Office of Energy Research

Notice 97-03
Environmental Management Science Program

Department of Energy
Office of Energy Research and
Office of Environmental Management

Energy Research Financial Assistance Program Notice 97-03;
Environmental Management Science Program

AGENCY: U.S. Department of Energy (DOE)

ACTION: Notice inviting grant applications

SUMMARY: The Offices of Energy Research (ER) and Environmental Management (EM), U.S. Department of Energy, hereby announce their interest in receiving grant applications for performance of innovative, fundamental research to support the management and disposal of DOE radioactive, hazardous chemical, and mixed wastes; the stabilization of nuclear materials and spent nuclear fuel; remediation of contaminated sites; and the decontamination and decommissioning of facilities.

The DOE Environmental Management program currently has ongoing applied research and engineering efforts under its Technology Development program. These efforts must be supplemented with basic research to address long-term technical issues crucial to the EM mission. Basic research can also provide EM with near-term fundamental data that may be critical to the advancement of technologies that are under development but not yet at full scale nor implemented. Proposed basic research under this notice should contribute to environmental management activities that would decrease risk for the public and workers, provide opportunities for major cost reductions, reduce time required to achieve EM's mission goals, and, in general, should address problems that are considered intractable without new knowledge. This program is designed to inspire breakthroughs in areas critical to the EM mission through basic research and will be managed in partnership with ER. ER's well-established procedures, as set forth in the Energy Research Merit Review System, as published in the Federal Register, March 11, 1991, Vol. 56, No. 47, pages 10244-10246, will be used for merit review of applications submitted in response to this notice. This information is also available on the World Wide Web at http://www.er.doe.gov/production/grants/merit.html.
Subsequent to the formal scientific merit review, applications that are judged to be scientifically meritorious will be evaluated by DOE for relevance to the objectives of the Environmental Management Science Program. Additional information can be obtained at http://www.em.doe.gov/science.

DATES: Potential applicants are strongly encouraged to submit a brief preapplication. All preapplications, referencing Program Notice 97-03, should be received by DOE by 4:30 P.M. E.S.T., January 15,1997. A response encouraging or discouraging a formal application generally will be communicated to the applicant within three weeks of receipt. The deadline for receipt of formal applications is 4:30 P.M., E.D.T., April 16,1997, in order to be accepted for merit review and to permit timely consideration for award in Fiscal Year 1997.

ADDRESSES: All preapplications, referencing Program Notice 97-03, should be sent to Dr. Roland F. Hirsch, ER-73, Mail Stop F-240, Office of Health and Environmental Research, U.S. Department of Energy, 19901 Germantown Road, Germantown, Maryland 20874-1290, telephone: (301) 903-5349. Preapplications will be accepted if submitted by United States Postal Service, including Express Mail, commercial mail delivery service, or hand delivery, but will not be accepted by fax, electronic mail, or other means.

After receiving notification from DOE concerning successful preapplications, applicants may prepare formal applications using the instructions in the Office of Energy Research Application Guide and in the Supplementary Information in this notice. Applications must be sent to: U.S. Department of Energy, Office of Energy Research, Grants and Contracts Division, ER-64, 19901 Germantown Road, Germantown, Maryland 20874-1290, Attn: Program Notice 97-03. The above address for formal applications must also be used when submitting formal applications by U.S. Postal Service Express Mail, any commercial mail delivery service, or when hand carried by the applicant. Please note that notification of a successful preapplication is not an indication that an award will be made in response to the formal application.

Awards

Multiple-year funding of grant awards is anticipated, contingent upon the availability of funds. Award sizes are expected to be on the order of $100,000 - $300,000 per year for total project costs for a typical three year grant. Applications for collaborative projects involving several research groups or more than one institution may receive larger awards if merited. Investigators considering submitting collaborative projects are encouraged to prepare a single application incorporating the entire research program and a combined budget as well as separate budgets for each collaborating institution. DOE reserves the right to fund in whole or part any or none of the applications received in response to this Notice.

