

COMMITTEE ON ENVIRONMENT AND NATURAL RESOURCES
SUBCOMMITTEE ON TOXICS AND SOLID AND HAZARDOUS WASTES
IMPLEMENTATION PLAN

9/29/94

INTRODUCTION and STATUS

This is a first draft of the implementation plan for the Toxics and Wastes Strategy. This will become Chapter 2 of the combined strategy and implementation plan based on the CENR outline.

The current draft is comprised of four individual implementation plans addressing human health issues, ecosystem issues, risk management, and social/economic issues. The sections each follow the outline specified by CENR, but the plans are not yet complete and are not yet integrated. The path forward is to address the gaps, address comments from participating agencies, and integrate and redraft the plans so that they are more complete and consistent. In order to track the format of the strategy, the human health and ecosystem plans would be integrated under a "risk assessment" section, and risk management and social/economic sections would remain to mirror the strategy.

DRAFT

Revised 9/28/94

CENR Subcommittee on Toxic Substances/Hazardous and Solid Waste
Implementation Plan: Human Health

1. Program Objectives and Plans

The overall program objective is to promote human health and quality of life by preventing and controlling disease, injury and disability related to the interactions between people and their environment. The human environment is defined to include home, work and ambient environments and exposures by all routes (i.e. ingestion, inhalation, dermal contact) and by all media (i.e. food, water and air.)

The means to this goal is through the reduction of scientific uncertainty in predicting and understanding effects of human exposures to environmental agents. This requires the development of biological methods and models to improve scientists abilities to estimate health risks, improvement of human exposure assessment to indicate needs in control methodologies, and better methods to translate these biologic and exposure data into predictive risk assessments for policy decisions. Basic to this ability to understand and appropriately control human health risks is knowledge of the basic mechanisms of how environmental agents interact with biological systems at the organ, cell and molecular levels.

Great progress has been made in this field over the past 25 years. Recent breakthroughs in understanding genetic control of cellular functions has led to a remarkable opportunity to investigate how foreign chemicals might perturb these natural control mechanisms and cause disease. Furthermore, understanding the mechanistic basis of toxicities of model chemicals is leading to the ability to better interpret toxicity tests in laboratory animals (usually rodents) and their relevance to humans and human exposure levels.

It has been estimated that pollution control technologies cost the US economy between \$100 and \$200 billion per year. This level of expenditure must be scientifically justifiable. Unfortunately, much regulation is based upon scanty scientific knowledge and many conservative assumptions in lieu of data and interpretable information. Therefore, support of research efforts to better define what is truly hazardous to human health and therefore what and how much control is needed is an investment which can pay dividends of several orders of magnitude.

The agencies represented on the health working group of the toxics subcommittee of CENR have distinct roles in the process of developing information, data, and knowledge for the purpose of policy decisions relating to human environmental health. The NIEHS is the principal agency of the NIH dealing with the basic biology of the interactions of chemicals and other environmental factors on human systems. The EPA is a regulatory agency with research programs in human and ecological health which directly support their regulatory responsibilities. The CDC and its NCEH, NIOSH, and ATSDR components investigate adverse human health outcomes and their potential association with work place or environmental conditions such as areas near superfund chemical waste sites. The DOE

focuses on the health risks of energy-related agents, providing the basis for more cost-effective solutions for dealing with energy generation and by-products thereof. All agencies have both basic programs biology as well as human population studies investigating associations between exposures and disease. These support the priorities described in the strategic plan by developing the knowledge base used in human health risk policy decisions.

2. New efforts for FY95-96 and Beyond

Environmental health policy is only as good as the scientific foundation upon which it rests. NIEHS' challenge is to maximize the effectiveness of public policy decisions by providing the most complete information on the environmental components of human disease and on the biological mechanisms by which these diseases occur.

The understanding of mechanisms is key to accurately predicting health risks from exposure to environmental agents. Without mechanistic understanding, risk assessors must make assumptions based on data from test exposures of "biological models" (laboratory rodents or cell cultures) to the agent. These are called "default" assumptions, and are usually very conservative. Mechanistic knowledge on metabolism and identity of the actual form of the agent which causes the toxicity can modify the risk assessment dramatically. Although an environmental component for a number of human diseases and dysfunctions can be logically presumed, identifying actual causative or promoting agents has proven difficult. For those disorders with suspected environmental components, increased research efforts are needed to identify these agents and the mechanisms by which they act. Of particular interest are environmental components of women's and children's health, aging, lung diseases, neurological and immune system dysfunction, and cancer. Additionally, it is important to develop clinical research programs that can more readily translate laboratory-based findings into practical human therapies.

Environmental equity is a newly emerging social issue. It refers to the fact that where one works and lives is a matter of choice largely dependent upon socioeconomic factors. Intuitively, one would expect that the poor and politically disenfranchised are at a greater risk of living near hazardous waste sites or working at hazardous occupations. For these reasons they would be more likely to suffer from environmentally related diseases than would those in the middle and upper socioeconomic classes. It is necessary to provide the scientific foundation needed to structure productive public discussions and decisions on issues of social policy. New programs in this area are planned.

The consequences of manmade activities in terms of global warming and ozone depletion is a hotly contested environmental issue. It is important to provide information on health effects expected from climate change and the technologies that arise to circumvent these changes. Research projects include: expected health effects of increased UV light exposures; the toxicologic characteristics of proposed replacements for ozone-depleting chlorofluorocarbons (CFCs); health effects of fuel oxygenators, new metals used in solar cells and batteries, and air pollution. Research programs in these areas are under development.

Other programs planned in the environmental and health effects research and general life science areas are directed towards the broad goals of reducing important scientific uncertainties. These include: improving the predictability of effects in critical areas, such as global climate change and the health risks of energy-related agents, providing the basis for more cost-effective solutions for dealing with environmental protection and remediation, advancing national priorities such as exploiting dual-use technologies, biotechnology and improving health care at a lower cost, and ensuring the safety and health of workers and the public. New emphasis areas include: Greatly improved molecular tools for health risk assessment, and the ability to detect, predict and evaluate the impacts on human health, of exposures to low levels of radiation and energy-related chemicals in the workplace and the environment, including an understanding of the basis of individual susceptibilities; greatly improved understanding and ability to predict the global effects of energy-related emissions on climate and the biosphere; biotechnologically enhanced, medical diagnostic and therapeutic capabilities through integration of molecular biology, computational simulation, genetic engineering, optical, sensor and imaging technologies, nuclear medicine, and easily accessible scientific data and medical information to provide more cost-effective health care; exploitation for practical purposes of diverse and unique microorganisms, such as for environmental bioremediation by microorganisms found at extended depths below the soil surface, or for novel chemical technologies; completed high resolution physical maps of all human chromosomes and development of automated DNA sequencing technologies 50 fold faster than currently possible; advances in structural biology and genome research coupled with information technologies to develop a national information infrastructure for biology and biomedical communities; epidemiologic research focused on prevention of illness and injury, addressing critical scientific questions, and meeting the needs of special populations exposed to the residue of nuclear weapons and nuclear energy production and use.

Other new areas of emphasis include an evaluation of the impact of pesticides on children. This work will focus on characterization of the susceptibility of infants and children to the health effects of pesticides. Emphasis will be on developmental toxicity, reproductive toxicity, neurotoxicity, and immunotoxicity. Dietary exposure, and both immediate and delayed effects will be evaluated. A second new effort will be in environmental hormones. This work will focus on characterization of the effects from environmental exposure to chemicals that interact with the endocrine system. The approach will include human health research, ecological research and monitoring studies. Development and validation of methods and models for use in screening large numbers of potentially hormonally active chemicals is an important part of this research. An effort which will receive increased emphasis should additional resources become available is risk assessment research. Specifically, a comprehensive program has been designed that will address a significant portion of the recommendations made by the National Academy of Sciences in its report Science and Judgment in Risk Assessment.

The relative level of research, development, and evaluation efforts will be increased in the areas of national surveillance of occupational and environmental disease and disability; psychosocial factors and work organization as they relate to occupational disorders;

engineering control technologies and other preventive interventions; epidemiologic attention to high-risk communities, including inner-city urban poor, and the population along the U.S.-Mexico border; and the impact of health services and their delivery in the workplace. A national clearinghouse for birth defects data is planned, as is an increase in the support of extramural research programs.

3. Challenges

Understanding the environmental components and basic biology of disorders can lead to prevention and intervention strategies to circumvent many adverse health effects. Traditionally these strategies have focused on primary prevention techniques such as eliminating or reducing environmental exposures. These techniques will continue to be important parts of the nation's environmental health programs. An integral part of this program is the development of the science that will enable risk assessors to determine how much reduction of exposure is needed to protect public health. Generating risk assessment levels relies strongly on rodent data and on extrapolation of results in rodents to probable effects in humans. The relevance and power of these assessment schemes will be greatly enhanced when the biological mechanisms for adverse effects are incorporated into the mathematical models used to estimate risks from low exposures.

As we understand the molecular and cellular basis of environmentally induced diseases, secondary prevention and intervention techniques could be developed to treat people following an adverse environmental exposure. These molecular intervention techniques would rely on manipulations of the biological mechanisms underlying environmentally induced diseases, such as activating and inactivating enzymes, receptors, and other molecular components. They would be particularly useful in dealing with environmental exposures that are ubiquitous or difficult to eliminate. They also would have important implications in the pharmaceutical and pesticide industries, which could in the future develop products with maximal effectiveness and minimal side effects based on a structural understanding of underlying biological mechanisms.

