# REPORT OF THE
# SECRETARY OF ENERGY ADVISORY BOARD'S
# PANEL ON EMERGING TECHNOLOGICAL
# ALTERNATIVES TO INCINERATION

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Secretary of Energy Advisory Board
U.S. Department of Energy

**Secretary of Energy Advisory Board**
**Panel on Emerging Technological Alternatives to Incineration**

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| | |
|---|---|
| AEA | Atomic Energy Act |
| AMWTF | Advanced Mixed Waste Treatment Facility |
| AMWTP | Advanced Mixed Waste Treatment Project |
| CBD | Commerce Business Daily |
| CERCLA | Comprehensive Environmental Response, Compensation, and Liability Act |
| CFR | Code of Federal Regulations |
| DOE | United States Department of Energy |
| DOT | United States Department of Transportation |
| EM | United States Department of Energy's Environmental Management |
| EPA | United States Environmental Protection Agency |
| ES&H | Environmental, Safety and Health |
| FACA | Federal Advisory Committee Act |
| HEPA | High-Efficiency Particulate Air |
| HWFP | Hazardous Waste Facility Permit |
| IDC | Item Description Code |
| INEEL | Idaho National Engineering and Environmental Laboratory |
| LDR | Land Disposal Restrictions |
| MOU | Memorandum of Understanding |
| PCB | Polychlorinated biphenyl |
| R&D | Research and Development |
| RCRA | Resource Conservation and Recovery Act |
| RDD&D | Research, Development, Demonstration and Deployment |
| RFI | Request For Information |
| RWMC | Radioactive Waste Management Complex |
| SAR | Safety Analysis Report |
| SARP | Safety Analysis Report for Packaging |
| SDA | Subsurface Disposal Area |
| SEAB | Secretary of Energy Advisory Board |
| SWB | Standard Waste Box |
| TDOP | Ten Drum Overpack |
| TMFA | Transuranic and Mixed Waste Focus Area |
| TRU | Transuranic |
| TRUPACT II | Transuranic Package Transporter, Model II |
| TSA | Transuranic Storage Area |
| TSA-RE | Transuranic Storage Area Retrieval Enclosure |
| TSCA | Toxic Substances Control Act |
| USNRC | United States Nuclear Regulatory Commission |
| VOC | Volatile Organic Compound |
| WAC | Waste Acceptance Criteria |
| WETO | DOE's Western Environmental Technology Office |
| WIPP | Waste Isolation Pilot Plant |

**REPORT OF THE SECRETARY OF ENERGY ADVISORY BOARD'S PANEL ON EMERGING TECHNOLOGICAL ALTERNATIVES TO INCINERATION**

## Executive Summary


The Panel on Emerging Technological Alternatives to Incineration, a task force of the Secretary of Energy Advisory Board, was created following a dispute over the proposed incineration of radioactive mixed waste at the Idaho National Engineering and Environmental Laboratory (INEEL). The Board asked the Panel to "evaluate and recommend emerging non-incineration technologies for treatment and disposal of mixed waste," including the "waste that the DOE had planned to incinerate in the Advanced Mixed Waste Treatment Facility (AMWTF) at INEEL." The Panel's principal conclusions and recommendations, based on six months of inquiry and much very instructive public comment, include the following:

1. The disposal of mixed transuranic (TRU) waste – containing radioactive material, PCBs and other hazardous constituents – poses a unique problem, and existing regulations were not designed specifically to address such wastes. The principal public concern regarding the treatment of such wastes by incineration and alternative technologies involves the potential release of plutonium. An assessment of technologies for waste treatment should take into account, among others, the overall risks and costs associated with handling and disposing of all the effluents, including but not limited to, front-end handling, aqueous waste treatment, primary treatment, and off-gas treatment.

2. In addition to the wastes defined in the Panel's mandate, which are located at the Transuranic Storage Area at INEEL, volumes of waste of the same general kind and at least equal magnitude are buried in pits and trenches on an 88-acre disposal site. The Panel notes that the problem is serious, and urges the Department of Energy to put increased emphasis on adequately defining the subsurface phenomena involved, and as quickly as possible to put in place comprehensive plans to deal with the issue before significant crises can develop.

3. While the Panel recognizes that waste disposal regulations can evolve and will influence any long-term strategy for research, development, demonstration, and deployment (RDD&D), the Panel's recommendations do not assume changes in the current state and federal requirements.

4. The Panel adopted seven criteria for evaluating alternatives to incineration: Environmental, Safety and Health Risk Considerations; Stakeholder and Regulatory Interests; Functional and Technical Performance; Operational Reliability; Pre- and Post-Treatment Requirements; Economic Viability; and Maturity.

5. The Panel evaluated technologies that may be grouped in five general categories: thermal treatment without incineration, aqueous-based chemical oxidation, dehalogenation, separation (soil washing, solvent extraction and thermal desorption), and biological treatment.

6. The Panel finds that there are promising technological alternatives to incineration. None of the alternatives is ready for immediate implementation; all need to be further developed, adapted and tested with actual mixed waste.

7. The Panel's intent was not to endorse or reject specific commercial applications, but rather to

focus on technology categories, identifying those that appear most promising for near-term application and for long-term developmental funding. The Panel classified the technological alternatives to incineration in three groups: (1) those that clearly appear promising and should have highest priority for funding [steam reforming, thermal/vacuum desorption, DC-arc melter, plasma torch]; (2) potentially promising technologies for which important unresolved issues remain [mediated electrochemical oxidation, microwave decomposition, supercritical water oxidation, solvated electron dehalogenation]; and, (3) technologies to which the Panel accords lowest priority [iron chloride catalyzed oxidation, molten aluminum, solvent extraction, high temperature hyperbaric chamber, silent discharge plasma, soil washing with a chelating agent, treatment with sodium in mineral oil followed by chemical oxidation with peroxydisulfate, and biological treatment].

8. The result of this evaluation is a varied and robust set of technologies that deserve a place in DOE's RDD&D program. The nation should emerge with improved and feasible solutions to a costly dilemma. DOE should seriously consider technologies identified in the most promising category as alternatives for an incinerator at the AMWTP. Tests of these technologies should be conducted on both surrogates and actual wastes to prove their applicability.

9. No single technology may by itself be adequate to meet the desired environmental health and safety standards and achieve the desired destruction of hazardous and PCB waste. Robust solutions are likely to require combinations of several technologies.

10. DOE should consider technologies that are presently deemed less mature for further development and testing with the aim of either advancing them to readiness for deployment or eliminating them from further consideration. Also, a program of basic and applied research should be pursued to identify and nurture the next generation of technologies that are sure to be needed.

11. In the period following creation of the Panel, DOE has been preparing an RDD&D plan for developing and deploying safe, cost-effective and timely technological alternatives to incineration. The Panel appreciates and generally supports DOE's substantial ongoing efforts to devise this strategy, and believes that if its recommendations are followed, DOE should be able to achieve results consistent with the deadline of the Idaho agreement, other regulatory requirements, and broader public interest considerations applicable to mixed waste throughout the nation.

12. The Panel expects that the DOE will change its proposed Plan for Developing Technological Alternatives to Incineration in response to the Panel's recommendations. DOE should first categorize in detail the wastes that need to be treated, and then link the actual wastes to processes in proposed work scopes.

13. The Transuranic and Mixed Waste Focus Area (TMFA) is not now funded adequately to underwrite the testing of the technological alternatives to incineration. As an essential first step, the Panel supports a budget for this purpose that would provide approximately $91 million over the four fiscal years beginning in 2001. Urgent needs start with proof testing of the candidate technologies, using the actual materials involved. The TMFA is the logical home for this testing work. The testing program should be cognizant of and responsive to the needs of the entire DOE complex. The Panel is concerned that mechanisms may not yet be in place to ensure that the results of such testing form the basis for the actual treatment.

