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Research and Development

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Long-Range Research Agenda for the Period 1988-1992

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Contents

EXECUTIVE SUMMARY

The mission of the Agency is to administer, in a comprehensive and balanced manner, specific federal legislation developed to control and abate adverse impacts of pollution on the human environment. To support the Agency in a cost-effective manner, a research program is required which addresses both fundamental information needs common to all the operating program offices and those relating to program-specific issues. Each program office needs (1) reliable estimates of the risk of adverse impacts to the public health and the environment associated with any policy action, (2) reliable estimates of cost-effective risk reduction options, and (3) reliable measurement methods for the indicators used to assess the state of the environment for the pollutants specified by the legislation being administered. The Office of Research and Development (ORD) plans to continue to provide a strong cross media multidisciplinary research program that enables the office to respond to both the specific programmatic applied research and technical assistance needs of the Agency and to anticipate future scientific information requirements. The core program which has general utility to all program offices is based on a framework that comprises four broad areas of research. They are:

1. human health risk methods development and application,
2. ecological risk methods development and application,
3. total exposure methods development and applications, and,
4. risk reduction/control technology.

Research activities in the major category of human health risk assessment will focus on assessment methods for non-cancer endpoints, improvement in techniques for using data from animal studies for estimating risks to humans, development of statistical models to characterize dose-response relationships and associated uncertainties, and determination of utility and limitations of structural activity relationships for estimating the potential toxicity of untested chemicals.

For the major category of ecological risk assessment, emphasis will be placed on research activities that contribute to improved prediction of impacts on ecosystem function and structure, on techniques for assessing effects from complex mixtures and on characterizing uncertainties in risk estimates.

In the major area of total exposure methods development, emphasis will be directed toward developing techniques for determining frequency distributions of population exposures to toxic chemicals. Biological indicators of exposure and effect in human and other ecosystem populations will be emphasized through the use of pharmacokinetic and metabolic information.

In the area of risk reduction/control technology, emphasis will be placed upon improving transport, transformation, and fate models as well as upon working with industry to explore alternative treatment technologies such as biodegradation, advanced separation processes, advanced thermal degradation, and waste stabilization techniques.

The media-specific research to be emphasized during the next five years is as follows:

Air/Radiation

For the air program, emphasis for the period is directed toward evaluating the potential hazards posed by unregulated air pollutants. Specifically, sources will be characterized, the chronic impacts of real time exposures (complex mixtures, exposure rates) will be evaluated, and control methods will be developed In addition, attention will be given to the following areas of concern: (1) incineration of municipal wastes, (2) impacts of global climate, (3) ozone damage to forests, (4) impacts of air pollutants on susceptible populations, (5) the contribution of indoor air exposures to total human exposures, and (6) stratospheric ozone depletion.

Water

Most of the water research issues are expected to continue into the next decade. Research activities which support evaluation of risks to humans and ecological systems resulting from exposures to specific chemicals, complex mixtures, and biological agents in water (drinking, surface, ground, estuarine, marine) will continue to be required for the development of drinking water standards, health advisories, and toxicity based National Pollutant Discharge Elimination System (NPDES) permits. A new effort will be initiated to develop methods to safeguard the ground-water resources of wellhead protection areas. Improvements in analytical capability to identify potential deleterious contaminants and bioassay development for toxicity based water quality permitting will be continued. In the area of alternative treatment technologies, biological degradation of toxics in wastewater through the use of engineered

organisms (biotechnology) and process modifications will be emphasized.

Pesticides/Toxics

For these media areas, current and future research needs include (1) improved capabilities to monitor human exposure and risk assessment, (2) ecological risk assessment methods development and application and (3) methods to detect and assess ground-water contamination by pesticides. Improving human health risk assessment will be emphasized, including research on noncarcinogenic health endpoints, biological markers as indicators of exposure and effects, and risk assessment transformation methods for both dose-rate effects and non-human species responses. Continued evaluation of structure activity relationships (SARs) for improved assessment of risk to humans and to ecosystems is planned, as is the evaluation of potential adverse impacts of microbial agents and products of biotechnology

Hazardous Waste/Superfund

Specific research is planned for characterizing the potential exposure of populations to hazardous wastes and the deleterious effects of exposures to complex mixtures. Such research includes increased efforts in multimedia monitoring, transport and fate of hazardous wastes in groundwater, identification of potential toxic emissions from municipal combustors, and development of improved measurement techniques for problem diagnoses (e.g., exposure detection). Development of alternatives to land disposal is also of high priority.

Multimedia/Energy

The recommendations of the interagency National Acid Precipitation Assessment Program form the basis of the research activities to be emphasized in this area. The long-term goals of the acid deposition program are to develop the following products:

- inventories and maps of receptors that have been or may be adversely impacted,
- estimates of the rate of change in the extent of effects,
- acid deposition dosimetry for specific regions and receptors, and
- source-receptor models for local and long-range situations. Long-term monitoring of lakes, streams, mountain top clouds, forest exposures, and watersheds.

Interdisciplinary

The interdisciplinary research program will continue to provide for the development of risk assessment guidelines, for supporting the dissemination of scientific and technical data from ORD, for exploratory research grants and centers programs and for support of the central management of an Agencywide quality assurance program.

I. INTRODUCTION

Congressional Request[1,2]

The Long-Range Research Agenda is prepared in response to the Congressional requirement that the U.S. Environmental Protection Agency (EPA) submit an annual revision of a comprehensive five-year plan for environmental research, development and demonstration not later than two weeks after the President submits his annual budget to the Congress. The annual revision is required to convey the plans for no growth, moderate growth, and high growth budget projections and should include an explanation of the relationship to existing laws which authorize the environmental research, development, and demonstration. The budget projections contained herein assume a 3% increase for the moderate growth scenario and a 6% increase for the high growth scenario. The budget projections are subject to change associated with new Agency priorities and the availability of funds

Office of Research and Development (ORD) Mission and Obligations

ORD is obliged to develop and implement an integrated program which supports the mission of the Agency. That mission is to administer, in a comprehensive and balanced manner, specific Federal legislation developed to control and abate adverse impacts of pollution on the human environment.[3,4]

Agency management, therefore, requires quality information on a timely basis for decisions relating to risk assessment and to risk management of known and anticipated environmental pollution issues. Agency management must make decisions regarding development of policy, guidance, standards and regulations; monitoring programs (surveillance and compliance assessment); environmental impact analyses; quality assurance and quality control; grant applications and training

In view of the diverse products and services required from ORD in support of Agency decision making (research, problem diagnosis, technical support documents, risk assessments, expert witness consultation, quality assurance management, etc.), ORD staff is required to maintain an awareness of environmental research being performed by other governmental agencies (federal, state, and local), industry, academia, and the public interest sector. The

information needs of the decision makers are critically evaluated in terms of the information available or forthcoming from all the aforementioned sources. See Appendix A for a listing of interagency coordination.

The research emphasized in EPA/ORD is in those areas specified in the Congressional appropriation and on subjects considered by the Agency-wide research committees as not receiving sufficient emphasis to provide the information required for Agency decision making.

To support the Agency cost effectively, a research program is required which addresses both fundamental needs common to all of the operating program offices and program-specific issues. Common needs include (1) reliable estimates of the risk of adverse impact to public health and the environment associated with any policy action, (2) reliable estimates of cost-effective risk reduction options, (3) reliable measurement methods for the environmental indicators used to specify the state of the environment.

These primary needs drive a continuing core research program consisting of:

1. human health risk methods development and application,
2. ecological risk methods development and application,
3. total exposure methods development and application, and
4. risk reduction research.

Research activities in the major category of human health risk assessment will focus on methods assessment for non-cancer endpoints, improvement in techniques for using data from epidemiological, clinical, and animal studies for estimating risks to humans, development of statistical models to characterize dose-response relationships and associated uncertainties, and determination of utility and limitations of structural activity relationships for estimating the potential toxicity of untested chemicals.

For the major category of ecological risk assessment, emphasis will be placed on research activities that contribute to improved prediction of impacts on ecosystem function and structure, on techniques for assessing effects from complex mixtures, and on characterizing uncertainties with risk estimates.

In the major area of total exposure methods development, emphasis will be directed to techniques for determining frequency distributions of population exposures to toxic chemicals. Biological indicators of exposure and effect in human and ecological populations will be emphasized through the use of pharmacokinetic and metabolic information.

In the area of risk reduction/control technology, emphasis will be placed upon developing transport, transformation, and fate models as well as working with industry to explore alternative treatment technologies such as biodegradation, advanced separation processes, advanced thermal degradation and waste stabilization techniques.

ORD Planning Process

Integrated planning, quality assurance programs, and peer review are all fundamental to assuring that ORD fulfills its obligations. Integrated planning of the ORD program is accomplished through the use of agency-wide research committees. The research committees are structured primarily along regulatory program office lines (air/radiation, water, pesticides/toxics, hazardous waste/superfund, multimedia/energy and interdisciplinary). Membership is comprised of senior level representatives from the regulatory offices, the lead regions and the ORD laboratories. Each committee is co-chaired by a senior manager from ORD and from the appropriate program office and each office director in ORD is represented on all committees. Each committee is responsible for ascertaining the priority research and development issues of concern to the subject program office and for recommending a comprehensive, media-oriented research plan (objectives, priorities, outputs, schedules, and resource allocations) to the Assistant Administrator (AA)/ORD.

The ORD program must be flexible enough to respond to changes in Agency priorities while still providing sufficient stability to the research undertaken to obtain the quality technical information required to support Agency decision making. Flexibility is accommodated by reprogramming in the operating year. Priorities for reprogramming are established through discussions involving the Congress, Agency management, and ORD management.

Since the ORD office directors and their respective laboratory directors are responsible for implementing the program and for obtaining peer reviews of their respective programs on a regular basis, they provide recommendations to the AA/ORD concerning the program as viewed from an integrated disciplinary perspective. Based upon these inputs and his interactions with the program office Assistant Administrators, the AA/ORD recommends an overall integrated program for ORD to the Administrator, which is considered to be an appropriate balance between top down and bottom up planning as recommended by the National Academy of Science.[5]

Plan Perspectives

A variety of alternative primary frameworks can be utilized to categorize the ORD program. Examples of the suggested perspectives for categorization of the total ORD program include legislative, regulatory program office, research discipline, source, pollutant, and effects. Unfortunately, no single focus is ever fully satisfactory to the variety of groups interested in the ORD program, especially in the case of ORD special interest cross media, multidisciplinary studies. Since the Congressional request requires an indication of the relationship of the plans to existing laws authorizing the Agency's environmental research, development, and demonstration program, the total program is presented primarily from the research committee perspective, which is equivalent to the regulatory office perspective. Cross media, multidisciplinary problems receiving special emphasis at present, and for the foreseeable future, include the following, and the cooperating research committees contributing to resolution of these problems are included parenthetically:

1. Ground Water (water, hazardous waste/superfund, pesticides/toxic substances).
2. Total exposure assessment measurement (air, water, hazardous waste/superfund, pesticides/toxic substances).
3. Municipal waste combustion (air, hazardous waste/superfund).
4. Accidental releases (air, water, hazardous waste/superfund).
5. Indoor radon (air, water).
6. Comparative risk for complex mixtures (air, water, hazardous waste/superfund, pesticides/toxic substances).
7. Acid deposition (air, water, energy).
8. Biotechnology (air, water, pesticides/toxic substances).

A letter commenting on the review of the ORD program by the Agency Science Advisory Board (SAB) is presented in Appendix B.

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[1] Public Law 94-475, Section 5, 10/1/76 (authorization bill)

[2] Public Law 95- 155, Section 4, 11/8/77 (authorization bill).

[3] National Environmental Policy Act, 1969.

[4] Presidential Reorganization Plan #3 of 1970.

[5] Analytical Studies for the U.S. Environmental Protection Agency, Volume III, Research and Development in the Environmental Protection Agency, Commission on Natural Resources, National Research Council, National Academy of Science, 1977.

II. RESEARCH COMMITTEE (LEGISLATIVE) PERSPECTIVES

Each of the media-specific research programs contains elements of activity which are related to the aforementioned core research program. The media specific issues and associated research planned to resolve these issues is described in the following paragraphs.

Air/Radiation

Under the Clean Air Act (CAA), EPA is responsible for setting ambient air quality standards for air pollutants emitted from both stationary and mobile sources. National Ambient Air Quality Standards (NAAQS) have been set for six "criteria" pollutants: ozone (O_3); carbon monoxide (CO); particulate matter (PM); sulfur dioxide (SO_2); nitrogen dioxide (NO_2]; and lead (Pb) These standards must be reviewed every five years and revised if necessary Compliance with these standards is the responsibility of each state through the development and implementation of State Implementation Plans (SIPs) which limit emissions from sources, set time tables for compliance and establish monitoring procedures. The Agency is also responsible for setting technology-based New Source Performance Standards (NSPS) to limit air pollutant emissions from new sources or from existing sources which have been modified. In areas where the air quality is better than that required to meet primary and secondary standards, emissions from new or modified sources are restricted under the Prevention of Significant Deterioration (PSD) program In addition, EPA is responsible for limiting emissions of air pollutants that are hazardous to human health but are not already regulated as criteria pollutants.

ORD provides the scientific data bases, methods, models, assessments, emission reduction technologies and corresponding quality assurance support to implement these legislative authorities. Five major issues have been identified within the scope of the air research program which cut across scientific disciplines and the pollutant-specific structure of the research program. In addition, EPA conducts a radiation monitoring and quality assurance program and a program to mitigate and prevent radon in homes.

EPA has identified several topics within the air research program which will require special attention in the coming years. Among these are indoor air pollution, radon, support for the ozone attainment program, toxic air pollutants,

stratospheric ozone, and global climate modification. In addition, attention is being turned to the problems of municipal waste incineration, accidental releases of toxic pollutants, unregulated pollutants in urban air, and the effects of ozone on forests. It is these issues which will be emphasized during the next five years of air pollution research.

Major Research Issues

Criteria Pollutants

What scientific support is necessary to develop and review primary and secondary NAAQS?

Health Effects: For each of the criteria air pollutants, many of the sensitive population groups and the pollutant exposure ranges of interest have generally been identified. However, health effects testing of these pollutants must continue in both animal and human subjects to ascertain dose-response relationships. The health endpoints of concern are mainly respiratory, metabolic, and immune system effects of O_3, NO_2, SO_2 and particulate matter; and the cardiovascular and neurologic effects of CO. In addition, research may be done on the health effects of very short exposure to high levels of particles and SO_2 This research would support reevaluation of emergency level standards, particularly as they apply to sources which emit occasional bursts of pollutants for extremely short periods of time. Emphasis will also be placed on evaluating the effects of long-term, low-level versus short-term, higher-peak exposures to oxidants, particularly NO_2, and the effects of both long-term and short-term exposures to the coarse fraction of airborne particles smaller than 10 microns in diameter. The information obtained from this research will be factored into the next round of criteria documents and used in the review of NAAQS.

To improve our ability to relate animal data to actual human consequences and to develop more reliable risk estimates of exposure to air pollutants, techniques will be developed to extrapolate from animal to human effects, from high to low doses and from acute to chronic effects. To do this, information in three critical areas will be considered: dosimetry--the amount of pollutant which reaches specific target sites in the body after exposure to a given concentration of pollutant; species sensitivity--the potential variations in response of different animal species to the same dose of pollutant; and dose/response.

Human volunteers are being exposed to criteria pollutants for brief periods of time at concentrations similar to those encountered in daily life, in order to measure the resulting effects on heart and lung function, immune response, and other physiological and biological parameters. Similar

studies are being conducted with animals. Animals are also being exposed chronically to these pollutants and the cumulative lifetime effect of these exposures will be determined. This dose-response data, combined with dosimetry and species-sensitivity information, provides the information necessary to infer the effects that chronic exposure to a given pollutant may have on humans.

Epidemiological research provides the most direct evidence of human health effects from environmental exposures to pollutants. Epidemiology studies are being done to ascertain the health effects of total exposures (indoor and outdoor) to the criteria air pollutants.

Welfare Effects: To assess the need for secondary air quality standards for criteria pollutants, research is needed on the impact of air pollution on vegetation and visibility degradation. Recent research on the effect of O_3 on crops indicates that physiological stress such as from soil moisture deficits or fluctuations of O_3 levels in conjunction with other conditions may seriously affect crop plant response. Field work under way to quantify and reduce these uncertainties will continue at several sites. Soil moisture stress modeling and ozone exposure research on forages, a major area of uncertainty, will continue.

In addition to the crop response work, a research program to determine the extent of harm done to forests by ozone is being undertaken. For regulatory purposes EPA needs to quantify O_3 effects on forests to: determine what types of forests are affected and to establish their relative sensitivity; to define dose-response relationships which allow estimates of benefits from reduced O_3 exposure; and, for translation into air quality standards.

Atmospheric Processes: Research will be conducted to determine the extent of visibility impairment. Specifically, the role of aerosols on visibility reduction will be assessed; visibility trends for the U.S. will be determined using available data bases; and measurement and monitoring techniques will be developed to characterize more completely the extent of visibility changes. A regional visibility research network will be established to provide data for analyzing source-receptor relationships, and models will be developed to assess visibility protection strategies. Research is also needed to assess the influence of particle size and composition on soiling, and to aid in the development of a risk assessment.