FOR FURTHER INFORMATION CONTACT: Dr. Roland F. Hirsch, ER-73, Mail Stop F-240, Office of Health and Environmental Research, Office of Energy Research, U.S. Department of Energy, 19901 Germantown Road, Germantown, Maryland 20874-1290, telephone: (301) 903-5349, fax: (301) 903-0567, electronic mail: roland.hirsch@oer.doe.gov, or Dr. Carol J. Henry, Office of Science and Technology, Office of Environmental Management, 1000 Independence Ave. SW, Washington, D.C. 20585, telephone:(202) 586-7150, electronic mail: carol.henry@em.doe.gov.

SUPPLEMENTARY INFORMATION: The Office of Environmental Management, in partnership with the Office of Energy Research, sponsors the Environmental Management

Science Program (EMSP) to fulfill DOE's continuing commitment to the cleanup of DOE's environmental legacy. The program was initiated in Fiscal Year 1996.

Purpose

The need to build a stronger scientific basis for the Environmental Management effort has been established in a number of recent studies and reports. Among the important observations and recommendations made by the Galvin Commission (Alternative Futures for the Department of Energy National Laboratories, February 1995) are the following:

There is a particular need for long term, basic research in disciplines related to environmental cleanup . Adopting a science-based approach that includes supporting development of technologies and expertise could lead to both reduced cleanup costs and smaller environmental impacts at existing sites and to the development of a scientific foundation for advances in environmental technologies.

The objectives of the Environmental Management Science Program are to:
Provide scientific knowledge that will revolutionize technologies and clean-up approaches to significantly reduce future costs, schedules, and risks; and Bridge the gap between broad fundamental research that has wide-ranging applicability such as that performed in DOE's Office of Energy Research and needs-driven applied technology development that is conducted in EM's Office of Science and Technology; and Focus the Nation's science infrastructure on critical DOE environmental management problems.
Representative Research Areas

Basic research is solicited in all areas of science with the potential for addressing one or more of the areas of concern to the Department's Environmental Management program. The scientific disciplines relevant to the program include, but are not limited to, biology (including cellular and molecular biology, ecology, bioremediation, genetics, biochemistry, and structural biology; plant sciences are listed as a separate category below), chemistry (including analytical chemistry, catalysis, heavy element chemistry, inorganic chemistry, organic chemistry, physical chemistry, and separations chemistry), computational sciences (including research and development of mathematical/ numerical, informatics, and communication procedures and software technology, for example for deterministic simulations and optimization), engineering sciences (including control systems and optimization, diagnostics, transport processes, thermophysical properties and bioengineering), geosciences (including geophysical imaging, physicochemical dynamics and chemical transport in fluid-rock systems, and hydrogeology), health sciences, materials science (including condensed matter physics, metallurgy, ceramics, waste minimization, welding and joining, degradation mechanisms, and remote sensing and monitoring), physics (including atomic, molecular, optical, and fluid physics) and plant science (including mechanisms of mineral uptake, intercellular transport, and concentration and sequestration).

Projects in bioremediation that fall within the scope of Notices issued by the Natural and Accelerated Bioremediation Research (NABIR) Program of the Office of Energy Research (such as Notice 97-04) should be submitted to that program rather than to the Environmental Management Science Program. Projects outside the scope of NABIR but within the scope of this Notice may be submitted to the EMSP.

Applicants to the EMSP are strongly encouraged to collaborate with researchers in other institutions, such as universities, industry, non-profit organizations, the DOE National Laboratories, and/or other Federal Laboratories, where appropriate, and to incorporate cost sharing and/or consortia wherever feasible. Applicants are encouraged to provide training opportunities, including student involvement, in applications submitted to the program.

Major Environmental Management Challenges

The following is an overview of the major technical challenges facing the Environmental Management program that are the focus of this announcement. More detailed descriptions of the specific technical needs and areas of emphasis associated with these problem areas can be found in the background section of this Notice.

The Department is the guardian of over 300 large storage tanks containing over 100 million gallons of highly radioactive wastes, which include organic and inorganic chemical compounds, in solid, colloidal, slurry, and liquid phases. The environment within the tanks is highly radioactive and chemically harsh. A few of the tanks have leaked to the environment while others are corroding. The contents of these tanks need to be characterized, removed from the tanks, treated, and converted to safe forms for disposal.