Prevention and intervention schemes must also take into account the social and cultural lifestyle and behavioral factors that contribute to environmentally associated disorders. It is part of the federal research agencies' responsibility to provide the scientific foundation that can structure and define discussions on the contribution of societal and cultural behaviors in the development of these disorders.

Training is another part of prevention and intervention strategies. A well-trained medical work force that is able to identify environmental components of diseases will be critical to protecting human health. Equally critical will be providing for a laboratory-based research work force that is both multidisciplinary and multicultural. It is the federal government's role to assure that the country has the human resources necessary to deal with issues in human environmental health.

4. Resources--(Use the budget Matrix)

5. External Input

Each of the participating agencies uses a variety of external input mechanisms including advisory panels, peer review committees, boards of scientific advisors, and interagency coordinating committees. These are numerous and could be listed in an appendix, if required.

6. International dimensions

Each agency similarly has international contacts and agreements which could be described individually in an appendix.

7. Performance measures

Each agency has various performance measure parameters which can be classified as following categories: Program and technical reports, progress toward Year 2000 goals, publications both in the scientific and open literature, participation in hearings and scientific meetings, grants awarded, numbers of individuals trained in various specialties, regulations developed and metrics of chemicals controlled, health status figures, etc.

This is a tough section which requires further guidance before much additional effort is made to develop it.

Appendix-Agency Roles and Current Programs/Accomplishments

National Institute of Environmental Health Sciences: The mission of the NIEHS is to define how environmental exposures affect our health, how individuals differ in their susceptibility to these effects, and how these susceptibilities change with age. To help reduce the burden of environmentally associated diseases, the Institute must provide the science that is necessary for understanding the impact of the environment on human health, translate this information into prevention and intervention strategies, and communicate this information to the American public.

NIEHS-supported research has provided some of the most significant research findings in the environmental health sciences. Examples include:

Lead Exposures: NIEHS-supported studies showed that even low-to-moderate lead exposures can cause learning disabilities and behavioral problems in children. These results galvanized the public health service, Congress and communities to strengthen programs to reduce lead in the environment.

Dioxin Health Risks: Dioxin, a manufacturing by-product that is widely distributed in the environment, is known to cause cancer, reproductive impairment, and other toxic effects. What is less certain, however, is the relative potency of its effect in people. NIEHS scientists provided the quantitative and qualitative information that was pivotal in EPA's determination of allowable dioxin levels that would protect the public health. This work also illustrated the power of mechanistically based data in developing relevant regulatory standards.

Testing Program: Through its participation in the National Toxicology Program (NTP), NIEHS has made significant contributions in providing state-of-the-art toxicological characterization for a host of commercially important environmental agents. Because of the irrefutably high quality of these studies, they serve to guide risk assessments both in this country and abroad. Additionally they are an outstanding resource for evaluating the usefulness of short-term assays and mathematical prediction schemes.

Basic Research: Studies at NIEHS have provided important insights into the basic mechanisms of chemical toxicities, including mutagenesis and the role of oncogenes and tumor suppressor genes in chemical carcinogenesis. Another area of emphasis has been the action of exogenous estrogens, especially as they affect development and hormonal carcinogenesis. NIEHS-supported studies on the mechanics of such processes as cellular signalling, cellular differentiation, and cellular aging enable us to better understand the actual mechanism by which environmental agents can cause disease.

Environmental Protection Agency: The overall goal of the EPA's human health effects research program is to improve the biological basis of health risk assessment by working at

the interface between basic and applied research. The focus is on developing the biological methods, models and data needed to improve EPA's ability to estimate health risks. Human exposure assessment research is designed to provide cost-effective methods for sample collection and analysis, measurement and monitoring programs to assess past trends and current status of population exposures, and predictive models, to characterize and predict past, present and future exposures to important pollutants. Human risk assessment methods research is focused on developing animal toxicologic and human clinical physiologically-based pharmacokinetic models, and biologically-based dose-response models.

Ongoing efforts include highly targeted research efforts in the following areas to address certain specific environmental issues (i.e. environmental releases of biotechnology, drinking water pollution and disinfection, and bioremediation) as well as research which cuts across many specific environmental problems (e.g. research to improve health risk assessment).

Neurotoxicity research is designed to understand neurotoxic effects of disinfection byproducts, environmental factors in neurodegenerative diseases, neurotoxicity extrapolation, significance of cholinesterase inhibition, and mechanisms of neurotoxicity, and to develop in vitro and in vivo neurotoxicity test methods. Developmental and reproductive toxicity research is designed to understand the developmental effects of disinfection byproducts, principles of developmental and reproductive toxicity, and evaluating and improving methods for detecting reproductive and developmental toxicity. Immunotoxicity research includes studies designed to develop protocols to assess infectivity, pathogenicity and immunotoxicity, and to improve interpretation of immunotoxicity data. Cancer research includes performing bioassays of selected water pollutants, evaluation of genotoxicity of bioremediation byproducts, and research on cancer extrapolation. Research which cuts across scientific discipline is aimed at understanding the pharmacokinetics of disinfection byproducts and metals, development of physiologically-based pharmacokinetic models, dioxin reassessment research, molecular modeling research, biologically-based dose-response research, developing epidemiology biomarkers for human studies, evaluating the health of pesticide applicators, and performing epidemiology studies on humans exposed to chemicals and microbes in water. Exposure assessment research includes development of methods and models for assessing exposure from multiple pathways (inhalation, dermal, ingestion). In addition, research is being performed to develop biomarkers of exposure, to quantify "microlevel" activities that are relevant to ingestion and dermal contact, and to develop approaches for integrated exposure assessments. EPA's highest priority for human exposure research is to design and implement a national and regional human exposure monitoring effort to measure status and trends in human exposure (NHEXAS).

Department of Energy: The Department of Energy is entrusted to contribute to the welfare of the Nation by providing the technical information and the scientific and educational foundation for the technology, policy, and institutional leadership necessary to achieve efficiency in energy use, diversity in energy sources, a more productive and competitive economy, improved environmental quality, and a secure national defense.

DOE has contributed significantly to progress in health science. It has promoted the groundwork for new disciplines that offer fresh approaches to important problems. Under the programs of DOE's predecessors, radiobiology, radioecology, and health physics matured together with nuclear medicine, which aimed at applying new tools of radiation and radioactivity to the relief of human suffering. Genetics and biology were enriched with powerful techniques and devices, allowing scientists to delve into increasingly deep levels of biological organization, to uncover the molecular events responsible for biological damage, and to provide insights into repair and recovery processes. Extensive studies on human populations exposed to radiation, especially A-bomb survivors in Hiroshima and Nagasaki and radium-dial painters, have provided quantitative estimates of human cancer risk from this source. These estimates are much more precise than the assessments for any other environmental carcinogen. Databases, research designs, and models developed during decades of atmospheric, terrestrial, and aquatic research continue to yield dividends in time and money saved. Measurement concepts and devices such as flow cytometry, positron emission tomography, and resonance ionization spectroscopy, in concert with advances in lasers and new isotopes, are used in a broad range of applications. These applications aim to produce human gene libraries, study genetic disease, detect DNA lesions produced by carcinogens, and distinguish mental disorders, and coronary bypass candidates in the elderly as well as to measure oceanic circulation and date groundwater for waste isolation. Begun in FY 1987, the Human Genome Initiative is widely recognized by the scientific community here and abroad because it addresses one of modern biology's most significant challenges.

Centers for Disease Control: The CDC agencies (NIOSH, ATSDR and NCEH) promote health and quality of life by preventing and controlling disease, injury, and disability related to the interactions between people and their environment, both inside and outside the workplace. This is accomplished by investigating the properties of toxic substances and other environmental hazards; by investigating adverse human health outcomes and their potential association with workplace or environmental conditions; by implementing or recommending to appropriate regulatory agencies strategies to prevent or mitigate adverse outcomes; and by building the infrastructure necessary to achieve these goals. Activities include: Evaluations of environmental and workplace hazards, including rapid response investigations of disease outbreaks; intramural and extramural research to characterize anthropogenic and natural toxicants; recommendations for appropriate regulatory actions to protect human health; assistance to and collaboration with federal, state, and local authorities; and support of risk communication, training, and education programs for the general public, workers, and professionals. Risk assessment is used as a tool to describe the extent of risks, and research is supported to develop new or improved risk assessment techniques.

NIOSH has a statutory relationship with the DOL Occupational Safety and Health Administration (OSHA) and Mine Safety and Health Administration (MSHA) whereby NIOSH conducts research into workplace hazards and makes science-based recommendations to DOL for workplace standards. As a result, NIOSH makes numerous recommendations for regulatory actions and frequently participates in rule-making proceedings. NIOSH has a statutory right of entry to investigate alleged workplace hazards

that results in over 600 health hazard evaluations annually; it carries out legislatively mandated medical surveillance programs for underground coal miners; and it administers a national testing and certification program for industrial respiratory protective devices.

ATSDR's public health activities are required at hazardous waste sites proposed for, and those that are listed on, the Superfund National Priorities List, and sites that are the subject of a petition from the public, under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA). ATSDR also conducts public health activities under the Resource Conservation and Recovery Act (RCRA), the Medical Waste Tracking Act of 1988, the Great Lakes Critical Programs Act of 1990, the Clean Air Act of 1990 and the Housing and Community Development (Lead Abatement) Act of 1992. Roles and accomplishments include public health assessments at over 1,400 hazardous waste sites; health studies on priority health conditions; a National Exposure Registry with four subregistries (TCE, dioxin, benzene and chromium) and a Hazardous Waste Workers Surveillance Project; and a Minority Health Initiative Program to address health-related issues in minority communities where hazardous substances have been released into the environment.

