thereafter through fiscal year 1967. Individual grants limited to 30 percent of cost of project or $600,000, whichever is smaller; where project will serve more than one municipality, the total of such grants is limited to $2.4 million).

4. Authorized to make grants-in-aid to public and private agencies and institutions and to individuals for the conduct of research or training projects and for demonstrations, and to contract for such activities.

5. Authorized to establish and maintain research fellowships.

6. Authorized to provide technical training to personnel of public agencies and other qualified persons.

7. Authorized to provide technical assistance to any State water pollution control agency or interstate agency, community, or industrial plant.

8. Directed to develop comprehensive river basin programs for the prevention and control of water pollution, in cooperation with the other Federal

agencies, State and interstate water pollution control agencies, municipalities and industries involved.

9. Directed to determine the need and value of storage in any Federal reservoir for flow regulation for the purpose of water quality control, and make recommendations thereto.

10. Directed to institute Federal enforcement action for the control of pollution of interstate or navigable waters endangering the health or welfare of any persons whenever requested by the Governor of any State or a State water pollution control agency, or (with the concurrence of the Governor and the State agency) the governing body of any municipality; or when he has reason to believe that pollution originating in one State is endangering the health or welfare of persons in another State.

11. Directed to conduct a broad program of research, experiments, investigations, demonstrations and studies relating to the causes and control of water pollution; and specifically to develop and demonstrate: (*a*) Practicable means of removing the maximum possible amounts of pollutants from sewage and other waterborne wastes; (*b*) improved methods and procedures for identifying and measuring the effects of pollutants on water uses; and (*c*) methods and procedures for evaluating the effects on water quality and uses of augmented streamflows to control water pollution not susceptible to other means of abatement ($5 million annually up to an aggregate of $25 million authorized for these three areas of research).

12. Directed to collect and disseminate basic data on chemical, physical, and biological water quality and other information relating to water pollution prevention and control.

13. Directed to establish, equip, and maintain field laboratory and research facilities, including but not limited to locations in the Northeast, Middle Atlantic, Southeast, Midwest, Southwest, Pacific Northwest, and Alaska, for the conduct of research, investigations, experiments, field demonstrations and studies, and training relating to pollution control.

14. Directed to conduct research and technical development work and studies with respect to present and future water quality on the Great Lakes and means of solving water pollution problems.

Further, the Act authorizes the establishment of a Water Pollution Control Advisory Board appointed by the President to advise, consult with, and make recommendations to the Secretary on matters of policy relating to his activities and functions under the Act; and a cooperative program to control pollution from Federal installations.

Additional Responsibilities

In addition to its legislated programs, the Department has additional responsibilities of providing specialized technical services to other Federal agencies relating to water supply and pollution control. These stem from the Department's membership on the Interagency Committee on Water Resources and on U.S. Study Commissions, its agreements with other Federal agencies, services required by International Commissions, and special needs of States and regional jurisdictions. Also, by agreement with the Department of the Army, the Department is required to make determinations of the needs for municipal and industrial water supply storage, and the value thereof.

RESOURCES NEEDED TO SOLVE THE NATIONAL PROBLEM

The national water pollution problem is seriously complicated by the very large backlog of needed waste treatment works; the unsolved problems left over from the past; the development of new and highly complex problems at a rate much faster than our ability to deal with them; the inadequate numbers and diversity of skills available in this field, and the competition in recruiting and maintaining them; and inadequate support to obtain the resources required to catch up and keep up with the national problem.

Manpower Needs

A major resource need is adequate manpower at all levels of pollution control responsibility. Manpower needs are threefold: (1) The sheer number of persons required; (2) a wide diversity of skills not previously required; and (3) the need for graduate level training among these persons. No real problems are foreseen in competing for subprofessional personnel; the difficulty lies in training, obtaining and maintaining the numbers of professional persons in the various disciplines that are needed.

Based on a study of graduate needs by Herbert Bosch, Professor of Public Health Engineering, University of Minnesota, and other estimates of graduate and undergraduate professional personnel needs by 1970, the following projections of national manpower requirements for water supply and pollution control are made, including those of Federal, State, and interstate agencies, local government units, universities, and industry:

Trained Personnel Needs in Water Supply and Pollution Control, 1961–70 [1]

Period	Engineers	Scientists	Total
	Graduate trained		
1961–62	200	500	700
1963–64	500	1,200	1,700
1965–66	800	2,000	2,800
1967–68	1,200	3,000	4,200
1969–70	1,600	4,000	5,600
Cumulative total	4,300	10,700	15,000
	Undergraduate trained		
1961–62	100	240	340
1963–64	200	475	675
1965–66	300	760	1,060
1967–68	475	1,225	1,700
1969–70	625	1,600	2,225
Cumulative total	1,700	4,300	6,000
1970 Needs total	6,000	15,000	21,000

[1] Takes into account losses of personnel due to deaths, retirement, and transfers to other fields.

These projections show that in the 1961–70 period we will need an additional total of 6,000 engineers and 15,000 scientists (in this sense includes lawyers, political scientists, economists, and other specialized professions), two-thirds of which have graduate training. This is a very substantial increase over the estimated presently employed 2,000 engineers and 2,000 scientists. The current rate of recruitment for these professions in water supply and pollution control is about 10 percent of needs.

Federal Water Supply and Pollution Control Program Needs

The Federal program needs for manpower and budget were the subject of a detailed study early in 1961 by the Presidentially appointed Water Pollution Control Advisory Board. Various projections were made based on the total responsibilities assigned by Public Law 660, and on legislation then pending (later enacted) in Congress; also additional water resources responsibilities to other Federal agencies, including interdepartmental agreements. Long-range plans to meet these responsibilities had been made which showed a need for a fairly rapid buildup of programs to 1966, after which needs would begin to level off in sustaining a full-scale program.

The fiscal year 1962 budget contains $80 million for construction grants, $8.77 million for operating grants, and $11.5 million for direct Federal activities; it authorizes personnel numbering 969. The study of Federal program needs showed for fiscal year 1965 manpower requirements of 2,220 persons and budget needs of $100 million for construction grants, $22 million for operating grants, and $30 million for direct Federal activities. For fiscal year 1970 manpower needs will be 2,700 persons, construction grants of $100 million (if authorized), $36 million for operating grants, and $39 million for direct Federal activities. About half the manpower needs will be for engineering and scientist personnel and the remainder for administrative, clerical and maintenance personnel. The Advisory Board accepted the above estimates as "conservative and realistic, and in line with expanding program needs."

Facilities Needs

Water quality management requirements are becoming increasingly scientific and precise, and a fundamental need is adequate facilities in which the intelligence needed for decisions can be produced.