Monitoring: New and improved monitoring methods are needed to identify areas where public health and welfare are threatened and to establish air quality trends. In addition, accurate, reliable monitoring methods are necessary to determine compliance with standards and to evaluate the need for enforcement actions. This will be

carried out through the testing, evaluation, improvement, and standardization of methodology and systems for measuring ambient pollutants. Emphasis will be on non-methane organic compounds and fine particles.

Quality assurance is required to provide a reliable estimate of the precision and accuracy of the data obtained from measurements from sources such as the State and Local Air Monitoring Networks. This is carried out through the use of audits of the laboratories and from the use of standard reference materials which have been prepared, verified and distributed to the user laboratories.

Scientific Assessment: The review and revision of NAAQS is a continuing effort, based upon new and evolving scientific information. ORD contributes to this function by publishing new or revised Air Quality Criteria Documents (AQCDs) which are then used by regulators to revise NAAQS. In the immediate future, revision of the criteria documents for lead and ozone will continue and an addendum to the PM/SO_x criteria document will be initiated. Technical evaluations are being conducted for use by the regulatory office in evaluating the NAAQS for lead, SO_x, O_3 and PM. Literature searches of recently reported data will be initiated to update the data bases for carbon monoxide and NO_2.

Control Technology: Research will be conducted to characterize emission sources and evaluate and improve the cost effectiveness of emission reduction technologies, thereby reducing the cost of complying with SIPs.

Because much is already known about other criteria pollutants, priorities for control technology have shifted to volatile organic compounds (VOCs), to assist in meeting ozone level attainment goals. VOCs, which react with NO_x and sunlight to produce ozone, are a major cause of the ozone non-attainment problem. Although emissions from major stationary sources are being reduced, small sources, such as dry cleaners, gas stations and paint users, are not being widely controlled. Although these sources individually emit small amounts of pollutants, collectively they may constitute a significant problem. Control technologies such as industrial flares, carbon adsorption, catalytic oxidation and thermal incineration will be assessed to determine their performance and cost in reducing VOC emissions from such sources. Emphasis will be placed on developing and evaluating methods to control VOCs without resorting to costly add-on control devices.

Improved control technology is also needed for sulfur and nitrogen oxides. For SO_x, further research will be done on conventional spray drying for utility and industrial boilers. Also, comparative assessments are needed for various absorbents to reduce the cost of spray drying flue gas

desulfurization (FGD). The role of dry injection techniques in FGD systems will also be investigated. Research to control NO_x will focus on evaluating the applicability of combustion modification techniques to industries. Needed research on reburning and changes in precombuster burner designs will continue.

Research to control particles focuses on improving the performance, reliability and cost-effectiveness of the multi-stage electrostatic precipitator (ESP) and fabric filtration. The major purpose of this research is to improve collection of small particles which have become increasingly important in meeting particle standards. ESPs may assist in acid rain mitigation when used with dry add-on SO_2 removal processes. Precipitators are also appropriate when facilities switch to low-sulfur coals, with their more difficult-to-collect fly ashes Another particle control measure which shows promise is electrostatically augmented fabric filtration (EAFF) Also, recent research indicates that proper conditioning of the particulate matter can reduce pressure drop significantly, resulting in fabric filters one-third the size of conventional units Additional research to verify this finding is necessary and has begun.

Atmospheric Processes: Pollutants emitted into the air often undergo chemical reactions that change the initial pollutants into different compounds. Models to predict this phenomenon are being developed at the urban and regional scale and for complex terrains, such as mountainous areas These models, when fully developed, will provide information necessary to develop, evaluate and implement cost-effective air pollution control strategies for SIPs and PSD determinations.

Over the last few years, a variety of air quality models have been developed and evaluations of these models indicate that they need to be improved to increase the accuracy and reliability of modeling predictions. To improve urban scale models, smog-chamber studies will be conducted to obtain a better understanding of the atmospheric chemical processes associated with the formulation of oxidants and inhalable particulate matter. Emphasis will be placed on the impact of lower hydrocarbon/NO_x ratios and the role of specific categories of VOCs such as aromatic hydrocarbons and aldehydes in producing atmospheric ozone and other oxidants. Source apportionment modeling techniques will be developed and evaluated for both non-volatile and volatile organics.

In order to make dispersion and mathematical models available to the regulatory and research community, the User Network for Applied Modeling of Air Pollution (UNAMAP) will be updated to include state-of-the-art models.

On the regional scale (up to 1,000 km), laboratory and field studies will be conducted to improve the ability of models to predict the atmospheric transport, transformation and deposition processes for air pollutants such as ozone and particulate matter. Alternative mathematical techniques and new meteorological tracers will also be evaluated to determine their ability to improve modeling predictions. The regional scale models will be adopted to predict both episodic (hours, days) and longer term (months, seasons) time periods.

Monitoring: Research will be conducted to provide improved, standardized methods for stationary source monitoring. An important goal is to increase the precision and accuracy of these monitoring systems. This will be carried out through the use of audits and quality assurance assistance for state, local, or Federal laboratories making measurements of NO_x, organic precursors, SO_2, sulfate, particulates or lead. Reference materials and guideline documents need be and will be provided to carry out the requirements of the CAA. Quality control standards will be prepared, verified, and distributed to such laboratories.

Remote monitoring systems are being developed, evaluated and applied for use in areas where data are needed for SIP evaluation or revisions and for Agency evaluation of the need for new standards

Hazardous Air Pollutants (HAPs)

What scientific support is needed for regulatory decisions about potentially hazardous air pollutants?

Monitoring: Few monitoring methods are available for measuring the concentration of potentially hazardous air pollutants, especially organic compounds; therefore, new sampling and analytical systems and a set of validated source-sampling methods will be developed for important sources of hazardous air pollutants that currently cannot be monitored with adequate precision and accuracy Research to develop methods of monitoring ambient hazardous air pollutant concentrations will be accelerated, as will work on passive monitors and new sorbents. This will extend the measurement capability to chemicals not collected by current methods and to new monitoring situations such as exposures near hazardous waste sites. The nationwide Toxic Air Monitoring System (TAMS) will be continued, to characterize urban atmospheres and determine the magnitude and extent of the hazardous air pollution problem. In addition, TAMS will support the "urban soup" program, which is a multidisciplinary effort to characterize and assess risks in a complex mixture of pollutants in urban areas. The previous Total Exposure Assessment Methodology (TEAM) studies will be evaluated and several focused TEAM exposure studies will be undertaken to

better document and define the human exposures to HAPs and the sources of these exposures. The TEAM methodology will be extended to other pollutants and other areas of the country to determine the relationship of exposures to geographical factors.

Health Effects: In general, the strategy for investigating the health effects of toxic air pollutants must be quite different from that employed in the study of criteria pollutants. First, because of the potential hazards of these pollutants, clinical studies of exposed human volunteers cannot be conducted; however, epidemiological studies may be feasible. Direct animal-to-man extrapolation is difficult, so it is necessary to develop animal models that use biological indicators of neurotoxic, genetic, reproductive, or developmental effects in humans. Research to develop such models will be undertaken during the next five years.

Control Technology: The highest priority for research in this area is to assess technologies for their ability to reduce toxic emissions from various industrial and combustion sources. A near-term goal is to control emissions from wood-burning stoves, beginning with evaluations of the efficiency and longevity of wood stove catalysts

As part of the long-term strategy to control HAPs, industries which are deemed to be high-priority sources of HAPs will be identified. Such industries include petroleum refining, organic chemical manufacturers, and iron and steel mills. Research will be performed to develop efficient and effective control strategies for such high-priority emitters.

Atmospheric Processes: Consideration of the formation, atmospheric stability, and removal of HAPs is essential in assessing exposure and risk. Of particular concern is the formation in the atmosphere of toxic pollutants from chemical reactions among individually innocuous compounds. On a schedule consistent with the Agency's regulatory calendar, laboratory and field studies will be performed to determine the reaction rates, products, and natural variabilities of HAPs under review Chemistry will be studied in isolated laboratory systems to obtain accurate data on kinetics and mechanics. HAPs will also be investigated in photochemical smog chambers, which provide a better basis for extrapolation to the atmosphere. New studies will be undertaken to determine the extent to which HAPs are formed in the atmosphere from innocuous compounds.

Integrated Air Cancer Program: There is a great deal of uncertainty regarding the relationship between air pollution and human cancer. Determining the extent to which air pollution is responsible for or related to human cancers could have a major impact on EPA's regulatory program Thus, a long-term, interdisciplinary research program has

been developed to address the major scientific questions regarding the relationship between air pollution and the development of human cancer.

The three basic goals of this program are to: (1) identify the principal airborne carcinogens; (2) determine which emission sources are major contributors of carcinogens to ambient air; and (3) improve the estimate of comparative human cancer risk from specific air pollutant emission sources. Field tests of relatively isolated single-source categories are essential for developing methods to evaluate the more typical multiple-source environments to which the general population is exposed. Therefore, a field test is being conducted in Boise, Idaho, an area with a simple airshed and a severe wood smoke problem during the winter months. The study focuses on quantifying carcinogens emitted from residential wood-fired combustion systems and motor vehicles. The results of this study will be immediately useful, particularly as surrogates for similar environments, while the study design can be adapted for use in more complex environments.

In the monitoring and modeling component of the project, samples of ambient air in the "breathing zone" of persons in an urban/industrial area and a suburban area are being collected and analyzed for carcinogens and mutagens. Comparisons between the ambient and personal samples and between the urban and suburban concentrations will be made, and relationships between exposure and dose will be studied. The relative importance and contribution of gaseous and volatile organic compounds, semivolatile and particulate organic compounds to total airborne carcinogens will be determined. In addition, laboratory studies will be conducted to determine the atmospheric formation and fate of bioactive compounds.

Health research focuses on development of methods and data gathering to evaluate the human cancer risk from individual and, ultimately, complex source emissions. A comparative methodology to predict risk will be adapted to evaluate and utilize short-term mutagenesis and animal carcinogenesis data on emissions. Research to identify the major sources of hazardous air pollutants and to characterize these emissions from industries and combustion sources of primary concern will serve as the basis of the engineering component of the project.

Scientific Assessment: A three-tiered process is employed in assessing scientific data-bases for substances considered to be HAP listing/regulation candidates. Tier I reports are an initial review of literature on health effects associated with a given chemical or class of chemical substances. If no adverse health effects are found likely to be associated with exposures and the Office of Air and Radiation (OAR) decides not to list the substance as a

HAP, then the Tier I report is published. However, if significant effects appear likely, then a draft Health Assessment Document (HAD) is prepared for review by a scientific workshop (Tier II). The final tier (Tier III) would include public review and comment, SAB review and publication of the HAD. In the coming year, final comprehensive HADs will be completed on four chemicals and External Review Drafts (ERDs) will be prepared for three to six chemicals Tier I screening documents for six to eight chemicals will be completed and another three to six will be initiated. Increased emphasis will be placed on toxic mobile source pollutants and non-cancer endpoints. Technical assistance will be provided to the regions and states on issues related to air toxics. Risk assessment methods will be developed on specific non-cancer health effects. As part of this new effort, techniques for using pharmacokinetic information in risk assessments will be developed. Future emphasis will be on toxic effects rather than on cancer issues, since the majority of the cancer-causing high priority pollutants (list of 25) have been scientifically evaluated and now are entering their regulatory pathways.

Mobile Sources

What scientific support is needed to develop mobile source regulations?

Atmospheric Research: As the driving fleet ages and changes occur in engine design, models to assess the impacts of mobile source emissions on ambient air quality need to be refined and studies must be conducted to evaluate the impact of new emissions Greater emphasis will be placed on evaluating promising alternative fuels, particularly methanol The two primary pollutants of importance from methanol-fueled vehicles are methanol and formaldehyde Analytical procedures to measure methanol and formaldehyde will be developed and emission characterizations performed Research to determine the photochemistry of emissions from methanol-fueled vehicles will also be conducted Emissions from future gasoline-fueled vehicles and diesel-fueled vehicles equipped with advanced control technologies will be characterized. Also, evaporative emissions from motor vehicles will be characterized under a number of simulated driving conditions

Monitoring: Improved exposure-activity pattern models will be developed from exposure data from past field studies. Further refinements of the Simulation of Human Activities and Pollutant Exposures (SHAPE) model will be conducted, and the basic modeling approach will be adapted to additional mobile source air pollutants. Validation of the SHAPE model and other exposure models will

continue using existing human exposure data bases Such tools are required for making adequate estimates of risks from mobile source air pollutants.

Health Effects: Studies of the cardiovascular and neurotoxic effects of CO will continue. A new research effort on the health effects of fuel and fuel additives will begin. The Health Effects Institute is expected to continue its program on CO, NO_2, O_3 and diesel exhaust, and aldehyde research, and new emphasis will be placed on studies to support risk assessment for diesel exhaust and the possible oncogenicity of ozone.

Global and Microenvironmental

What scientific data are needed to determine the impact of the quality of global and micro-environments on public health and the environment?

Stratospheric Modification: By preventing most harmful ultraviolet (UV-B) radiation from reaching the earth's surface, the stratospheric ozone layer serves as an important shield protecting human health and welfare. Evidence is mounting that chlorofluorocarbons (CFCs) can cause depletion of stratospheric ozone if used in sufficient quantities. Several serious consequences are possible, including (1) increases in melanoma and other skin cancers, (2) suppression of the human immune system, (3) decreased productivity of commercial crops and aquatic organisms, and (4) accelerated degradation of polymeric materials. In addition, there has been substantial interest recently in the possible climate change effects brought about by the increase in carbon dioxide and trace gases and the "Greenhouse" effect.

Substantial evidence exists that the composition of the global atmosphere is changing, particularly with respect to carbon dioxide and trace "Greenhouse" gases that impact the energy balance of radiation to and from the earth's surface and atmosphere. There are uncertainties associated with the precise timing, magnitude, and spatial patterns of the atmospheric effects, but there are indications that changes may occur leading to long-term increases in surface temperatures and sea-level elevations, and to shifts in global weather, climate, and hydrology patterns. The research program under development provides for a coordinated effort focusing on ecological effects research, development of control technology, and determinations of the factors influencing the formation, transport, and fate of pollutants affecting global weather.

With regard to UV-B light, research is planned to: (1) evaluate potential future rates of growth in CFC emissions; (2) model changes in the ozone layer which may result from changes in atmospheric composition; (3) analyze

predictive models in light of new atmospheric monitoring data; (4) determine potential health effects, particularly the contribution of increased UV-B radiation to the development of malignant melanoma; and (5) determine the effects of UV-B on crop productivity

In conjunction with other agencies, research will be accelerated on the development, validation and use of global tropospheric/stratospheric chemistry models to predict the impacts of changes in trace gases, temperature and humidity on global climate and the resulting effects on health and welfare. Results will be incorporated into an international strategy for dealing with trace gases which affect climate. Effects of global warming on crops, marine and terrestrial systems, and other biota will be estimated.

Indoor Air: In the 1970's, indoor air pollution began to attract increasing public attention when the Federal Government encouraged energy conservation measures for buildings.

As Congressional interest in indoor air quality began to surface, EPA and other federal agencies were directed to begin exploring the dimensions of the potential indoor air quality problem. As a result, in 1982 and 1983, approximately $500 thousand were appropriated to EPA each year for research on indoor air. For fiscal years 1984, 1985 and 1986, resources totalling approximately $7 million were appropriated for research on indoor air and radon gas mitigation technologies. EPA has coordinated its research on indoor air quality with its federal agency partners on the Integrated Committee on Indoor Air Quality, formed in 1983

In September 1986, EPA's SAB reviewed both ongoing research projects in indoor air quality and the Office of Research and Development's plan to conduct a Research Needs Assessment during the ensuing six months to determine what is currently known about indoor air problems and what critical research still needs to be done. The SAB was positive about the quality of research now underway, and endorsed ORD's plan to conduct a Research Needs Assessment prior to designing and implementing any new research strategy. While the needs assessment is underway, ORD is continuing certain basic efforts uninterrupted as recommended by the SAB These include some methods development, health effects, combustion characterization, and exposure testing activities

NHANES-III: EPA is participating in an interagency consortium that will conduct the next National Health and Nutrition examination Survey (NHANES-III). EPA's chief goal in this endeavor is to obtain national baseline data on a variety of factors that affect pollutant exposures and that influence health outcomes associated with those exposures.

Radiation Research

What technical support is necessary to ensure that the public is adequately protected from exposure to radioactive materials in the environment?

Monitoring: On a continuing basis, EPA supplies comprehensive radiological monitoring and surveillance services to the Department of Energy (DOE) to meet that Agency's nuclear test monitoring requirements, especially at the Nevada Test Site. Other locations at which such support is regularly provided include Mississippi, Colorado, and New Mexico. Advanced monitoring systems are employed, primarily offsite, to measure the amount of radiation escaping the site following test blasts. A report is generated yearly which details the locations monitored and test results. This work is expected to continue at the same level of effort during the next five years.

EPA conducts a radiochemical analytical quality assurance program which supports federal, regional, state, and local laboratories making radioactivity measurements to assess the impact of local nuclear facilities. The purpose of this program is to ensure that scientifically credible data, methodologies, and assessments are used when determining public exposure to radioactive materials. Each year, EPA reports on laboratory radionuclide studies conducted during the previous year. This is a continuing effort and is expected to remain at its current level.