14. Also in this regard, the Panel strongly supports increased and continuing basic scientific and developmental work over the longer term on processes to deal with mixed waste. DOE's emphasis on 'near ready' or 'mature' technologies should not preclude further evaluation of innovative alternatives, and the proposed RDD&D schedule almost certainly will have to be extended to allow full assessment of such technologies.

15. In evaluating the most promising alternatives to incineration, DOE should take a systems approach, and should consider the alternative technologies (especially the air effluent containment technologies) as a system under both normal and upset conditions.

16. Citizen stakeholder involvement is essential for successful deployment of waste treatment technologies. Citizen stakeholders should involve people of various expertise from around the country and region. DOE should follow the example of the Army's chemical weapons disposal program by broadening stakeholder outreach beyond the agency's site-based Citizen Advisory Boards (CABs) and making sufficient, specific budgetary provision for technical assistance to committees of citizen advisors. The Panel endorses a 2001 national conference on alternative technologies to incineration, and encourages DOE to involve, in both the Steering Committee and the conference itself, not only the local CABs but also other persons and groups with regional and national perspectives and expertise. Opportunities should be provided for ongoing public participation in periodically assessing the progress of the technology developments on alternatives, e.g., the peer review process.

17. DOE's initial technology selections should be made on the basis of the Panel recommendations. Given the likelihood that the DOE plan itself will change in light of this report, the Panel asks the full SEAB to review progress and continue to advise the Secretary on these matters after DOE has had the opportunity to recast its initial proposal to reflect the Panel's findings and recommendations. DOE should assume full responsibility for whether or not the waste treatment processes are satisfactory for the task at hand. Nothing must be allowed to get in the way of selection, testing, implementation and deployment of a technology or technologies that, in this sensitive situation, will get the job done, while also demonstrating good faith to all parties with an interest in seeing the job is getting done well.

# REPORT OF THE SECRETARY OF ENERGY ADVISORY BOARD'S PANEL ON EMERGING TECHNOLOGICAL ALTERNATIVES TO INCINERATION

## I. Statement of the Problem

### A. The Panel's Charge and Approach

The Blue Ribbon Panel on Emerging Technological Alternatives to Incineration is a task force of the Secretary of Energy Advisory Board (SEAB). The Panel was created following a dispute over the proposed construction of an incinerator for treatment of radioactive mixed waste at the Idaho National Engineering and Environmental Laboratory (INEEL), which resulted in the Department of Energy's (DOE) April 2000 commitment to appoint a 'blue ribbon' panel of independent experts to explore technological alternatives to incineration that might become available for use at DOE facilities nationwide.[1]

#### 1. Secretary of Energy Advisory Board's Terms of Reference

More details on the Panel's mission appear in the Terms of Reference subsequently established by the SEAB, based on the Settlement Agreement:

> The SEAB Panel . . . will evaluate and recommend emerging nonincineration technologies for treatment and disposal of mixed waste on which the Assistant Secretary of Environmental Management's Office of Science and Technology should focus efforts for development, testing, permitting and deployment. The Panel will evaluate technologies to treat low-level, alpha low-level and transuranic wastes containing polychlorinated biphenyls (PCBs) and hazardous constituents, including the up to 14,000 cubic meters of such wastes that the DOE had planned to incinerate in the Advanced Mixed Waste Treatment Facility (AMWTF) at INEEL. The Panel will also evaluate whether these technologies could be implemented in a manner that would allow the department to comply with all the legal requirements, including those contained in the Settlement Agreement and Consent Order signed by the State of Idaho, DOE and the Navy, in October 1995. That agreement requires the Department to remove 65,000 cubic meters of waste at the INEEL from Idaho by the end of 2018. [2, 3]

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[1] Settlement Agreement: Keep Yellowstone Nuclear Free v. Richardson, et al.; No 99 CV 1042J (D. WY).

[2] Terms of Reference are in Appendix I.

[3] While the Panel's charge is to address non-incineration technologies for treating the 65,000 cubic meters of aboveground waste at INEEL, we also acknowledge that other DOE facilities have unique waste forms that must be treated. For example, TRU and fission-product contaminated kerosene from the PUREX process at the Savannah River Site and wastes at Hanford must also be treated.

## 2. The Panel's History and Procedures

The Panel consisted of nine members, appointed by the Secretary of Energy (five members), the Governors of Idaho and Wyoming (one member each), and public interest groups (two members). Biographical summaries appear in Appendix II.

The Panel held five formal meetings (Table 1). As required by the Federal Advisory Committee Act (FACA) all meetings were open to the public and the Panel sought public comments at each meeting. Briefings to the Panel at these meetings covered applicable regulations, inventory and characteristics of the waste, technology state-of-the-art, and DOE plans for research and development (R&D) on alternatives to incineration. In addition, the Panel issued a Request for Information (RFI) through the Commerce Business Daily (CBD) to solicit a broad range of industry and other views on mixed waste treatment options.[4] A Subpanel, consisting of five Panel members[5], initially reviewed the responses to the RFI and reported their findings to the full Panel. The Subpanel received technical assistance from three independent reviewers and a DOE review team.

**Table 1. Blue Ribbon Panel Meetings**

| Meeting Number | Location | Date | Purpose |
|---|---|---|---|
| I. | Washington, DC | June 22, 2000 | 1. Task Definition<br>2. Planning and Procedures<br>3. Public Comment |
| II. | Idaho Falls, ID<br>Jackson, WY | August 22-24, 2000 | 1. Regulatory briefing & discussion<br>2. Waste inventory /characterization<br>3. Technology options<br>4. Public Comment |
| III. | Washington, DC | September 27, 2000 | 1. Discuss DOE R&D Plans<br>2. Discuss Final Report Structure<br>3. Public Comment |
| IV. | Denver, CO | October 11, 2000 | 1. Further review DOE R&D Plans<br>2. Discuss responses to RFI<br>3. Review drafts of Final Report<br>4. Public Comment |
| V. | Jackson, WY | December 5-6, 2000 | 1. Complete Final Report<br>2. Public Comment |

[4] CBD announcement of RFI and list of responders appear in Appendix III.

[5] Subpanel members: Dr. Carl Anderson, Dr. Robert J. Budnitz, Dr. Mario Molina, Dr. Marvin Resnikoff, and Dr. Charles Till.

In addition to the Panel meetings, five full-Panel conference calls and four Subpanel conference calls were held to prepare, discuss and organize materials for the formal meetings (Table 2).

**Table 2. Panel Conference Calls**

| Conference Call Date | Participants |
|---|---|
| August 2, 2000 | Full Panel |
| August 18, 2000 | Full Panel |
| September 22, 2000 | Subpanel |
| October 2, 2000 | Subpanel |
| October 10, 2000 | Subpanel |
| November 1, 2000 | Subpanel |
| November 6, 2000 | Full Panel w/ Independent Reviewers & Public |
| November 20, 2000 | Full Panel & Public |
| November 27, 2000 | Full Panel & Public |

## B. Overview of the Issues

As early as the 1970's, the scientific community recognized that the release to the environment of waste streams containing persistent organic compounds, such as polychlorinated biphenyls (PCBs) poses unacceptable hazards to humans and to ecological systems. One approach for treating PCB contaminated wastes has been incineration. However, this can lead to the formation of compounds such as dioxins and furans that are even more toxic. These emissions can be minimized by proper design and control of the incineration facilities. On the other hand, no such solution exists for radioactive wastes, and the principal public concern regarding incineration involves the potential release of plutonium. The U. S. Government's choice for disposal of this waste has been deep underground at the Waste Isolation Pilot Plant (WIPP) in New Mexico.