States: The individual States have a need to considerably expand their programs in basic data collection, enforcement, field surveys and investigations, cooperative river basin planning with other agencies; developmental research, and technical assistance to communities and industries; also, to participate fully in comprehensive river basin planning. All of these activities require substantial laboratory support for which adequate facilities, fully equipped and staffed, must be provided.

Federal: The Federal program is basically a field program and includes responsibilities for research, basic data collection, enforcement, technical assistance, development of comprehensive river basin programs, training and administration of grant programs—construction, State program, research, training, and demonstration. To effectively discharge Federal responsibilities the program requires considerable expansion and there is a pressing need for both central facilities and regional facilities.

Central facilities: In the Federal program there is need for adequate facilities to accomplish the following purposes:

1. Housing the Headquarters staff that is responsible for program policy, planning, and direction and budgeting; central administrative and personnel services; liaison with higher echelons in the Department; cooperation with other Federal agency headquarters; and communication with Members of the Congress.

2. House the staff responsible for the basic Federal water supply and pollution control research program; for the direction of Federal field research programs; liaison with the research programs of universities, industry, States, and others; and coordination with other Public Health Service Divisions in the environmental health aspects of water pollution. The nature of these responsibilities is such that it would not be necessary for this staff to be housed in the same facility as the Headquarters staff but should be readily accessible to it.

Regional facilities: The 1961 Amendments to the Federal Water Pollution Control Act recognized the need for field laboratory and research facilities to support field programs in the various regions of the country. These regional facilities are required for the following specific purposes:

1. Laboratory support of a detailed and diversified nature for the extensive field programs in comprehensive program development, basic data, enforcement, and technical assistance.

2. Research, basic and developmental, on water supply and pollution control problems peculiar to the individual regions.

3. Technical training of qualified personnel from State and interstate agencies, municipalities and industries, including demonstrations, seminars and conferences.

4. Coordination of Federal water supply and pollution control programs with the water resources development programs of other Federal agencies, the State programs, and university research and training activities.

These facilities should be strategically located on the basis of carefully developed criteria and the Subcommittee's recommendations are appended.

MEASURES NECESSARY TO PROVIDE REQUIRED MANPOWER

Research and administrative programs in water supply and pollution control require the skills of many disciplines, including not only sanitary engineers, but specialists such as chemists, physicists, biologists, and many others. The critical shortage of qualified engineers and scientists creates the need for support of the graduate training potential of university departments which have competence in the water supply and pollution control field.

The major share of funds to support these research and training programs must come from the Federal Government and the States. Industry, which has considerable manpower needs in water supply and pollution control needs to contribute also. The Federal Water Pollution Control Act authorizes the Secretary of Health, Education, and Welfare to make grants-in-aid to public or private agencies, institutions, and to individuals, for research or training projects and for demonstrations. These several types of support are described below, and all need to be fully implemented as rapidly as orderly expansion permits.

Manpower for research: Research grants are awarded to institutions and individuals to support the study of basic and applied investigations in problems of water supply and pollution control. These grants apply the talents of engineers and scientists to research related to water quality problems, stimulate investigations throughout the country, and add to the specialized knowledge needed in this field.

Demonstration grants: Demonstration grants are awarded to public and private institutions and agencies to support field investigations and studies of an applied nature, and to demonstrate the feasibility of new methods. These grants are intended to evaluate the application of new research findings and to expedite incorporation of new knowledge into routine water supply and pollution control practice. Grants of this type are particularly applicable to utilizing the resources and competencies of State water pollution control agencies, water resources agencies, and conservation organizations.

Health research facilities grants: Health research facilities grants are awarded to assist universities and other institutions to construct and equip additional research facilities as a means of insuring adequate laboratory space and equipment to conduct research.

Manpower for training: Research fellowships are awarded to broaden the base of manpower, competent in the application of various disciplines to research needed in water supply and pollution control. These fellowships assist outstanding graduate scientists and engineers to carry on independent research.

Research training grants: Research training grants are awarded to institutions to establish or expand graduate research training in water supply and pollution control by providing funds to defray institution expenses for research training activities and to support graduate students participating in the program.

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Project training grants: Project training grants are awarded to institutions to establish or expand graduate training in water supply and pollution control. These grants support new and expanded training programs in a variety of departments, encourage multidiscipline teaching concepts, and expand and improve faculties.

Traineeships: Traineeships are awarded to increase the number of service and administrative personnel and to bring new people into the field through training opportunities afforded.

PHS inservice training: Inservice training support provides for the postgraduate training of professional PHS staff members to fill gaps in earlier training or broaden their competency in environmental sciences.

Future utilization of grant support: Measures necessary to provide the required manpower for problems of water supply and pollution control through the research and training grants support would include:

1. Stimulation of interest of engineers and scientists by disseminating information about the technical and research opportunities in this field so that these will be recognized, particularly by those who might be recruited into the field.
2. Provide opportunities for summer employment to stimulate the interest of high school and undergraduate students.
3. Implement, expand, improve, and extend research and training grant programs; specifically, the several public health service programs in the field of water supply and pollution control.

The future effectiveness of training programs will require close integration of the concepts and skills of the physical and biological sciences with engineering. The logical way to achieve this goal is to encourage the development of schools that assemble these varied disciplines in a united faculty, and that combine the training of scientists and engineers related to problems of water supply and pollution control.

DISTRIBUTION OF NATIONAL EFFORT: FEDERAL, STATE, LOCAL, INDUSTRIAL, UNIVERSITY

Responsibility

The national scope of the water supply and pollution control problem generates the need for action at all levels, resulting in a five-way sharing of responsibility. In broad terms, these responsibilities are defined as follows:

The State has primary responsibility for water pollution control. It sets the standards in its jurisdiction, and applies its laws and regulations, including intrastate enforcement. It conducts surveys and investigations, collects and analyzes data, provides technical assistance to local governments and industry, including training, and does development research.

Local Governments construct and operate municipal sewage treatment works, conduct surveys, provide technical assistance and consultation to industries, and enforce their regulations and ordinances.

Universities are responsible for conducting research and for training engineer-waste reductions, and construct and operate waste treatment works if separate from municipalities. Industries make alterations in the plant or adopt new processes to reduce or eliminate pollutants. They conduct research to develop or improve waste treatment processes, and to reduce waste production.

Universities are responsible for conducting research and for training engineering and scientific manpower needed by the other jurisdictions. They also provide technical services and consultation.