Radon: In support of EPA's Radon Action Plan, ORD will continue developing and demonstrating cost-effective methods of mitigating and preventing radon entry into homes. Publications directed to states, builders, homeowners, and business on protecting against elevated indoor radon levels will be updated, based on the results obtained from additional field demonstrations and other newly available information. Our radon activities will be coordinated with DOE's enhanced radon research program.

Summary of Long-Term Trends

During the past 15 years, much progress has been made in cleaning up the nation's air. Increased use of lead-free gasoline has sharply decreased ambient lead levels and the recent move to speed up the lead phase-down program promises to cut these levels even further. Urban areas are experiencing fewer severe pollution episodes. Catalytic converter use has greatly diminished carbon monoxide and hydrocarbon emissions from automobiles. Although some areas still exceed allowable levels of ozone, most locations across the country are generally in compliance with NAAQS.

Given these trends, priorities are shifting in the air research program. New questions include: What are the hazards posed by unregulated toxic pollutants? What are the sources of these pollutants? Do the complex mixtures of urban air pollutants pose particular dangers? What are the long-term health consequences of continued exposure to low levels of criteria pollutants? What physical and chemical interactions in the atmosphere can create or increase toxic pollutants? What are the actual pollutant exposures encountered by people throughout the day? To what extent do conditions or materials in the home contribute to those exposures? What effect do man-made pollutants have on global climate? Does ozone have a negative effect on commercial species of trees? What can be done to minimize health threats from accidental releases of toxic air pollutants? What technology is available to control emissions from incineration of municipal wastes? What health effects are associated with these pollutants?

Within the area of toxic air pollution research, EPA will focus on several objectives. Monitoring methods will be improved and attempts will be made to characterize urban atmospheres and determine national pollution trends. TEAM studies will be undertaken, with the goal of developing a profile of HAP exposures across the nation. Efforts will be made to identify the most toxic pollutants, by source, and to determine their health effects. The formation, transport, and fate of HAPs will also be investigated The Integrated Air Cancer Program (IACP) will be expanded, drawing on the resources of several EPA laboratories to discover the extent to which toxic pollutants contribute to this country's rising cancer rates. The health effects of pollutants associated with the burning of municipal wastes and with new motor vehicle fuels will be studied Research on control technology for municipal waste incineration will be performed. Studies will be done to characterize transport patterns following accidental releases of toxic air pollutants

With the cooperation of other federal agencies interested in the hazards of indoor air pollution, EPA will be applying modern methods to monitor indoor exposures to radon, VOCs, NO_2 particulates, and other contaminants. Indoor emissions will be characterized and exposure models will be constructed to predict indoor exposures to specified pollutants. Ultimately this information will be of use in determining the total exposure -- indoor and outdoor -- that humans receive to these pollutants.

Within the criteria pollutant program, an important new issue is the need to determine the extent to which ozone is responsible for damage to forests, low growth rates, and susceptibility to disease. Additional concerns remaining include ozone non-attainment, health effects exposures to NO_2 and particulates. Ozone control research will focus on

small stationary sources of VOCs, such as dry cleaners and gas stations, to develop applicable, low-cost methods of cutting VOC emissions. Health research on NO_2 will concentrate on clinical, epidemiological, and toxicological evaluations of exposure, particularly in susceptible populations, such as children and persons with impaired respiratory systems.

Resource Options

1987 Revised Current Estimate: $ 63.0M
1988 President's Budget: $ 65.5M

	Projections			
Growth	FY 1989	FY 1990	FY 1991	FY 1992
None	65.5	65.5	65.5	65.5
Moderate	67.5	69.4	71 5	73.7
High	69.4	71.5	73.7	75 9

No Growth: The program would proceed as described in this Agenda.

Moderate: Additional efforts would be devoted to augmented research in risk assessment, formation and control of ozone, long-term health effects of pollutants and mitigation of risk. Specifically, emphasis would be placed on determination of risk. Reduction in the criteria air pollution program would be restored.

High: Additional emphasis would be placed on determining subtle but major health risks from both criteria and non-criteria pollutants. Additional support would be given to control technology research and efforts to characterize dispersion patterns and atmospheric reactions of pollutants. Research outreach activities would increase, including technical assistance, technology transfer, and regulatory support.

WATER

EPA's water research program provides the technical and scientific support necessary to implement the Agency's regulatory responsibilities under the Clean Water Act (CWA), the Safe Drinking Water Act, the Marine Protection, Research and Sanctuaries Act, and a number of Executive Orders and omnibus statutes. Most of the research on water issues is conducted by the ORD laboratories, although a valuable contribution is made by universities and private research institutions supported in part by EPA grants and cooperative agreements. EPA's water research is important to the development of both drinking water and ambient water quality regulations. In addition, the program is heavily involved in the evaluation of innovative and cost-effective treatment technologies and the provision of technical assistance to municipalities, industry and private landowners, and is accelerating its research into the environmental impacts of pollution upon aquatic biota and their ecosystems.

The water research program will continue to provide support in the following areas: developing new and revised drinking water Maximum Contaminant Levels and Health Advisories; developing Criteria Documents and the scientific underpinnings of ambient water quality regulatory policies; assisting the Regions and states in meeting the growing demand for toxicity based NPDES permits; and providing technical support to the municipal waste-water construction program in pretreatment, sludge, operation inflow and other areas.

The six research areas described in this report--Water Quality Based Approach; Marine, Estuarine and Great Lakes; Wastewater Treatment Technology; Drinking Water Technology, Drinking Water Health, and Ground Water--represent the principal concerns in the water research area and correspond both to the organizational structure of the Water Research Committee and the Agency's water research budget. Although this is a comprehensive program, it does not include all ongoing research which contributes to EPA's water protection mission.

Major Research Issues

Water Quality Based Approach Permitting

What information and methods are needed to support a water quality based approach to pollution control?

The CWA recognizes two types of regulatory requirements needed to restore and maintain the quality of the nation's waters: (1) technology-based guidelines set uniform national requirements for discharges by industries and sewage treatment facilities; and (2) water quality based standards define the uses to be made of water, such as drinking water supply or recreation, and subsequently establish site-specific criteria protective of that use. Despite significant reductions in point-source pollutant levels as a result of the implementation of technology-based discharge limits, some water bodies still do not meet water quality standards. Moreover, there are increasingly important water quality problems caused by toxic substances, diffuse (non-point) sources, and reduced flow.

Ecological Hazard Assessment for Water Quality: This research will develop data bases that support the Agency in implementing the regulations under development for the disposal of sewage sludge under Section 405 of the CWA. It will provide needed data on plant uptake and effects on plant and wildlife populations due to land application and incineration of sludges. Bioaccumulation, toxicity, and sediment sorption/desorption data bases will also be developed. Ecological criteria will be developed by integrating terrestrial and aquatic characteristics into an assessment protocol.

Microbiological Contamination of Shellfish: EPA will continue to support a cooperative research effort with the U.S. National Oceanic and Atmospheric Administration (NOAA) and the U.S. Food and Drug Administration (FDA) to determine if a quantitative relationship exists between microbial indicators of water quality and disease incidence in consumers of shellfish (oysters and clams). Two field sites have been selected to study the occurrence of microbial water quality indicators and to harvest oysters and clams. Shellfish harvested from these sites (both are currently acceptable) will be fed to human volunteers to determine the incidence of gastrointestinal disease. The microbial water quality indicator that best correlates to the disease incidence in consumers will be proposed as the revised shellfish growing water quality indicator.

The microbial water quality health research program will emphasize resolution of the question of how non-point sources of pollution from both humans and animals affect the relationship between microbial water quality indicators and disease incidence in both recreational and shellfish growing waters. This is an important research issue because water quality standards based on upstream wastewater effluents (point sources) may be overly restrictive when applied to waters impacted by non-point sources. The relationship between the pathogen and indicator organisms and observed disease may be

drastically different (preliminary data support this) and thereby affect the dose-response curve on which the standard is based. This could lead to unnecessary closure of recreational or shellfish growing waters or to requiring costly non-point source pollution control technology for minimal reduction of risks. Research studies, using molecular biology techniques, will be undertaken to differentiate human from animal pathogens and to determine the differences in the dose-response curves from exposure to these organisms.

Waste Load Allocation: Environmental processes characterizations will increase available data bases, and waste load allocation models will be developed, improved, simplified and tested to implement the water quality based approach. The Center for Water Quality Modeling in Athens, Georgia will catalogue, maintain and provide models, user manuals and associated training and technical assistance to EPA Regions and states

Monitoring and Quality Assurance: EPA will continue to identify, evaluate, standardize and validate analytical procedures for characterization/monitoring of waterborne pollutants. Emphasis will be given to the establishment of protocols which screen water quality through biochemical and/or biological testing. In the area of chemical methods development, generic instrumentation approaches to monitoring (rather than a chemical-by-chemical approach) will be evaluated. Contamination of the water column, underlying sediment or introduced sludge will be individually addressed in an attempt to maximize the economy of each class of measurement Additionally, the proposed externalization of quality assurance costs (charging user fees for QA services) will require the private sector to reimburse EPA for services rendered.

Water Quality Criteria - Aquatic Life: Toxicity testing methods for aquatic life will be developed, validated and provided to Regions and states for predicting in-stream water and biological impacts in fresh and brackish water and marine systems. Research will continue to support the integration of pollutant specific controls with whole-effluent-toxicity testing procedures and Best Available Technology. The significance of toxicity and persistence factors to biota will be determined and methods developed for integration into the permitting process. Field tests will compare site-specific criteria modification techniques with the whole-effluent-toxicity approach. Freshwater and marine water quality criteria and advisories for protection of aquatic life based on specific chemicals will be developed as needed and experimental "expert" systems for environmental assessment will be developed and tested.

Water Quality Criteria - Health Effects: Health effects bioassays developed in previous years to determine toxicity

of municipal and industrial waste discharges will be field tested at several different locations. The results of these field evaluations will be combined and produced as a methods manual to support the NPDE5 program.

Wetlands in Water Quality Protection: The Agency will initiate an effort on wetlands research to establish a scientifically-valid framework for categorizing wetlands and measuring the impact of change so that regulatory actions can be effectively tailored to specific problems.

This research will define wetlands values and functions. A protocol that incorporates scarcity, ecological functions, ecosystem coupling, replaceability, and cumulative impact will be developed. This research will also identify water quality impacts and interactions of wetlands decisions, assess the effectiveness of wetlands mitigation and determine the role in water quality protection.

In other areas, guidance for assessing the risk of human exposure to mixtures of toxic chemicals, the evaluation of site-specific health hazards and evaluations for CWA Section 301(g) permit modification requests will continue under the scientific assessment program. The cooperative ecological research with the People's Republic of China will address the impact of contaminants on freshwater organisms, emphasizing field verification of methodologies.

Marine, Estuaries and Great Lakes

What information and methods are needed to support environmentally sound ocean disposal, estuarine and Great Lakes programs?

Ocean Disposal: EPA is charged with regulating waste disposal activities in the marine environment. Among these activities are the dumping of wastes such as dredged material, sewage sludge and industrial wastes, the disposal of municipal and industrial wastewater through ocean outfalls, the incineration-at-sea of industrial wastes and the permitting of discharges through the NPDES program. An improved understanding of the ecological consequences of these ocean disposal actions is needed to guide future public policy, satisfy international marine treaties and, where possible, protect and enhance coastal fisheries resources. Key questions concerning ocean disposal actions involve procedures to be used in assessing the impacts of ocean disposal and procedures necessary to monitor dumpsites for long-term impacts and validate predictions made about potential impacts. The CWA requires secondary treatment for ocean outfall discharges from publicly owned facilities, although waivers are allowed in selected cases. Therefore, EPA must have a scientific basis for determining when secondary treatment

requirements may be modified and what effluent limitations should be imposed.

To support the ocean dumping and outfall regulatory programs, EPA's research will focus on the development and validation of protocols needed for prediction of impacts from these activities. This program will continue the development and testing of ocean disposal impact assessment procedures, coastal and deepwater monitoring methods, and procedures for characterizing the bioaccumulation potential and effects of ocean disposed contaminants. Technology research related to ocean disposal will provide information used in correlating the types of treatment with subsequent environmental impacts in order to assess appropriate levels of treatment for ocean disposed wastes. This research will focus on the desorption of toxic organics from sludges to marine waters and on the fate of toxic organics and metals during treatment.

Estuaries: Estuaries are valuable ecological systems that are directly important to man as fisheries and recreation resources and indirectly as nursery areas for estuarine and coastal fisheries. Estuaries are subject to impacts by the production, transportation, consumption and release of toxic chemicals. Basic scientific uncertainties exist regarding these assessments which involve the quantification of loads, their transport and fate, and their cumulative effects on the resources. EPA's estuarine research program will concentrate on the development and validation of hazard-assessment protocols for improved source-control decisions in the NPDES and Construction Grants Programs. The estuarine research program will develop generic procedures for conducting wasteload allocations in estuaries.

Great Lakes: Increased use of industrial chemicals and their presence in the Great Lakes have raised public concerns about toxic pollutants, particularly persistent synthetic organic compounds Because of the complexity of many of these compounds, it is difficult to predict the potential adverse impact of these chemicals on organisms in the food chain, including humans. Analytical methods needed to detect environmental concentrations of organic compounds at trace levels are often inadequate Also, existing methods have limited ability to relate pollutant exposure levels to the sources, determine the biological availability and environmental effects of toxic organics EPA will continue to study transport, fate and effects of toxic materials in selected areas of the Great Lakes ecosystem, with emphasis on contaminated sediments This information will be used by the Great Lakes National Program Office, EPA Regions, states and the International Joint Commission under the U S /Canada Water Quality Agreement.

Wastewater Treatment Technology

What information is needed to develop and assist the states in implementing sludge disposal regulations and to improve the reliability and cost-effectiveness of wastewater treatment facilities?

Sludge Management: The processing and disposal of sludge accounts for about half the total operating costs of a typical sewage treatment plant. Municipalities are facing increased economic and public problems with current land and ocean sludge disposal practices. Approaches to disposal are needed that will significantly reduce the volume of sludge, destroy pathogens, ensure that toxic metals are not a problem, reduce toxic organic compounds, and ensure that sludge disposal does not present a threat to ground water, the environment and public health. To support EPA's regulations, research will focus on sludge use criteria, procedures and requirements applicable to the regulatory process. EPA will refine methods to assess sludge-disposal options including research into ecosystem resiliency or stress resulting from disposal and methods to predict human health effects from exposures to sludge.

Research on potential human health effects from sludge disposal involves collecting data on various chemical and bacteriological contaminants in sludges and sludge products and developing hazard indices for effects associated with different exposure pathways. Studies have been initiated to evaluate health hazards from exposures to sludge where composted sludge is sold as fertilizer. Results from these and other studies will provide data for determining the effects of various sludge treatment processes on mitigating disease.

Health assessment profiles will support regulatory decision making on the effective treatment, conversion, use and disposal of municipal sludge. EPA will develop information on mitigating risk through sludge treatment, on disposal options, and will produce guidelines for conducting health risk assessments of sludge disposal. Research results will be used to calculate indices for cancer and oral chronic toxicity related to hazards in the food web and inhalation and aquatic toxicity associated with the incineration and ocean disposal of sludge.

The Agency will continue to maintain and update the existing gas chromatography/mass spectrometry (GC/MS) tape library and will develop new analytical data bases of toxic pollutants found in industrial wastewaters.

Research on sludge stabilization, pathogen reduction and dewatering offers a major opportunity to reduce substantially costs associated with sludge processing while causing minimal environmental impact. Pilot- and large-

scale combinations of activated sludge, and anaerobic digestion to determine the mass and volume reducing capabilities of the system will be evaluated, along with promising methods such as mechanical composting and conversion of sludge to fuel. Engineering research addressing sludge applications in agriculture, forests, landfills and land reclamation is needed to establish safe application rates and management techniques and to minimize surface and groundwater impacts.

Innovative/Alternative (I/A) Technology: EPA will provide technical and program support to states, municipalities, consultants and equipment manufacturers in the areas of facility plan reviews, emerging technology assessments, technology evaluations, small wastewater flow technology and technology transfer. Also, assessments of promising wastewater treatment processes that have had limited full-scale application will be made.

Upgrading and Correcting Designs: The Agency will provide information to municipalities to upgrade existing plant capabilities and achieve compliance with minimal capital costs. Research in this area encompasses evaluation of high biomass systems, enhanced oxygen transfer, second generation nutrient control schemes, and a variety of innovative long-range approaches to biological treatment such as genetic engineering

Toxics Treatability and Toxicity Reduction: EPA will evaluate the fate and effects of toxic pollutants in municipal wastewater treatment systems as a component of effects to develop enhanced control of toxics in such systems. The Agency will also develop toxicity reduction evaluation procedures for municipal and industrial wastewater treatment plants in support of water quality based permit limitations.

Water Quality Planning and Regulation Support: EPA will provide engineering data and managerial techniques necessary for states to apply a cost-effective systems engineering approach to implement wasteload allocations within their water quality control programs. This will provide more reasonable margins of safety in determining allowable stream loadings and reduce over-design of advanced treatment plants.

Quality Assurance: EPA will continue the quality assurance and repository samples program. The performance of major NPDES dischargers' laboratories will be evaluated, and actions on NPDES alternate test candidate procedure applications will be recommended

Drinking Water Technology

What new technologies are needed to continue to assure the safety of drinking water?