The Department is the custodian of several thousand metric tons of spent nuclear reactor fuels, resulting primarily from weapons fabrication activities during the Cold War, but also including fuel from research and naval reactors. The long-term containment performance of the fuel under storage and disposal conditions is uncertain. Such uncertainties affect the ability to license disposal methods.

The Office of Environmental Management is the custodian of large quantities of fissile materials which were left in the manufacturing and processing facilities after the United States halted its nuclear weapons production activities. These materials include plutonium solutions, plutonium metals and oxides, plutonium residues and compounds, highly enriched uranium, and nuclides of other actinides. Additional scientific information is required to choose processes for converting these materials to stable forms.

The Department currently has on its sites over one hundred sixty thousand cubic meters of waste containing both radioactive and hazardous materials. This mixed waste contains a wide variety of materials, as varied as protective clothing, machining products and wastes, packaging materials, and process liquids. Fundamental scientific data are needed to improve processes associated with treatment systems, such as characterization, pre-treatment, and monitoring.

The Department is committed to the safe disposal of all radioactive wastes, including high-level wastes, mixed wastes, and fissile materials. Safe disposal of these materials requires that the wide range of potential waste streams be converted into insoluble materials for long term storage. Some radioactive material-containing forms have been successfully developed and are being produced; however, at present, research challenges still exist in developing suitable forms for each material to be stored.

The Department is currently conducting cleanup activities at many of its sites, and is preparing plans for additional remediation work. There is much scientific uncertainty about the levels of risk to human health at the end stages of the DOE clean-up effort.

The aforementioned areas of emphasis do not preclude, and DOE strongly encourages, any innovative or creative ideas contributing to solving EM challenges mentioned throughout this Notice.

Application Evaluation and Selection

Scientific Merit. The program will support the most scientifically meritorious and relevant work, regardless of the institution. Formal applications will be subjected to scientific merit review (peer review) and will be evaluated against the following evaluation criteria listed in descending order of importance as codified at 10 CFR 605.10(d).
1. Scientific and/or Technical Merit of the Project
2. Appropriateness of the Proposed Method or Approach
3. Competency of Applicant's Personnel and Adequacy of Proposed Resources
4. Reasonableness and Appropriateness of the Proposed Budget.

External peer reviewers are selected with regard to both their scientific expertise and the absence of conflict-of-interest issues. Non-federal reviewers may be used, and submission of an application constitutes agreement that this is acceptable to the investigator(s) and the submitting institution.

Relevance to Mission. Subsequent to the formal scientific merit review, applications which are judged to be scientifically meritorious will be evaluated by DOE for relevance to the objectives of the Environmental Management Science Program. These objectives were established in the Conference Report for the Fiscal Year 1996 Energy and Water Development Appropriations Act, and are published in the Congressional Record--House, October 26, 1995, page H10956.

DOE shall also consider, as part of the evaluation, program policy factors such as an appropriate balance among the program areas, including research already in progress. Research funded in the Environmental Management Science Program in Fiscal Year 1996 can be reviewed at http://www.doe.gov/em52/science-grants.html.

Application format

Applicants are expected to use the following format in addition to following instructions in the Office of Energy Research Application Guide. Applications must be written in English, with all budgets in U.S. dollars.

ER standard face page (DOE F 4650.2 (10-91))
Application classification sheet (see below for list of categories)
Table of Contents
Project Abstract (no more than one page)
Budgets for each year and a summary budget page for the entire project period (using DOE F 4620.1)

Budget Explanation
Budgets and Budget explanation for each collaborative subproject, if any
Project Narrative (recommended length is no more than 20 pages; multi-investigator collaborative projects may use more pages if necessary up to a total of 40 pages)
- Goals
- Significance of Project to the EMSP
- Background
- Research Plan
--- Preliminary Studies (if applicable)
--- Research Design and Methodologies
Literature Cited
Collaborative Arrangements (if applicable)
Biographical Sketches (limit 2 pages per senior investigator)
Description of Facilities and Resources
Current and Pending Support for each senior investigator

While the original application and seven required copies must be submitted, applicants are encouraged to also provide a 3.5-inch diskette containing the application in electronic format. The label on the diskette must clearly identify the institution, principal investigator, title of application, and the computer system and program used to prepare the document.