The Federal Government supplements and supports programs of the other four. It conducts research and investigations, collects and analyzes data on a nationwide basis, and provides technical assistance to State and local governments and industries, including training. It develops comprehensive water supply and pollution control programs and coordinates these with the States and with the water resources programs of other Federal agencies. It carries out the enforcement provisions of the Federal Water Pollution Control Act. It provides grants for State program development and incentives to municipalities for construction of sewage treatment works, and for research, demonstrations, and training.

Distribution of Effort by Manpower Needs

The distribution of effort in the national program can be demonstrated by manpower needs in 1970. Based on the previous projection of these needs, the distribution of manpower effort would be as follows:

Distribution of National Effort Based on Manpower Needs by 1970

	Engineers	Scientists	Total
States [1]	2,300	2,300	4,600
Municipalities [2]	2,800	2,800	5,600
Industries [3]	3,000	3,000	6,000
Universities [4]	300	700	1,000
Federal [5]	1,000	3,000	4,000
Total	9,400	11,800	21,200

[1] Based on average of 1 engineer and 1 scientist per 100,000 population, 1970 population of 230 million.

[2] Based on average of 1 engineer and 1 scientist per 50,000 urban population, 1970 urban population of 143 million.

[3] Based on estimate that 1 out of 3 wet process industries having separate discharge will be of a size and nature to require an average of 1 engineer and 1 chemist.

[4] Based on 1959 faculty, student output, and manpower need projections.

[5] Based on present staff members in other Federal agencies and on specific study of Division of Water Supply and Pollution Control needs by the Water Pollution Advisory Board in 1961.

The above table would indicate the operations efforts should be fairly well divided among the State agencies, municipalities, industries, and Federal agencies. The kinds and scope of operations will differ in accord with the individual primary responsibilities of these groups.

Distribution of National Effort by Expenditures

From a budgetary standpoint, the distribution of effort for pollution control will be quite different. Municipalities, in addition to supporting personnel, will be constructing, operating, and maintaining sewage treatment facilities. With needs indicating an annual expenditure of $600 million per year for sewage treatment plant construction, and their operating and maintenance costs estimated to be at least $215 million in 1970, municipalities will probably need to be spending close to $1 billion annually by 1970 for the pollution control measures for which they are responsible.

The next largest expenditure for pollution control will need to be made by industry. Its construction needs are less well known than municipal but believed to be about equal in dollars when inplant changes are included. Its operation and maintenance costs will be lower because of the fewer number of individual plants involved, and because a number of industries will be able to make part-time use of regular plant employees. On the other hand, industry's annual expenditures for pollution control by 1970 may well be in the area of $750 million.

The Federal operating grant programs account for the major share of the Federal water pollution control budget effort. It has been estimated that these programs will need support amounting to more than $31 million in 1970. Direct operations needs by 1970 have been estimated to be at least $39 million. Should the State program and construction grant program be continued at present levels through 1970, this will require another $105 million. For the programs under the Federal Water Pollution Control Act, then, 1970 budget support should be in the $175 million range annually. The related programs in other Federal agencies (e.g., Saline Water Conversion, U.S. Geological Survey) will substantially increase this total.

The States at present appropriate a total of about $7 million annually for pollution control activities. To meet needs by 1970, it is estimated that States will have to more than triple present appropriations to the $25–$30 million range. Should more of the States enact legislation providing financial incentives for waste treatment works construction, their appropriations will be substantially higher.

Not enough water supply data are immediately available on which to base estimates on distribution or expenditures. There are data which show that water supply needs approach the magnitude of sewerage and sewage treatment needs, and the distribution of expenditures among the regulatory agencies, municipalities, and industry is proportionately the same for each activity.

RECOMMENDED OBJECTIVES FOR THE FEDERAL WATER SUPPLY AND POLLUTION CONTROL PROGRAM

The Federal Water Pollution Control Act, as amended, assigns to the Secretary of Health, Education, and Welfare broad responsibilities in leadership and program to be carried out in cooperation with Federal, State, and local agencies, and with organizations and individuals having responsibilities and interests in water resources.

The national program objective is the conservation of water quality and quantity to assume continuously an adequate supply of water suitable in quality for public and industrial water supplies, propagation of fish and aquatic life and wildlife, recreation, agriculture, and other legitimate uses.

Specific program goals for each of the legislated activities in the act have been developed and these are described in a Supplement following this report.

Supplement

WATER SUPPLY AND POLLUTION CONTROL PROGRAM GOALS

1. *Recommended Criteria for the Selection of Sites for Federal Regional Water Pollution Control Field Laboratory and Research Facilities*

AUTHORIZATION

Public Law 87-88, approved July 20, 1961, provides that the Secretary shall establish, equip, and maintain field laboratory and research facilities including, but not limited to, one to be located in the northeastern area of the United States, one in the Middle Atlantic area, one in the southeastern area, one in the midwestern area, one in the southwestern area, one in the Pacific Northwest, and one in the State of Alaska, for the conduct of research, investigations, experiments, field demonstrations and studies, and training relating to the prevention and control of water pollution. Insofar as practicable, each such facility shall be located near institutions of higher learning in which graduate training in such research might be carried out.

FUNCTIONS

Each facility must provide the laboratory and technical support to the field programs, required in carrying out the following departmental responsibilities under the Federal Water Pollution Control Act:

1. Developing comprehensive programs for control of pollution of interstate waters.
2. Providing technical assistance on specific problems, in response to and in support of the needs of State and interstate water pollution control agencies.
3. Determining the need for and value of including storage for regulation of streamflow for water quality control, in the survey or planning of any reservoir by the Corps of Engineers or other Federal agency.
4. Conducting research, investigations, experiments, demonstrations, and other studies, within the Department relating to the causes, control, and prevention of water pollution.
5. Training personnel of public agencies and other suitably qualified persons in technical matters relating to the causes, prevention, and control of water pollution.
6. Collecting, evaluating, and disseminating basic data on water quality and other aspects related to the existence, prevention, and control of water pollution.
7. Enforcing measures for the abatement of pollution of interstate or navigable waters.
8. Encouraging and facilitating cooperation by all Federal agencies with State and interstate agencies in preventing or controlling the discharge of pollution from Federal installations.

In addition, the Department has responsibilities for providing technical assistance on matters relating to water supply and water pollution to the Interagency Committee on Water Resources, with its five field committees, the International Joint Commission, and the U.S. Study Commission, current and future. The Department is also responsible, under agreement with the U.S. Army Corps of Engineers (signed November 4, 1958), for determining the need for and value of including storage for municipal and industrial water supply purposes in the planning of any reservoir by the corps. A large portion of this technical assistance requires laboratory services.