EPA's drinking water technology research program provides engineering data to support the development and revision of drinking water regulations as well as engineering information and technological support to states, municipalities, EPA Regions and utilities concerned with drinking water regulations and compliance. Major technological problems include the relationship between treatment strategies and deterioration of water quality within the distribution systems, other factors causing deterioration within distribution systems, and bringing small systems into cost-effective compliance A related concern is the impact of distribution system corrosion on drinking water quality and the need for low-cost techniques to solve this problem.

Disinfection By-Products: Research will continue on improving the knowledge of a number of unidentified by-products produced by chlorination as well as by-products of alternate disinfectants to chlorine Evaluations of trihalomethane (THM) control using alternative disinfectants and treatment modifications will continue.

Overall System Integrity: The persistence and regrowth of organisms in distribution systems are influenced by the physical and chemical characteristics of the water, system age, pipe materials and the availability of suitable sites for bacterial colonization. Investigations will also be carried out on other key factors that influence microbial regrowth, such as nutrients, temperature and sediment accumulations. Theoretical, laboratory and field studies will define factors associated with distribution system repair and replacement criteria. Laboratory and field studies will evaluate the impact of changes in treatment and disinfection practices brought about by existing and new regulations.

Small-System Compliance: EPA is directing special attention to small drinking-water systems and their compliance with regulations. Research is evaluating the cost and engineering feasibility of specific treatment techniques to remove or control chemical, particulate and microbiological contaminants. Several evaluations will be at pilot- or full-scale. Laboratory studies are defining variables that govern the effectiveness and efficiencies of treatment processes prior to large-scale evaluations.

Monitoring and Quality Assurance: The Drinking Water Technology Research Program oversees the Agency-wide mandatory quality assurance program for drinking water. Ten regional laboratories are involved in the National Interim Primary Drinking Water Regulations laboratory certification

program. Monitoring activities will also develop methods and total measurement systems for precise chemical, microbiological and radiochemical analysis. This will provide accurate and cost-effective analytical procedures to monitor contaminants for use by the Agency, states, municipalities, and operators of public drinking water systems.

Drinking Water Health

What are the health effects from exposure to chemical and microbiological contaminants found in drinking water?

EPA is required to develop national drinking water standards for contaminants that may cause an adverse health effect. Research to determine the effects and risks from exposure to drinking water contaminants is an essential step and has been explicitly recognized by a provision of the Safe Drinking Water Act. Such research will be continued

Health Effects Data and Risk Assessment: Toxicological research to develop dose/response data will support development of Maximum Contaminant Levels and Health Advisories for disinfectants and disinfectant byproducts, synthetic organic chemicals, inorganic chemicals, radionuclides and microbes as required under the Safe Drinking Water Act Amendments of 1986. Risk assessments and criteria documents will be developed for drinking water contaminants. Epidemiological studies will determine the associations between drinking water disinfection and cardiovascular disease, and drinking water quality and bladder, kidney, liver and colon cancer.

Methods Development: Research will be done to improve extrapolation of toxicological data from high to low doses and from laboratory animals to humans. The effects of different exposure pathways are being evaluated to improve the accuracy of risk assessments Microbiological methods are being developed to identify infectious disease agents in water and determine the significance of the occurrence of these agents in water supplies. Methods to determine exposure and risks from chemical mixtures are also being developed.

Ground Water

What is needed to improve the scientific capability to monitor, predict, and clean up ground water contamination problems?

EPA and the states have a number of mandates for protecting ground water, and almost every regulatory and enforcement program in the Agency has some interest in ground water protection. In response to these needs, EPA's ground water research programs cover source control,

monitoring methods, analytical methods and quality assurance, prediction and resultant assessment of risks, drinking water treatment and health effects, and cleanup methods for contaminated soils and ground water This section focuses on: wellhead protection, monitoring technology; prediction and assessment tools, underground injection control; aquifer cleanup, and technology transfer. These areas are not covered within the Hazardous Waste/Superfund or the Pesticides and Toxics chapters in this Research Outlook

The research will be used to evaluate the ground-water flow, and fate and transport models available for wellhead protection and delineation. Methods and information will be developed on critical wellhead protection factors such as radius of influence around a well or well field, depth of drawdown of water table by well or well field, and the time and rate of travel of various contaminants in various hydrogeologic settings. In addition, the research would provide analysis of the impact on well head protection areas from sources of contamination and evaluate the effectiveness of control methods both technical and institutional on the prevention of ground-water contamination in the wellhead protection area.

Predictive Methods: Predictive research provides the basis for assessing the risk of ground water contamination upon drinking water supplies and for understanding subsurface processes that eventually may lead to cleanup methodology. Sorption, biotransformation, transport, mixed solvent interactions, oxidation reduction, hydrolysis, dechlorination, dispersion, fractured flow, and immiscible flow will be investigated for organic chemicals that could pose significant risk. Research will continue on virus survival and transport, and metals mobility. Contaminant-transport models will be adapted and modified to include the improved process descriptions. field evaluations will determine the degree of confidence that can be expected from predictive models in various hydrogeologic environments.

Monitoring Technology: EPA's research will improve cost-effectiveness and accuracies of monitoring in three areas: methods, geophysical techniques and interpretive analysis. Sampling and well-construction methods will be evaluated to determine their effects on the accuracy of results. Fiber-optics technology will be used for inexpensive and reliable ground water monitoring. Current methods will be adapted for use on underground storage tanks and non-hazardous landfills. Vadose zone (unsaturated) techniques will be evaluated for their applicability to various situations and soil-gas monitoring will be developed into an inexpensive and reliable method for plume delineation.

Geophysical methods adapted from the energy and minerals resource industry will be evaluated for their applicability to such ground water contamination problems as detecting leakage from underground injection wells, location of abandoned wells, and contaminant plume detection. Quality assurance methods will be developed and standardized to improve confidence in these techniques

Interpretive analysis will be used to obtain more information from monitoring data and to improve reliability. Efforts will continue to determine the completeness of coverage for methods to locate abandoned wells. "Variance analysis" will be applied to determine the frequency of sampling required in monitoring wells to gain the appropriate confidence under different circumstances. Finally, geographically based information systems will be used to make ground water monitoring data more useful to decision makers

Underground Injection Control: This research will be extremely important over the next few years due to the regulatory requirements of the Hazardous and Solid Waste Amendments of 1984. EPA is required to reconsider the safety of underground injection as a hazardous waste disposal method and to ban such injection should there be migration out of the injection zone. EPA has a number of research activities underway to aid the Office of Drinking Water in making these determinations, including determining the fluid movement from wells, describing the interaction of injected fluids with the geological strata, and characterizing saline formations in the Texas Gulf Coast as receptors of hazardous wastes. Research will determine the mechanical integrity of injection wells, the location of abandoned wells and the practices associated with nonhazardous injection.

Aquifer Restoration: Aquifer cleanup research will provide cost-effective methods for cleanup of contaminated soils and ground water. Alternatives are needed to current approaches such as withdrawal and treatment or containment. Promising laboratory methods for enhancing subsurface biotransformation will be field tested, the safety of using genetically-engineered organisms for biodegradation will be determined, and the application of these methods to leaks from underground storage tanks will be evaluated

Technology Transfer: Information transfer will continue to be an important part of ground water research. Specific training materials are under development in addition to technical assistance to the EPA regions and the states. Support will continue to the National Ground Water Information Center, a computerized bibliographic retrieval database, and the International Ground Water Modeling

Center, a clearinghouse for ground water models and training.

Summary of Long-Term Trends

Most of the water research issues described in this chapter will continue into the next decade, with gradually changing degrees of activity and emphasis. Better analytical capabilities will continue to improve the capability to measure trace constituents in water, resulting in better identification of greater numbers of potentially deleterious chemical contaminants. With more toxicological and epidemiological information, water quality managers will face increasingly difficult decisions involving the environmental significance of complex mixtures of pollutants.

A significant near-term issue includes the development of toxicant information for complex mixtures. The growing inventory of chlorinated organic contaminants in complicated combinations requires significant changes in the research strategies and technological methods used to assess them. Whole-sample evaluations such as matrix bioassays, biological indicators and chemical surrogates will play a larger role in the future. To remain responsive, EPA's water research program must simultaneously develop and validate new methods for evaluating complex mixtures and their impacts while applying them in regulatory situations.

The environmental water quality issues, including estuary protection, ocean disposal and the water quality based approach, all reflect the emerging need to develop new tools to test and monitor ecological impacts, including effects on the community at a system level. Over the next decade, major strides will be made in identifying safe or "no-effect" levels of toxic organic contaminants in sediments and water and in methods to establish biological availability and bioaccumulation in tissues of aquatic life.

Many communities and landowners rely upon ground water sources for drinking and irrigation. Questions regarding the quality of ground water have been increasing in recent years. Consequently, the dynamics of ground water and the residence times and fates of leached contaminants in aquifers will be a major water resource issue for the remainder of the century. The coming decade will see the refinement of the capability to simulate and predict the impacts of contaminants on underground sources

In the wastewater treatment areas, emphasis will be on control of toxics in wastewaters and sludges. Improved engineering and the periodic emergence of innovative and alternative technologies may reduce costs. A major breakthrough in wastewater treatment may come from biological engineering, possibly through the development of

organisms which could be more effective in treating wastewater and sludges.

Resource Options

1987 Current Estimate. $ 48.4M
1988 President's Budget: $ 48.6M

	Projections			
Growth	FY 1989	FY 1990	FY 1991	FY 1992
None	48.6	48.6	48.6	48.6
Moderate	50.0	51.5	53.0	54.5
High	51.5	53.0	54 5	57.3

No Growth: The program would proceed as described in this Agenda.

Moderate: Additional emphasis would be given to research on wetlands, pollutant fate and effects in ground water, sludge, estuaries, and near coastal studies. In addition, efforts would be directed towards developing techniques to quantify health risks from exposure to complex mixtures and to augment the drinking water repository samples and quality assurance programs

High: The research cited under the moderate growth option would be augmented and accelerated, and additional research on water quality criteria would be conducted

Pesticides and Toxics

Pesticides and toxic substances research provides support to meet the current and future needs of the Toxic Substances Control Act (TSCA), the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) and, to a limited extent, the Federal Food, Drug and Cosmetic Act (FFDCA). Research efforts are geared toward providing scientifically valid yet cost-effective methods for evaluating the risks associated with pesticides uses and the manufacture and use of new and existing chemicals.

The research program in support of TSCA and FIFRA will continue to develop, evaluate, and validate health and environmental test methodologies and procedures to improve the predictability of human risk estimates, develop exposure monitoring systems, environmental fate and effects methods, and develop guidelines to perform environmental risk assessments. Additional research will develop and evaluate release and control methods for new and existing chemicals, structure activity relationships as predictors of chemical fate and biological effects, and procedures for ensuring the human and environmental safety of the products of biotechnology. The contamination of ground water from pesticides will be another area of interest in the ongoing research program.

Major Research Issues

Test Method Development

What new procedures or tests are needed to ensure that industry's data on environmental or health effects are accurate, reproducible and consistent?

Under TSCA and FIFRA, manufacturers must test chemicals and pesticides for potential hazards to the public health and environment. Consequently, research is conducted to provide guidance for performing such tests. Regulatory decisions on a chemical depend on qualitative and quantitative scientific data from industry regarding potential adverse environmental and human health effects of exposure to the chemical. Since the sensitivity, reliability, cost and time constraints of these tests vary widely, carefully screened methods are being developed and approved by the Agency. When completed, such methods will be incorporated into testing guidelines for use by industry and others who must evaluate the safety of chemicals.

Scientific assessment efforts in the test method development area will focus on research activities to improve the Agency's ability to assess exposure to and the potential health effects associated with the use of pesticides

or the manufacture, production, distribution, use or disposal of chemical substances or mixtures. This research is largely targeted on data inadequacies identified in the course of scientific assessment of chemicals during regulatory analyses. These research activities involve issues critical to the assessment of exposure and various adverse effects (carcinogenicity, developmental toxicity, reproductive effects, other chronic effects, and the estimation of heritable risk at low doses).

The monitoring program will focus on chemical and biological test methods needed to assess chemical hazards to humans and the environment. Real-time and rapid screening tests are needed for environmental monitoring to rapidly determine the existence of an environmental problem. In this area, research will be conducted with enhanced laser Raman spectroscopy to develop a real-time method for identifying chemical hazards. Bioassays using *in vitro* tissue culture responses and monoclonal antibody techniques will also be evaluated as potential screening tools for field evaluations. Finally, human exposure methods research will focus on advances in GC/MS analyses and the development of biochemical and immunochemical markers to detect exposure to particular pollutants. In the pesticides areas, new and/or improved cost-effective methods will be developed for detecting and analyzing pesticide chemicals. There is a continuing need for research into new and more sensitive analysis methods for various classes of compounds evaluated under both FIFRA and TSCA programs.

Environmental effects research will evaluate existing methods and perform field studies to determine the sensitivity of available tests and identify species for potential future test methods development. In this area, major advances will be required to relate single-species and microcosm data to actual ecosystem effects and to adequately relate observed effects on one species to probable effects on other species (comparative toxicology).

Health effects research efforts are directed toward developing predictive, reliable and cost-effective bioassays.

Test methods development will focus on prediction of toxic hazards in the following areas: reproduction/teratology, neurotoxicity, immunotoxicity, mutagenic or carcinogenic effects, and genetically inheritable disorders.

Structure Activity Relationships (SARs)

What information is needed on substances and their similarity of chemical structure to determine what additional testing is needed to assure the safety of humans and the environment?

To enhance the efficiency of the regulatory process for toxic substances, it is convenient to group various chemicals which share common or similar chemical characteristics rather than to deal with each individual chemical. If it can be demonstrated that chemical relationships, such as similar molecular structures and similar modes of toxic activity, form a firm scientific basis for estimating probable environmental risks, then better guidelines and techniques can be applied and regulatory actions can be completed more quickly using less resources. This approach will provide both the regulator and the regulated a standard basis for determining if a substance might be toxic and detrimental to living organisms or their environment.

SAR is vital for reviewing and screening PMN chemicals under Section 5 of TSCA. The findings and techniques established in this research will be used to select appropriate toxicity tests, to document test results, to develop fate and effects data bases where necessary and to provide the modeling means to predict toxicity.

Environmental effects research will include data base compilation and improvement in the precision and validation of SAR for predicting toxicity and such parameters as photolysis, biodegradation and likely metabolites in multimedia matrices.

Health research will focus on development of methods using a combination of descriptors based on molecular structure to predict genetic, carcinogenic, and other toxic activities using pattern recognition, statistical and thermodynamic techniques. Data bases containing bioassay data for use in predicting the mutagenic and carcinogenic potential of new chemicals in the environment will also be developed. These data bases will relate genetic and carcinogenic effects to toxicological response.

Special Human Data Needs

What effects do specific chemicals have on actual populations occupationally or environmentally exposed to the chemicals?

To improve the Agency's ability to estimate human health risk, these activities will examine population groups exposed to environmental contaminants which are suspect toxicants. Research is continuing to determine whether biological indicators of dose and/or effects are related to environmental levels of exposure and if they are correlated with adverse effects measured by traditional methods.

Ecology: Transport/Fate/Field Validation

What methodologies (including mathematical models) are needed to assess the fate and effects of toxic chemicals and pesticides in the environment?

To adequately evaluate the likely perturbations a pesticide or toxic chemical may cause in the environment, it is necessary to understand probable exposure concentrations/durations, movements through ecosystems, degradation rates, reservoirs, effects and residues. The Agency must have available techniques which may be applied to attain this information, must be capable of interpreting findings and must have a predictive capacity to anticipate problems. Activities in this area are designed to meet these needs, to improve the criteria and standards against which industry, the users or the Agency must comply. The intent is to provide new or improved state-of-the-art techniques to fill data gaps in order to have scientifically credible and legally defensible regulatory actions.

Research will be conducted to evaluate microcosms at freshwater, estuarine/marine and terrestrial semi-natural and natural field sites. Multi-species laboratory bioassays will also be validated to allow data bases to be documented and published that will predict the effects of toxic chemicals on aquatic and terrestrial vertebrates and invertebrates. System level investigations will validate multi-species and community level toxicology methods. Field tests will be conducted to assess the influence of colloidal organic matter on the uptake of chlorinated toxic chemicals by benthic organisms. Finally, field evaluations will be carried out to verify select organisms responses to sediment bound toxics found in freshwater ecosystems.

Efforts in this area will also determine the specific species and testing methods to assess the effects of toxic chemicals on terrestrial, freshwater and estuarine/marine species to provide data which can be used as surrogate information for other organisms. Evaluations will focus on comparative toxicology correlations and on validating promising correlations. Wild species testing will be emphasized to compare with previously conducted laboratory tests especially with finfish which will be used as surrogates for mammals. Terrestrial toxicology research will also be conducted to validate tests which determine the toxicity of chemicals to different strains and sources of birds.

Pesticide oriented investigations will focus on representative estuarine, freshwater and terrestrial field sites and will consider pesticide dose, exposure, effects and functional alterations at the species/population level. Non-target organisms (e.g., fishes, invertebrates, crustaceans, birds) effects will be quantified in terms of mortality, reproduction

rates and resiliency. This includes residue analysis and population censusing (pre- and post-treatment) information. Through extensive field sampling, data collection and analysis and simulated exposures, field findings will be compared to lab findings. Final evaluations will be published if lab results are comparable to field results and if hazard assessment criteria are adequate. Additionally, laboratory and field studies will commence to determine the relationships among the use of pesticides and other agricultural practices, pesticide characteristics and field conditions to mitigate ground water contamination problems.