Application Categories

In order to properly classify each preapplication and application for evaluation and review, the documents must indicate the applicant's preferred scientific research field and environmental category, selected from the following lists. More than one environmental category may be indicated if desired.

Field of Scientific Research:

1. Biology, not including plant science
Chemical Sciences (2-6):
2. Analytical Chemistry and Instrumentation
3. Catalysis
4. Heavy Element Chemistry
5. Separations Chemistry
6. Other Topics in Chemistry
7. Computer and Mathematical Sciences
8. Engineering Sciences
Geosciences (9-11):
9. Geophysics
10. Geochemistry
11. Hydrogeology: Flow Modeling and Subsurface Science
12. Health Sciences
13. Materials Science
14. Physics

15. Plant Science
16. Other

Environmental Category:

A. Decontamination / Decommissioning
B. Health / Ecology / Risk
C. High-level Radioactive Waste
D. Waste Disposal Forms
E. Fissile materials
F. Spent Nuclear Fuel
G. Subsurface Characterization
H. Subsurface Contaminant Treatment
I. Waste Characterization & Separations
J. Waste Treatment & Destruction
K. Other

Program Schedule

Preapplications must be received by DOE on or before January 15, 1997, and full applications on or before April 16, 1997, at the times and addresses noted above. It is anticipated that awards will be made no later than September 30, 1997.

Program Funding

Up to a total of $20,000,000 of Fiscal Year 1997 Federal funds is expected to be available for new Environmental Management Science Program awards resulting from both this Notice and a parallel announcement to government laboratories and Federally Funded Research and Development Centers, including the DOE national laboratories. All projects will be evaluated using the same criteria, regardless of the submitting institution. The program will be competitive and offered to investigators in universities or other institutions of higher education, other non-profit or for-profit organizations, non-Federal agencies or entities, or unaffiliated individuals. Apart from this notice, the program also will be offered to DOE national laboratories and other Federal laboratories.

Preapplications

A brief preapplication may be submitted. The original and five copies must be received by January 15, 1997, to be considered. The preapplication should identify on the cover sheet the institution, name, address, telephone, fax and electronic mail address for the principal investigator, title of the project, and the field of scientific research and category(ies) of environmental application to which the project is responding (using the list above). The preapplication should consist of up to three pages of narrative describing the research objectives and the plan for accomplishing them, and should also include a paragraph describing the research background of the principal investigator and key collaborators if any. A 3.5 inch diskette

containing the preapplication in any common word processing format may also be submitted in addition to the required printed copies.

Preapplications will be evaluated relative to the scope and research needs of the DOE's Environmental Management Science Program by qualified DOE program managers from both ER and EM. Preapplications are strongly encouraged but not required prior to submission of a full application.

Information

Information about the development, submission of applications, eligibility, limitations, evaluation, the selection process, and other policies and procedures may be found in 10 CFR Part 605, and in the Application Guide for the Office of Energy Research Financial Assistance Program. The Application Guide is available from the U.S. Department of Energy, Office of Energy Research, ER-73, 19901 Germantown Road, Germantown, Maryland 20874-1290. Telephone requests may be made by calling (301) 903-5349. Electronic access to ER s Financial Assistance Application Guide and forms is possible via the World Wide Web at http://www.er.doe.gov/production/grants/grants.html.

Background

The United States involvement in nuclear weapons development for the last 50 years has resulted in the development of a vast research, production, and testing network known as the nuclear weapons complex. The Department has begun the environmental remediation of the complex encompassing radiological and nonradiological hazards, vast volumes of contaminated water and soil, and over 7,000 contaminated structures. The Department must characterize, treat, and dispose of hazardous and radioactive wastes that have been accumulating for more than 50 years at 120 sites in 36 states and territories. By 1995, the Department had spent about $23 billion in identifying and characterizing its waste, managing it, and assessing the remediation necessary for its sites and facilities. Over the next ten years at current budget projections, another $60 billion will be spent. The DOE cleanup of the Cold War legacy is the largest cleanup program in the Federal Government, even larger than that of the Department of Defense legacy. The Office of Environmental Management (EM) is responsible for waste management and cleanup of DOE sites. The EM operations have been historically compliance-based and driven to meet established goals in the shortest time possible using either existing technologies or those that could be developed and demonstrated within a few years. Environmental Management is also responsible for conducting the program for waste minimization and pollution prevention for the Department.