SITE CONSIDERATIONS

In order to serve these functions, the site should meet as many as possible of the following requirements:

1. *Proximity to universities, institutes, and other operating research installations covering a broad spectrum of scientific disciplines and activities.* This requirement is contained in the act. Relatively close proximity to such installations will provide important opportunities and scientific resources for cooperative programs in research, technical services, and graduate training. They are important as sources of personnel, as well as for providing the "scientific community" which will prove stimulating to the staff. The institutions should be strong in the fields which support engineering, sciences, and medicine. Good computer laboratory facilities are another asset.

2. *Proximity to major regional water resources problems.* Because watercourses do not limit themselves to political boundaries, and each major drainage area has its own characteristics insofar as regional problems are concerned, water resources should be dealt with on a river basin basis. Therefore, each water pollution control laboratory should be centrally located, insofar as practicable, with respect to both the water resources area it must serve and to the principal problem areas.

3. *Availability of transportation facilities.* Good transportation facilities must be available in order that the installations may (*a*) adequately serve and support the Department's programs in comprehensive planning, basic data, enforcement, research, and others; (*b*) facilitate coordination with water resources program of Federal, interstate, State, and other agencies; (*c*) provide the technical services and assistance to the Federal and State agencies; and (*d*) bring about close coordination with the maximum number of universities. Good transportation assures prompt transfer of personnel and samples from and to all points within the area served, as well as ready accessibility to cooperating agencies.

4. *Special library facilities suitable for scientific and technical research needs.* Good library facilities are necessary and should include broad coverage in engineering, physical sciences, biological sciences, and economics.

5. *Availability of needed technical and nontechnical personnel of the required quantity and quality.* The municipality in which the facility is located will be an important source of needed manpower. While the key staff may initially be drawn from other Department activities or sources elsewhere, much of the nontechnical staff required for continuing and day-to-day operations must be recruited locally.

6. *Public utilities, including communications, power, water supply, and waste disposal.* These are necessary for the proper operation of the laboratory facility

and of the various experimental, demonstration, and research projects which must be conducted at these installations.

7. *Proximity to Federal, State, and other agencies having related responsibilities in water resources development.* The Federal agencies having major related responsibilities in water resources development include the Department of Defense (Corps of Engineers); Department of the Interior (Geological Survey, Bureau of Reclamation, Fish and Wildlife Service, and National Park Service); Department of Agriculture (Soil Conservation Service, Agricultural Research Service); Department of Commerce (Census Bureau, Weather Bureau); and Federal Power Commission.

State and other agencies having related responsibilities are generally located in the capital city or the largest city, and frequently in or near the field headquarters cities of the Federal agencies cited above.

Proximity to as many of these as possible is essential to assure maximum coordination of the Department's responsibilities with those of other agencies concerned with water resources programs.

8. *The Community: social, cultural, and general living conditions.* Attractive community facilities are very important in the recruitment and retention of personnel. Factors to be considered include a good school system, housing to accommodate several economic levels, recreational and religious facilities, and general attractiveness of the area.

2. *Recommended Objectives for the Federal Water Supply and Pollution Control Program*

NATIONAL PROGRAM OBJECTIVE: CONSERVATION OF WATER QUALITY AND QUANTITY

To assure continuously an adequate supply of water suitable in quality for public and industrial water supplies, propagation of fish and aquatic life and wildlife, recreation, agriculture, and other legitimate uses.

The act assigns to the Secretary of Health, Education, and Welfare broad responsibilities in leadership and program to be carried out in cooperation with Federal, State, and local agencies, and with organizations and individuals having responsibilities and interests in water resources.

The area of effort should include—

a. Development of comprehensive programs for all drainage basins of the country; Federal enforcement; basic data collection, evaluation, and dissemination; direct research; research fellowships, grants, and contracts for research or training projects and for demonstrations; administration of construction grants to municipalities and program grants to State and interstate agencies; technical assistance to other Federal agencies, State and interstate agencies, municipalities and industries; training and information.

b. Cooperation to the maximum extent with other Federal agencies and with State agencies in the best development of the Nation's water resources.

c. Encouragement and support of State, interstate, and local agencies in improving and maintaining water supply and pollution control programs adequate to meet their responsibilities and commensurate with the problems.

OBJECTIVE FOR DIRECTED RESEARCH

To conduct research and to contract for research by others designed to improve processes for purifying water to remove from water or render harmless, sewage, industrial waste, and other contaminants, and to extend knowledge of the physical, chemical, and biological characteristics of substances found in water and their effects on human health.

The area of effort should include—

a. Bacterial, virus, fungus, adaption, epidemiological and toxicological studies designed to solve problems relating to long-term toxicity of water impurities, epidemiological significance of water contaminants, the adaption of organisms to degrade wastes, and the role of water in the transmission of viral diseases.

b. Projects in industrial waste, their interference and persistence, and particularly organic contaminants and petrochemical waste processes.

c. Research in water conservation, water quality criteria, suspended solids and colloid separation and interference organisms.

d. Investigations of advanced waste treatment methods including the technological practicability and economic feasibility of processes involving absorption, extraction, freezing, hydration, oxidation, and membrane procedures.

e. The use of research contract to bring into the direct research effort those highly specialized skills, equipment, and facilities not available in the Federal program or which cannot be justified on a full-time basis; and to facilitate those phases of research projects which can be more economically and quickly performed by others.

OBJECTIVE FOR RESEARCH GRANTS

To support research by others in a wide variety of basic and applied problems of water supply and pollution control, to develop a nationwide interest among many scientific disciplines in conducting studies of this nature, and to encourage investigators to undertake research in neglected areas.

The area of effort should include—

a. Detection, determination, and evaluation of all types of hazards involved in the use and consumption of water.

b. Water supplementation and management by various means, such as: ground water recharge, suppression of evaporation, low-flow augmentation, reduction of waste materials at source, improved water, sewage and waste treatment processes, and byproduct discovery and recovery.

c. Fundamentals of chemistry, physics, biology used or useful in a better understanding and utilization of natural and induced water phenomena.

d. Water and wastes engineering applications of mathematical models and systems analysis and techniques.

e. Sociological and economical aspects of water supply and pollution.

f. Ecology of aquatic organisms related to water resources, treatment, distribution, and pollution.

g. Fish and wildlife as affected by water quality.

h. Lake, river, estuarine, and ocean waters in relation to man's health, comfort, and welfare.

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Objective for Research Fellowships

To complement the research grants and direct research operation programs by the award of research fellowships to support outstanding graduate scientists and engineers in the conduct of independent research needed for water supply and pollution control.

The area of effort should include—

a. All scientific and engineering disciplines related to water supply and pollution control research.

b. Support of predoctoral, postdoctoral, and special research fellowships.

c. Award of research fellowships for study at appropriate institutions chosen by applicants.