NCEH has developed methods to measure over 200 of the most common toxic compounds in humans. The NCEH laboratory collaborates extensively on studies of health effects of toxicants and has helped to identify new causes of environmental outbreaks of diseases and has assisted in emergency responses. NCEH assisted DOE by developing a national research agenda for radiation and energy related analytic epidemiologic research. NCEH prevention activities are geared to eliminating environmental-related diseases. The Childhood Lead Poisoning Prevention Program combines grants to over 30 States with applied prevention research.

DRAFT

IMPLEMENTATION PLAN

Ecological R&D Supporting Risk Assessment and Management of Toxic Substances and Hazardous Waste1. Program Objectives and Plans

Minimizing and eliminating ecological risk from toxic substances and wastes, in addition to human health risks, is emphasized in many statutes. CERCLA, CWA, RCRA and other environmental statutes call for protection of the environment and for mitigation and restoration where toxic materials have injured the environment. Managing and mitigating the effects is difficult, in part because the sources are multiple and varied, and the effects range in spatial extent and in type of ecosystem affected. Research to support ecological risk assessment must provide the knowledge to predict impacts and differentiate the severity of impacts from different contaminants on different types of habitats. Such research must also develop the capability to identify the critical processes and factors important in the functioning of key populations indicative of ecological health so that mitigative actions are effectively focused. Although many of the general research needs relating to human health are similar as those for ecological health, such as the need to determine the critical mechanisms causing effects and the need to examine non-cancer effects, research approaches differ due to the complexity of the interactions of multiple species and the difficulty inherent in studying non-human populations. The primary goal of ecological research on toxic materials is to identify critical processes or mechanisms in indicator populations for different habitats that effect the sustainability of that population when exposed to toxic materials.

A. Ongoing Efforts

Focused research relating to ecological systems reported under the Toxics Subcommittee is limited. Several agencies are synthesizing information on toxic materials into databases to support different fate, transformation and transport models. In some cases, the models are providing estimates of potential environmental impact based upon contaminant levels known to cause tumors. There is also a limited effort ongoing summarizing screening level benchmarks for ecological receptors at Superfund sites. Using "state-of-the-art science" methods, values are being generated for approximately 100 chemicals in soil, surface water and sediment. Research is ongoing on the risks associated with releasing products developed through biotechnological methods, including genetically modified organisms into the environment. This research includes investigations of some of the mechanisms associated with the biodegradation of toxic materials in order to identify the toxic potential of intermediate degradation products. Research is being conducted on contamination of groundwater and subsurface waters, with special emphasis on dense non-aqueous phase liquids and metals. The combination of improved fate and transport models and innovative, non-intrusive technologies for removing or transforming such contaminants should improve the capability to cost-effectively treat such

September 28, 1994
DRAFT

contaminated waters. Research is being conducted on the fate and transport of pesticides in water and soil, including the developing of a computerized system that allows a variety of scenarios to be constructed to estimate pesticide movement in the environment. A project is being conducted in Chesapeake Bay to determine the importance of aerial deposition in contributing to the observed pesticide levels in the Bay.

Limited research is being conducted on the effects of oil and the recovery of the environment following spillage and associated cleanup actions. Some effort is being spent in improving physico-chemical models that predict the fate, form and behavior of oil and chemical releases and presenting such information in forms that operational personnel can use.

Substantial data are being collected as part of the natural resource damage assessment process to document pathways and effects from historical uses of toxic materials; however, these data are focused on the development of evidence for legal actions, not on the mechanisms controlling ecological effects and recovery.

More detailed descriptions of ongoing agency research efforts are included in the appendix.

B. New or Changed Efforts

Past research has emphasized the direct ecological impacts of conventional toxics; in FY 1996, an initiative has been proposed to study the ecological effects of endocrine disrupter-type chemicals and how their effects are expressed at the ecosystem scale of organization. Investigations of the potential environmental effects from new biotechnology products will be slightly reduced in FY 1996. New work will begin in FY 1995 on the use of magnetic resonance imaging as a non-invasive tool for detecting cancer in field organisms, specifically coastal fish. Models are being developed, beginning in FY 1995, to estimate atmospheric pesticide movement into Chesapeake Bay from agricultural use.

C. Programmatic Milestone/Schedule

Programmatic milestones are linked to the completion of various phases of research or initiation of new initiatives. In FY 1997, there will be field testing of a multiphase flow model for estimating movement of dense non-aqueous phase liquids in subsurface waters. Reports of field investigations documenting the biological, physico-chemical, and geological recovery of oiled sites in Prince William Sound will be published annually. Technical reports and journal articles will be periodically published on other research efforts.

D. Performance Measures, Metrics, Evaluation Criteria

Measures of success or effectiveness are difficult to define, since the success of this research is dependent, in great part, on the usefulness of the product or research results in making management decisions that better protect the environment, mitigate past impacts, or accelerate recovery of the impacted ecosystem. The success of models can be judged on the effectiveness of the

model estimations in predicting contaminant fate, form, concentration and effect. The success of studies on the long term recovery of Prince William Sound can be judged upon the impact that research results have on future spill cleanup actions and the increased focus given to spill monitoring studies on effective parameters to evaluate recovery. The success of all such studies is determined by the impact the research has on managers' decisions and the public's actions relating to toxic materials and wastes, and consequently, the impact on the health of the ecosystem. Other measures of success relate to the effectiveness of coordination of research projects among the federal agencies and with the private and public sectors in a) minimizing duplication, b) building upon knowledge and experience from other projects, and c) combining resources to increase efficiency of effort.

E. Assessments needed

There is a limited amount of research being conducted within the government specifically targeted on the ecological effects of toxics/wastes, contaminant fate and transport, and environmental restoration from toxic materials. A large amount of ecological research that has broad application to toxic materials has been reported under other committee efforts (i.e., Biodiversity or Water Resources Subcommittees). Much of this research is looking at broad trends in contaminant levels in the environment at the national and regional scale. Research on habitats and non-human populations at the smaller scales at which many decisions affecting the environment are made is not receiving much attention.

There is insufficient effort in the area of hazard assessment on determination of effects from toxic substances that affect the maintenance of populations, with an emphasis on chronic, non-cancer effects, and multiple chemicals. Sufficient attention is not being paid to identification of appropriate indicators and methods to allow extrapolation of effects between species. Knowledge of interspecific variability is important. Determination of key biological and chemical "markers" in key species indicating habitat degradation and ecosystem recovery due to toxic chemicals requires more effort. Studies should include identification of critical processes that affect the sustainability, restoration and recovery of key populations. Cost-effective and ecologically sound protocols need to be developed to measure the ecological "health" of a habitat so that impact from toxic materials can be determined before being catastrophic and so that the effectiveness of restoration techniques following remediation can be determined.

In the area of exposure assessment, more effort needs to be spent collecting the field data to improve fate and transport models. Models that better handle the complexity of chemical substances that are frequently encountered at waste sites need to be improved. Processes affecting the bioavailability and bioaccumulation of contaminants and the susceptibility of biota to exposure need to be understood in order to predict the probability of adverse impact.

2. Agency Roles and Accomplishments

Agency research programs on toxic materials and wastes are driven primarily by agency mandates. The Departments of Defense, Energy, Interior and Agriculture are land managers and are thus responsible for wise management, including cleanup of waste sites, of these lands. In addition, the Department of Commerce's National Oceanic and Atmospheric Administration, although not a land manager, is a natural resource trustee for the public along with the Department of Interior of all natural resources and their habitat, regardless of whether occurring on federally owned land. Specific trusteeship is divided between the two departments primarily by geographic location of the resources (i.e., coastal vs. inland). Due to these responsibilities, each department/agency has developed certain expertise which is applied to problems affiliated with the general department mandate.

- The Department of Agriculture's Research Service (ARS) develops knowledge and technology to solve agricultural problems to ensure high quality food and agriculture products while maintaining environmental quality and its natural resource base. Within this context, the ARS is looking at strategies for off-site control of chemical buildup in ground water from agricultural practices, technologies of improving chemical application efficiencies, improved production systems for reducing water quality degradation, and use of agricultural, municipal and industrial wastes to improve soil productivity.
- The Department of Interior conducts research to support its natural resource trusteeship role, to support wise land management in association with its regulatory responsibilities of offshore and onshore minerals development, and to mitigate the result of past waste site practices on Interior lands, such as on Bureau of Land Management lands or in national parks. Much of the research conducted is to increase the knowledge of ecosystem functioning, rather than on specific contaminant issues. That research that is specifically directed at toxic materials and waste sites is primarily to support the cleanup of sites on Interior managed lands.
- The Environmental Protection Agency has an \$89 million research program focused in the Biodiversity Subcommittee of CENR and as contributing research in the Toxics Subcommittee. This program focuses on ecosystems and their stressors and appropriate management actions to lessen such stresses. Toxics is, in some cases, an important stressor that produces stress at the ecosystem level of biological organization.
- The National Oceanic and Atmospheric Administration, as part of its trusteeship role, provides scientific expertise to the EPA on the ecological consequences of the cleanup of CERCLA sites but conducts no research specifically directed at toxic materials problems. NOAA conducts research on oil spill problems as part of its responsibilities under the Oil

Pollution Act and Clean Water Act and to support its technical advisory role during oil and chemical spills defined through regulation.