The variety and volume of the Department's current activities make this effort a challenge itself. In some cases, fundamental science questions will have to be addressed before a technology or process can be engineered. There is a need to involve more basic science researchers in the challenges of the Department's remediation effort. The Office of Energy Research (ER) addresses fundamental, frequently long-term, research issues related to the many missions of the Department. The Environmental Management Science Program will use ER's experience in managing fundamental research to address the needs of technology breakthroughs in EM's programs.

This research agenda has been developed for Fiscal Year 1997, along with a development process for a long term program within EM, with the objective of providing continuity in scientific knowledge that will revolutionize technologies and clean-up approaches for solving DOE's most complex environmental problems. The following are descriptions of the technical challenges in addressing many of these issues, in areas which are of particular interest for this notice.

High-level Radioactive Waste Tanks. The Department is the guardian of over 300 large storage tanks containing over 100 million gallons of highly radioactive wastes, which include organic and inorganic chemical compounds, in solid, colloidal, slurry, and liquid phases. The environment within the tanks is highly radioactive and chemically harsh. A few of the tanks have leaked to the environment while others are corroding.

Specific areas of emphasis in technology needs and research challenges related to high-level waste tank problems include, but are not limited to:

The characterization and safe removal of the contents of these tanks, with the contents converted into forms suitable for long-term storage. Particular challenges include the need for improved characterization and separation methods of these wastes, including pretreatment, and methods to reduce the total volume of waste requiring long-term storage, which will reduce the large disposal costs associated with these wastes. Problems exist in the plugging of transport lines, mobilizing waste sludge, leak detection, process control, and conversion to final waste forms.

The separation of complex chemical and radioactive waste to minimize the final volume of high level waste remaining after processing. The removal of liquid from sludges is a difficult challenge. There is not yet sufficient understanding of the factors that control the selectivity and efficacy of chemical and physical interactions, including structure-function relationships, and the effect of particle shapes and kinetics. In pretreatment unit operations there is a need to understand waste behavior and effects at waste processing interfaces, as well as how pretreatment processes affect the ability to transport waste between unit operations. Difficulties also exist in separating radioactive species from high ionic strength, multi-component aqueous solutions of salts dominated by species such as sodium nitrate, nitrite, carbonate, and phosphate. Separation of radionuclides and hazardous substances from solid (e.g. calcined) waste streams is also of interest.

The physical state of the wastes in storage tanks. Some tanks contain distinct layers of sludge, salt cake and supernatant, and these layers may also not be homogeneous. There is evidence that much of the solid waste exists as colloidal particles that may remain suspended, settle out of solution, or gel and solidify with changes in conditions. Fine solids or colloidal particulates can carry a large fraction of contaminant and can interfere with subsequent processing. Important unknown factors which inhibit the remediation of tank wastes include the effects of temperature, pH, particle chemistry and morphology on agglomeration, sedimentation, viscosity, partitioning, dissolution, and speciation.

The optimization of waste conversion processes. The presence of radionuclides results in radiation-induced, high-energy chemical reactions and in waste heating, which can accelerate

chemical reactions. Some of these reactions may be catalyzed by extreme pH conditions and an array of active surface sites on the solids suspended in the waste. These processes lead to considerable variability in the chemical composition of the waste and therefore to difficulties in treatment process design. Some wastes or processes include byproducts which are unacceptable for long-term storage (e.g. organics, nitrates, nitrites, ferrocyanides, nitrogen oxides, chlorinated hydrocarbons) and which therefore must be destroyed or eliminated from the system. Treatment of both acidic and alkaline (up to several molar hydroxide) aqueous solutions is required.

Spent Nuclear Fuel. The Department is the custodian of several thousand metric tons of spent nuclear reactor fuels which resulted primarily from weapons fabrication activities during the Cold War, but also include fuel from research and naval reactors. The long-term containment performance of the fuel under storage and disposal conditions is uncertain. Such uncertainties affect the ability to license disposal methods.