Objective for Training Grants

To award training grants to institutions to support the development and expansion of teaching programs at an advanced level for training research and administrative manpower required in the operation of water supply and pollution control programs.

The area of effort should include—

a. Support of staff, facilities, and students at an advanced level for training in public and private institutions.

b. Augmenting competence of institutions and departments to provide training in needed areas.

c. Establishing specialized and multidiscipline training facilities for scientists, engineers, and administrators in water supply and pollution control.

Objective for Demonstration Grants and Contracts

To award demonstration grants and contracts to public and private agencies to support field investigations and studies of an applied or developmental nature. These awards provide the necessary step between the completion of research investigations and the direct application of results to use, and thus broaden the water pollution control effort.

The area of effort should include—

a. Demonstration of the feasibility of new methods of water pollution control.

b. Development of field studies or multidiscipline approaches to the solution of problems.

c. Stimulating the application of data, skills, and facilities of organizations not otherwise available.

Objective for Traineeships

To provide individual stipend awards directly to qualified scientists in order that they may undergo advanced, specialized training in one of the fields relating to water supply and pollution control.

The area of effort should include—

a. Advanced training for the development of highly competent administrative personnel in Federal, State, interstate, and local water pollution control agencies.

b. Expansion of individual competence in the multidiscipline approach toward problems in this general area.

c. Development of research and administrative effectiveness in newly developing applications of knowledge in the solution of problems relating to water supply and pollution control.

OBJECTIVE FOR COMPREHENSIVE PROGRAMS

To develop and maintain comprehensive water pollution control programs for the major drainage basins of the Nation and their tributaries.

The area of effort should include—

a. Detailed demographic, economic, hydrologic, and engineering studies of the Nation's river basins.

b. Determination of present and future water requirements of the river basins, in terms of quantity and quality.

c. Determination of present and future pollution loads of each drainage basin and the remedial measures required to maintain water quality commensurate with the needs.

d. Integration of comprehensive water supply and pollution control program with all other water resource development.

OBJECTIVE FOR TECHNICAL ASSISTANCE

To provide technical services to overcome unusual problems that delay implementation of State and interstate water supply and pollution control programs; to render technical assistance in the water supply and pollution control aspects of Federal water resource developments; and to assist municipalities, industries, and individuals on difficult problems when they cannot sustain the necessary staff and facilities.

The area of effort should include—

a. The necessary budgetary, administrative, and consultative services required in support of field staffs providing technical assistance.

b. Assignment of headquarters personnel to technical assistance projects requiring special competencies not available in the field, such as administrative, legislative, and economics.

c. In cooperation with the Research Branch, the assignment of personnel having highly specialized scientific and engineering talents not available in regional offices.

OBJECTIVE FOR PROTECTION OF WATER QUALITY THROUGH ENFORCEMENT ACTIVITIES

To establish and maintain the quality of the Nation's waters at a level that will insure human health and welfare by assisting and encouraging States to enforce their laws and to invoke Federal action when necessary.

The area of effort should include—

a. Support of State enforcement activities at their request by providing consultation and technical services.

b. The maintenance of up-to-date files on all waters under Federal enforcement jurisdiction and the evaluation of possible detrimental effects to water users in those areas.

c. Preenforcement surveys of possible problem water areas, and where needed, informal discussions with States of remedial actions necessary.

d. Institution of Federal enforcement proceedings consisting of a conference of State and interstate agencies concerned a public hearing for the purpose of making a finding of interstate pollution and, when necessary, Federal court action to abate the pollution each step taken if the previous one fails.

e. Post action surveillance to determine whether or not progress in the pollution abatement is in accord with the enforcement action taken.

Objective for Basic Data Collection and Dissemination

To collect, analyze, and disseminate the necessary data to detail the causes and effects of water pollution on water quality and use, and to develop the intelligence upon which successful control and prevention programs can be based.

The area of effort should include—

a. The collection, analyzation, and dissemination of data regarding municipal, industrial, and Federal waste disposal facilities, contract awards for water and sewage works, municipal bond sales for water and sewage, municipal water facilities, and pollution-caused fishkills.

b. Information on long-term water quality trends through the operation of th National Water Quality Network, scheduled to consist of 300 sampling stations.

c. Special related studies that obtain data on the effects of pollution on water quality; the present and future required uses of the affected waters; the remedial measures needed to accommodate the water uses; the kinds, costs, and efficiencies of the remedial measures; and the costs and benefits of pollution and its control.

Objective for Increased Municipal Waste Treatment Construction

To stimulate municipal treatment construction to a level commensurate with existing and future needs, including Federal grants-in-aid.

The area of effort should include—

a. Program policy and guidance for field staffs administering grants-in-aid to municipalities to assist in the construction of sewage treatment plants; review and decision making on matters that cannot be reconciled in the field.

b. Collection and evaluation needed on construction costs data.

c. In cooperation with State regulatory agencies, the determination of sewage treatment construction needs and progress.

Objective for Uniform State Legislation and Interstate Cooperation

To promote interstate cooperation in water pollution control through interstate compacts and enactment of uniform State legislation.

The area of effort should include—

a. The preparation of digests of State water pollution control laws and an analysis of the legislative situation.

b. The revision of the existing suggested State water pollution control act.

c. The provision of technical assistance and a legislative reference service relative to pollution control legislation and compacts.

d. Encouragement of informal interstate collaboration on specific problems.

Objective for Strengthening State Programs

To strengthen State water supply and pollution control programs to enable them to meet adequately their responsibilities, including grants-in-aid.

The area of effort should include—

a. Administering grants-in-aid to State and interstate agencies to assist them in establishing and maintaining adequate water pollution control programs.

b. Review and approval of State water pollution control plans as required by the Federal Water Pollution Control Act.

c. All areas of effort involved in other program goals pertain also to the goal of strengthening State programs.

Objective of Information and Education

To fully inform the lay public and to quickly disseminate to the scientific and administrative personnel concerned, all publications, research results, investigation reports, basic data, and other material pertinent to water pollution, its prevention and control.

The area of effort should include—

a. Stimulating the interests of national organizations and providing them with the kinds of information and assistance they require in supporting water pollution control, including articles for journals, exhibits and films for meetings, and instruction kits and Government publications for distribution.

b. Publishing at regular intervals basic data, summaries of pollution control programs, reports on research, scientific and administrative progress and other appropriate information.

c. Support of regional and other field personnel with information, visual aids, and publications for use in working with any persons or groups requesting their aid.

d. Obtaining wide publicity through the various news media on the water supply and pollution control situation.