Transport and fate processes and exposure information is highly critical to the Office of Pesticides and Toxic Substances (OPTS) operations. Various laboratory tasks will contribute exposure information on such parameters as sorption kinetics in sediments, pesticide transformation, biodegradation and movement. Methodologies applied will derive rate constants and determine the extent of the reactions observed resulting in descriptive mathematical expressions and exposure concentration estimates. Mechanisms and rates of degradation by natural microbial communities will be studied. Controlling environmental conditions and processes effecting degradation will be determined and quantitative relationships between the pesticide chemical characteristics and the environmental parameters will be factored in.

Field evaluation of methods and exposure models (with emphasis on leaching models) will be conducted via laboratory and field studies including analysis of residues in soils. This includes information generation on variability of soil water releases and ground water contamination and includes model calibration and improvements to predict exposure concentrations and toxicant movement. Appropriate workshops and symposia may be convened to transfer results to users. When developed and evaluated, these models will predict the environmental impact of pesticides and toxic substances.

Health: Markers, Dosimetry, and Extrapolation

How do we relate external dose to internal dose and to early indicators of disease states and how can we better extrapolate (from high dose to low from differing routes of exposure and from laboratory animal to man) to support risk assessments?

For both the pesticides and toxic substances programs, health effects research will be focused on development of methodologies for extrapolation of animal data from high to low doses and between mammalian species to enhance human health risk assessment predictability. Additional studies in the toxic substances research program involve

defining the relationship between biochemical indicators of exposure to neurotoxicants and behavioral dysfunction as well as studies in dosimetry and extrapolation related to genetically mediated health effects. Additional pesticides research includes evaluating the relationship(s) of age and dermal absorption using *in vivo* animal models as well as research on compound-induced reproductive alterations following exposure during developmental periods Data generated in the toxics and pesticides areas will be used to extrapolate toxicant risks to humans.

Exposure Monitoring

What improvements are needed for the monitoring methods, systems and analysis used to provide the data bases for estimating human exposure?

TSCA related monitoring efforts will be directed toward improvement in monitoring systems to estimate human exposure through use of the Environmental Methods Test Site (EMTS) at Chattanooga, TN Research will also be continued to develop approaches for multi-media/multi-pathway monitoring systems which generate data that will provide an estimate of total human exposure. Studies will also be conducted to incorporate environmental dose into personal exposure monitors and to provide a better understanding of the contribution of the different exposure routes on pollutant intake. The relationship of network monitoring to personal exposure monitoring will be evaluated at EMTS in a WHO/UNEP Human Exposure Assessment Location (HEAL) Project.

Biotechnology/Microbial and Biochemical Pest Control Agents

What methods and technologies are needed to assure safety to public health and the environment from microbial agents and products of biotechnology?

Many of the techniques required to adequately control or regulate microbial organisms or "biochemical" products (e.g., pheromones) apply to both TSCA and FIFRA mandates. Beyond these basic techniques, however, there is a divergence -- microbial applications under TSCA are usually industrially oriented and relate to workplace exposure or accidental releases; the microbial applications under FIFRA are an intentional dispersion to control undesirable flora or fauna. Such microbial pest control agents (MPCA's) may be "natural" selected stock or may be genetically-altered.

Users of biotechnological products must follow recommended Agency guidelines in a testing regime designed to help prevent adverse environmental impacts. ORD helps establish these techniques, determines if

environmental effects are exhibited by previously untested non-target organisms and conducts field-oriented validation studies as necessary to insure that testing criteria and guidelines are appropriate and functional. Engineering research will also be conducted to develop and/or improve methods to contain or destroy genetically engineered organisms.

Under FIFRA, research will develop or improve bioassay methodologies for determining the effects of biological control agents (BCA's) on non-target receptors or hosts. This includes providing testing protocols and effects information for unaltered and genetically altered microbial BCA's. Investigations will focus on routes of exposure, methods to detect and identify agents, toxicity, infectivity, persistence and effects. The information will be used for revising subpart M guidelines and for regulatory decisions in pre- and post-registration actions.

Pesticides health research in biotechnology involves development of data on the immunologic effects of microbial pesticides (both microbial and biochemical pest control agents and bioengineered organisms) on mammalian cells. Methods are also being developed using monoclonal antibodies and biotinated DNA probes to enable the identification of genetic material from biological pesticides in non-target sites such as mammalian cells. These methods will provide the basis for validation of subpart M guidelines for testing microbial pesticides.

Under TSCA, efforts will be continued to develop scientific rationales, procedures and monitoring methods for evaluating the environmental survivability, reproduction, distribution, effects and risk associated with the escape of genetically manipulated organisms. The results will be used to prepare protocols for use in evaluating TSCA products involving environmental application of microbes. This research will also support regulatory rulemaking specifying which products are to be considered under TSCA.

In the toxic substances health research area, studies will be conducted to determine the genetic stability and function of a baculovirus expression vector in vertebrate cells. The ability of genetically engineered organisms to genetically transfer novel metabolic capabilities to normal gut flora will be studied to determine the potential for adverse health effects.

Engineering Release and Controls

What engineering and technological information is needed to identify the release of and exposure to toxic substances and to determine alternatives for control of these substances?

Under the premanufacture notification (PMN) process, manufacturers are required to submit information to EPA on the release and control of new chemicals and significant new uses of existing chemicals. EPA uses existing data to predict the risks of and from the release of new substances, and under the existing chemicals control program, evaluates technological alternatives to reduce the release of and exposure to chemicals that are already in use.

Models will be developed which predict release of and exposure to classes of new chemicals in order to assess chemical-unit operations and processes, and the physical and chemical properties of chemical substances. Additionally, models to predict potential exposure and release levels, and the best control measures to control release of and exposure to new chemicals will be developed. Treatability testing of potentially toxic chemicals will also be conducted.

Alternatives to mitigate the release of and exposure to specific existing and new toxic substances will be defined through the evaluation and adaptation of control measures related to the release of chemicals in the workplace and into the environment. Technologies, management practices, and personal protective equipment to limit the release into the environment and exposure to those toxic substances will be evaluated.

Under FIFRA, EPA is responsible for pesticide exposure studies, for reviewing and approving pesticide labels, for administration of the pesticide Farm Safety Program, and for supporting training and education programs for pesticide users through state extension services. The Agency is concerned that protective clothing currently recommended for use by pesticide users is not providing acceptable protection. This situation is aggravated by a lack of appropriate data In order to improve the situation, EPA requires greatly improved documentation regarding the effectiveness of protective clothing. This program will focus on generating breakthrough time and steady-state permeation rate data for concentrated formulations of high toxicity pesticides through a range of commonly available polymer gloves that may be suitable for use by mixers and loaders of pesticides. Evaluations of the job compatibility and degree of protection provided by clothing items other than gloves will also be conducted via laboratory and field testing.

Ecology: Ecotoxicity and Risk Assessment

What methods are needed to evaluate ecosystem risk as a result of exposure to existing and new chemicals?

In the past, the emphasis of ORD's scientific assessment program has been placed on the assessment of risk to

human populations. However, there is also a need to assess the risk to non-human populations and the environment. The development of ecological risk assessment protocols and guidance for terrestrial and aquatic ecosystems (primarily endangered species and commercial fisheries) is necessary to quantify the probability that adverse effects may occur as a result of exposure to a toxic substance and to estimate the significance of such effects in the environment. Since environmental data developed by industry may vary greatly from chemical to chemical, procedures need to be developed which provide guidance and consistency for the various environmental exposure activities. This work will provide risk assessment protocols and guidelines for the assessment of effects to terrestrial and aquatic ecosystems.

Ecosystem risk research will provide a scientifically based system to assess ecological risks from exposure to environmental toxicants. This system will provide the capability to assess risks associated with different uses of chemicals resulting from various options for regulating pesticides and toxic chemicals to protect organisms in their natural environment. This research will provide for prognostic assessment, extrapolations to any patterns and levels of environmental release, inferences of types of responses to be expected in natural systems, and estimates of uncertainties in the assessments.

Finally, it will integrate chemical fate, exposure, and effects to provide the capability to conduct risk assessment for terrestrial and aquatic systems.

Major program components will include development of a computerized framework linking all components to provide the capability to carry out appropriate analyses and obtain results in any desired form. It also will include data bases of scenarios such as river reaches, endangered species habitats, chemical properties, and properties of organisms including geographical range and habitat preferences. Such activities will utilize and develop traditional analysis techniques and models that calculate bioconcentration and effects for populations, communities and ecosystems and provide quantitative and qualitative probability statements of uncertainties involved in the assessments.

Support

What support is required for preparation and review of scientific assessments and for quality assurance?

For certain assessments the technical expertise of the ORD staff is required to conduct literature searches, interpret data or render technical and scientific judgments because of the lack of data. In cases where program office evaluations are complicated and/or controversial,

independent peer review of assessments are required to ensure consistency. There is a continuing need for ORD participation in and review of major exposure and hazard assessments conducted by OPTS for supplying Agency policy makers with technical assistance from qualified scientists and for improving the scientific basis of Agency decisions in regulatory matters.

When requested, ORD will provide critical review of test rule documents for existing chemicals and screening of selected new chemicals under Section 5 PMN notifications. Such activities will support validation of toxicity tests, assist with exposure and risk assessments, and preparation and update of TSCA testing guidelines. This support will also encompass evaluation of complex problems associated with environmental fate, hazards and risks of toxic chemicals and bioengineered organisms as necessary for implementing TSCA.

Finally, in both the pesticides and toxics areas, support will continue for quality assurance and maintenance and dissemination of standard reference materials.

Summary of Long-Term Trends

Pesticides and toxic substances research efforts focus on both intentional and unintentional releases of chemical substances into the environment. Each of the issues covered in this chapter will continue into the next decade. Various degrees of emphasis are addressed below:

Test method development efforts will continue in support of both TSCA and FIFRA guidelines. As current methodologies are standardized, new techniques will be developed to fill gaps in existing methods. These new methods will focus mainly on endpoints other than carcinogenicity, and will provide more effective means to conduct quantitative risk assessments. To this end, efforts will increase for developing extrapolation techniques (from high to low doses and from animals to humans) for reducing the uncertainty of laboratory data used in predicting human risk. The development of biological markers will also assist in this area by providing more accurate measures of human exposure levels as well as serving as tools for epidemiological studies. Concurrently, the development of exposure monitoring systems will increase to provide new monitoring methods, systems and analyses.

Ecological risk assessment research will continue to develop methods for determining the fate and effects of chemicals. These effects and exposure methods will provide the means to evaluate risks. The integration of such methods and data will provide the means to develop protocols for environmental risk assessments.

Research to provide information on the release and control of new and existing chemicals from manufacturing processes will allow the rapid and accurate prediction of how much and where chemicals will be released into the environment, and with increasing accuracy, an estimation of their environmental effects. Such information is vital to the PMN review process and it is anticipated that the need for such data will continue to increase as the manufacture of new chemicals continues to grow.

EPA will provide methods to protect public health and the environment from the potential adverse impacts of microbial agents and the products of biotechnology. This research will help to determine containment facilities for bioengineered organisms and means of monitoring the survival and distribution of those intended for release.

The structure-activity research program will continue as the methods for predicting fate and effects of parents and degradation compounds become available, and the need for field validation efforts will increase to ensure the reliability of methods used to test chemicals.

Resource Options

1987 Current Estimate: $ 43.6M
1988 President's Budget: $ 42.2M

	Projections			
Growth	FY 1989	FY 1990	FY 1991	FY 1992
None	42.2	42.2	42.2	42.2
Moderate	43.5	44.8	46.1	47.5
High	44.8	46.1	47.5	48 8

No Growth: The base program would proceed as described above. Established priorities would continue to guide the research. In general these priorities are: biotechnology research, SAR, risk assessment and field validation studies including transport and fate.

Moderate: The same level of effort would be maintained for TSCA research; increased resources would enhance and expand field validation studies.

High: With a high level of resources, the studies on ground water contamination would be increased.

Hazardous Waste and Superfund

The Resource Conservation and Recovery Act (RCRA) authorizes a regulatory program to identify wastes which pose a substantial hazard to human health or the environment, and develop waste management standards which protect human health and the environment. Research support for this program provides the scientific and engineering basis for characterizing wastes, determining the hazards they pose and formulating controls. In addition, Section 311 of the Clean Water Act authorizes research to support prevention and control of hazardous materials releases.

The Office of Emergency and Remedial Response (OERR) requires scientific research and technical support from the Office of Research and Development to investigate and mitigate health and environmental problems at the priority sites listed under authority of the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA). ORD's research program provides a core of scientific and technical information to support the implementation requirements of CERCLA and the enforcement actions undertaken to obtain cleanup and recovery of costs. It concentrates on assessing health and environmental risks posed by Superfund sites and on evaluating equipment and techniques for discovering, assessing, preventing, controlling, removing and ultimately disposing of hazardous substances released into the environment. Research and support activities consist of programs to develop and evaluate validity of methods for detection and evaluation of adverse human and environmental effects, to evaluate alternative control and removal technologies, and to develop effective monitoring systems.

The ORD program for SARA is intended to, among other things, respond to reauthorized CERCLA authorities to enhance the Agency's internal research capabilities related to Superfund activities and is also focused on responding to more comprehensive site-specific evaluation needs for Superfund sites. Plans provide for increased site-specific assessments, quality assurance, and technical support for the monitoring program; increased technology transfer activity; initiation of innovative/alternative treatment and detection technology research, development and demonstration programs for both monitoring and engineering; initiation of research on health effects, health risk assessment, and increases in the support to Regional Offices for risk assessment activities; increases in support to the Regional Offices in the areas of groundwater

sampling, analysis, and data interpretation by the multidisciplinary groundwater support team.

Major Research Issues

Alternative Technologies

What information and data are needed to support and permit the use of alternatives to land disposal?

The Agency is currently beginning to implement a program which will ban land disposal of certain classes of untreated hazardous wastes. Banning these wastes could require the availability of proven alternatives for treating or recycling waste materials. Although many of these technologies currently exist, there are many questions regarding their effectiveness on specific wastes and their capacity to address the anticipated volumes that will require treatment. This research will provide support for the Office of Solid Waste (OSW) in implementing the portions of the RCRA amendments which require banning certain hazardous wastes from land disposal.

Research on alternative technologies assesses the environmental impacts of the major alternatives now under development, and in selected instances supports the evaluation of processes found by the Agency to offer substantial improvements over conventional hazardous waste disposal methods. Such evaluations will be conducted and used with existing data to form the basis for treatment standards.

Assessments of alternative technologies will be conducted at bench, pilot and field scales with emphasis on waste streams assigned high priority by OSW. Included will be aqueous waste streams from the chemical industry that are likely to be banned from landfills and wastes with a high potential for volatile air emissions.

What technologies are appropriate to clean up priority sites?

The ORD program for SARA will be expanded from its start-up level to provide an innovative/alternative treatment technology demonstration program at the level authorized by the Superfund Amendments and Reauthorization Act. Increased resources will allow the Agency to conduct 10 demonstrations to assist in evaluating the possibility of privatizing developed technologies that will provide permanent clean ups on priority sites.

Engineering evaluations of emerging technologies to accelerate private development will be increased. Technologies to be developed will continue to be selected from applications submitted to the Agency in response to solicitation in the Commerce Business Daily. The focus will

continue to be in the areas of recycling, separation, detoxification, destruction and stabilization that promise significant new methods for cleaning up Superfund wastes.

This activity will also provide increased test and evaluation of newly developed, but unproven, innovative monitoring techniques for applicability to Superfund monitoring situations. In addition, promising advanced/innovative monitoring techniques and systems which are not yet ready for demonstration will continue to be further developed so that their utility for Superfund pollutant characterization can be demonstrated.

Activity will also continue to identify, evaluate and promote the technical improvement of commercially available or prototypical protective clothing, equipment and procedures for use in responses at Superfund sites. Reports on personnel hazard detectors, personnel cooling devices, vital signs monitors, intra-EPA and interagency workshops will be provided.

Site Assessment and Support

What information and technical support is available for site-specific risk analysis and risk reduction?

For SARA the new effort on review of regional risk assessments will be substantially expanded. This will include providing a central point for coordinating review of regional risk assessments and establishment of a focal point for regional offices to request risk assessment assistance. This program will also continue to provide site-, situation- and chemical specific exposure and risk assessments to assist the program office and regions in evaluating the degree of hazard at uncontrolled waste sites. Specific activities will include preparation of site/situation-specific risk assessments, rapid response health assessments and Health Effects Assessments for use in Remedial Investigation/ Feasibility Studies (RI/FS) and other remedial planning efforts.

Increased resources will allow enhanced efforts to evaluate, validate, standardize and field test monitoring techniques to support program office monitoring at sites. Analytical methods for hazardous substances at sites will continue to be validated for Superfund waste matrices.

Engineering expertise will continue to be provided to assist the program office in RI/FS of specific Superfund sites during efforts to plan responses. Updated RI/FS treatability and cost estimation information will continue to be provided.