- The Department of Defense's mission is the maintenance of a ready, capable fighting force. DoD activities such as troop support and training, weapons and equipment research and development, materiel acquisition and maintenance operations all have environmental implications. DoD Environmental Quality Research and Development Program addresses the services' most pressing, often unique environmental problems directly supporting the accomplishment of the DoD mission. DoD has established four focus areas for environmental R & D: cleanup, compliance, conservation and pollution prevention. In addition to this direct funded program, DoD leverages other dollars from related programs (e.g., Strategic Environmental Research and Development Program (SERDP), Defense Environmental Restoration Account (DERA), Legacy Resource Management Program and the Environmental Security Technology Certification Program (ESTCP)) to assist in carrying out its mission.
- One of the major missions of DoE is to conduct focused environmental research and technology development to support environmental restoration and waste management activities. In that context, DoE focuses technology development activities on major DoE cleanup problems to maximize return on investment, utilize a life-cycle systems engineering approach (including total mass balance, economics, transportation, etc.) and maximize commercial and stakeholder involvement.

More detailed descriptions of agency mandates and research programs are included in the appendix.

3. Challenges

There has not been a recognition of, and consequently a commitment to, long term studies to answer some critical research questions, such as ecosystem recovery and effectiveness of different actions in effecting impact. Field studies are essential for validating models and laboratory studies; field studies, however, cannot be accelerated to provide a rapid answer. The complexity of ecological systems and biological variability is a deterrent for many credible studies, but must be coped with if the capability to wisely manage ecosystems is to become a reality. One of the major challenges will be to refocus regulatory actions on environmentally-driven guidance and criteria, rather than on technology driven requirements. Due to the emphasis on criteria that are easy to administer (e.g., numerical standards), research on ecological systems, their ability to assimilate contaminants, the key factors indicating degradation, and appropriate actions for facilitating recovery have not received sufficient attention. There is also the need to improve communication between those who study human health effects and ecologists who study the non-human biological effects from toxic materials, for

hindsight has shown that there are benefits that could be gained from the transfer of research findings and experiences.

4. Resources (submitted separately)

5. External Input

Much of the research is being carried out through contract or grants with the private sector and academia.

6. International Dimension

Research coordination on oil spills is conducted through international biennial workshops specifically focused on increasing the effectiveness of resource expenditures on R & D. International organizations involved in this effort include the International Maritime Organization, and the Commission of the European Communities.

APPENDIX

AGENCY MANDATES, ONGOING AND PLANNED RESEARCH

DEPARTMENT OF AGRICULTURE, AGRICULTURAL RESEARCH SERVICE PROGRAM

The Agricultural Research Service (ARS) is an in-house research arm of the U.S. Department of Agriculture. It has as its mission to develop new knowledge and technology needed to solve technical agriculture problems of broad scope and high national priority in order to ensure adequate production of high quality food and agricultural products to meet the nutritional needs of the American consumer, to sustain a viable food and agricultural economy, and to maintain a quality environment and natural resource base. The ARS has primary responsibility to:

- Provide initiative and leadership in agricultural research;
- Conduct research on broad regional and national agricultural and related problems;
- Conduct research in support of Federal action and regulatory agencies;
- Provide technical expertise to meet national food, food safety, and environmental emergencies; and
- Serve as an agricultural science resource to the executive and legislative branches.

Ongoing Efforts - FY 1994

Modeling Agricultural Processes to Reduce Contamination. A computerized pesticide property database of 235 compounds with 15 property values has been put on-line for every one engaged in modeling pesticide movement in soils. Models have been developed to predict both nitrate and pesticide movement under a wide scenario of water, soil and management conditions.

Bioremediation of Soils using Indigenous and Engineered Microorganisms. A consortium of soil microorganisms has been isolated from a dump site that can rapidly metabolize organophosphate insecticides at other locations. Genes responsible for enzymes that degrade the widely used herbicide Atrazine, the most frequently detected pesticide detected in groundwater, have been isolated and characterized. One goal this project is to move the genes responsible for the initial reactions into more robust soil microbes.

A Comprehensive Nutrient Management System has been developed for on-farm reduction of fertilizer inputs. A new soil nutrient testing procedure has been developed that allows on-site decisions of the exact nitrogen amounts needed to economic crop production, which will avoid overuse currently responsible for high concentrations of nitrate in groundwater.

September 28, 1994
DRAFT

Plants that hyperaccumulate metals reduce soil contamination. Plants are being developed that accumulate large amounts of toxic metals from soils. *Thlaspi caerulescens* is a small perennial herb that can remove zinc and cadmium from contaminated soils. These hyperaccumulators could play an important role in phyto-remediation of soils containing radioactive metals.

Air Sampling indicates that atmospheric deposition is a major pesticide route in the Chesapeake Bay. Extensive land, water and air sampling in the Chesapeake Bay and watershed indicates that aerial deposition is a major route by which many agricultural chemicals enter the Bay. The pesticides detected in air are representative of regional use patterns on the land.

A Waste Disposal Unit Destroys Pesticide Residues in Waste Water. A binary waste disposal unit has been developed that uses initial oxidation of pesticide molecules followed by microbial metabolism of the fragmented molecule offers a unique system for on-farm destruction of pesticide residues in water.

New Efforts

Magnetic Resonance Imaging (MRI) Detects Early Cancer Lesions in Fish. MRI of an estuarine fish species, *Fundulus heteroclitus* (mummichog), is being used as a functional measurement of water quality. The advantage which MRI has over other diagnostic tests, particularly its non-invasive, non-destructive nature, are vital to some studies. It can be particularly effective in chronic studies of the bioeffects of toxins found in water and sediments. Native populations of *Fundulus* occur in shallow water environments up and down both coasts of the United States. Because the range of individual fish is very small (typically 30 meters radius), they make very precise bioindicators. Lesions identified by MRI have been confirmed by conventional pathologic methods including light microscopy.

Modeling Atmospheric Pesticide Movement in the Chesapeake Bay. Based on field volatility studies and air sampling measurements over the Bay, a major cooperative modeling effort is underway to attempt to predict the amount of aerial movement of pesticides into the estuary. ARS, EPA and the University of Michigan will cooperate in this study. The project will be based on Henry's Law Constants for specific pesticides, field volatility measurements, and air samples over the Bay. Soil, weather, and agricultural practices will be examined to determine those conditions that will reduce atmospheric pesticide deposition.

Plant Genes Examined to Reduce Metal Uptake into Plants. Recently, certain agricultural crops have been rejected on the European market because of high cadmium residue. Intensive plant variety studies are underway to detect those species that do not take up significant cadmium residues. Molecular biologists are now trying to isolate the plant gene that control expression of the enzymes responsible for cadmium and several toxic metals into plants. Isolation and

insertion of these genes into economic plant could materially reduce human exposure to these toxic metals.

Precision Farming Systems Using Satellite Data. A new cooperative effort is underway to use remotely sensed data to make major farm management decisions that will reduce environmental pollution. The use of satellite imagery, geographic information systems and global positioning system coupled with variable rate application equipment could revolutionize current farming systems. Future decisions on fertilizer or pesticide use would be facilitated by digitized mapping systems that would precisely place only the needed amount of chemical at the exact location in the field. This precise placement technology would substantially reduce pesticide and fertilizer use.

DEPARTMENT OF ENERGY

The mission of the Department of Energy (DOE) cleanup technology development program is to conduct problem/solution-oriented, focused environmental research and technology development to support environmental restoration and waste management activities. Guiding principles for program implementation include:

- 1) cooperation across DOE offices and other user programs,
- 2) focus technology development activities on major DOE cleanup problems to maximize return on investment,
- 3) utilize a life-cycle systems engineering approach (includes total mass balance, economics, transportation, etc.),
- 4) maximize commercial sector involvement, and
- 5) optimize stakeholder participation.

DEPARTMENT OF COMMERCE, NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION (NOAA)

NOAA is a science agency that supplies environmental information, provides stewardship of living marine resources, oceans and atmosphere; and conducts research to explain the processes of the changing global environment. NOAA's actions demonstrate that sound research must precede and serve management and policy decisions. NOAA's activities relating to toxic materials and wastes are in two areas: spill response and waste site remediation. NOAA has developed a broad expertise on the effects of pollutants in the coastal and marine environments. As part of its responsibility to support the federal On-Scene Coordinator in controlling, mitigating and removing spills of oil and hazardous materials, NOAA, through regulation, provides the scientific coordinator for spills in the coastal and marine environment. Through this coordinator, technical support such as trajectory forecasts; identification of resource protection priorities; fate, transformation and behavior of the spilled substance;

environmental considerations associated with different countermeasures; and the effects of oil and hazardous materials on the environment and its biota is provided. NOAA is also tasked by the Oil Pollution Act to conduct long term monitoring of the environmental effects of large oil spills.

The primary research emphasis is on the effects of different cleanup or countermeasures on the marine and coastal environment, including appropriate monitoring strategies; the fate, transformation, and behavior of oil and chemicals following an accidental release; the recovery of coastal environments which have been impacted by an oil spill; and the integration of different scientific "tools" and technical information to form computerized operational support systems. NOAA's major effort is continuing to study the environmental effects and recovery from the Exxon Valdez oil spill, collecting biological, chemical, and geological data in areas that were cleaned with hot water, high pressure washing; in areas where shoreline berm was removed to the subtidal for natural cleansing; and in areas that received no cleaning. This 10-year program is funded using money provided by Exxon from the Restitution Fund established as a consequence of the spill. NOAA's research program also includes developing computerized tools, including data bases and models, to assist in preparing contingency plans and to support initial response actions.