APPENDIX

A. Membership of the Committee on Environmental Health Problems

B. Subcommittee Memberships

C. Consultants to Subcommittees

D. Public Health Service Organization for Environmental Health

E. Minutes of May 18, 1961, Meeting of the President's Science Advisory Committee Ad Hoc Panel on Environmental Health

F. Letter Dated July 5, 1961, to the Secretary of Health, Education, and Welfare From the Deputy Director, Bureau of the Budget

A. MEMBERSHIP OF THE COMMITTEE ON ENVIRONMENTAL HEALTH PROBLEMS

AHLBERG, CLARK D., DR.	Vice President for Administration and Research, Syracuse University, Syracuse 10, N.Y.
ANDERSON, GAYLORD, DR.	Mayo Professor and Director, School of Public Health, University of Minnesota, Minneapolis, Minn.
CHAMBERS, LESLIE A., DR.	Scientific Director, Allen Hancock Foundation for Scientific Research, University of Southern California, Los Angeles, Calif.
DACK, G. M., DR.	Director, Food Research Institute, University of Chicago, Chicago, Ill.
DAMBACH, CHARLES A., DR.	Director, Natural Resources Institute, Ohio State University, Columbus, Ohio.
DUBOIS, KENNETH P., DR.	Professor of Pharmacology, University of Chicago, Chicago, Ill.
GOLDBLITH, SAMUEL A., DR.	Professor, Department of Food Technology, Massachusetts Institute of Technology, Cambridge, Mass.
GORDON, SETH, MR.[1]	Vice President, North American Wildlife Foundation, 1390 Seventh Avenue, Sacramento, Calif.
GROSS, PAUL M., DR., *Chairman*	Professor, Department of Chemistry, Duke University, Durham, N.C.
HANDLER, PHILIP, DR.	Chairman, Department of Biochemistry and Nutrition, Duke University School of Medicine, Durham, N.C.
HATCH, THEODORE F., DR.[2]	Professor of Industrial Health Engineering, University of Pittsburgh, Pittsburgh, Pa.
LOGAN, JOHN, DR.	Chairman, Department of Civil Engineering, Northwestern University, Evanston, Ill.
MERRILL, MALCOLM, DR.[3]	Director of Public Health, State Department of Public Health, Berkeley, Calif.
METZLER, DWIGHT, MR.	Director, Division of Sanitation, Kansas State Board of Health, State Office Building, Topeka Aveune at 10th, Topeka, Kans.
MORGAN, RUSSELL, DR.[4]	Professor of Radiology, Johns Hopkins University Medical School, Baltimore, Md.

[1] Water Pollution Control Advisory Board Member, August 7, 1958–June 30, 1961.
[2] Surgeon General's Advisory Committee on Occupational Health Member.
[3] National Advisory Committee on Community Air Pollution Member.
[4] National Advisory Committee on Radiation Member.

MRAK, E. M., DR.	Chancellor, Department of Food Technology, University of California, Davis, Calif.
SILVERMAN, LESLIE, DR.	Science Director, School of Public Health, Department of Industrial Hygiene, Harvard University, Boston 15, Mass.
WECKEL, K. G., DR.	Professor of Dairy and Food Industries, College of Agriculture, University of Wisconsin, Madison, Wis.

HOLLISTER, HAL, MR.	Chief, Radiological Health System Analysis, Division of Radiological Health, Public Health Service. Executive Secretary, Committee on Environmental Health Problems.
HYDE, ROBERT T., MR.	Chief, Scientific Publications, The Robert A. Taft Sanitary Engineering Center, Public Health Service. Final Report Editor, Committee on Environmental Health Problems.

B. SUBCOMMITTEE MEMBERSHIPS

Manpower Resources and Training	Dr. Handler (Chairman) Dr. Morgan
Applied Mathematics and Statistics	Dr. Silverman (Chairman) Dr. Dambach Dr. Ahlberg Dr. G. Anderson Dr. Logan
Pharmacology Toxicology, Physiology and Biochemistry	Dr. DuBois (Chairman) Dr. Handler Dr. Mrak Dr. Hatch Mr. Gordon
Analytical Methods and Instrumentation	Dr. Chambers (Chairman) Dr. Goldblith Dr. Merrill Mr. Metzler Dr. Morgan
Air Pollution	Dr. Merrill (Chairman) Dr. Dambach
Environmental Engineering	Dr. Logan (Chairman) Dr. Silverman Dr. Ahlberg
Milk and Food	Dr. Dack (Cochairman) Dr. Goldblith (Chairman) Dr. Mrak Dr. Weckel
Occupational Health	Dr. Hatch (Chairman) Dr. DuBois Dr. Handler
Radiological Health	Dr. Morgan (Chairman) Dr. G. Anderson
Water Supply and Pollution Control	Mr. Metzler (Chairman) Dr. Chambers Mr. Gordon Dr. Dambach

C. CONSULTANTS TO SUBCOMMITTEES

APPLIED MATHEMATICS AND STATISTICS

Dr. Frank Murray: Professor of Mathematics, Mathematics Department, Duke University, Durham, N.C.

Dr. Thomas F. Mancuso: Chief, Division of Industrial Hygiene, Ohio State Health Department, Columbus, Ohio.

Dr. A. G. Oettinger: Computation Laboratory, Harvard University, Cambridge, Mass.

Dr. Wilfrid Joseph Dixon: Professor of Preventive Medicine, University of California Medical Center, Los Angeles 44, Calif.

Dr. Frank Corbato: Deputy Director, Computer Department, Massachusetts Institute of Technology, Cambridge, Mass.

ANALYTICAL METHODS AND INSTRUMENTATION

Dr. Arnold Beckman: President, Beckman Instrument Co., Fullerton, Calif.

AIR POLLUTION

Dr. Eugene Gillis: Health Commissioner, Philadelphia Department of Public Health, Philadelphia, Pa.

Mr. S. Smith Griswold: Air Pollution Control Officer, Los Angeles County Air Pollution Control District.

Dr. Glenn R. Hilst: Vice President, Travelers Research Center, Inc.

Dr. H. F. Johnstone: Research Professor of Chemical Engineering, Department of Chemistry and Chemical Engineering, University of Illinois.

Dr. Robert A. Kehoe: Professor of Industrial Medicine, Kettering Laboratory, University of Cincinnati.

Dr. John T. Middleton: Chairman, Department of Plant Pathology, University of California.

Dr. Norton Nelson: Director, Institute of Industrial Medicine, New York University.

Mr. Alexander Rihm, Jr.: Executive Director, Air Pollution Control Board, New York State Department of Health.