With the acceleration of CERCLA activity, in general, a significant increase in enforcement activity is expected. This will increase the need for endangerment assessments. Site- and chemical-specific health assessments will be

prepared to respond to those needs to assess endangerment at Superfund sites where Enforcement has the lead for implementing remedial responses. Assessments to be provided will range from brief hazard summaries to many detailed, peerreviewed endangerment assessments for use in negotiations or litigation with potentially responsible parties.

Site-specific monitoring support will provide increased amounts of aerial imagery and photographic interpretation and other technical support to OWPE, OERR and the regions for use in pre- and post-remedial site assessment.

The engineering program will continue to provide technical advice and consultation to the program office on issues that arise during emergency and remedial responses at Superund sites and to Enforcement for case support.

Technical support will continue to be provided in response to specific requests from OWPE, OERR, and regions on groundwater sampling, analyses, data interpretation, and site assessment and remedial action issues. Increased emphasis will be given to the application of bioassessment techniques for determining acute toxicity and bioavailability of Superfund wastes, extent of contamination, and remedial action progress, and in transferring this technique to others in the public and private sectors. Other activities will include: the application of assessment methods to determine the appropriate control technology for minimizing the risks from contaminated marine sediments, which is important for limiting the uptake of hazardous materials by marine organisms and their impact on humans through the food chain; the improvement of toxicity tests for oil dispersants, making them more sensitive, reproducible, and less expensive; the application of emerging biotechnology techniques to Superfund sites for improving in-situ cleanup through biodegradation processes; and the application of multimedia exposure/risk assessment methods to Superfund sites.

An increased level of technology transfer assistance in issues relevant to Superfund cleanups will be provided to the program office, regions and states.

Waste Characterization

What health and risk assessment information and procedures are needed to characterize wastes and assess the hazards they represent?

Assessing the risks associated with various methods of waste disposal is a critical aspect of the Agency's RCRA program, but is an area of major scientific uncertainty. Developing the scientific and technical information needed to establish the quantity and types of wastes that escape

into the environment through different disposal methods the effects they produce for both human health and the environment and the methods for assessing their risks will remain a significant area for research activity for some time. Moreover, given that most existing information is based on the properties of individual chemicals, rather than the complex mixtures of chemicals typically found in wastes streams, the state-of-knowledge in this area will require several years to develop.

The information developed to support this research area will be used by OSW in permitting and enforcement decision making, regulatory policy making, and implementing the land-banning program. Products will provide more applicable, less expensive, and more accurate information and risk assessment methodologies.

A program to develop more accurate methods for predicting the quantity, composition and volatility of leachates from land disposal of wastes is underway. These and other methods for determining the escape of hazardous wastes into the environment, as well as predictive models in air, surface water and ground water, will have to be combined into multimedia tools for exposure assessment. Products of this research will be critical for the Agency's land-banning and ground water programs.

Chemical-specific Health and Environmental Effects Profiles (HEEPs) will be prepared to support RCRA 3001 listing decisions. Support will also be provided to the Agency's effort to ban land disposal of certain wastes and will include evaluation of existing Acceptable Daily Intake (ADIs) and Unit Cancer Risks (UCRs) for hundreds of chemicals to ensure that the information they contain is accurate.

Short-term *in vivo* and *in vitro* bioassays will be developed into a screening protocol for determining which wastes are hazardous. Screens for determining effects on seven human health endpoints (e.g., carcinogenicity and mutagenicity) will be evaluated. When validated, these tests will constitute a major advancement in the Agency's ability to assess the toxicity of complex mixtures of wastes.

Environmental processes research will include development of multimedia assessment models for land disposal sites; quantitative structure activity predictions of waste toxicity; and ground water models for predicting waste concentrations and methods to define hazardous waste processes in wetlands. Research addressing complex mixtures will be expanded to allow better characterization of their environmental toxicity for use in delisting, banning and permitting decisions.

For SARA, this activity will continue to provide chemical-specific carcinogenicity and chronic effects documentation

to support the program office's regulatory process which adjusts the Reportable Quantity for hazardous substances. Support to be provided will allow the Agency to continue the normal Reportable Quantity adjustment activity and complete adjustments pursuant to the additional requirements placed upon the Agency by the Superfund Amendments and Reauthorization Act of 1986. Also, review of previously calculated Reportable Quantities will be performed on request from the program office or when significant new data become available.

Increased research to support health risk assessment data generation and methods development will be provided in this program. Efforts will be expanded in research to understand risks posed to reproductive health resulting from exposure to chemical mixtures, on development of methods, on development of field available exposure information, on the development of pharmacokinetic methods, on development of a field guide to permit field personnel to apply risk assessment methods, and on methods to better characterize the risks from chemical mixtures. Work will begin on evaluating the role of promoters found at waste sites in carcinogenesis and on the provision of *ad hoc* research assistance as needed by the regions.

Health effects research begun in FY 1987 will be continued and expanded to a full level of effort. Emphasis will be in the areas of neurotoxicity and reproductive effects New research will be initiated on the health effects of toxicant combinations and complex mixtures in ground water, on development of statistical methods for dealing with complex toxicological interactions, on the importance of using human metabolism data in animal-to-human extrapolation of toxicological data, and on identification and use of genetic and dosimetric markers of human hazardous chemical exposures.

Increased development and validation of promising field screening techniques having potential to provide improved Superfund pollutant characterization will be pursued. In addition, increased efforts will be expended in development of monitoring systems which are useful in integrated multi-media health assessments.

Dioxin

What assessment and control information is needed to identify and address the problems associated with dioxins?

Research supporting this objective is intended to help the Agency assess and monitor the dioxin contamination problem and begin developing procedures for addressing it. Although much of the research is completed or nearing completion, health research and risk assessment activities

will be continued, as will transport and fate research and a quality assurance support program.

Waste Identification

What analytic methods are needed for identifying the chemical constituents of wastes and thereby determining which wastes are hazardous?

Additional analytical methods for implementing Section 3001 of RCRA must be standardized and tested to determine their validity and reliability. New methods and procedures for detecting the presence of hazardous wastes under field conditions are also required to help implement Section 3013 of RCRA, which authorizes EPA to establish facility monitoring requirements.

New hardware and software developments offer considerable promise for reducing the costs and time, while improving the sensitivity, of laboratory analyses. Examples of the emerging technologies are supercritical fluids, quadrupole-mass-spectrometry, and thermospray injection. Considerable effort will be directed to evaluating and applying such technologies for hazardous waste analyses. One particular thrust will be in the development of technologies for rapid screening of large numbers of samples, particularly ground water samples. A second effort will be toward obtaining more comprehensive chemical profiles of volatile and semi-volatile organic chemicals in solids and other complex matrices. Concurrent with these activities will be a continuing effort to upgrade the computer programs supporting the analytical equipment, with special attention to computer interpretations of measurements.

This program will support activities in the following areas: development of bioassays into a screening protocol for detecting hazardous waste; development of subsurface monitoring and network design protocols for detecting potential ground water contaminants; validation of published SW-846 analytical methods and development of new, more cost-effective analytical methods. These will include inductively coupled plasma and high performance liquid chromatography. Additional emphasis will be placed on addressing RCRA subtitle D facilities and as part of this, monitoring and quality assurance practices at these facilities will be assessed.

Land Disposal

What technical information is needed to support permitting of land disposal and land treatment facilities, as well as improvements in design requirements?

Research in this area will provide guidance on design, permitting, operation, maintenance, closure and regulation of land treatment, storage and disposal facilities. It will also

address controlling air emissions from facilities and include sampling and measurement procedures, evaluation of emission models and evaluation of control technologies.

Incineration

What technical information and data are needed to support permitting of incinerators and improvements in design requirements?

Results of this research will be used by EPA and other permitting officials to evaluate the acceptability of incinerating particular wastes and in monitoring operating units for compliance with performance requirements.

As the Agency begins banning certain wastes from land disposal, various disposal alternatives to land disposal will become increasingly popular, including incineration. However, in order to issue permits for incinerators, Regional Offices and the states will require technical information and assistance regarding their performance capabilities. Ensuring the safety of their operation will require that methods be developed to predict their performance, and that their reliability be increased through control of operational parameters which avoid formation of hazardous by-products.

Research will continue to produce performance tests on incineration of wastes burned at the Combustion Research Facility. Real-time methods of determining incinerator compliance with permits will be investigated, as will improved sampling techniques for monitoring thermal destruction operations. Guidance manuals for states, regions and industry will be produced addressing best practices for burning wastes in industrial boilers, and assessing the impacts on emissions of incineration failures. Bioassays will be applied to generate data for assessing the risk from various burner methodologies. Bioassays for cancer and for non-cancer effects will be applied.

Releases

What procedures and information are needed to prevent, contain and cleanup accidental discharges of hazardous materials? This research will support both the CWA's releases section and RCRA's underground storage tank (UST) provisions.

Accidental releases of oil and hazardous material to the land and water occur frequently and constitute a significant environmental hazard. Federal, state and local emergency response personnel require improved technologies for the prevention and control of hazardous material releases to make cost-effective, environmentally sound cleanup decisions.

Development and evaluation of geophysical/geochemical sensors and volatile organic emission sensors and sensor placement networks for detecting leaks of hazardous materials such as gasoline, toluene and benzene will also be conducted. Test protocols for determining appropriate performance criteria will be developed as well.

Engineering research will produce manuals on procedures for on-site treatment of wastes and evaluations of containment, removal and dispersant technologies for controlling floating spills. Evaluations of leak detection and monitoring methods will also be produced, as will guidance manuals on nondestructive techniques for locating buried tanks and on UST release prevention techniques. A continuing effort throughout this period will be the evaluation of new technologies for the prevention and cleanup of releases. Innovative new systems will be sought, and if shown to be feasible, field-evaluated.

Environmental processes research for the UST program will develop alternatives for corrective actions including hydrogeologic techniques for mobilizing immiscible waters and techniques for in-situ treatment

For SARA, technology-specific evaluations will continue to be provided in the major technical areas of in-situ and on-site treatment.

The emphasis will be on providing engineering information for the remediation process. In addition to activities on extraction, detoxification and immobilization processes, new efforts will include identification, at laboratory and pilotscale, of processes most suitable for soil fractionation in the field, as a function of the type and particle size distribution of soils. Such techniques would help in minimizing on-site treatment and disposal costs.

In microbial cleanup, technologies will continue to be applied and evaluated for use in program office responses to Superfund site cleanups. The emphasis will be on the use of techniques to enhance the metabolism of hazardous substances by indigenous microorganisms and the use of specially engineered microorganisms at actual field sites. Such techniques have the potential for being more effective and less costly than currently applied cleanup methods. These integrated laboratory and field studies will continue to be closely coordinated with the engineering program

Quality Assurance

What measures are needed to assure the reliability and consistency of monitoring and analytical techniques and data used in support of the RCRA program?

The purpose of this program is to ensure that data of known quality are used throughout the Hazardous Waste program.

Analytical standards and reference materials will be developed for and distributed to all participating laboratories. Quality control and performance evaluation samples are also being developed and distributed to appropriate laboratories. Technical support will be provided to all participating laboratories in the form of instrument calibration assistance and provision of reference materials

For SARA, this program will provide increased quality assurance support to the Agency's Contract Laboratory Program, additional precontract assessment, calibration materials, laboratory performance assessment and evaluation/improvement of analytical methods.

Summary of Long-Term Trends

Research to characterize the potential exposure and effects posed by hazardous wastes is likely to be an area of significant importance. In order to effectively manage risk, answer the questions and concerns of the public and make the policy choices that will have to be made, more will have to be learned regarding the behavior and health effects of hazardous materials released into the environment.

Development and evaluation of alternatives to land disposal of wastes will remain an Agency priority. Research remains in its early stages and considerably more work is needed before alternatives will be able to satisfy the disposal requirements of large scale generators. Extensive testing and performance evaluations are needed to make these technologies available and years of effort will be required. Research will also be accelerated to provide support for the land-banning program and to support RCRA UST provisions.

Increasing emphasis will also be placed on research supporting the Agency's ground water program and on identifying the problems associated with municipal waste combustors. Additional ground water research will respond to program shortfalls identified by the SAB and the Ground Water Task Force. It will focus on determining ground water pollutant transport and fate and developing the monitoring technology needed to identify problems and measure the effectiveness of mitigation techniques. Research addressing municipal waste combustors will begin identifying the pollutants they produce, assessing the hazards they may pose, and the monitoring and control technologies needed to address the problems. Development of field methods for in-situ analysis at waste sites is planned to continue.

Resource Options

1987 Current Estimate: $89.1M
(Hazardous Waste: $ 50.2M; Superfund: $ 38.9M)

1988 President's Budget: $104.3M
(Hazardous Waste: $45.2M; Superfund: $ 59.1M)

	Projections			
Growth	FY 1989	FY 1990	FY 1991	FY 1992
None	104.3	104.3	104.3	104.3
Moderate	107.4	110.5	113.8	117.0
High	110.5	113.8	117.0	120.2

No Growth: The program would proceed as described in this agenda.

Moderate: Additional resources would further support waste characterization activities in support of the land-banning program and risk management decisions, ground water research and municipal waste combustion research.

High: Research described under moderate growth would be accelerated and augmented.

Multimedia Energy

The multimedia energy research and development program is designed to provide the scientific and technical information necessary to support the Agency's permit-issuing and standard-setting processes, and to allow for the development and utilization of energy sources in an environmentally acceptable manner. Research will be conducted to expand our knowledge of the phenomenon of acid deposition and provide information upon which mitigation decisions may be made; provide data on the performance, reliability, and cost of the LIMB control technology.

Acid deposition research is coordinated through the NAPAP, which is administered by the Interagency Task Force on Acid Precipitation. EPA is one of three joint chairs of the Interagency Task Force. The term "acid rain" is used to refer to the atmospheric deposition of acidic or acid-forming compounds in either their dry or wet form. These compounds exist in the atmosphere as gases or aerosol particles containing sulfur oxides (SO_x), nitrogen oxides (NO_x), hydrogen chloride, sulfuric acid, nitric acid and certain sulfate and nitrate compounds. The objectives of acid deposition research are to develop the necessary data to fully understand the sources and characteristics of acid deposition; and to determine the extent of current damage or potential damage. This information is essential to the development of effective corrective strategies if such strategies are deemed necessary.

The other major research area is the development of the LIMB emission-reduction technology. The LIMB combines SO_x control with simultaneous NO_x control by using a mixture of pulverized coal and limestone in a low-NO_x burner. This technology may substantially lower the capital cost of SO_x control.

Major Research Issues

Emissions Inventories of Acid Precursors

How can emissions inventories be made more responsive to acid rain modeling and assessment needs?

Estimates of current emission rates (aggregated at the national level) are reasonably accurate for major categories of man-made acid deposition precursors. However, atmospheric transport models under development will require improvements in spatial and temporal resolution of emissions estimates.

Greater uncertainties exist in projecting future emissions, the effect of possible emissions-control requirements, and

their probable costs. The mix of emission sources in any specific region may also change with time. Efforts to project future emissions rates and to estimate the cost of alternative emissions-control strategies are dependent upon the development or improvement of models which replicate the behavior of each important "emitting sector" of the economy. These cost estimates must be consistent with methods which have been fully reviewed by the engineering and economic communities. Future estimates of emissions will rely more on actual data and detailed emissions models.

Atmospheric Processes Affecting Acid Deposition

How can the transport, chemical transformation, deposition processes and the exposure of ecologically sensitive areas and man-made materials be determined?

The transport, chemical transformation, and deposition processes associated with acid deposition will be investigated on both the regional and meso scales.

Our understanding of the atmospheric transport, physical and chemical transformation, and deposition processes of pollutants emitted into the atmosphere continues to improve. The program continues to emphasize model development, the collection of field data, and model evaluation to better differentiate the contribution of local versus distant sources of acid deposition. Results from this research will enable policy makers to predict changes in deposition levels resulting from reductions in nearby or distant emissions.

The Regional Acid Deposition Model (RADM) is an assembly of model components (modules or submodels) designed to simulate transport, dispersion, chemical transformation, precipitation scavenging and dry deposition. These modules will be updated and revised as the uncertainties in the processes become better understood and characterized. Field study data will be generated to improve our scientific confidence in RADM. RADM will be used in a number of important areas (e.g., to calibrate Lagrangian models, to assess engineering applicability and cost control, to perform source-receptor analysis, and to assess materials damage).

Dry-Acid Deposition Monitoring

What is the best method to obtain dry deposition monitoring data comparable to that from the existing National Trends Network (NTN) which concentrates on wet deposition?

The acid rain research program has been compiling several years of nationwide deposition data from wet precipitation It is well known, however, that dry sources of acid deposition

in the form of dust and humidity constitute a potentially significant component of total deposition. Very little data exist on this dry deposition due to the difficulty in developing and deploying accurate monitoring instruments. Also, dry deposition rates vary with surface cover and topography, as well as with environmental variables such as wind speed and humidity. As a result, the actual contribution of dry deposition in most areas is only estimated within an order of magnitude.

Prototype monitors do not measure dry deposition fluxes directly. Instead, they measure ambient air concentrations and use empirical factors to estimate the dry deposition rate. These monitors are being deployed in a network, in many cases co-located with wet deposition collectors. Samples are to be collected and analyzed in a central laboratory. The first several years will be dedicated to installing the network and making it fully operational. Once this is accomplished, the research emphasis will shift to developing direct methods of measuring the dry deposition rate.