NOAA's other activity relating to toxic materials is providing ecological expertise to EPA in the cleanup of toxic waste sites. Using CERCLA moneys, NOAA personnel are placed in EPA regional offices in the coastal zone to provide ecological expertise in support of the cleanup and mitigation of effects from hazardous materials releases. Through this network, NOAA more effectively carries out its responsibility as a natural resource trustee by incorporating ecological concerns in the EPA remedial process. No research is carried out through this program.

NOAA also carries out natural resource damage assessments for resources under its jurisdiction which are injured from oil or chemical releases. No research is carried out by this program.

DEPARTMENT OF INTERIOR

US Geological Survey, Center of Environmental Geochemistry and Geophysics is conducting research on the environmental consequences of the mining of certain ore deposition. mineral deposit extraction and utilization result in the physical and chemical dispersion of material over broad areas, which may adversely affect the health and well-being of humans and biota as well as local and regional ecosystems, in order to assess the magnitude of these effects both developed and undisturbed mineral deposits are being studied. Factors such as natural and human-induced processes, such as precipitation, sedimentation, weathering of rocks and soils, floods and landslides, and modern land-use

practices all affect how material from past and present mining activities are incorporated and/or dispersed into ecosystems. Studies are aimed at understanding the geological and geochemical factors that control the natural biotic variability of mineralized areas and of the mobility of elements in the near-surface environment. Studies are also being conducted to characterize the baseline geochemistry of soils, sediments, waters and biota and to develop element signatures for areas that have not been mined. Such signature definition will allow regulatory agencies to quantify the environmental impact of resource development on a region, watershed, or ecosystem.

The U.S. Fish and Wildlife Service (FWS) carries out many of the Department's natural resource trustee roles by evaluating technical documents and applying this knowledge to protecting endangered species, migratory birds, anadromous fish, marine mammals, wetlands and FWS lands. One of the goals of the Service is to prevent the extinction of plants and animals by helping to ensure that a balanced and healthy environment is established and maintained for all living species. Site-specific resource assessment and effects data emphasize detecting toxic substances in the environment, identifying sources, determine exposure pathways, and documenting the effects that toxic chemicals have on plants and animals. The Service maintains a two pronged approach consisting of 1) a national network of field biologists and support personnel, who apply toxicological information to address the myriad of contaminant problems confronting fish and wildlife and their habitat and 2) a program that provides cause and effect information, chemical analysis support, bioassessment tools and techniques, and related technical assistance. The Service responds to contaminant spill, provides technical advice to EPA for the cleanup of hazardous waste sites and implements natural resource damage assessments for resources under its jurisdiction.

To carry out its mandates more effectively, FWS, working with the National Biological Survey, has developed a system to track and report on all contamination investigations from its National Refuges. This system is designed to graphically illustrate the distribution of contaminant levels, transport pathways, and potential effects based upon estimated pollutant concentration levels. This system is being prototyped with the National Biological Survey on the effects of irrigation drainwater on ecosystems in the western U.S.

ENVIRONMENTAL PROTECTION AGENCY

The research program is partitioned into three research components: watersheds research, regional research, and national monitoring and assessment. The focus is ultimately to reduce uncertainty in ecological risk assessment at the watershed, regional and national scales through:

- monitoring the current and changing conditions of ecological resources from which the success for failure of ecosystem management nationally, regionally, and locally can be judged without bias;
- understanding more fully the structure and function of ecosystems to develop improved management options;
- modeling to predict the response of ecosystems to changes resulting from human-induced stress (chemical and non-chemical stress) from which optional ecosystem management strategies can be assessed; and
- assessing the ecological consequences of management actions so that decision makers can best understand their options.

There is also a synthesis effort being conducted in FY 1994 and FY 1995 benchmark screening levels for determining ecological receptors at Superfund sites. An initial suite of 36 chemicals are expected to be done by the end of CY 1994, with the remainder to be done in CY 1995. A total of 100 chemicals will be addressed.

DRAFT

Implementation Plan Managing Risks from Toxic Materials and Wastes

1. Program Objectives and Plans

Reducing risks from toxic substances requires an integrated program of pollution prevention, pollution control, remediation and restoration, all supported with state-of-the-art monitoring systems. The research efforts described in this strategy and implementation plan support a multi billion dollar effort in this area in both the public and private sectors. The stakes are extremely high because of the costs involved and because of the risks currently presented to human health and the environment by toxic substances. Thus, the most efficient and effective means need to be developed to manage these risks. The research programs needed to do that must build on a strong science base and must emphasize rapid field demonstration and commercialization. The programs described in this section by the various federal agencies address these needs.

A. Ongoing Efforts

Federal research and development (R&D) programs in this area are not new. Several agencies have been conducting R&D programs for many years at very significant levels. As a result, a strong foundation exists on which to move forward to achieve the goals set out in this strategy. A major contribution of this plan is to view these programs collectively, and to merge them into an integrated federal effort.

Existing efforts of the major federal research programs are described in the section entitled "Agency Roles."

B. New Efforts

Most of the research priorities in the strategy are being addressed, to a greater or lesser extent, by one or more Federal agencies. This section discusses areas that will be significantly strengthened over the next five years.

● Pollution Prevention

Emphasis will be placed on forming industry/government partnerships to develop a new generation of cleaner production processes, and to maximize use of existing prevention approaches to meet environmental goals. Generally, partnerships will be formed on an industry-specific basis. A representative partnership program is the Environmental Protection Agency's (EPA) Common Sense Initiative. Representatives of the following six industries

have agreed to participate: iron and steel, petroleum refining, electronics, metal finishing, automobile assembly and printing. Additionally, the Department of Energy (DOE) has targeted and identified a broad cross-section of partners from the chemical, pulp and paper, and iron and steel industries. Crosscutting R&D partnerships will also be formed by the Department of Commerce (DOC) National Institute of Standards and Technologies (NIST) through the Advanced Technology Program (ATP). Furthermore, NIST and EPA are launching a new environmental technical assistance program through the NIST Manufacturing Extension Partnership.

● Remediation and Restoration

-- Groundwater contaminant plume containment and remediation is not yet developed to a sufficient level of effectiveness despite significant on-going R&D. What is needed is an all-out coordinated government/industry effort to develop and field-test new approaches that will cost-effectively address confounding issues such as dense non-aqueous phase liquids. This type of effort is not incorporated into '96 budgets requests, and will be developed for FY '97 as a "national 5-year groundwater initiative" with roles and budgets for involved agencies defined and coordinated.

-- Refining its new approach to environmental R&D management, DOE has made a commitment to improve the overall effectiveness of its organizations and programs dedicated to the environmental restoration and waste management of DOE sites and production facilities. In short, DOE plans to utilize the best science and technology available to solve its most challenging environmental problems, including the treatment, storage and disposal of production wastes. In FY '95, DOE is strengthening efforts to communicate, coordinate, and address technology development overlaps more effectively within the agency as well as externally. Specifically, DOE will continue promoting the utilization of an Interagency Environmental Technologies Office (IETO) as an implementing arm for the National Science and Technology Council (NSTC). Initial IETO efforts will focus on addressing strategic guidance being issued by the NSTC Committee on Environment and Natural Resources (CENR), the Committee on Industrial Technology (CIT), and the Joint Subcommittee on Environment and Technology (JSET) which provides a direct linkage between representatives and activities of the CENR and CIT, respectively.

-- A network of national test sites is needed to more rapidly move innovative technologies to commercialization. Hence, the Department of Defense (DoD) will expand its newly established National Test Sites program to provide

controlled sites for the standardized evaluation of innovative technologies, particularly remediation technologies. Closely aligned with this effort is the Demonstration of On-Site Innovative Technologies (DOIT) program developed in conjunction with representatives of DOE, EPA, the Department of Interior (DOI), and the Western Governors Association (WGA).

-- Successful Application of Technologies Developed Through DOI's Clean Streams Initiative by the DOI will restore ecosystems impacted by coal mining operations. Another new DOI initiative is focused on developing and demonstrating methods for characterizing tailings and mine wastes contaminating surface water. In addition, this initiative will demonstrate new controls for acid mine drainage from abandoned coal mines.

-- Cross cutting technology development programs will be critical to developing improved risk management approaches. Ongoing programs include the Strategic Environmental Research and Development Program (SERDP) and the Technology Reinvestment Program (TRP), each being spearheaded by DoD. NIST's the Advanced Technology Program (ATP) is another vibrant program, one that has achieved much success and is projected to further expand in FY 96 and beyond. The newest cross-cutting technology development program is EPA's Environmental Technology Initiative (ETI). ETI was initiated in FY 94 and is targeted to expand significantly over the next eight (8) years.

-- Addressing social and economic issues associated with managing toxic wastes is an important, but relatively low cost, area that will be expanding over the next five (5) years. Environmental justice is one of the driving forces behind agency efforts in exposure assessment and risk management, and further research in these areas is needed. Similarly, improving economic incentives for technology development, including efforts to remove regulatory as well as non-regulatory barriers, is one of the ETI focus areas.

C. Programmatic Milestone/Schedule (To be added)

D. Performance Measures, Metrics, Evaluation Criteria

Agency approaches to program evaluation vary significantly. For example, biannual reporting on several performance measures used within DoD is underway including: (1) military readiness; (2) species diversity; (3) assessment of health and environmental risks; (4) resource expenditures; (5) projected versus actual costs; (6) assessment of ecosystem improvement or degradation; and (7) stakeholder perceptions impacting environmental technology development.