The disposal of mixed transuranic (TRU) waste – containing radioactive material, PCBs, and other hazardous constituents – poses a unique problem, and existing regulations were not designed specifically to address such wastes. For example, the removal of PCBs from mixed TRU waste requires some sort of treatment that might involve an overall risk to society higher than the risk of sending the untreated waste to a facility such as WIPP. In any event, treatment of mixed TRU waste, such as removal or immobilization of liquid, might be required for several reasons related either to long-term stability or to safe transportation to the disposal site. It might also be necessary to remove flammable volatile organic compounds and to minimize the radiolytic generation of hydrogen (from the interaction of alpha particles emitted by the radionuclides with organic compounds) in order to eliminate the potential for explosion of gases emanating from the waste.

The nature of the technologies to be utilized for the waste treatment depends on the purpose of treatment. For example, volatile and semi-volatile organic compounds can be separated from the mixed waste relatively easily – e.g., by evaporation at moderate temperatures, or by extraction under vacuum – and these compounds can be destroyed subsequently by oxidation to yield mostly carbon dioxide and water. PCBs are chemically very stable and are not volatile under ambient temperature conditions, so that their destruction is more difficult, requiring strong chemical or thermal treatment before or after separation from the waste stream; no suitable 'mild' treatment exists. At the same time, it is necessary to ensure that the radioactive material eventually remains in the solid waste stream, so that it can be safely disposed of. An assessment of technologies for mixed waste treatment should take into account the overall risks and costs involved with handling and disposing of all the effluents, including but not limited to front-end handling, aqueous waste treatment, primary treatment, and off-gas treatment.

Incineration involves high temperatures, an open flame, and a large volume of gaseous effluents. Although a wide array of technological alternatives to incineration exists, no single one may be suitable for treatment of all types of mixed waste: a combination of steps or a set of several technologies might be required to treat the multiplicity of mixed waste. Some of these alternative technologies might also require high temperatures, but are nevertheless clearly distinct from incineration. For example, they might operate under reducing conditions without an open flame, rather than under oxidizing conditions in an open flame, thereby minimizing the generation of dioxins and furans from PCBs. Many alternative technologies also generate small amounts of gaseous effluents consisting of volatile organic compounds. Once separated from the waste, these effluents can be oxidized, for example, by contact with a ceramic catalyst at high temperatures, in the presence of oxygen, so that only carbon dioxide and water are released to the atmosphere.

## C. Characteristics of the 'Mixed Waste' at Issue in this Report

For purposes of this report, 'mixed waste' means waste that contains both hazardous waste and radioactive material that is subject to the requirements of the Resource Conservation and Recovery Act (RCRA) and the Atomic Energy Act (AEA), which apply to generation of waste and to wastes already stored. In some cases, this waste is also contaminated with PCBs, which are regulated under the Toxic Substances Control Act (TSCA). The EPA and the States enforce the requirements imposed by RCRA and TSCA. DOE sites that store, treat, or dispose of mixed waste are regulated under RCRA, TSCA, and the AEA. In addition, mixed waste buried in the ground at DOE facilities is subject to section 120(a)(2) of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended. The term 'mixed waste' is used frequently in this report as a generic term for all the contaminated radioactive wastes under consideration by the Panel, although strictly speaking radioactive waste containing only PCBs (which are not regulated under RCRA as 'hazardous') is not 'mixed waste' under the prevailing technical definition.

Hazardous and radioactive wastes pose difficult challenges to DOE as owner and to EPA and States as regulators of these wastes. DOE must manage, treat, and dispose of these mixed wastes in an environmentally sound and cost-effective manner to ensure public health and safety.

### 1. Origin, Forms, and Status of the Stored Mixed Wastes at INEEL

DOE currently stores approximately 65,000 cubic meters of radioactive waste at the Transuranic Storage Area (TSA) at the Radioactive Waste Management Complex (RWMC) at the INEEL. Most of this waste, a product of nuclear weapons production operations at the Rocky Flats Plant in Colorado, was transported to the INEEL before the current definition of TRU waste was established (prior to 1982). This waste is managed as TRU waste, although not all of it meets the current definition. Approximately 95 percent of this waste is classified as 'mixed waste'. Some contains PCBs, which are regulated under TSCA. It should be emphasized that at this time we do not know precisely what is in all 65,000 cubic meters of waste, since not all has been characterized (e.g., pre-1973 drums, depending on interpretation of the data, comprise 7 to 18 percent of the total stored volume). In addition, a small volume of the waste may contain mercury, a metal that vaporizes at relatively low temperatures and is particularly difficult for off-gas systems to manage.

Of the 65,000 cubic meters, approximately 52,000 cubic meters (80 percent) is in wooden boxes and metal drums that were stacked on an asphalt pad and covered with tarps, plywood, and then soil to form an earthen-covered berm. The earthen-covered berm is enclosed within a metal building called the Transuranic Storage Area Retrieval Enclosure (TSA-RE), a RCRA interim status facility. Approximately 13,000 cubic meters of the waste (the other 20 percent) is stored in adjacent RCRA-permitted facilities at the RWMC.

Without treatment, a portion of these 65,000 cubic meters does not currently meet requirements for shipment to and disposal at the WIPP, nor does it meet other regulatory requirements for waste disposal and transportation that are reviewed in subsection D below. Initial planning for the Advanced Mixed Waste Treatment Project (AMWTP) incorporated the assumption that 78 percent of the waste would require incineration in order to meet these requirements. This included all non-debris and combustible debris (typically paper, rags, plastic and rubber). Improved understanding of the waste has resulted in successively lower estimates, and by early 1997 the AMWTP contractor had determined that only non-debris waste should be incinerated. As a result, the amount to be treated was reduced to 22 percent of the total.

In 1996, Congress exempted all waste designated for disposal at WIPP from the RCRA Land Disposal Restrictions (LDR). The Panel's understanding is that this action rested, at least in part, on the recognition that deep disposal at WIPP posed fewer hazards than the surface or near-surface disposal contemplated in the RCRA regime. This further reduced the quantity of waste to be treated, although the change did not become fully effective until a contract modification in early 2000, following regulatory action by the State of New Mexico. Only a fraction of many of the waste streams will now require treatment under existing shipment and disposal regulations. The current estimate is approximately 1,500 cubic meters (or about 2 percent), based on review of the envelope of waste comprising the full 65,000 cubic meters, published information about the waste, anecdotal evidence, and subsequent analysis or examination of the wastes.[6] The actual volume requiring treatment will be determined only after individualized analysis of each container, which must be completed before any waste is shipped or treated. The Panel does not expect the final volume requiring treatment to exceed the current estimate substantially, and indeed it could be significantly less.

At the AMWTP, these wastes will be received for inspection, characterization and then shipment or processing. Receipt is in wooden boxes, bins, or 55- and 83-gallon drums (which are generally lined with a high density polyethylene liner). The waste is usually contained in one or more plastic bags or in a smaller container (such as a one-gallon polyethylene container) wrapped in one or more plastic bags that are then placed in a large plastic bag inside a 55-gallon drum. Where the

[6] If the uncharacterized waste is similar in form to the characterized waste, as there is good reason to believe, the margin of error in this estimate is 10 to 20 percent. Expert testimony before the Panel suggested that the total volume of waste requiring treatment may be even smaller than this estimate suggests.

condition of the 55-gallon drum is suspect, it will be placed in an 83-gallon overpack drum to prevent the spread of contamination.

### 2. Other Mixed Wastes at INEEL

The Panel has focused upon the waste requirements defined in its mandate. During our deliberations, however, we heard much about another large quantity of waste on the INEEL site that arrived between 1952 and 1970, in addition to the 65,000 cubic meters addressed in the Panel's charter. This additional waste is buried in pits and trenches on an 88-acre disposal area.

The volume of this waste has been estimated at anywhere from 57,000 to 186,000 cubic meters in various published accounts. These very large differences appear to be caused principally by uncertainties about the volumes of contaminated soil in the neighborhood of the buried waste, which can only be determined by detailed testing and mapping of the actual conditions of the pits and trenches. However, the precise volumes are not the important issue. Whether the additional amounts are comparable to the 65,000 cubic meters at the TSA, or are two or three or more times greater, the fact remains that volumes of waste of the same general kind and at least equal magnitude to that under consideration by the Panel remain on the INEEL site. This waste is buried under conditions that are much less contained and much less predictable than the waste in the Panel charter, and the Panel urges that increased emphasis be given to this in some ways more worrisome quantity of waste. It must be immediately and seriously addressed by the Department.