Aquatic Effects of Acid Deposition

What future changes in surface water chemistry will occur assuming current levels of acid deposition remain constant, and what is the extent and rate-of-change to aquatic resources stemming from acid deposition?

The most pronounced effects of acidification are in sensitive aquatic systems. Acidic deposition is believed to be a major contributing factor in episodic depressions of pH resulting, in some cases, in fish kills and other biological disturbances. Historical assessments have been uneven and of limited utility due to variations in sampling and analytical methodologies, potentially biased selection of samples, variable effects among different aquatic systems and a relatively inadequate data base. The scientific uncertainties surrounding the aquatic effects of acidic deposition fall into several major categories: the extent of sensitive or acidic surface waters in the U.S.; the detection of long-term trends in surface water chemistry; modeling and the biological effects associated with surface water chemistry; and the biological effects associated with surface water acidification. These uncertainties can be expressed in terms of extent, rate, and magnitude of change attributable to acidic deposition.

To reduce the uncertainties related to the aquatic effects of acidic deposition, the EPA, in cooperation with the NAPAP Aquatic Effects Task Group, has undertaken a National Surface Water Survey (NSWS). The NSWS is a field project with three distinct phases to document the chemical and biological status of lakes and streams in regions potentially sensitive to acidic deposition. The Survey also will select

regionally representative surface waters based on chemical, physical, and biological parameters to quantify future changes in aquatic resources through a long-term monitoring program.

The first phase of the NSWS has quantified the chemistry of lakes and streams in areas believed to contain the majority of low-alkalinity waters. This phase of the survey was designed to determine what percentage of lakes and streams in the susceptible regions are acidic or have low alkalinity. Phase II is quantifying the biological components and the seasonal and spatial variability of a regionally representative subset of lakes and streams. These data should explain what percentage of lakes are devoid of fish, what chemical characteristics of surface waters are associated with the presence or absence of fish and what temporal variability can be expected in representative surface waters.

The third phase will define selected lakes and streams as regionally representative sites for a long-term monitoring program to quantify future changes in the chemistry and biology of aquatic ecosystems. The primary objective of this phase is to determine what chemical or biological changes are occurring in regionally representative surface waters and at what rate.

The detection of long-term trends in surface water chemistry is essential in understanding the response rates of natural systems to acidic inputs from the atmosphere and how fast natural systems might acidify due to natural causes. EPA's long-term monitoring program places sites in areas in which there is little or no disturbance from human activities and which are remote from point sources of air pollution. However, their regional representativeness has not been established. The NSWS will determine the criteria for regional representativeness and, in coordination with existing monitoring sites, will improve tracking of the responses of surface waters to changes in acidic inputs in various regions of the country.

One of the most important goals of the aquatic effects program is the production of reliable models of the temporal changes in surface water chemistry due to acidic inputs. A major priority in the modeling of surface water chemistry will be the estimation of the extent of direct response and delayed response systems in the U.S. Response time variations are expected on the basis of soil, bedrock and hydrological differences among systems. Therefore, some watersheds will be in dynamic equilibrium with acidic inputs from the atmosphere and will respond quickly, while others will exhibit significant sulfur retention or contain appreciable buffering capacities and will respond only after long delays. If direct response systems prevail in sensitive areas of the country, then no additional changes in surface water

chemistry would be expected, given no change in present acidic loading rates. However, if delayed response systems predominate, then more waters may become acidic even if current loading rates do not change.

A principal issue driving the debate over acid rain has been the biological effects of acidified surface waters. Preliminary research is expected to establish correlations between surface water chemistry and the status of fish populations. In order to do that, EPA will continue work that has already begun on the dose-response relationships between fish populations and concentrations of toxic metals (such as aluminum) that are thought to be elevated in acidic waters. EPA will continue work on the response of fish populations and other ecological endpoints in artificially acidified lakes as part of several large-scale ongoing or planned studies. These studies will increase the certainty of the actual extent of declines of fish populations and other ecological effects associated with acidic deposition.

A multiplicity of processes within watersheds affect the rate and magnitude of the acidification of surface waters. Watershed bedrock and geology, system hydrology and biological processes are all important determinants of the response of surface waters to acidic inputs from the atmospheres. EPA's research strategy for the next five years is two-fold. First, it will accelerate the process-level research in the geochemical and physical characteristics of soils that are important in the response of surface waters. Second, EPA, in collaboration with other agencies participating in NAPAP, is establishing a network of carefully monitored watersheds in sensitive regions of the country. Data will be collected and analyzed on all relevant physical, chemical and biological parameters associated with surface water quality.

Terrestrial Effects of Acid Deposition

What is the effect of acidic deposition, alone or in combination with other pollutants, on forests?

Forest effects studies in acidic deposition have been focused in the Forest Response Program, jointly funded and managed by the EPA and Forest Service. This program was initiated in 1983 in response to public concern over the role of acidic deposition and air pollutants in forest decline.

The mission of the program is three-fold: (1) to determine if acidic deposition, alone or in combination with other pollutants, are causing or contributing to forest decline in the U.S., (2) if so, to determine the mechanism of effect, and (3) if so, to determine the dose-response relationship of forest response to loadings of acidic deposition, alone or in combination with other pollutants.

To meet the goals of the Forest Response Research Program, research has been organized to include historical data analysis, controlled lab and field experiments, site investigations and monitoring. Research will be undertaken by Research Cooperatives organized by forest type. In areas where phenomena have been reported field investigations and historical review activities will concentrate on examining forest condition in relation to atmospheric deposition and natural factors. These Cooperatives will also sponsor controlled lab and field studies to test hypotheses of damage relevant to forest type and deposition scenario. The Eastern Hardwoods Cooperative and the Western Forest Cooperative will initially undergo exploratory research to identify if further research is needed in these forest types.

The Mountain Cloud Chemistry Program is investigating the mechanisms of tree dieback and reduced growth rates at higher elevations in the East These appear to increase in severity with increasing elevation. To address this research need, monitoring stations are to be established on the slopes and summits of selected mountains and will be co-located with forestry research stations Samples from the network of forest research and monitoring stations will be analyzed and archived by a central laboratory. Development and standardization of monitoring instruments to perform reliably under the physically demanding conditions at these elevations will be required A quality assurance and control program will be implemented to ensure long-term usefulness of these data and their intercomparability among sites.

Materials Damage from Acid Deposition

What is the quantitative relationship between acid deposition and damage to structures, buildings, and other materials?

Qualitative relationships between acid deposition and resulting damage have been identified for a few materials under various conditions of exposure. The issue now is to quantify the rate of damage as a function of acid deposition, and to extend the development of damage functions to other materials. The assessment of the overall impact of acid deposition on materials also requires knowledge of the distribution of exposed building components and the economic behavior of consumers so that an economic loss may be associated with acid deposition materials

Damage functions will be derived from physical chemistry theory, chamber studies and field exposure studies As we improve our understanding of the basic mechanisms of these damage functions, efforts will shift to predictive models of materials damage that will allow accelerated studies in controlled climate chambers. Studies will also be

extended to more complex systems of materials, such as reinforced concrete, brick and mortar, roofing systems, and painted surfaces.

In addition to the development of physical damage functions, it will be necessary to enhance the materials inventory and make estimates of consumer responses to acid deposition. This includes the way in which the end-of-the-service life of the material is determined, as well as the incremental costs of switching to more durable materials.

Summary of Long-Term Trends

The long-term goals of the acid deposition program are to develop a number of products for policy makers including:

- inventories and maps showing the magnitude and extent of receptors that have been affected or could be affected by acid deposition;
- estimates of the rate of change in the extent of effects;
- "target loadings" of acid deposition for different receptors in different regions of the country;
- quantification of the contribution of local versus long-range sources to acid deposition;
- source-receptor models that can indicate which long-range sources or source regions contribute to acid deposition.

One of the major obstacles which has delayed the scientific understanding of the acid deposition phenomenon and the formulation of control or mitigation options for acid deposition is the lack of high quality data from long-term monitoring programs and from continuously-monitored intensive research sites. Several years ago, the acid rain program established a monitoring network for wet deposition (the National Trends Network). This network is just beginning to provide the multi-year data necessary for trends analysis. Efforts are also underway to increase the number of species monitored through the dry deposition network, monitoring of lakes and streams, mountaintop cloud and forest exposure monitoring, and watershed monitoring.

Resource Options

1987 Current Estimate: $ 59.5M
1988 President's Budget: $ 58.9M

	Projections			
Growth	FY 1989	FY 1990	FY 1991	FY 1992
None	58.5	58.5	58.5	58.5
Moderate	60.7	62.5	64.4	66.3
High	62.5	64.4	66.3	68.3

No Growth: The program would proceed as described in this Agenda.

Moderate: Additional efforts would be made to evaluate the Regional Acid Deposition Model through field study data.

High: Additional efforts would be made to understand the linkages between terrestrial and aquatic ecosystems as they relate to acid deposition impacts. The program would accelerate acid deposition research to identify cause/effects mechanisms of forest changes, and expand the number of representative watersheds under study.

Interdisciplinary

The interdisciplinary research program develops risk assessment guidelines and ensures consistent application of these guidelines throughout the Agency. Activities in this area also support the dissemination of scientific and technical data from ORD. Finally, the interdisciplinary research program provides resources to conduct long-range exploratory research through the grants, centers and visiting scientists programs and provide central management, audits and compliance monitoring for the Agency-wide Quality Assurance program.

Major Research Issues

Scientific Assessments

What activities and methods are needed to ensure scientific consistency and technical quality in Agency risk assessments?

The scientific assessment function has three major components: development of risk assessment guidelines, activities of the Risk Assessment Forum, and development of generic test methods which support the risk assessment process The first guidelines were proposed in late 1984 and early 1985, and finalized in 1986. These include guidelines for: carcinogenicity risk assessment, mutagenicity risk assessment, health assessment of suspect developmental toxicants, health risk assessments of chemical mixtures and estimating exposures. In 1987 and 1988, the Agency expects to propose guidelines for assessing risk to the male and female reproductive systems and guidelines on the use of exposure measurements in risk assessment; final guidelines should be issued about a year later. The Agency is planning to develop guidelines for the assessment of systemic toxicants and for the assessment of ecological risk over the next several years. The Agency recognizes that guidelines are living documents, and therefore are subject to revisions and expansions, an effort which will take place in future years as appropriate.

The Risk Assessment Forum was established in 1984. It is a body of senior scientists within the Agency who meet regularly to resolve various scientific issues within the Agency. Its functions include: analyses of significant scientific and science policy issues, development of new risk assessment procedures, recommendations of revisions to the guidelines when appropriate, review of selected risk assessments nominated by top Agency management, and recommendations for risk assessment research.

Development of the generic test methods is also under the auspices of this research committee. These activities identify generic information gaps which will be filled in future risk assessments if the appropriate test methods are developed.

Technical Information and Liaison

What activities facilitate technology transfer to regions, states, and affected local governments?

ORD, as the primary research arm of EPA, provides scientific information needed by the regulatory offices of EPA to develop and enforce regulations. Appropriate and timely dissemination of research results supports the scientific basis for EPA regulations and increases confidence in the decision making process.

The Center for Environmental Research Information (CERI) provides centralized support for the production of information products in a cost effective manner, insures consistent uniform dissemination of research results, and provides a technology transfer program to synthesize information and develop presentations to more effectively support specific high-priority program objectives at the lowest cost to the government.

CERI will continue to provide support to ORD laboratories by writing summaries of research projects conducted by or for ORD, editing documents and summaries, assuring the quality of material submitted for printing, typesetting and producing documents, assuring the quality of and preparing documents for submission to the National Technical Information Service, controlling the distribution of documents, and responding to requests for publications and documents.

The technology transfer program will assess the status of research and regulations, discuss with the Research Committees their priorities for the dissemination of material, develop innovative information transfer mechanisms, and ensure that information on improved technology and management practices is distributed to appropriate audiences to comply with EPA regulations All information on products is developed using a team of participants from ORD, EPA program offices, and private industry.

Planned activities include:

- development of methods manuals for comparing different solid and hazardous waste treatment techniques and implementing those which are appropriate;
- dissemination of the results of research on the control of hazardous air pollutants;

- description of technologies, costs and operating effectiveness of the methods available to meet drinking water regulations; for small drinking water systems; and,
- dissemination of information on the effectiveness, cost, and design of new municipal waste treatment technology.

Exploratory Research Program

How will the Agency conduct longer-range mission-oriented research which is not tied to specific regulatory timetables or program office requirements?

Recognizing the need for a more fundamental understanding of potential or emerging environmental problems, ORD established the Office of Exploratory Research (OER) in 1980. OER's basic function was to establish and manage a program of investigator-initiated, long-range research through grants to qualified investigators and to establish and administer a program of environmental research centers. In addition, OER was responsible for operating a system of peer review for competitively selecting and awarding research projects. To date, through its Research Grants Program, OER has supported over 400 research projects in various priority areas as identified by the Agency's planning mechanisms and ORD's Research Committee process. Through its Research Centers Program, supports research conducted at eight university-based research centers on various topics of priority concern.

Research Grants Program: A primary function of the Research Grants Program is to stimulate extramural scientists to work on EPA's technical problems and to provide a stronger creative base of mission-oriented research needed for the Agency's regulatory and enforcement efforts.

The Research Grants Program solicits investigator-initiated proposals by issuing annually a solicitation document which describes EPA's high priority long-term research needs. The solicitation is broadly distributed and is intended to stimulate scientists in the academic, research and industrial communities to respond with fully developed proposals for innovative research in areas of interest to EPA. Although all valid proposals are considered, the solicitation has typically emphasized research needs in five interdisciplinary program areas: environmental health; environmental biology; environmental engineering; chemistry and physics in air; and chemistry and physics in soils and water. In the future, the emphasis may change to include an emphasis on ORD's major research initiatives.

The grants selection process uses a dual review system of evaluating research proposals. *Ad hoc* panels, chaired by

scientists or engineers from outside EPA, meet at least twice annually to discuss reviews of each proposal conducted by at least three experts in the relevant field. Applications that pass the scientific panel review are then reviewed by Agency personnel for their relevancy to the Agency's mission. The combined recommendations are rank-ordered and the grants are awarded based upon the availability of funds.

Grant support is typically awarded for two to three years and an EPA staff member is assigned as a project officer. Project monitoring is accomplished by the submission of technical progress reports and/or the publication of scientific papers in peer reviewed journals. Staff and formal site visits are conducted when appropriate.

The five interdisciplinary areas of the Research Grants Program are described below.

Environmental Health Research: The major objective of the Environmental Health Research Program is to obtain and provide a scientific basis upon which the Agency can make regulatory decisions concerning the protection of human health from environmental pollutants. The principle concern is to determine whether, and to what extent, exposure to various pollutants contributes to environmentally related health problems. Particular attention in the annual solicitation is on epidemiological studies, animal toxicology, bioassay development and mechanisms of action. Major areas of new emphasis will deal with understanding the mechanisms of inducement of disease and pathology, improving the validity of assays as predictors of potential human risks, and developing better model systems to determine the long-term effects of multi-media pollutant exposure.

Environmental Biology Research: The Environmental Biology Research Program supports a broad range of projects in the areas of ecosystem effects, aquatic ecosystem modeling, biotechnology monitoring, environmental assessment, marine studies and biodegradation in water and soil environments. The aim of the program is to provide a base of scientific knowledge which can be used to identify new and emerging problems and to develop appropriate remedies for their solution. One objective of this program is to provide information that, in combination with exposure data, allows the prediction of the environmental risk of pollution on individual organisms and on ecosystems. The risks include the reduction of productivity in agricultural areas, wetlands, and freshwater and coastal marine ecosystems as well as human exposure to toxic substances through accumulation in the food chain.

During the next five years, emphasis will focus on wetland problems and the development of modeling methods for

predicting the ecosystem effects on wetlands. Another area of focus will be the development of methods for monitoring genetically modified organisms in the natural environment.

Environmental Chemistry and Physics/Water: The Environmental Chemistry and Physics of Water Program supports research leading to basic scientific tools for establishing the levels at which pollutants occur or might occur in the environment under different conditions.

The program includes projects in analytical chemistry, studies on chemical reactions and their rates and on the physics of the movement of pollutants in the water and soil. The resulting tools and information allow the estimation of exposure levels needed for risk assessment. The research also provides possible approaches to the treatment of waste sources. It includes small-scale laboratory studies and large-scale field projects relating to the transport and transformation of pollutants.

This program will emphasize problems related to ground water, sediments and measurement methods. For ground water the emphasis will be on developing the techniques for estimating the parameters used in transport models and in validating the models. In the case of sediments, focus will be on the physics of movement and the capability of sediments to transport pollutants, particularly, heavy metals. Research on measurement methods will continue with some emphasis on methods applicable to sediments and associated substances such as humic materials.

Environmental Chemistry and Physics/Air: The Environmental Chemistry and Physics of Air Program is concerned with the study of the sources, transport, transformation and fate of air pollutants. The program reviews applications dealing with studies on time-space patterns of pollutant concentrations, detailed chemical and physical descriptions of pollutants, mathematical models connecting air pollutants with probable sources, and procedures for investigating the impact of pollutants on human health. The program draws upon the concepts and procedures of physics, chemistry and meteorology using models and measurement methods to develop quantitative description of these phenomena.

This program will emphasize models or other means of connecting air pollutants at a location with the contributing sources, the atmospheric chemistry of polyaromatic hydrocarbons (important toxic compounds) and reliable measurement techniques for detecting the particulates of health significance.