Specific areas of emphasis in technology needs and research challenges related to spent nuclear fuel problems include, but are not limited to:

Mechanisms which may adversely affect the performance of the fuel package during storage must be identified. Deleterious effects which are incompletely characterized include: radiolytic effects of the radiation field on surrounding materials; corrosion, degradation, and radionuclide release mechanisms and rates for the representative fuel matrices; mechanisms which may lead to accelerated degradation of containers; dissolution characteristics of the matrices; and the effects of microbes on fuel packages. Some fuel storage pools have water clarity problems during fuel movement which affect safe operations.

A technical basis is required for other steps in the spent fuel program, including: mechanisms of pyrophoricity and combustion parameters for various fuel types; gas generation during processing; determination of moisture content of fuel and maximum acceptable amount of moisture; degradation mechanisms and kinetics of spent fuel in a dry storage environment over a period of several decades; fissile and radioisotopic content of some spent fuel types; segregation behavior of elements; control of criticality in the very long term; and synergistic effects. Methods to remove moisture without damage to the structure of fuel elements are required.

Some spent fuel types require additional characterization, such as fission and/or gamma ray nondestructive assay or evaluation, before disposal activities can be commenced. Current characterization methods are either extremely expensive or may not yield the necessary information for performance criteria for safe interim storage, transportation, and repository deposition. Thermodynamic and kinetic properties of miscellaneous spent fuel types, such as mixed oxide fuels, are not known to the level of detail needed to include them in a general purpose treatment process. Online measurement of fissile content and nuclear poisons during stabilization must be developed.

Fissile Materials. The Office of Environmental Management is the custodian of large quantities of fissile materials which were left in the manufacturing and processing facilities after the United States halted its nuclear weapons production activities. These materials include plutonium

solutions, plutonium metals and oxides, plutonium residues and compounds, highly enriched uranium, and nuclides of other actinides.

Specific areas of emphasis in technology needs and research challenges related to fissile material problems include, but are not limited to:

Gaps exist in the information base needed for choosing among the alternate processes to be used in safe conversion of various types of fissile materials to optimal forms for safe interim storage, long term storage, and ultimate disposition. Necessary information includes accurate determination of thermodynamic redox potentials and heterogeneous electron transfer kinetics of selected actinides and actinide complexes; characterization of plutonium compound solubility in aqueous phosphate and sulfate media; actinide chemical thermodynamics and kinetics; behavior of mixed oxidation states of plutonium- containing materials; plutonium diffusion and corrosion behavior; the application of acid solution separation processes to neutralized and alkaline residues and wastes; the nature and effect of actinide interactions with organometallics, surfaces, and organic residues; and the performance of various analytical methods, including x-ray tomography, digital radiography, acoustic resonance spectroscopy, and actinide self-fluorescence.

Mixed hazardous and radioactive low-level waste. The term mixed waste refers to waste containing both radioactive and hazardous materials. There is currently estimated to be about 167,000 cubic meters of mixed waste in storage awaiting treatment and disposal. There are over 1,400 different mixed waste streams in inventory, located at 38 separate sites in 19 states. This inventory will be increased with newly generated mixed waste resulting from DOE s ongoing activities in environmental restoration, facility decontamination, and transition processes. Existing treatment and disposal capacities are presently too limited to allow the treatment and disposal of this inventory of mixed wastes. Research at a fundamental scientific level could lead to innovative processes or technologies, or could provide data to permit the advancement of technologies currently under development.

Specific areas of emphasis in technology needs and research challenges related to mixed waste problems include, but are not limited to:

Characterization technologies for non-destructive evaluation of drum and box contents for the presence of materials defined by the Resource Conservation and Recovery Act as hazardous in the waste, and for segregating and routing incoming waste streams to appropriate treatment processes, are lacking. Effluent monitoring must be improved to optimize treatment operations, and to ensure compliance with applicable environmental requirements.

Sorting of the large volume of wastes is impractical without improved nondestructive, noninvasive measurement techniques. Long-term performance of advanced waste forms still must be ascertained. To support equipment design and permitting of high-temperature treatment processes, more information is needed on the thermodynamics, transport and generation of regulated hazardous materials and radionuclides in these processes. Real time monitors for heavy metals, dioxins, and volatile organic compounds are also not available. Alternatively, nonthermal treatment processes could be used, but major technical issues remain unresolved. Methods for direct removal of radioactive material are also of interest.