Dr. Waldo L. Treuting: School of Public Health, University of Pittsburgh.

ENVIRONMENTAL ENGINEERING

Mr. Samuel Baxter: Commissioner and Chief Engineer, Philadelphia Water Department, Philadelphia, Pa.

Mr. Erick Mood: Director Bureau of Environmental Sanitation, New Haven Health Department, New Haven, Conn.

Mr. Paul Opperman: Executive Director, Northeast Illinois Metropolitan Area Planning Commission, Chicago, Ill.

Mr. Paul W. Purdom: Director, Division of Environmental Health, Department of Public Health, Philadelphia, Pa.

Mr. William A. Xanten: Superintendent, Division of Sanitation, District of Columbia Government, Washington, D.C.

OCCUPATIONAL HEALTH

Dr. Clyde Berry: University of Iowa.

Dr. Earl Irvin: Medical Director, Ford Motor Co.

RADIOLOGICAL HEALTH

Dr. Charles L. Dunham: Director, Division of Biology and Medicine, U.S. Atomic Energy Commission, Washington, D.C.

Dr. Donald R. Chadwick: Secretary, Federal Radiation Council Washington, D.C.

WATER SUPPLY AND POLLUTION CONTROL

Dr. Lewis Koenig: Physical Chemist Consultant, San Antonio, Tex.

D. PUBLIC HEALTH SERVICE ORGANIZATION FOR ENVIRONMENTAL HEALTH

The Environmental Health activities of the Public Health Service are carried on principally through its Bureau of State Services. This Bureau is responsible for two main types of activities: (1) Community health services, having to do with the provision of health services for the individual in a community; (2) environmental health. The environmental health activities are in turn carried out in five divisions:

1. Water Supply and Pollution Control
2. Environmental Engineering and Food Protection
3. Air Pollution
4. Occupational Health
5. Radiological Health

E. PRESIDENT'S SCIENCE ADVISORY COMMITTEE AD HOC PANEL ON ENVIRONMENTAL HEALTH

An Ad Hoc Panel was convened on May 18, 1961, to consider the Department of Health, Education, and Welfare proposal for an Environmental Center at Rockville, Md. Members of the panel attending were:

Dr. Colin MacLeod, Chairman
Dr. Rolfe Eliassen
Dr. George Kistiakowsky
Dr. Robert Loeb
Dr. Gerald McDonnel
Dr. Russell Morgan
Dr. Dickinson Richards
Dr. James H. Sterner
Dr. James Whittenberger
Dr. Abel Wolman
Dr. Herbert Bosch

The Panel heard briefings by representatives of Health, Education, and Welfare on the scientific aspects of the proposed Center program, the personnel requirements and a general discussion of the overall program plans, including budget estimates for grants, contracts, and fellowships for the next 5 years. Bureau of Budget representatives discussed long-range significance of the proposed Center.

The Panel identified what appeared to be the major issues and discussed each of the following:

1. *Does the Public Health Service require a new center for administrative and research activities in environmental health?*

The consensus was that such a center is necessary, not only to house its present activities, but also for future development. There was agreement that activities at the Taft Center and associated laboratories in Cincinnati plus those required by the rapid expansion proposed for the next 5 years, cannot be accommodated without extensive additional construction. For a variety of reasons, Cincinnati is not considered a suitable location for expanded facilities. These include inadequate land area at the present sites, difficulty in attracting scientific and technical personnel, lack of strong academic institutions in the area and physical separation from administrative branches of the PHS and other departments of Government such as Interior, Agriculture, and Commerce.

2. *Should the new environmental health center be located in the Washington area?*

The Panel endorsed the plan to locate the regulatory, technical assistance, and administrative functions of the program in the Washington area, but had reservations as to the requirement for housing the major Government research facilities of all phases of the proposed program in a single Center.

The Washington Area has clear-cut advantages because of proximity to administrative branches of PHS, the research activities of the NIH, and the related programs of other departments of the Federal Government. Further, it can be argued that administrative, control, and enforcement activities will benefit from close proximity to laboratories conducting research on the technical problems. At the same time, it is recognized that decentralization has been successful in the cases of the Communicable Disease Center in Atlanta and the various laboratories of the Atomic Energy Commission. The Panel was not aware of a study to determine the feasibility of establishing decentralized Federal Research Units either at existing Government laboratories or in association with universities. See paragraph 4 below.

3. *What is a reasonable rate of growth for the proposed center program?*

It is clearly apparent that the chief problem in developing sound scientific as well as control programs is the availability of competent people in the various fields of science who can contribute to the solution of problems of environmental health.

The Surgeon General's Report to the Congress in 1960 and the testimony of experts before the Appropriations Subcommittee of the House in March 1960 emphasized the critical shortage of persons qualified for research on problems of environmental health. In recognition of this need the PHS established research training grants and "project" grants in the fields of radiological health, industrial hygiene, etc. These grants have had the immediate effect of increasing competition among universities for competent faculty members as well as for the few promising students entering the environmental health field. Undoubtedly, in the long run, these grants will enable universities to train more highly qualified people, particularly when the importance and the attractions of the field of environmental health become better recognized. In the meanwhile, the best interests of the program will be served by restricting expansion to limits set by the availability of highly qualified people.

One of the difficulties besetting environmental health research is the requirement of participation by many disciplines, including not only medical scientists and engineers, but also a long list including chemists, physicists, ecologists, and many others. Past experience has shown that, on the average, the less able graduates in the various disciplines have been attracted to the environmental health field. After entering the field, they may suffer by isolation from the main streams of advance in the parent discipline. This factor is also relevant to a decision about the wisdom of centralizing Federal research in a single facility in Washington, since there are no strong academic institutions in the community, with interests in environmental health.

For these reasons, the Panel believes that Government research facilities should be developed on a selective basis to satisfy specific needs. The proposed broad expansion appears too rapid for the supply of qualified manpower. Implicit in this consideration is the necessity for a clear delineation by the PHS of the substantive nature of the research program to be carried out in the proposed Center. The Panel is of the opinion that the program has not been given adequate consideration and that this is a fundamental requirement for sound planning for the Center.

4. *Need for evaluation of existing governmental laboratories that can contribute to studies of environmental health.*

Program planning of new facilities for the five major areas of research proposed for the Center should include an evaluation of existing Government laboratories with demonstrated competence in closely related scientific areas. For example, in the field of radiological health, the Panel noted the potential availability of the several AEC National Laboratories for the conduct of large scale radiobiological and chronic toxicity experiments. The PHS does require laboratories for epidemiologic research on human populations, since this area of public health concern is not adequately provided for by other agencies.