For cleaning up weapons manufacturing sites, DOE will use five (5) performance measures to gauge progress and document FY 1996 environmental research and technology development activities. These measures include: (1) number of improved technologies/systems (bench-, pilot-, or full-scale) demonstrated that address major environmental problem areas facing DOE; (2) number of improved technologies/systems available for transfer; (3) number of improved technologies/systems included in final decision documents at DOE sites; (4) percent of technology budget directed to the private sector; and (5) cost savings through implementation of new or improved technologies.

Within DOC, early benefits associated with standards development shall include improved environmental assessment and monitoring (where there is immediate need for standards harmonization) and advanced measurement science to facilitate international trade and to support decisions on environmental issues. In FY 1996, expertise in measurements, standards, and data will be applied to assist industry while Federal agencies will be supported in assessing environmental quality and monitoring changes through development of standards, databases, and advanced measurement methods. Collectively, government and industry representatives will form collaborative partnerships to optimize processes for more sustainable technologies.

DOI activities will focus on demonstrating new characterization methods for public lands, and a guidance document governing such activities is planned for release in FY 1997. Additionally, acid mine drainage technologies will be demonstrated in FY 1996. A framework for a predictive methodology will be developed to assist regulatory agencies in assessing mine drainage potential of new mine sites.

2. Agency Roles and Accomplishments

DOE, DoD, DOC, DOI and EPA are the principal agencies with roles in R&D for risk management for toxic materials and wastes. The roles of these agencies are summarized briefly below and explained more fully in Appendix A.

The mission of the DOE environmental technology development program is to conduct problems/solution-oriented focused environmental research, development and demonstration to identify and advance new cleanup technologies capable of supporting environmental restoration and waste management activities. Guiding principles for program implementation include: 1) Cooperation across DOE Offices and other user programs, 2) Focus technology development activities on major DOE cleanup problems to maximize return on investment, 3) Utilize a life-cycle system engineering approach, 4) Maximize commercial sector involvement,

and 5) Optimize stakeholder participation. This mission is consistent with the environmental vision of the CENR R&D Strategy to understand, prevent, reduce, or eliminate human and ecological exposure to toxic materials and their adverse human health, ecological, social, and economic consequences.

DoD's overriding mission is the maintenance of a ready, capable fighting force. Activities such as troop support and training, weapons and equipment research and development, material acquisition, and maintenance operations, however, all have environmental implications. Hence, DoD has taken a leading role through its Office of Environmental Security (DUSD-ES) and Office of the Director for Defense, Research and Engineering (DDR&E), respectively, to ensure its mission is accomplished in compliance with all applicable environmental laws, regulations, and policies.

DoD is also overseeing the growth and development of the National Sites program, and has taken a lead role in a number of activities including: standardization of evaluation and testing methods for technologies; and coordination with other Federal agencies and offices to establish new procedures and criteria for the validation and certification of technologies.

NIST laboratories and facilities are ideally poised among Federal laboratories to contribute to technology development efforts because its wide-ranging mission encompasses enhancing U.S. industrial competitiveness through technology development as well as taking a leading role in providing unbiased, authoritative measurements, calibrations and quality assurance. In addition, NIST's broad-based expertise allows it to make substantive contributions to Federal activities directed at solving environmental problems. By building on its past successes (e.g., industry-government collaborations supporting cooperative research and development programs, the Manufacturing Extension Partnership (MEP), and ATP), NIST can help industry improve the environment while enhancing competitiveness and creating jobs. In addition, the NIST program builds on existing strengths in all aspects of environmental technology R&D.

EPA is the only Federal agency whose mission is specifically focused on the protection of human health and ecological systems from risks associated with pollutants. EPA strives to base this protection on high quality science and innovative solutions. For example, the agency has developed specific environmental goals in thirteen (13) areas including the following: clean air; clean water; cleanup of contaminated sites; ecological protection; improved understanding of the environment; prevention of waste and harmful releases; safe drinking; safe food; ecosystem protection; environmental justice; pollution prevention; strong science and data; and partnerships and environmental accountability. EPA has thirteen (13) R&D laboratories focused

on broadening or establishing the science base, and developing and evaluating innovative technology to support individual programs.

3. Challenges

Regulatory barriers impeding the demonstration and validation of innovative technologies are major constraints facing technology developers. Without public acceptance or regulatory permits, innovative environmental technologies cannot be implemented. Standard cost and performance data are issues, as well as standardized criteria and technology certification by regulatory agencies. Regulatory and stakeholder acceptance of technology demonstrations and results validation is also costly and time consuming. Furthermore, uncertainties in regulatory provisions and difficulties in securing public acceptance are reasons why innovative environmental technologies are not easily transferred to industry for commercialization. Significant regulatory reform, coupled with increased emphasis on stakeholder partnerships, is needed to provide relief.

Environmental liability associated with government R&D contracts with industry is another major institutional barrier constraining the acceptance and application of environmental technologies. Because there is no uniform liability provision governing federal agency sponsorship of environmental technology development activities, there is confusion and concern throughout industry that actual and/or potential gaps in coverage will inhibit or actually prevent the successful demonstration of innovative technologies produced by industry on Federal sites. Small firms especially fear massive adverse impacts from liability claims.

Funding constraints are also a major barrier limiting cost-effective treatment of coal acid mine drainage and adversely impacting overall responsiveness to meeting critical requirements. In addition, technology gaps and downsizing of laboratories promise to inhibit program responsiveness, and individual land management agencies will lack adequate access to characterization methodologies and restoration technologies for remediating public lands and their respective ecosystems and water resources.

4. TO BE ADDED

5. External Input

Stakeholder partnerships between interested and affected individuals and groups are essential to successful implementation of the National Environmental Technology Research Strategy. Agency relationships with stakeholders are being strengthened. Valuable assistance is provided by various groups, including: Environmental Management Advisory Board, National Governors'

Association, State and Tribal Government Working Group, and Site Specific Advisory Boards at respective DOE sites. The Western Governors' Association representing 20 Western states provides advice on stakeholder models for technology development. Stakeholders are assured their input and concerns are addressed; agencies gain maximum benefit from stakeholder participation.

On a related front, an interagency coordination capability, Interagency Environmental Technologies Office (IETO), has been established to provide assistance to Federal agencies charged with coordinating and implementing executive branch and congressional environmental technology initiatives. All federal agencies with waste management cleanup requirements can participate to coordinate research, development, demonstration and commercialization of innovative environmental technologies. IETO plans to communicate and interface with representatives of industry, academia and other private/public sector organizations on environmental cleanup issues. In an IETO forum, innovative solutions to common and/or national environmental cleanup problems can be collaboratively identified and addressed.

Within DOI, several environmental remediation contractors, State and Federal regulatory agencies, trade associations, private industry, and environmental groups provided input to the revised Hazard Ranking System under CERCLA governing National Priority List (NPL) mining sites. Similar input addressing mine waste issues is anticipated during the Congressional debate on proposed reforms to the 1872 Mining Act Law and the Clean Water Act.

At NIST, interactions with industry are integral to priority setting for measurement and technology needs and improving national standards. Extensive collaboration with other government agencies provides a measurement foundation for mission-related environmental work. Workshops, cooperative research agreements, memoranda of understanding, and agency-wide working groups are commonly used methods of collaboration.

6. International Dimension

International cooperation and collaboration is many faceted across federal agencies. Cooperative projects between the U.S. and Russia address contaminant transport, separations, vitrification, mixed waste, and high-level waste tank remediation challenges.

A number of programs are currently underway to assist NATO members, former Warsaw Pact countries, and others in the evolution of environmental programs. Emphasis is placed on development of environmental technologies, and development of training programs.

International technology transfer activities focus on the identification and import of foreign technologies and includes export assistance for environmental products and services developed by Federal agencies in partnership with U.S. industry.

International coordination activities focus on cooperative efforts by international organizations (e.g., International Atomic Energy Agency) and trade associations to advance international capabilities in environmental restoration and waste management. Cooperative environmental efforts involve, among others, Canada, Bolivia, Peru, Poland, United Kingdom's Health and Safety Executive, Norwegian Petroleum Directorate, Danish Energy Agency, and the National Energy Board.

The measurement infrastructure for national environmental technology will assist U.S.-based industries in introducing innovative environmental technologies into the global marketplace. Measurement methods and reference materials provide the basis for uniform measurements in the chemical, biochemical processing, clinical services, instrument manufacturing, metals-producing, and advanced materials industries.

Appendix A

Agency Roles and Current Programs:

DoD.

The DoD has a well established Environmental Quality Research and Development Program, one that is fully coordinated among the DoD component armed services and commands. The DoD Environmental Quality Research and Development (EQ R&D) Strategic Plan addresses the services' most pressing, often unique environmental problems and provides a framework for the accomplishment of the DoD environmental security mission. The DoD EQ R&D program is an integrated, requirements driven investment strategy that leverages the capabilities of DoD laboratories, selected Federal organizations, and other government agencies. Academic and private industry resources have been and are being developed, and are also leveraged and utilized extensively. DoD environmental technology objectives are based on critical user defined requirements and risk and health assessments. They are organized within the following four (4) DoD EQ pillars:

1. **Cleanup**

DoD technology developments achieved within the Cleanup pillar will reduce remediation costs and quicken the pace of cleanup while protecting human health and the environment. These advances will also provide faster, more cost-effective site characterization and remediation capabilities. Human health risk assessments and exposure models, as well as fate and effects models, will be developed for DoD relevant chemicals.