Monitoring for the presence of mercury and other toxic metals in wastes, and removal of mercury from wastes, are high priorities but large-scale techniques are not yet available. Relative to mercury containing wastes, methods are required for the stabilization of mercury and for the amalgamation of bulk, non-recyclable mercury to meet Universal Treatment Standards and leachability testing standards. Improvements are required in techniques for identifying alpha-emitting radionuclides.

Removal of radioactive components from waste in solid forms. These wastes include sludges from defense reprocessing activities, metals and concrete from decontamination and decommissioning activities, and calcined wastes. Highly radioactive sludges are typically metal oxides with large amounts of potentially soluble materials such as sodium or aluminum. A method for direct removal of the small radioactive fraction of these materials would greatly reduce disposal costs, but such methods are lacking.

Waste Disposal Forms. Safe disposal of radioactive wastes requires that a wide range of potential waste streams be converted into insoluble materials for long term storage. Some radioactive material-containing forms have been successfully developed and are being produced; however, the forms must be developed and optimized for each material to be stored, including high-level wastes, low-level wastes, mixed wastes, and fissile materials.

Specific examples of technology needs and research challenges relating to waste forms include, but are not limited to:

Borosilicate glass is a waste form which is currently used for the storage of some high level waste and is considered a candidate for disposal of other high and low level wastes. It is unclear whether all waste types can be dissolved in borosilicate glass. Many common waste components, such as phosphates, sulfates, and chromates, are thought to have low solubilities. Some extractant materials, such as crystalline silicotitanate, may have limited solubilities as well.

A better understanding of waste form leaching performance is required, including the hydrodynamics of fluids in cracked media, transport phenomena and phase separation at surfaces, and radiation-enhanced dissolution at interfaces. Validated chemical and thermodynamic models are required to predict leaching and gas bubble formation. The structure and bonding of waste components in waste forms, as well as the effect of the waste and the radiation field on stability, solubility, durability, and processing of the host, must be elucidated.

Waste forms for mixed waste which have higher waste loading, improved stability and chemical durability than current forms are required to reduce disposal costs and facilitate waste acceptance. Evaluation of the long-term performance is required to ensure that disposal satisfies stakeholder concerns and regulatory requirements.

Vitrification of certain plutonium-contaminated waste materials may be preferred to cementation due to the lower volume of the final waste form. Vitrification has not been as highly developed for actinide residues or wastes as for fission product wastes. For other actinide wastes, mineral waste forms may be preferred; however, an enhanced technical basis for alternate waste forms

for stabilizing plutonium is needed before mineral compositions can be used as intermediate- and long-term storage materials.

Risk, Quantitative Methodologies, Human and Environmental Health Analyses. There is much scientific uncertainty about the levels of risk to human health at the end stages of the DOE clean-up effort. Research challenges in the area of risk, quantitative, and health analyses include, but are not limited to:

Accurate risk analyses require thorough knowledge of contaminant characteristics, basic ecological processes and principles, rates at which contaminants move through ecosystems, and health and ecological effects. In particular, better knowledge of radionuclide and toxic chemical transport dynamics and the potential effects of long-term exposure to low levels of radionuclides, in combination with other contaminants, is essential.

There is a need for health and environmental research to support adoption of performance standards that present quantifiable criteria for the levels to which high level waste tanks must be cleaned prior to closure.

Research is required to improve understanding of threatened and damaged ecosystems and processes to restore the viability and quality of these ecosystems.

Details of the programs of the Office of Environmental Management and the technologies currently under development or in use by Environmental Management Program can be found on the World Wide Web at http://www.em.doe.gov and at the extensive links contained therein. These programs and technologies should be used to obtain a better understanding of the missions and challenges in environmental management in DOE when considering areas of research to be proposed.

References for Background Information

Note: World Wide Web locations of these documents are provided where possible. For those without access to the World Wide Web, hard copies of these references may be obtained by writing Dr. Carol J. Henry at the address listed in the contacts section.

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National Commission on Superfund Members. Final Consensus Report of the National Commission on Superfund. March 1994. Keystone Center and the Environmental Law Center of Vermont Law School. N/A

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