Whether or not an expanded central laboratory is established in the PHS, some leaders in the environmental health field believe strongly that there should be regional laboratories, based in or very closely associated with universities having interest and competence in one or more of the fields of environmental health. Three considerations lead to this conviction:

a. The critical shortage of research personnel creates the need to take advantage of the leadership and training potential of university departments which have competence in environmental health. One of the recognized limitations of Government research laboratories is that they contribute very little as research training institutions, in contrast with universities.

b. Environmental health problems are often of greater regional interest than national concern, for example, air pollution in California and water pollution in the Ohio River basin. Such regional challenges increase the likelihood of attracting able research workers, especially if a university is involved. The Public Health Service has taken advantage of some opportunities of this kind, but could do so in more effective fashion.

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c. The field of environmental health is very broad and engages the attention of many disciplines. A university-centered laboratory would enable research workers to maintain close contact with other workers in their own discipline. Continuing contact with the parent discipline promotes research skills of the individual and also increases the possibilities of fruitful interchange between basic and applied research.

RECOMMENDATIONS

1. The Panel recognizes and endorses the position of the Public Health Service that there is an urgent need for expanded activities in research and control measures related to environmental health and concurs that a Center in the Washington Area to house administrative support and certain research activities will facilitate development of the field.

2. The proposed program expansion (to the level of $300 million per year in 5 years) is rapid. The Panel is acutely aware of the severe shortage of well-qualified scientists in the field, and for this reason recommends that major emphasis for the immediate future be given to the development in the universities of scientific personnel. The expansion of the proposed central facility should be related to availability of personnel for the needs of the Federal Government as well as those of communities and universities throughout the country.

3. The research program of the proposed center requires much more careful delineation and projection. Except in the case of ongoing programs to be transferred from facilities such as the Taft Center, the Panel did not feel that enough effort had been directed to identification of major problems and drafting of the blueprints of specific research to be undertaken.

4. In consonance with recommendations of other committees, it is recommended that strong, university-based centers be set up not only for research and education, but also to help in the solution of local environmental health problems. The present and proposed "regional laboratories" which are in essence "field stations" do not fulfill this requirement.

5. The potential of other Federal laboratories to assist in the solution of problems of environmental health requires serious exploration. This does not appear to have been done with the thoroughness and imagination that the potentialities merit. For example, the superb facilities at the Brookhaven and Oak Ridge National Laboratories have not been considered in the field of radiological health.

F. EXECUTIVE OFFICE OF THE PRESIDENT

BUREAU OF THE BUDGET,
Washington 25, D.C., July 5, 1961.

MY DEAR MR. SECRETARY: On June 14, the President sent to the Congress an amendment to the 1962 budget in the amount of $3,515,000 for site acquisition and detailed planning for the proposed Environmental Health Center. The discussion which preceded this action, in which you, members of your staff, the President's Science Adviser and staff of the Office of the President participated, produced a number of understandings which I would like to confirm in this letter.

1. The funds for detailed planning included in the budget amendment will be reserved pending a further study and review of environmental health research programs and facility needs. As a part of the review, a Departmental task group will prepare long-range research objectives in each program area and recommendations on the appropriate Federal programs to accomplish those objectives. The task group will give special attention to (*a*) research manpower requirements, both Federal and non-Federal, and necessary training and other programs to meet those requirements, (*b*) the appropriate emphasis between intramural Federal research efforts and extramural efforts, and Federal programs, both as to personnel and facilities, needed to carry both efforts forward, and (*c*) the current research activities and facility resources of other Federal agencies and appropriate interrelationships and coordination, including the possible sharing of research facilities. The review will be concluded by December 1, with a target date of November 1 for completion of work by the Department's task group. The plans and conclusions developed in this review will produce a determination of facility requirements for the various environmental health programs which will permit detailed planning for the new facilities to proceed. Enclosed is a more complete outline of the steps involved in this review.

2. Acquisition of about 690 acres for the main population center at the facility and special radiation research facilities will proceed as soon as funds become available, with the understanding that no commitment is involved as to the type or extent of the latter facilities. The decision to seek funds for 690 acres in the absence of an approved facility plan was based in large part upon a general belief that land acquisition requests should take into account the full range of possible future needs. Should the needs in this case fail to materialize, the excess acreage can either be retained as a general Federal acreage reserve for future development or can be returned to private ownership.

3. Procurement of land for special open area facilities for such purposes as an animal farm is postponed indefinitely pending further development of research program and facility needs. If needed at a later date, it is understood that acreage for these general purposes would be sought at a separate location in an area not planned for high density development.

4. The Department will continue to work closely with the National Capital Planning Commission, both with respect to the specific acreage to be acquired and with respect to the size and location of structures, utilities, and facilities to be constructed.

Sincerely yours,

(Signed) ELMER B. STAATS,
Deputy Director.

The Honorable SECRETARY OF HEALTH, EDUCATION, AND WELFARE.

Enclosure.

General Outline for Review of Environmental Health Research Programs and New Facility Needs

1. A departmental task group will be formed to undertake the necessary review in each of the five program areas. The task group will include, in addition to departmental officials, appropriate outside consultants, and possibly representatives from other interested Federal agencies. Consultants will be selected in consultation with the President's Science Adviser. The task group is to prepare long-range research objectives in each program area and recommendations on the appropriate Federal programs to accomplish those objectives. Special attention will be directed to (*a*) research manpower requirements, both Federal and non-Federal, and necessary training and other programs to meet those requirements, (*b*) the appropriate emphasis between inhouse Federal research efforts and extramural efforts, and Federal programs, both as to personnel and facilities, needed to carry both efforts forward, and (*c*) the current research activities and facility resources of other Federal agencies and appropriate interrelationships, coordination, and possible sharing of research facilities.

2. The Bureau of the Budget and the Office of the Science Adviser, with agency representatives, will broaden and intensify its current review of the relative biomedical research responsibilities and activities of the Atomic Energy Commission and the Department of Health, Education, and Welfare in the radiation field in order to formulate an effective delineation of responsibility for major research areas between the two agencies. Such study will give specific attention to future utilization of existing research facilities as between the two agencies.

3. Following completion of steps 1 and 2, the Executive Office will undertake, through the facilities of the Science Adviser's Office and the Budget Bureau, to obtain the views of other interested Federal agencies with respect to the proposed research programs and related facility needs.

4. The ad hoc panel of scientists convened on May 18 by the Science Adviser to review the Public Health Service research plans and facility proposals will be recalled for an overall review of the plans and conclusions stemming from the foregoing.

5. Step 1, above, will be completed by November 1 and entire review will be completed by December 1.

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