This waste has been known to be a problem for many years, and the Panel is aware that DOE has a continuing program that attempts to deal with it. DOE is working with EPA Region X and the Idaho Department of Environmental Quality to develop and implement a remedy for the buried waste under the INEEL CERCLA cleanup program. A Record of Decision identifying the remedy is scheduled to be issued in December 2002.

However, no viable cleanup plan has yet been devised. It is generally agreed that these wastes are not properly contained. In fact, they pose a substantial threat to the Snake River Plain aquifer underlying the site. This aquifer is one of the largest underground water bodies in America, and any threat to it carries with it legitimate cause for concern. In the public comment periods of the Panel's meetings, this buried waste emerged repeatedly as a matter of utmost concern to the citizenry. In light of these facts, the Panel notes that the problem is serious, and urges the DOE to put increased emphasis on adequately defining the subsurface phenomena involved, and as quickly as possible to put in place comprehensive plans that will protect the environment and in particular the aquifer before significant crises can develop.

## D. Why do Mixed Wastes Require Treatment?

Wastes must be treated for two principal reasons: (1) to meet transportation requirements and (2) to meet WIPP WAC. Elements of these two overlapping sets of requirements are specified by regulations or set by permits. Transportation requirements restrict the shipment of materials that would create a hazard during transit. The WIPP WAC restricts the amount and nature of waste components that can be accepted. Three INEEL waste components can trigger a need for treatment: potential hydrogen generators, flammable volatile organic compounds (VOCs), and PCBs.

The Nuclear Regulatory Commission has imposed a flammable gas (e.g., hydrogen, methane, etc.) concentration limit on contact-handled TRU waste transported using the Transuranic Package Transporter, Model II (TRUPACT-II). This limit is set at the lower explosive limit of 5percent by volume for hydrogen in air. To meet this limit, hydrogen generation rates are limited by the WIPP WAC and by the TRUPACT II (shipping container) specifications. Hydrogen can be produced by the action of alpha particles on water or organic materials and the restriction calls for evaluation of steady-state hydrogen release rates for every container.

VOCs are limited by transportation requirements, which are intended to avoid fire hazards during shipping. VOCs must be measured in the headspace of every container.

PCB disposal is restricted by WIPP WAC to concentrations below 50 parts-per-million. The PCB concentration must be verified by records or by sampling and analysis.

Transportation requirements and WIPP WAC require inspection of each package. That is, packages can only be certified for shipment or disposal based on knowledge of their contents, and not on the fact that the contents have undergone a particular treatment or set of treatments.

The wastes transported to and accepted at the WIPP facility are controlled by a variety of requirements, including but not limited to:

- New Mexico Hazardous Waste Act (incorporating 40 CFR)
- WIPP Hazardous Waste Facility Permit (HWFP)
- TRUPACT II (shipping container) Safety Analysis Report For Packaging (SARP)
- Department of Transportation Regulations (49 CFR)
- WIPP Safety Analysis Report (SAR)
- WIPP WAC

These sources provide the criteria (summarized in Table 3) for management, storage, transportation to, and disposal of mixed waste at the WIPP facility.

At INEEL, the AMWTP will process stored mixed TRU waste for disposal in New Mexico at WIPP, and mixed low-level waste for disposal in another appropriate facility. The process will include waste retrieval, characterization, sorting, size reduction, repackaging, sorption, supercompaction, certification, and loading of the waste for shipment. Waste that does not meet the applicable disposal requirements will remain in storage at INEEL until appropriate processing is available.

One recurring issue for the Panel was the option of transporting the INEEL mixed wastes without further treatment, either to WIPP or a commercial disposal site. As indicated earlier, this is not possible under current regulations. For example, WIPP will not accept wastes with PCB concentrations of 50 ppm or greater. Those regulations could change over the period of the DOE/Idaho agreement; indeed, applications now pending before the EPA seek amendments to WIPP's WAC that would affect the treatment required in order to ship INEEL mixed wastes to WIPP. If EPA concurs, DOE would need also to petition the State of New Mexico for a change to the permit. Any such regulatory changes would require extensive consultations with interested parties and states, and no amendments in the WIPP WAC are possible without the consent of the State of New Mexico. Accordingly, while the Panel recognizes that waste disposal regulations can evolve and will influence any long-term R&D strategy, the Panel's recommendations do not assume amendments to the current regime.

**Table 3. Comparison of Disposal and Transportation Requirements**

| WAC Section | Requirement | Transportation | Disposal SAR | Disposal RCRA |
|---|---|---|---|---|
| 3.3.2 | Fissile Material Quantity | Pu-239 limits for 55-gallon drums, pipe components, SWBs, and TDOPs (including 2 times the measurement error). | Pu-239 limits for 55-gallon drums, SWBs, and TDOPs (including 2 times the measurement error) | No requirements |
| 3.3.3 | TRU Alpha Activity Concentration | Dewatered, soiled or solidified TRU and tritium-contaminated materials and wastes. | > 100 nCi/g | No requirements<br>> 100 nCi/g is part of the TRU waste definition in the HWFP |
| 3.3.4 | Pu-239 Equivalent Activity | No requirements | Pu-Equivalent Ci limits for 55-gallon drums, SWBs, and TDOPs. | No requirements |
| 3.3.5 | Radiation Dose Rate | Surface dose rate $\leq$ 200 mrem/hr | Surface dose rate $\leq$ 200 mrem/hr | No requirements<br>Surface dose rate $\leq$ 200 mrem/hr is part of the definition in the HWFP |
| 3.4.1 | Liquid | < 1% by volume of the payload container | < 1% by volume of the payload container | < 1% by volume of the payload container |
| 3.4.2 | Sealed Containers | Sealed containers > 4 liters prohibited | No requirements | Sealed containers > 4 liters prohibited |
| 3.5.1 | Pyrophoric Materials | Pyrophoric radioactive materials < 1% by weight | Pyrophoric radioactive materials < 1% by weight | Non-radionuclide pyrophoric materials are prohibited |
| 3.5.2 | Hazardous Waste | No requirements | No requirements | EPA hazardous waste numbers not listed in the HWFP are prohibited. |
| 3.5.3 | Chemical Compatibility | Chemical constituents shall confirm to the allowable chemical lists in the TRUPACT-II SARP. | Wastes containing chemicals that would cause adverse reactions with other payload containers are prohibited. | Wastes incompatible with backfill, seal and panel closure materials, container and packaging materials, shipping container materials, or other wastes are prohibited. |
| 3.5.4 | Explosives, Corrosives, and Compressed Gasses | Explosives, corrosives, and compressed gasses are prohibited | Explosives, corrosives, and compressed gasses are prohibited. | Explosives, corrosives, and compressed gases are prohibited. |
| 3.5.5 | Headspace Gas VOC Concentration | Flammable VOCs equal to or less than 500 ppm in the headspace of any payload container | No requirements | Headspace gas must be reported using sampling and analysis |
| 3.5.6 | PCBs | No Requirements | There is a bounding requirement | PCB concentration $\geq$ 50 ppm are prohibited |
| 3.6.2 | Decay Heat | Decay heat of each payload containers $\leq$ limit in the TRUPACT-II SARP. | No requirements | No requirements |
| 3.6.3 | Test Category Waste | Steady-state hydrogen gas generation release rate shall not exceed the limit specified in the TRUPACT-II SARP. | No requirements | No requirements |

| WAC Section | Requirement | Transportation | Disposal SAR | Disposal RCRA |
|---|---|---|---|---|
| 3.6.4 | Flammable VOCs | Equal to or less than 500 ppm in the headspace of any payload container | No requirements | No requirements |

Note: SWB = Standard Waste Box
TDOP = Ten Drum Overpack

## II. Criteria for Evaluating Technological Alternatives to Incineration

The Panel adopted the following seven criteria for evaluating alternatives to incineration, and included these criteria in an August 2000 RFI:

1. **Environmental, Safety and Health (ES&H) Risk Considerations**
   The safety of the system, potential ES&H risks and the difficulty in designing and constructing a system to meet the ES&H requirements in radioactive service with special emphasis on upset conditions.