DoD is also developing a National Test Sites program which will provide controlled sites (i.e., R&D test beds) for the standardized evaluation of innovative environmental technologies. These test sites will be made available for private industry testing as well. In addition to the National Test Site program, DoD is actively participating in initiatives to standardize approaches for the evaluation, verification and certification of environmental technologies. These include the Demonstration of On-Site Innovative Technologies (DOIT) and the Western Governors Association (WGA) technology certification program. The DoD is also an initial sponsor, along with DOE, of an Interagency Environmental Technologies Office (IETO). The IETO provides a forum for the coordination and exchange of information between Federal Agency environmental problem

holders, regulators, industrial partners, and stakeholder groups.

2. Pollution Prevention

Technology developments in the Pollution Prevention pillar will lead to the installation of pollution abatement techniques for all DoD operations and activities. Developments will minimize waste generation and enable DoD to sustain its mission without deleterious effects to the environment or human health.

3. Compliance

Within the Compliance pillar, DoD technology developments will help to ensure continuation of the DoD mission in full compliance with all environmental laws and regulations. Developments will provide a scientific characterization of pollutant and waste behavior so that assessments and policy decisions are based on solid information and understanding. Advances in waste control and monitoring capabilities, as well as assessment tools, will also be pursued and achieved.

4. Conservation

DoD technology development in the Conservation pillar will help to conserve, protect, and enhance natural resources while the DoD mission is maintained. The management of natural resources will provide the realistic training environment in which to exercise and test the capabilities of the military forces. Objectives include protection of biological health and diversity, development of monitoring and assessment tools, protection of threatened and endangered species, and the determination of natural and cultural resource baselines.

Ongoing efforts with DoD include the extensive leveraging and integration of the established direct funded R&D programs with the more recent following initiatives: 1) The Strategic Environmental Research and Development Program (SERDP), an interagency initiative which enhances basic and applied environmental research efforts, 2) The Defense Environmental Restoration Account (DERA) which provides for the risk assessment and cleanup of contaminated sites and active military installations, 3) The Legacy Resource Management Program which targets the accomplishment of conservation stewardship within the DoD mission, and 4) The Environmental Security Technology Certification Program (ESTCP) which enhances the DoD capability to demonstrate and validate innovative environmental technologies and gain widespread regulatory and public acceptance.

DOE.

Many Federal environmental research and technology development programs share the fundamental goal to develop, demonstrate, and deliver faster and more cost-effective innovative technologies/technology systems to the private sector for commercialization to reduce or eliminate the risk to human health and the environment. This goal is consistent with both the Environmental and Health and the Scientific and Health goals specified in the CENR R&D Strategy. Within DOE, an integrated team management structure has been established to ensure the technology development activities remain focused on major environmental management problems. This organizational and managerial framework is designed to improve the effectiveness of the following environmental problem areas (termed Focus Areas): Contaminant Plume containment and Remediation; Mixed Waste Characterization, Treatment, and Disposal; High-Level Waste Tank Remediation; Landfill Stabilization; and Facility Transitioning, Decommissioning, and Final Disposition. Four cross-cutting programs serve the Focus Areas: Efficient Separations; Characterization, Monitoring, and Sensor Technology; Robotics; and Technology Transfer. The following are summaries of the specific efforts addressed in each of the five Focus Areas. These efforts are consistent with and support the R&D priorities described in the CENR R&D Strategy.

1. **Contaminant Plume Containment and Remediation** - The identification and development of cost-effective soil and groundwater contaminant plume assessment, containment, and remediation solutions to meet the cleanup schedule and specific technology needs of the Department of Energy (DOE) complex. Research activities include: R&D, demonstration and scale-up, and integrated assessment.
2. **Mixed Waste Characterization, Treatment, and Disposal** - This concerted effort is to develop, demonstrate, and deliver technologies and treatment systems that can treat DOE's mixed low-level and transuranic waste inventory. Eighty percent of the research activity is focused on demonstration and scale-up, and a specific target is to conduct at least three pilot-scale waste treatment technology demonstrations within the next three years.
3. **High-Level Waste Tank Remediation** - Research and technology development activities focus on the development of safe, reliable, cost-effective methods for characterization, retrieval, treatment, and final disposal of the wastes. The main goal is to eliminate

the risk to human health and environment by demonstrating and delivering innovative technology systems for safe and efficient remediation of radioactive waste-storage tanks. The ongoing activities include the development, testing, and demonstration of technology systems to remediate underground storage tanks and waste safely and cost effectively.

4. **Landfill Stabilization** - The major emphasis is on developing technologies that are applicable across the DOE complex such that they can be incorporated in the appropriate regulatory and compliance decision documents. The basic goal is to demonstrate, develop, and deliver safer, more cost-effective and efficient technologies for the management of landfills and remediation of radioactive and hazardous buried wastes and contaminated soils, especially evaluation of landfill stabilization technologies.
5. **Facility Transitioning, Decommissioning, and Final Disposition** - This near-Term development and demonstration program is aimed at developing and improving technologies and systems for deactivation and decommissioning of facilities and the recycling of contaminated building materials. The main goal is to develop and demonstrate improved processes for facility shutdown and stabilization; surveillance and maintenance; sampling; imaging and characterization; decontamination and dismantlement; and recycling and disposition.

DOC.

NIST has established as major goals (1) enhancement of technological development and commercialization through cooperative research and development with industry, and (2) promoting stewardship of the global environment through monitoring and impact assessment of global oceanic and atmospheric conditions. In assisting industry in the development of sustainable technologies and waste remediation, and developing an environmentally relevant measurements infrastructure, NIST will be accomplishing these goals.

NIST will assist U.S. industry in the development of environmentally-friendly products and processes necessary to achieve sustainable development, and will provide the underlying science infrastructure required for the application of environmental technologies effecting pollution prevention, pollution control, remediation, and monitoring and assessment. Through cooperative research

agreements with industry and other Federal agencies, NIST will develop, implement and transfer to the private sector the necessary reference materials, databases, and associated advanced measurement technologies. These efforts will help to establish and maintain a U.S. leadership role in: reducing pollution and preserving critical resources; decreasing energy consumption; enhancing international competitiveness; securing more jobs; and improving quality of life.

The National Oceanic and Atmospheric Administration (NOAA) is a natural resource trustee for resources and their habitat in the coastal and marine environments. Related to this responsibility, NOAA has developed a broad expertise in the effects of pollutants on these environments. As part of its responsibility to support the Federal On-Scene Coordinator in controlling, mitigating and removing spills of oil and hazardous materials, NOAA (through its National Oil and Hazardous Materials Contingency Plan implementing regulation) provides the scientific coordinator for spills in the coastal or marine environment. Through this coordinator, technical support such as trajectory forecasts; identification of resource protection priorities; fate, transformation and behavior of the spilled substance; environmental considerations associated with different countermeasures; and the effects of oil and hazardous materials on the environment and its biota is provided.

NOAA is also tasked by the Oil Pollution Act to conduct long-term monitoring of the environmental effects of large oil (and chemical spills) to support its operational responses. The primary emphasis is on the effects of different cleanup or countermeasures on the marine and coastal environment including: appropriate monitoring strategies; the fate, transformation, and behavior of oil and chemicals following an accidental release; the recovery of coastal environments which have been impacted by an oil spill; and the integration of different scientific "tools" and technical information to form computerized operational support systems. NOAA's major effort is continuing to study the environmental effects from the Exxon Valdez oil spill, collecting biological, chemical and geological data on areas that were cleaned with hot water, high pressure washing on areas where the shoreline berm was removed to the subtidal, and on areas that received no cleaning. This 10-year program is funded using restitution moneys from the Exxon Valdez settlement. NOAA's research program also includes developing computerized tools to assist in preparing contingency plans and to support initial response actions.

DOI

The problem of acid/metal-contaminated drainage is nationwide and present at many mining and mineral processing sites. Contaminated drainage from mineral wastes typically results from the natural weathering of sulfide-containing minerals and waste rock. Metal contaminated drainage threatens the health of people using these waters and the aquatic ecosystems dependent on them. The proven current remediation technology is perpetual treatment of the water--clearly an expensive and impractical approach for most situations. There is no proven technology at this time to minimize or eliminate contamination before it occurs. Ongoing efforts include the following:

1. In cooperation with the BLM, sites will be identified for characterization and remediation.
2. The results of the medical waste vitrification studies and unit design will be transferred to the waste treatment industry.
3. A demonstration of a pilot-plant to demonstrate remediation of a small arms firing range.
4. The results of studies on the use of hydrologic models and metal dissolution and migration in flooded mines will be used to provide guidance to land management and regulatory agencies on the proper design of flooding systems for the control of mine drainage contamination.
5. In cooperation with state and Federal land management agencies, arrangements will be made for field testing of in situ passive technologies to inhibit the generation of acid drainage at two sites.
6. Development of a comprehensive program to identify and control spilled oil in an aquatic setting through: improving remote detection, identifying better chemical agents for treating and dispersing purposes, establishing capabilities for in-situ burning of spilled oil, and identifying the principal characteristics of spilled oil as it weathers.
7. Continue to establish a scientific basis for regulatory and safety-related techniques applicable to the conduct of offshore deep-water operations.

Accomplishments:

- An arc vitrification system has been used to immobilize wastes from medical waste disposal furnaces. Vitrified

wastes are being subjected to a series of severe leaching tests to assure the immobility of contaminants.