Environmental Engineering Research: The Environmental Engineering Research Program supports more basic fundamental research needed to provide solutions to multi-media pollution control problems outside the scope of the

Agency's response-directed research program. Therefore new, innovative pollution control and waste management techniques are sought to provide cost-effective solutions to complex problems involving air, water, and soils. Areas emphasized include water disinfection, wastewater treatment, water-related process biomonitoring methods, residuals control, and air pollution concerning volatile organic compounds, fine particles, SO_x, and NO_x. Hazardous wastes continue to receive particular attention, especially incineration processes and improved cleanup techniques.

Environmental Research Centers Program: As part of EPA's strategy for approaching long-term research needs, ORD has created the Environmental Research Centers Program to support environmental research in science and engineering. The objective of the program is to support high-quality exploratory research in areas of importance to EPA. It is achieved by providing stable funding to institutions with a demonstrated capability and interest in a major area of research of concern to EPA. The program, which was established in 1980, consists of eight university-based environmental research centers, working in four general areas: (1) industrial and municipal waste abatement and control, (2) pollutant transport and transformation, (3) ecological and biological effects of pollutants, and (4) environmental epidemiology. Each broad area of research is discussed below.

Industrial and Municipal Waste Abatement and Control: Three centers conduct research in this area The Industrial Waste Elimination Research Center (IWERC) focuses its attention on reducing or eliminating the creation of pollutants. Two centers, the Advanced Environmental Control Technology Research Center (AECTRC) and the Hazardous Waste Research Center (HWRC), study the removal of wastes once they are formed. The AECTRC works primarily on the removal of contaminants from dilute waste streams, such as sewage discharges and stack effluents, while the HWRC studies methods to stabilize, detoxify or destroy waste products containing high concentrations of hazardous pollutants.

The principal areas of research at IWERC, listed in order of current priority, are: (1) metals speciation and separation, (2) sorption/ desorption phenomena, (3) particle size and shape control, and (4) process catalysis and control. This priority list is not expected to change significantly, though more emphasis will be placed in the future on process and catalysis control, and on particle size and shape control.

AECTRC has investigated the degradation of low concentrations of organic contaminants in drinking water sources using biofilm systems This work is expected to expand in the future, as is work on the supercritical

extraction of pollutants. Current work on wet air regeneration of powdered activated carbon will be deemphasized. In the area of air pollution, AECTRC will increase efforts on studying the simultaneous collection of submicron aerosol particles, sulfur dioxide and oxides of nitrogen. With respect to the indoor radon activities, a systematic study will be made of the adsorption of radon on charcoal as a function of charcoal type, design parameters of the collection system, and interference from other gaseous species.

The HWRC will continue to emphasize the destruction, separation, and stabilization of hazardous waste constituents, particularly the development of optimal design parameters for complete or nearly complete incineration of combustible organic hazardous wastes. Future research will focus on: (1) the operation and modeling of a full-scale industrial incinerator, (2) in-situ biodegradation of targeted environmental toxins in soil, (3) investigations of the feasibility of rotary kilns as low energy thermal desorbers for soil and solid waste contaminated with organics, and (4) the transport mechanisms involving pure organic phases in the unsaturated and saturated zones below spill and dump sites.

Pollutant Transport: Two centers study the movement and alteration of pollutants in the environment.

The National Center for Ground Water Research (NCGWR), devotes itself to understanding the movement and alteration of pollutants through the subsurface environment. Directly or indirectly, ground water is the major source of the nation's drinking water, but it may be contaminated with pollutants from a wide variety of sources. Efforts to mitigate this contamination are complicated by the extremely slow movement of pollutants underground.

In the next five years, the NCGWR will emphasize studies on subsurface biodegradation and on facilitated transport of trace organic compounds in saturated aquifers. Future studies will deal with microbial metabolism as a process involved in the fate of contaminants The comparative ecology of aerobic microbes as influenced by subsurface parameters such as soil type and electron acceptors will be studied in order to predict and control microbial involvement in the fate of contaminants at hazardous waste disposal sites. Current work on subsurface anaerobic environments will be expanded to include isolation of chemical intermediates and end products. Another new project will be initiated, using state-of-the-art optical techniques, to determine whether sorption of contaminants is dominated by organic carbon or mineral surfaces

The other center, the National Center for Intermedia Transport Research (NCITR), studies the important physical and chemical processes associated with the transport of

particulate or gaseous environmental pollutants from one medium to another. Current and future studies at NCITR will emphasize the movement of hazardous wastes through air, land, or water.

Specific projects at the NCITR will concentrate on five topics: wet and dry deposition, soil and water processes, multimedia transport, ecosystem modeling and structural characterization, and source allocation Plans for research include development of an improved correlation between dry deposition velocity and the roughness layer, determination of the ambient compositions and concentrations of organic pollutants in rain, fog and dew, studies on the chemisorption of halocarbons by clay, and the mitigation of organic pollutants in the unsaturated soil zone. In addition, NCITR will maintain current levels of research on studies to determine the significance of nitrogen-bearing trace compounds in air to nitrogen levels in desert ecosystems, the transfer rate of submicron aerosols to vegetation, and the effects of vegetation on the transfer of atmospheric pollutants.

Ecological and Biological Effects: Research on ecological and biological effects is conducted at two centers: the Ecosystems Research Center (ERC) and the Marine Sciences Research Center (MSRC) The mission of the ERC is to evaluate the state of knowledge on whole biological communities and ecosystems and to investigate its applicability to environmental regulation and management. Research conducted at ERC has been in the areas of ecotoxicity, biotechnology, air pollution effects on forests, plant-pest interactions, and impact assessment for the Hudson River system. The ERC plans to continue its research in all of these areas except research on the Hudson River system which will be phased down ERC plans to develop projects in two additional areas. The first of these, functional classification of ecosystems, has as its eventual goal to classify ecosystems into functional types, both in terms of the natural rates at which processes occur and in terms of their responses to anthropogenic disturbances The other new area of research will be freshwater wetland ecosystems. The purpose of this project is to develop concepts and methods for simplifying assessment of the effects of human-induced changes in hydrology on northern freshwater wetlands.

The objective of research at the MSRC is to increase understanding of processes in coastal marine ecosystems that are of importance in evaluating the effects of pollutant discharges. The primary approach to research at MSRC is experimental, specifically, the use of mesocosms as models for predicting the responses of biological communities in coastal systems to pollutant loadings, and to determine the

fates of pollutants. Such mesocosms fill a gap between laboratory experiments and field observations.

A major shift in research emphasis at MSRC is occurring. Previous studies emphasized the determination of the fates and biological effects of sewage sludge, fuel oil and specific hydrocarbons. These studies were "passive" in the sense that they described impacts of pollutants on coastal systems. In the future, more emphasis will be placed on studies whose objective is to recommend methods for control of unsightly, odorous coastal waters, rather than simply predict the occurrences of such events. As a start, MSRC has initiated a program to determine the efficacy of silica enhancement of ocean outfalls to control the explosive growths of phytoplankton (e.g., red tide) often associated with mephitic waters. Another major effort will be a field program to evaluate the state of Narragansett Bay with respect to a number of environmental features related to pollution or other anthropogenic effects. This effort is being carried out in cooperation with other studies of pollutant inputs, shellfish health, bacterial contamination, hydrodynamic modeling, etc., in association with the Narragansett Bay Project, also supported by EPA.

Environmental Epidemiology: The area of environmental epidemiology is addressed by one center, the Center for Environmental Epidemiology. Its primary objective is to improve the theoretical understanding of the human health risks associated with environmental pollution. The center has established four research priorities: (1) problem definition and feasibility assessments for epidemiology studies, (2) research to develop and improve epidemiological methods related to environmental health, for example, research on statistical and analytical methods, (3) research on exposure assessment relevant to epidemiological investigations, and (4) research support to EPA including review of data and reports, and identification of problems where epidemiology can support EPA's mission.

Emphasis will be given to indoor air contamination, where research will focus on inhalation exposures to volatile constituents from water used for purposes other than drinking. A project relating to volatile constituents from shower water will be completed and a new study initiated to determine the source, strengths and dissemination of indoor volatile and gaseous constituents from water and other materials. Plans will be made to extend this project to measurements of organics in exhaled air of humans in homes where environmental exposures have been well-characterized. This research will be a joint project between the University of Pittsburgh and Carnegie-Mellon University.

Efforts will be directed toward better characterization of environmental contamination. Work will be carried out on the development of a passive sampler which has optimal properties for the routine monitoring of airborne vapors at very low concentrations such as are found in the general environment.

Some preliminary investigations will also be made in an area new to the center. This area is characterization of heterotrophic bacteria in air and water and the identification of pathogens. Work here will be exploratory and will be closely coordinated with work being conducted elsewhere in EPA. There is some evidence that these bacteria are important in human respiratory disease

Quality Assurance

How does the Agency assure that its environmental data collection is of high quality?

A significant portion of EPA's budget is spent on collecting environmental data. Quality assurance activities play an integral role in the planning and implementation of environmental data collection efforts and in the evaluation of the resulting data. Quality assurance is the process of assessing whether the data provided by data collectors to line managers is of the quality needed and claimed. Quality assurance should not be confused with quality control (QC); QC includes those activities required during data collection to produce the data quality desired and to document the quality of the collected data (e g., sample spikes and blanks).

The Quality Assurance Management Staff (QAMS) is charged with overseeing the quality assurance activities of the Agency. QAMS came into being in May 1979, when the Agency recognized the need for formalizing an Agency-wide quality assurance program for all environmental data collection activities. More recently, with the issuance of EPA Order 5360.1 in April 1984, the Agency's quality assurance program has been significantly strengthened and broadened. The Order mandates that QA be an integral part of all environmental data collection activities, from planning through implementation and review

In recent years, the Agency's QA activities have focused on identifying the basic elements that are essential to effective quality assurance for environmental data QAMS has put considerable effort into issuing guidance defining and analyzing these key elements The long range outlook for the QA program is a transition from the guidance phase to implementation. During the next several years, QAMS will support all EPA environmental data collection programs in pursuit of the following priorities: 1) quality assurance program plans, 2) data quality objectives, 3) management

systems audits and audits of data quality, and 4) documentation of routinely used measurement methods.

Summary of Long-Term Trends

The scientific assessment activity has three components. risk assessment guidelines, the Risk Assessment Forum, and development of methods for risk assessment The first round of risk assessment guidelines are in place and work on longer term issues well underway. These include development of guidelines for. health assessment of suspect reproductive toxicants, health risk assessment of systemic toxicants, and using data measurements for estimating exposures. The Agency has stated its commitment to continual review of all the guidelines and updating of them as new theories of toxicology or new risk assessment methods become accepted.

The Risk Assessment Forum meets regularly to resolve scientific disputes and recommend new science policies for Agency use. Though many of its analyses are short-term, its work includes longer-term analyses such as development of better methods for low-dose extrapolation in carcinogen risk assessment.

Technology transfer is a continuing responsibility. In response to requests from the EPA program offices and the needs expressed by the regions and the states, ORD disseminates the available technology and technical data to states and localities to enable them to meet their regulatory responsibilities. Technology transfer activities will include the design, production, quality control, and distribution of materials such as design manuals, user's guides, handbooks, and workshops

The goals of the research grants and centers program are to stimulate investigation of emerging environmental problems and identify steps which can predict their occurrence, address exploratory research needs of importance to EPA's mission that require multi-media and multidisciplinary approaches, extend the capabilities of EPA's laboratories, and establish links between EPA and the scientific and technical communities.

Among the areas which will be emphasized in the grants program during the next five years are modeling of wetlands ecosystem effects, the capability of sediments to transport heavy metals, and incineration processes for hazardous wastes. In the centers program, the trend will be to increase research on hazardous waste removal and control, modeling of marine ecosystems, and control of indoor radon.

During the next several years, QAMS will support all EPA environmental data collection programs in pursuit of the following priorities: 1) quality assurance program plans, 2) data quality objectives, 3) management systems audits and

audits of data quality, and 4) documentation of routinely used measurement methods.

Resource Options

1987 Current Estimate. $ 27.9M
1988 President's Budget: $ 22.9M

	Projections			
Growth	FY 1989	FY 1990	FY 1991	FY 1992
None	22.9	22.9	22 9	22.9
Moderate	23.6	24.3	25.0	25.7
High	24.3	25 0	25.7	26.5

No Growth: The program would proceed as described in this Research Outlook.

Moderate: Additional development of new risk assessment methods would be sponsored. Also, solid and hazardous waste technology transfer would be expanded. Additional seminars and manuals would be developed to provide regional and state regulatory enforcement personnel with information on protection of drinking water supplies from ground water contamination and pollutant leaching from surface impoundments. In addition, the process for developing and implementing Audits of Data Quality would be accelerated.

High: Risk assessment support would be provided to offices not normally part of the Research Committee process, for instance, the Office of Policy, Planning, and Evaluation. In addition, a major effort to expand and computerize the data base for routinely used measurement methods would make it more useful and accessible to all Agency users

III. APPENDIX

Interagency Coordination

Reorganization Plan 3, which established the EPA, did not intend that all relevant environmental research be included within the EPA in-house research establishment. The Agency was expected to rely in part on relevant research and development performed by other federal agencies as well as non-federal organizations[1]. Acquiring and integrating such information was considered to be an important function of the EPA R&D operation.

A review of the recent Directory of Federal Laboratory and Technology Resources[1] indicates the breadth of environmentally related research and development being done in the non-EPA federal laboratories. In order to prevent unnecessary duplication of research efforts, awareness of such activities and available information is considered in the development of the EPA research program

In addition, interagency cooperation and coordination is utilized to bring the appropriate expertise to bear on environmental problems. Interagency committees and interagency agreements are techniques utilized to effect the communication and coordination

The Office of Research and Development presently has active interagency agreements with the following agencies*:

- Department of Agriculture (measurements, ecology, health, engineering)
- Department of Defense (measurements, engineering)
  - Army (measurements, ecology, health, engineering)

    Army Corps of Engineers (engineering, measurements, ecology)
  - Navy (engineering, measurements)
  - Air Force (engineering, measurements, ecology, health)

[1] Directory of Federal Laboratory and Technology Resources, 1986-1987, PB86 100013, Center for Utilization of Federal Technology, U S Department of Commerce, NTIS, 1986

* Disciplines and/or areas of cooperative agreement are inserted parenthetically

- Department of Commerce (measurements, ecology, health, engineering)
  - National Bureau of Standards (measurements)
  - NOAA (transport and fate)
- Department of Energy (engineering, assessment, measurements, ecology)
- Executive Office of the President (measurements, exploratory research)
- Department of Health and Human Services (ecology, health, engineering)
- National Aeronautics and Space Administration (health, ecology)
- Department of the Interior (measurement, ecology)
- National Science Foundation (exploratory)
- Tennessee Valley Authority (ecology, measurement)
- Department of Transportation (engineering)

Examples of the interagency committees on which EPA/ORD is represented include the following:

- Interagency Committee for Stratospheric Ozone Protection
- Task Force on Environmental Cancer and Health and Lung Disease
- Interagency Committee on Indoor Air Quality
- Committee on Ocean Pollution Research, Development, and Monitoring
- National Acid Deposition Assessment Program
- Biotechnology Science Coordinating Committee
- Interagency Advisory Committee on Water Data

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON D C 20460

January 16, 1987

Honorable Lee M. Thomas
Administrator
U. S. Environmental Protection Agency
401 M Street, S. W.
Washington, D. C. 20460

SAB-EC-87-019

Dear Mr. Thomas:

The Science Advisory Board has conducted a series of scientific reviews of Agency research programs that have proven to be a highly useful means of assessing the quality and relevance of existing research, identifying research needs and involving the scientific community in the research planning process. Such reviews have also aided internal communication within the Office of Research and Development (ORD) and between ORD and the program offices.

The specific research programs SAB has reviewed since January 1986 include the following:

- Dioxins
- Biotechnology
- Extrapolation Modeling
- Water Quality
- Ecological Risk Assessment
- Alternative Hazardous Waste Control Technologies
- Superfund Innovative Technologies Evaluation
- Indoor Air Research Plan
- Integrated Air Cancer Project
- Radon Mitigation Program
- FY '88 Budget Proposal for the Office of Research and Development

In addition, the Science Advisory Board is scheduled to conduct scientific reviews for the following research programs later this fiscal year: advances in neurotoxicology, health effects of disinfectants and disinfectant by-products; acid deposition; radon and indoor air; biological control agents; effectiveness of asbestos removal processes; control of water quality in water distribution systems; land disposal; and waste minimization.

The purpose of presenting this information is to inform you that such reviews have focused both the SAB's and the Agency's thinking on research plans and needs to a degree never before achieved through preparation and review of the Five Year Research and Development Plan (Research Outlook). As you know, Congress has required that the Agency provide the SAB with the opportunity to review the Plan. The Board believes that its extensive research program reviews fulfill the spirit and intent of Congress for SAB oversight of the Agency's research program. Comments on specific issues in the five year plan have also been addressed in individual research program reviews.

The Board reiterates its long-standing support of research directed to address problems beyond the immediate regulatory needs of the Agency. It is preparing a separate report on this and other issues as it reviews the proposed research budget for Fiscal Year 1988.

Sincerely,

Norton Nelson
Chairman
Science Advisory Board

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