2. **Stakeholder and Regulatory Interests**
   The degree to which there may be resistance or delays in implementing the technology or system due to either public concerns or regulatory requirements.

3. **Functional and Technical Performance**
   The technical performance of the treatment process to include destruction efficiency, volume reduction capability, secondary waste generation, robustness and flexibility of the system, final waste form performance and capability to be shipped.

4. **Operational Reliability**
   The reliability and availability of the treatment process, its complexity, and the potential exposure to maintenance workers.

5. **Pre- and Post-Treatment Requirements**
   The pre-treatment and post-treatment requirements of the waste, and the requirements for treating the effluents from the process.

6. **Economic Viability**
   The total life-cycle cost of the system, the cost per unit volume of waste treated, the market for the technology, and the potential that the technology will be commercially available to treat the waste.

7. **Maturity**
   The level of development of the technology, field experience with the technology in radioactive service, and whether the technology will be available in the time frame required.

In its application of the criteria, particularly those bearing on ES&H, the Panel placed special emphasis on performance under potential 'upset conditions'. In addition, the Panel fully recognizes that worker safety has been and remains a significant concern of all well-managed programs. The Panel wishes to underscore that this concern is an important part of its ES&H criterion.

Although meeting all applicable ES&H regulations is an essential criterion for any technology, the Panel believes that an even more stringent standard should be applied during the evaluation process. Specifically, a technology should be highly favored if it can demonstrably meet such regulations by very large margins, affording much higher degrees of protection and much higher confidence in that protection. The crucial words here are 'demonstrably' and 'large margins,' because only then can both the technical community and the larger public have strong confidence in the proposed technology. We have tried to apply this philosophy throughout our evaluations.

## III. Overview of the Technological Alternatives

Many parties have brought to the Panel a broad array of technological alternatives to incineration. We have reviewed a large number of options at very different stages of development. From the perspective of research, development, demonstration and deployment (RDD&D), the challenge is to apply inevitably constrained resources productively without prematurely narrowing the field of potential candidates. The Panel's aim is to help DOE assemble an RDD&D technology portfolio that is diverse in both technology characteristics and levels of maturity; to that end, we have identified what we think are the most promising of the relatively mature and the still emerging options. We also sought to narrow the field in a productive way. Some elements of the portfolio should be ready for comparison testing on an aggressive schedule over the next several years, while others will need substantially more time (while still being potentially available to meet DOE's commitments to the State of Idaho).

### A. Description of the Alternatives

#### 1. Thermal Treatment without Incineration

Thermal treatment of hazardous waste involves use of high temperature as the primary means to change the chemical, physical, or biological character and/or composition of the waste in the absence of air or free oxygen and without a flame. Relatively high temperatures decompose organic compounds, convert them to gases, and break their chemical bonds to form organic fragments that may require subsequent oxidization or reduction. If the decomposition products are allowed to cool in an inert environment, the products are typically carbon, and a gas containing CO, $H_2$, HCl, $CH_4$, and low molecular weight hydrocarbons (e.g., syngas). If sufficient oxygen is present, the oxygen will combine with the organic fragments to form $CO_2$ and $H_2O$. A reducing environment implies the presence of a material with a high affinity for oxygen (e.g., hydrogen or aluminum) and the absence of free oxygen. The reductant reacts with the organic fragments to produce carbon, $H_2$, $CH_4$, HCl, or $Al_2O_3$ (depending on the environment and stability of the compounds at the process temperature) and low molecular weight hydrocarbons from the reduction of straight-chained and aromatic hydrocarbons.

Incineration, by contrast, involves use of fuel (usually natural gas or fuel oil, but sometimes the waste itself) with air or oxygen to produce a flame for the destruction and oxidation of the organic waste material. Typically, a secondary combustion chamber with a flame is also required to complete oxidation of any organic material escaping in gases from the main combustion chamber. Incinerators require high volumes of air and extreme turbulence to ensure adequate mixing of the waste and vapors with air, and adequate time to complete the oxidation. Because of gases from the combustion of the fuel and the excess air, incinerators generate large volumes of off-gases requiring treatment before release.

Thermal treatment processes not involving incineration include plasma arc melters, DC-arc melters, metal melters, steam reformers, molten salt oxidation, and supercritical water oxidation, each of which operates under different thermal and environmental conditions.

Plasma or DC-arc melters may be operated in at least three modes: an oxidation mode in which sufficient oxygen is supplied to oxidize the organic material; a pyrolysis mode (e.g., an oxygen deficient atmosphere); or a steam-reforming mode. In the steam-reforming mode, steam provides both hydrogen and oxygen to react with the high temperature decomposition products.

Metal melters operate in a reducing mode in which the molten metal (such as iron or aluminum) has a high affinity for oxygen.

Steam reformers operate at lower temperatures than melters and interact steam directly with heated waste materials in the absence of free oxygen; steam provides a source of both hydrogen and oxygen to produce a combustible gas mixture of CO, $H_2$, $CO_2$, $H_2O$, $CH_4$, HCl and low molecular weight hydrocarbons.

In molten salt systems, organic waste and oxygen are injected into a hot molten salt bath that provides the thermal energy to break the chemical bonds of the organic material, and a medium that enables intimate contact between the oxygen and the organic fragments.

Supercritical water oxidation is a thermal process in which high temperature and high pressure are used to generate a supercritical state of water. Supercritical water readily dissolves organic material and stimulates rapid reaction between the organic material and the oxygen to produce $CO_2$ and $H_2O$. This reaction is similar to, but much more rapid than, the conventional chemical processes described next.

### 2. Aqueous-Based Chemical Oxidation

Aqueous-based chemical oxidation uses chemical oxidants other than oxygen or air as the primary means to destroy or detoxify hazardous materials. Moderate increases in temperature can be used to accelerate the rates of the organic destruction reactions, but the temperature alone is not sufficient to break the chemical bonds. Chemical oxidation processes use strong oxidants in an aqueous, acidic solution. Examples of strong inorganic oxidants are nitric acid, $Ag^{2+}$, $Ce^{4+}$, $Fe^{3+}$, and ammonium peroxydisulfate $[(NH_4)_2S_2O_8]$. The organics are typically converted to $H_2O$, CO, $CO_2$, HCl, and mineral salts. Because the reactions are strongly surface area dependent, solids and some liquids require significant size reduction and/or mixing for adequate oxidation to occur, whereas soluble organics are more easily oxidized. Because the reactions take place at low temperature and in a liquid state, the times required for the reactions are much longer than for thermal systems, and typically, more secondary waste is generated by the oxidizing agents.

### 3. Dehalogenation

Dehalogenation refers to chemical reactions in which halogens (chlorine, bromine, iodine) are removed from the molecular structure of organic compounds and replaced by other atoms to form non-hazardous or less hazardous products. For example, the solvated electron process is used to replace chlorine in PCBs. Byproducts from treating PCBs include hydrocarbons, sodium chloride, and sodium amide.

### 4. Separation

Three types of separation processes are used for removal of organic material from a waste matrix: soil washing, solvent extraction and thermal desorption.

Soil washing uses an aqueous solution and detergent to remove organic material from the surface of soil particles and to separate fine particulates (which contain most of the organic contaminants in the porous fines) from the coarse soil. Soil washing does not destroy the organic material but produces three products: a wastewater stream, a sludge of contaminated fine particulates, and soil that may contain regulated levels of heavy metals and radionuclides.