- A comprehensive study of the water quality of impounded water from two mines which were plugged to control ground water contamination has been completed.
- In cooperation with the U.S. Forest Service (USFS), Bureau of Land Management (BLM) and state agencies, promising remediation technologies at remote sites were demonstrated at several field sites convening a range of geochemical and site characteristics. The design and operating experience from these demonstrations will be transferred to other government and private parties interested in addressing metal contamination.
- Laboratory testing and assessment of process economics of several at the source mitigation technologies has been completed.

EPA.

EPA has a broad multi-media R&D program in risk management that spans the spectrum from fundamental research to field demonstration and evaluation. Most of the program emphasis is on applied R&D that either supports specific regulatory activities or leads to the development of more cost-effective, innovative approaches to obtaining environmental improvement. Partnerships with industry, academia and other agencies are an integral part of these R&D programs. EPA views its role as one of a catalyst and leader to encourage, guide and participate in needed development. Specific elements of EPA's risk management program are capsulized below.

• Pollution prevention. R&D focuses on: developing innovative methods and tools, such as life cycle assessment; developing and evaluating innovative technologies and processes; and, outreach and technical assistance. The program is shifting to an industry sector focus. Specifically, a major new technical assistance program for small businesses has recently been launched in partnership with NIST.

• Air Toxic Control. Risk management is a component of a program to identify and measure hazardous air pollutants emitted from major and area sources, to characterize and assess risks, and identify pollution prevention and control techniques.

● Water-borne toxic. Contaminated drinking water presents a significant threat to human health, both domestically and internationally. Small community systems are most frequently out of compliance with existing rules. In addition, additional controls are needed for all systems to deal with problems of disinfection associated with by-products derived from chlorination, lead from distribution systems, and persistent microbial contaminants such as cryptosporidium. EPA's drinking water R&D is developing approaches to reduce risk from these contaminants.

Non-point source run-off and waste water are additional toxic sources that present a risk to human health and ecological systems. Current research efforts in wastewater are being phased out due to the mature nature of the technology and other competing new priorities. Non-point source runoff can best be dealt with through pollution prevention approaches.

● Waste and Remediation. R&D related to hazardous waste is focused to develop and evaluate the performance and cost of technologies to implement RCRA regulatory programs. Resources have been declining due to maturing technologies and competing priorities. Municipal waste R&D has been phased out for the same reason.

R&D on surface and groundwater cleanup continues to be a major priority. Major programs underway include remediation technology evaluation under the SITE program where over 60 innovative technologies have been evaluated and performance verified to date. Innovative technologies have been developed such as based catalyzed dechlorination, and a significant technical assistance effort is in place to assist EPA site managers in selection of innovative technologies for cleanup of Superfund sites. Bioremediation is another on-going priority that has lead to important advances through a series of bench, pilot and field scale projects. A new government/industry partnership called the Remediation Technologies Development Forum is testing new bioremediation and other in-situ approaches at three field test sites. (This is also connected with the DoD National Test Site program). Groundwater clean-up is the highest priority overall, and is being addressed through a broad-based program that includes bioremediation and other approaches. Development and field verification of innovative site characterization technologies is another priority area.

● Innovative Technologies. Development of innovative technologies is one of the highest priorities and crosscuts all environmental media. The Environmental Technologies Initiative was initiated as a Presidential directive in FY

'94 and is expected to grow significantly over the next several years. The program focuses on partnerships with other federal agencies and on support for private-sector development.

● Social and Economic Research. Current R&D efforts in this area are modest. Most current work is focused on pollution prevention, particularly understanding the factors that motivate corporate decision making in this area. Issues related to environmental justice are a new area of research that are expected to grow.

National Science Foundation (NSF).

NSF supports a broad portfolio of fundamental research related to the management of toxic substances. A program entitled "Environmentally Benign Chemical Synthesis and Processing" involves partnerships with the EPA Office of Pollution Prevention and Toxics, the EPA Cincinnati Lab, and the Council for Chemical universities by chemists and chemical engineers, but each project must involve intellectual input from the chemical industry. NSF-supported projects related to the management of toxic chemicals includes research on chemical separations and analysis, development of new analytical instrumentation, development of new catalysts to supplant those based on precious or toxic metals and to improve synthetic efficiency and minimize waste, and new synthetic methodologies which minimize or eliminate the use of toxic solvents and starting materials, and minimize waste.

Two NSF Industry-University Cooperative Research Centers focus on improvements in chemical manufacturing processes, namely the Chemical Process Modeling and Control Research Center at Lehigh University and the Center for Process Analytical Chemistry at the University of Washington. Aims of the Hazardous Substance Management Research Center at the New Jersey Institute of Technology include assisting industry in minimizing, treating and managing hazardous waste, and to furnish technology to identify and remediate hazardous substance spills and burial sites. Researchers at the Center for Plastics Recycling Research at Rutgers University are developing economically viable and environmentally acceptable ways to recycle plastics.

NSF grants support the training of a substantial fraction of future industrial R&D workers who will work on the management of toxic substances. A traineeship grant in environmental chemistry at MIT is both training students and developing appropriate curricula in this area.

DRAFT

IMPLEMENTATION PLAN

SOCIAL AND ECONOMIC ASPECTS OF RESEARCH ON TOXIC SUBSTANCES

1. Program Objectives and Plans

Goals relevant to social and economic effects include:

- To instill a prevention-based ethic in all sectors of society;
- To achieve environmental protection and economic growth simultaneously through government and private sector collaboration;
- To ensure that stakeholders are informed about levels of pollution in their communities and about the risks involved, and that stakeholders are involved in all aspects of environmental decision making;
- To ensure that the benefits and costs of environmental protection are shared appropriately by all segments of society;
- To collect the needed data and develop evaluative methodologies for assessing the social and economic consequences of pollution and environmental regulation.

A. Ongoing Efforts

Most of the relevant ongoing research efforts are contributory, rather than focused, with investments in focused research estimated at only \$9M, and contributory efforts at only \$22M, in FY95, amounting to only 0.65 and 2%, respectively, of the total research investment in the province of this subcommittee. The only specific focused efforts which have been reported by the various agencies are:

- DOI is developing models to allow risk-based decisions on the levels of contaminants allowable for the protection of fish and wildlife resources, i.e., to define "how clean is clean."
- EPA supports development of methodological tools to identify, implement and measure the economic benefits of pollution prevention technologies and practices, and sociological research on factors affecting the adoption of pollution prevention and on mechanisms for disseminating information on pollution prevention.
- HUD is assessing public awareness of health risks from lead-based paint, the extent of evaluation and reduction activities in various categories of housing and the extent of disclosure to buyers and tenants. Also being developed is a strategy for hazard reduction through a combination of public enlightenment and hazard reduction. NIST is developing performance criteria for encapsulants and enclosures for hazard reduction.
- While reporting no focused research on the social and

economic aspects of toxic substances, NSF supports research on risk assessment across a broad front. Relevant projects include studies of health-related risk perceptions in distinctive social groups, studies of expert and lay judgments of chemical risks, studies of how prior risk perceptions affect public response to chemical emergencies, a study of whether the cost of some regulations induce more fatalities than the regulations themselves avoid, ranking and rating systems as vehicles for management decisions on cleanup of hazardous waste sites, and development of methodologies for assessment of the cost of compliance with environmental regulations.

D. New Efforts

The only new efforts identified for FY96 are not really research efforts, but rather plans to address issues of environmental justice, to improve communication with stakeholders and the general public, and to provide opportunities for stakeholders to participate in environmental decisions. For example, the Office of Public Accountability of DOE's Environmental Management Program is spearheading efforts to improve stakeholder advocacy, implement Executive Order 12398 on environmental justice, improving Tribal input to environmental efforts related to Native American Communities, and improving communications with stakeholders and the public.

Examination of agency plans reveals important gaps which need to be filled if the goals outlined above are to be achieved. Research priorities listed in the Strategic Plan but not addressed specifically in the agency plans include:

- Development of analytic tools for integrating environmental and economic decisions;
- Development of methodologies and models for assessing the real cost of regulation;
- Studies and surveys relating involuntary risks from toxic materials to socioeconomic factors;
- Studies to identify barriers to commercialization of new environmental technologies and ways to overcome these barriers;
- Development of new approaches to providing the public with quality information about toxic substances in an understandable form, to enable rational rather than emotional responses.
- Development of educational materials and strategies for widespread use of these for alerting citizens, especially low income groups, of the dangers of hazardous materials encountered in their daily lives, such as tobacco smoke, household chemicals, lead-based paint, etc.

C. Programmatic Milestones

Within one year all of the agencies charged with regulatory responsibilities concerning toxic substances and hazardous wastes, and also the agencies with major problems related to contaminated sites (especially DOD, DOE and EPA), are expected to have in place plans for involving stakeholders and the public in decisions and for implementing Executive Order 12898 on environmental justice.

D. Performance Measures and Evaluation Criteria

Agency investments in this area are sufficiently small that performance measures have yet to be developed.

2. Agency Roles

All of the mission agencies are developing plans for ensuring environmental justice and, where appropriate, public involvement in decisions concerning the cleanup of contaminated sites. As a basic research agency, NSF supports research across a broad front in social and economic science, including risk assessment and studies of public perception. While most of this research is not specific to toxic substances, but the methodologies which are developed are applicable in this area.

3. Challenges

The challenges have been covered very well already under the "Management" section.