Solvent extraction uses a solvent to remove soluble contaminants from the waste (not unlike dry cleaning). A subsequent step removes the contaminants from the solvent, which can be re-used, leaving the liquid organic contaminant to be treated by other means. A special case of solvent extraction uses supercritical carbon dioxide to remove organics from the waste.

Thermal desorption uses relatively high temperatures, and sometimes a vacuum, to convert organic contaminants from a solid waste to a gas and extract them. These volatile and semi-volatile organic contaminants are then condensed and collected in an off-gas system for subsequent treatment by other means, which can be technically difficult for some contaminants (e.g., radionuclides and mercury). In some cases, heat and vacuum can pyrolyze non-volatile organic material (plastics, wood, PVC, etc.) to produce volatilized organics and a residue that remains in the desorber.

### 5. Biological Treatment

Biological treatment (or biodegradation) refers to the processing of organic waste material using microorganisms such as bacteria and fungi. Aerobic degradation is performed by microorganisms, which require oxygen for growth. Aerobic process residues are usually CO, $CO_2$, $H_2O$, salts and biomass sludge (dead cell material). Anaerobic degradation is carried out in the absence of oxygen and yields $CH_4$, $CO_2$, and biomass. Since the contaminants must be available to the microorganisms, contaminants that are not water-soluble (e.g., solids and immiscible organics) are more difficult to treat. Chlorinated organics are difficult to treat because their degradation is not a significant source of energy for the bacteria. Nonetheless, some bacteria do degrade chlorinated organics in the course of metabolizing other, more easily degraded compounds.

## B. Evaluation of the Alternatives

In aid of its evaluation, the Panel formed a Technical Subpanel chaired by Dr. Molina, which also included Dr. Anderson, Dr. Budnitz, Dr. Resnikoff, and Dr. Till. The Subpanel and the rest of the Panel also benefited from extensive assessments prepared by Mr. William Schwinkendorf (chairing a DOE team), Mr. James Cudahy, Dr. Francis Holm, and Dr. Peter Lederman, all of which are part of the record of the proceedings that produced this report.

The choice of technologies depends on the purpose of the treatment. As indicated in Section I-D, this purpose consists of removal from the waste stream of potential hydrogen generators, VOCs, PCBs and possibly the ignitable and corrosive streams that carry the D001 and D002 EPA hazardous waste codes.

Destruction of the unwanted components can be accomplished either before or after separation from the main waste stream. In general, technologies that satisfy all the treatment needs simultaneously are preferable. In any case, it is important to assess the fate of the radioactive components to ensure that they remain in the solid waste stream for disposal. This, in turn, requires actual tests with authentic mixed waste.

Each treatment option creates its own waste streams, some of which are potentially hazardous and thus may require additional remedial strategies that themselves form an important part of any life-cycle comparison of the risks and costs of the technological alternatives. Thus, it is important to evaluate not only the main treatment process itself, but also the additional steps necessary to deal with the required pretreatment of the waste as well as the secondary waste streams and their treatment.

The Panel evaluated the technological alternatives described in Section III-A utilizing the published criteria from Section II of this report. Most, but not all, technologies were brought to the Panel in response to the RFI described in Section I-A-2. The Panel's intent was not to endorse or reject specific commercial applications, but rather to focus on categories of technologies, identifying those that appear most promising for near-term application and for longer-term developmental funding. We have grouped the technological alternatives in three categories for discussion below: (1) those that clearly appear promising and should have highest priority for funding; (2) potentially promising technologies for which important unresolved issues remain; and (3) technologies to which the Panel accords lowest priority. Of course, even the most promising alternatives are not yet fully demonstrated, in particular with mixed waste. None of the alternatives are ready for immediate implementation, and subsequent sections of this report address next steps in the development and testing process.

### 1. Most Promising Technologies

The most promising technologies are relatively mature, so that (a) there are fewer issues regarding their capabilities to treat the DOE waste in question; (b) they generally are robust (e.g., they can treat a variety of waste types with a minimal pre-treatment); (c) they have minimal secondary wastes, which can be successfully treated; and (d) they appear to pose less risk to workers, the public and the environment.

#### a. <u>Steam Reforming</u>

Steam reforming coupled with volatilization directly from waste drums is a very promising technology to remove and destroy organic components in the waste stream. It is a robust, mature technology, applicable to a wide variety of waste streams and requiring little or no pretreatment. It operates in a reducing environment (i.e., in the absence of oxygen), producing an off-gas stream consisting of organic effluents (syngas), carbon dioxide and water vapor. This gaseous stream requires treatment to decompose the organic effluents (e.g., oxidation by a high-temperature ceramic catalyst), but the emissions to the environment can be measured and controlled and are likely to be minor. The relatively low temperature should allow the plutonium and most other radionuclides and heavy metals to be retained in the residue, which can be sent to a disposal site. However, some radionuclides and metals may be volatilized and must be captured by off-gas systems.[7]

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[7] To the extent that some steam reforming technology variants require levitation of a heterogeneous mixture, significant technical issues remain for resolution.

**b. Thermal/Vacuum Desorption**

This separation process removes volatile and semi-volatile organics from the inorganic portion of the waste stream and pyrolyzes non-volatile organics in an oxygen-starved atmosphere to produce organic vapors and a solid residue. The volatilized organics may be treated by some other means: oxidized in a high-temperature ceramic catalyst or absorbed onto a carbon bed or condensed back to a liquid for subsequent destruction, or possibly treatment at an existing commercial facility. The low gas flow and low temperature minimizes particulate carryover into the off-gas system and should allow the plutonium and most other radionuclides and heavy metals to be retained in the residual solids. Thus, the emissions to the environment can be controlled and are likely to be minor. Little or no pretreatment is required for a wide variety of wastes.

**c. DC-Arc Melter**

This is a process with very high destruction efficiency. It is very robust, can treat any waste or medium with minimal or no pretreatment, and produces a stable waste form. The DC-arc melter uses carbon electrodes to strike an arc in a bath of molten slag. Use of consumable carbon electrodes that are continuously inserted into the reaction chamber eliminates the need to shut down for electrode replacement or maintenance and the need for a torch gas. The high temperatures produced by the arc convert the organic waste into light organics and primary elements in a steam-reforming or reducing atmosphere. The combustible syngas is cleaned in the off-gas system and oxidized to $CO_2$ and $H_2O$ in ceramic bed oxidizers. The potential for air pollution is low due to the use of electrical heating in the absence of free oxygen and the low amount of off-gas. The inorganic portion of the waste is retained in a stable, leach-resistant slag, which may be necessary for a mixed non-TRU waste that will be disposed of in a RCRA-regulated landfill.

**d. Plasma Torch**

Plasma torch systems are similar to DC-arc systems in that an arc is struck between a copper electrode and either a bath of molten slag or another electrode of opposite polarity.[8] As with DC-arc systems, the plasma torch system has very high destruction efficiency, is very robust, and can treat any waste or medium with minimal or no pre-treatment. The inorganic portion of the waste is retained in a stable, leach-resistant slag, which may be necessary for mixed non-TRU waste that will be disposed of in a RCRA-regulated landfill. However, the water-cooled copper torch must be replaced periodically to prevent burn-through at the attachment point of the arc and a subsequent steam explosion due to rapid heating of the released cooling water. The air pollution control system is somewhat larger than for the DC-arc due to the need for an arc-stabilizing torch gas. Concerns have been raised regarding the reliability of this technology.

## 2. Potentially Promising Technologies with Unresolved Issues

[8] The plasma torch technologies evaluated by the Panel should be distinguished from 'plasma arc incinerators,' as defined by EPA in 40 CFR section 260.10.

From the RFI and other sources, the Panel identified a number of technologies that may contribute to solving the INEEL waste treatment problem. However, potentially significant issues need to be addressed before final decisions are made about integrating these technologies into DOE's RDD&D program. These technologies are generally less mature than those in the first category, are less robust, or have questionable ability to safely treat DOE waste. These technologies include mediated electrochemical oxidation, microwave decomposition, supercritical water oxidation, and solvated electron dehalogenation.

For each of these potentially viable alternatives, the Panel's views are summarized below.

**a. Mediated Electrochemical Oxidation**

Mediated electrochemical oxidation relies on an oxidizing element (e.g., silver or cerium) to destroy organic compounds. Metals, including plutonium and americium, may be dissolved in the anolyte solution. Recovery of the oxidizing element from the analyte and reuse back in the process is critical for economic operation. It is not clear if recovery/reuse is possible or economically viable in the presence of radionuclides. Also, to reduce process retention times and increase solubility of organic constituents, waste streams are fed to the system as liquids or slurry. This may require significant waste pre-treatment. Other issues include the capability to treat PCBs adequately, and the highly corrosive nature of the process and related safety concerns.

Positive characteristics include low temperature, low off-gas, and an apparent ability to treat diverse waste streams. The Panel's concerns center on 1) recovery/reuse of the analyte solution; 2) amount of pre-treatment; and 3) corrosion and erosion of the system components.

**b. Microwave Decomposition**

This technology involves a specific type of chemical decomposition, and may have promise for the treatment of INEEL wastes, but it has been applied only to limited waste streams (medical waste and tires). Research and development is needed to determine its efficacy for treating radioactive and TRU wastes. Other potential unknowns and concerns include this technology's ability to treat PCBs, amount of pre-treatment, nature of the effluents, including the level of off-gas treatment required, and radionuclide accumulation in carbon precipitated on the walls of the treatment chamber (this char could present significant decontamination and worker safety issues).

Positive attributes include low off-gas and low system operating temperature and pressure.

**c. Supercritical Water Oxidation**

At supercritical pressure and temperature conditions, water can dissolve organic constituents. This is a relatively mature technology with a long history of development for specific applications. Positive attributes of the supercritical water oxidation system include very low off-gas, high destruction efficiencies for organics, and effluents that are relatively easy to manage, including brine, filtered solids and salts.

On the other hand, the high pressure (and the difficulty in injecting particulate-laden erosive slurries into the process) and corrosiveness of the system present significant safety concerns. Moreover, the waste stream feed must be in a liquid or slurry form, which requires substantial pre-treatment of wastes. Proponents anticipate using a bulk feed system, but key details are lacking on its design and development.

#### d. **Solvated Electron Dehalogenation**

In this technology, solvated electrons, created in a mixture of anhydrous ammonia, sodium metal, and waste, remove halogens (primarily chlorine) from organic molecules. This is a relatively mature and simple technology that operates at low temperature with low off-gas and good destruction efficiencies for chlorinated compounds.

Potential concerns with the solvated electron technology include: 1) the management of treatment residues, including further treatment of non-chlorinated organics to meet WIPP WAC; 2) the amount of pre-treatment needed to maximize exposure of the chlorinated compounds to the electron solution; 3) the process's ability to treat the diversity of INEEL wastes (waste pH and moisture content appear to be important); and, 4) safety associated with handling sodium and anhydrous ammonia and high system pressure (200 psi) in a radioactive environment.

### 3. Lowest Priority Technologies

In its review, the Panel was impressed by the number and variety of treatment processes submitted for consideration in response to the RFI. Given constrained R&D resources, the Panel felt compelled to adopt a winnowing process to yield a manageable number of candidates for further testing and development. Most of the treatment options submitted to the Panel clearly have promise for some forms of waste, but our charge compels a focus on very specific wastes.

The Panel concluded that technologies not recommended in this report for further development and testing were qualitatively less promising, across the full range of characteristics necessary to deal with the INEEL wastes. Several of these technologies were not applicable to the DOE wastes in question, others had serious safety issues, and others were so immature or had so little information available that an informed evaluation was impossible. In reviewing candidates for near-term testing, the Panel sought convincing evidence of technological maturity; where the issue was eligibility for further development, our focus was promise of superiority in simplicity, efficiency and economics.

The technologies examined by the Panel and placed in this third category include iron chloride catalyzed oxidation, molten aluminum, solvent extraction, high temperature hyperbaric chamber, silent discharge plasma, soil washing with a chelating agent, treatment with sodium in mineral oil followed by chemical oxidation with peroxydisulfate, and biological treatment.

### 4. Conclusions and Recommendations

The Panel finds that there are promising technological alternatives to incineration. At present, such technologies have not been fully demonstrated and need to be further developed, adapted and tested with actual mixed waste streams.

In the Panel's judgment, this evaluation has identified a varied set of technologies that deserve a place in DOE's RDD&D program. The Panel's recommendations also include basic scientific work that should broaden the base of technologies further. The nation should emerge within a few years with improved and feasible solutions to a costly dilemma.

The Panel recommends that DOE seriously consider technologies identified in the most promising category as alternatives for an incinerator at the AMWTP. Tests of these should be conducted on both surrogates and actual wastes to demonstrate their applicability. These tests should be concluded within 3 to 5 years, and should include total system evaluations including pre- and post-treatment requirements and should seek to identify performance under potential upset conditions.

The Panel also notes that no single technology may by itself be adequate to meet the desired ES&H standards and achieve the desired destruction of hazardous and PCB waste. Robust solutions are likely to require combinations of several technologies. Some of the most promising technologies yield secondary wastes that require further treatment. For example, steam reforming generates a combustible gas that may require subsequent thermal oxidation using a catalytic reactor to accomplish destruction without incineration. Dehalogenation can effectively destroy PCBs, but it leaves non-halogenated hydrocarbons and many of the VOCs untouched; the treated wastes still contain enough of these materials so that shipment or disposal may not be possible without further treatments. For wastes being sent to a burial site, further treatments of the hazardous inorganic chemicals (e.g., stabilization) may be needed to meet land disposal requirements. Greater stabilization of the final waste may be required for mixed waste burial sites, compared with TRU wastes disposed of at WIPP.

The Panel also recommends that DOE consider less mature technologies for further development and testing, with the aim of either advancing them to readiness for deployment or eliminating them from further consideration.

Finally, a program of basic and applied research should be pursued to identify and nurture the next generation of technologies that are sure to be needed. It is important and appropriate that DOE address the completion of relatively near term waste management actions such as meeting the agreement schedule for removal of stored mixed TRU and low-level waste from Idaho. Nonetheless, as noted elsewhere in this report, there are other wastes that will need to be treated, and the total problem will not be quickly solved. New technologies will rely on new science that can only result from investments in basic and applied research.

## IV. DOE's Current Plan for Developing Technological Alternatives to Incineration

### A. Overview of the Evolving DOE Plan

In the period following creation of the Panel, DOE has been preparing an RDD&D plan for developing and deploying safe, cost-effective and timely technological alternatives to incineration. This subsection summarizes the current status of that plan. A complete executive summary of DOE's RDD&D plan appears in Appendix V.

A recent review of the DOE Environmental Quality R&D Portfolio concluded that, "The greatest gap identified among mixed waste technologies is the need for alternatives to incineration." Moreover, "Although there has been R&D on other technologies for destroying hazardous organics and for volume reduction, little such R&D is now under way and, more importantly, no specific technology is currently acceptable to replace incineration." The review concluded that, "Just as there is a gap identified with alternatives to incineration, there is an opportunity to fill that gap. Several candidate technologies have been brought forth in the past and prioritization of those to identify most likely successors, followed by development and demonstration activities should commence."[9]

DOE has made provision for public review of all elements of this plan, and revisions are possible as that review proceeds. The Panel places particular emphasis on this issue, and Subsection B below presents comments and recommendations on public involvement and other elements of the DOE plan.

The preliminary DOE plan includes stages of development ranging from basic science research through full-scale integrated demonstrations. The development and deployment plan which would be initiated in FY 2001 by DOE's Transuranic and Mixed Waste Focus Area (TMFA) includes provisions for regulatory and public involvement. Regulatory issues will be addressed by working directly with the various state and federal agencies (e.g., the EPA and state environmental regulators) throughout the alternatives development process. A DOE-EPA Memorandum of Understanding is already in place for this purpose. Developers will be informed of the data needed for permitting purposes, and will be notified of pending regulatory changes that may affect the future applicability of their alternative technology.

Technical issues will be addressed through a development effort involving side-by-side comparisons of emerging alternative technologies. Technologies selected for comparative study will be relatively mature. The comparative study will collect the necessary performance, design, scale-up, and permitting data for each selected technology. Testing with identical waste surrogates and/or actual wastes will ensure that each alternative technology generates comparable data.

Starting in FY 2001, the TMFA will establish facilities for the comparison tests and issue the appropriate competitive calls to initiate the testing program in FY 2002. DOE's Western Environmental Technology Office (WETO) in Butte, Montana will support the majority of the comparison testing, and would be equipped with the required additional monitoring and analytical equipment in FY 2001. Based on the competitive solicitation issued in FY 2001, three to five primary alternative treatment processes would be selected for comparison testing at WETO in FY 2002. The current strategy is to select enough processes to represent the three general classes of alternatives: thermal, aqueous-based chemical oxidation, and separations.

The two-year long comparative study of mature alternatives will be supplemented with a series of basic science research efforts and with development activities to optimize the auxiliary systems required for completely integrated alternative methods. The efforts in basic science research would span three years and, at a minimum, would include studies in materials research, off-gas pollutant formation, and

[9] "Adequacy Analysis of the Environmental Quality Research and Development Portfolio" (September 2000).

long-term waste form stability. Auxiliary system testing would include activities involving pretreatment, waste feed pre-sizing, off-gas monitoring, and residue stabilization. Upon completion of the comparison testing in FY 2003, two to three of the better performing alternatives would be selected for integrated prototype testing, starting in early FY 2005. If appropriate, the current plan is to conduct this final test phase at a single location. Integrated testing is expected to last at least two years and to culminate with deployments by FY 2007.

Following extended discussion at its October public meeting in Denver, the Panel asked DOE staff to provide initial estimates of budget impacts associated with the principal elements of its preliminary draft plan, which are summarized below.

## B. The Panel's Conclusions and Recommendations Regarding the DOE Plan

The Panel appreciates and generally supports DOE's substantial ongoing efforts to devise a strategy for developing technological alternatives to incineration. This section presents our recommendations for designing and executing that strategy. If these recommendations are followed, the Panel believes that DOE should be able to achieve results consistent with the deadline of the Idaho agreement, other regulatory requirements, and broader public interest considerations applicable to mixed waste throughout the nation.

BUDGETARY NEEDS: It is the view of the Panel that the TMFA is not funded adequately to underwrite the testing of the technological alternatives to incineration. As an essential first step, the Panel endorses the budget additions summarized in Table 4. These additions reflect an analysis prepared by DOE staff at the Panel's request, based on the new DOE RDD&D plan that is described in Section IV-A. The Panel has not tried to allocate the additions among the line items in Table 4 (that is properly a DOE management function), but urgent needs start with proof testing of candidate technologies, using the actual materials involved. Even focusing only on the relatively mature alternatives with the most immediate promise of meeting commitments to the State of Idaho, none have had the benefit of demonstration of capability to treat the wastes at issue here. And longer-term alternatives that appear to have advantages in overall robustness or in specialized areas with potential application across the DOE complex, need not only testing but extensive developmental work. The Panel also believes that more basic work on processes will identify much-improved alternatives that could pay off handsomely down the road. Adequate funding is necessary to make all of this possible. The Panel intends no implication that any other DOE budget allocation should be reduced to accommodate its proposal.

For materials specifically requiring treatment in lieu of incineration, there is no substitute for proof testing of each process with the actual materials to be treated. Testing of surrogate materials can create considerable useful knowledge, but only testing with actual materials will reveal the inevitable surprises that are experienced in practice. For example, some elements, notably americium, can be difficult to contain. Where there is plutonium there is americium.[10] For both, adequate confinement is crucial. Worker exposure to both is of the highest concern, and worker uptake of transuranics must be zero. Processes that break down very stable compounds such as PCBs are of necessity vigorous, and establishing where the transuranics go is of considerable importance to the viability of the process.

[10] Pu-241 decays with a 14-year half-life to produce Am-241.

Such testing will cost in the range of several million dollars a year, with total costs ultimately in the range of a few tens of millions. But the costs of failure are in the hundreds of millions of dollars, and much more than dollars is at stake. In light of the attention that has now been focused on the issue, and the likelihood of continued skeptical scrutiny by the public and by the states involved, even partial success will not be good enough.

The Panel believes that some of the unsuccessful efforts in the past to deal with the waste in Idaho might have been avoided if more adequate proof testing had been done before large commitments were made. For this reason, the Panel has strong convictions about the value of proof testing. Where as here, good faith is in question, and testing beyond that dictated by normal engineering considerations is advisable. Economies made possible without adequate validation would be unwise.

The Panel concludes that the TMFA at INEEL is the logical home for coordinating this testing work. The testing program should be cognizant of and responsive to the needs of the entire DOE complex. Such testing can be expected to settle the issue of adequacy of process. It should also give a real and palpable demonstration of Departmental good faith in doing all that could reasonably be asked in accomplishing what needs to be done. Put directly, proven success through properly directed testing provides the best hope of eliminating the need for incineration. For all these reasons, we believe this work should be given high priority.

**Table 4. Preliminary Analysis of Budget Impact of Draft RDD&D Plan for Alternatives to Incineration.** (All values are shown in millions of dollars).

[CAUTION: This draft budget has not been fully reviewed internally at the DOE and does not necessarily represent its views or recommendations.]

| ACTIVITY | 2001 | | 2002 | | 2003 | 2004 | TOTALS | |
|---|---|---|---|---|---|---|---|---|
| | Original | Panel Version | Original | Panel Version | Panel Version | Panel Version | Original | Panel Version |
| **TECHNICAL** | | **9** | | **20** | **29** | **28** | | **87** |
| Comparison Testing and Developments | | | | | | | | |
| Competed Alternatives | | | .05 | | | | **.05** | |
| Surrogate Testing | | | 4.50 | | | | **16.50** | |
| Actual Waste Testing | | | | | | | **16.00** | |
| Leveraged Alternatives | 1.80* | | | | | | **5.80** | |
| Prepare Test Facilities to Host Comparisons | .25 | | | | | | **.25** | |
| Specific Development for Transuranic Waste | 2.10 | | 1.70 | | | | **8.30** | |
| Integrated Demonstrations | | | | | | | **4.00** | |
| Basic Science and Applied Research ** | .75 | | 3.00 | | | | **19.75** | |
| Testing of Auxiliary Systems | .70 | | .50 | | | | **2.25** | |
| **REGULATORY** | **.10** | **.4** | **.10** | **.5** | **.5** | **.5** | **1.20** | **2** |
| **STAKEHOLDER** | **.05 *** | **.5** | **.05** | **.5** | **.5** | **.5** | **1.10** | **2** |
| | | | | | | | | |
| **TOTALS** | **5.75** | **10** | **9.90** | **21** | **30** | **29** | **75.2** | **91** |

* Draft RDD&D plan is preliminary and has not been fully developed or reviewed internally
** There is a research proposal call planned for FY 2002 to solicit solutions to TRU/Mixed Waste problems

This work is useful, however, only if it underlies and supports actual treatment of the waste. Successful proof testing only shows the way. The Panel is concerned that mechanisms are not yet in place to ensure that the results of such testing form the basis for the actual treatment. There is a contract in place with BNFL, and DOE continues to emphasize privatization of the treatment process. The Panel has no comment on this, one way or the other. But the Panel does have a view that there is an unmet need for organizational definition, to ensure that technology with the greatest chance of success is in fact implemented. The very formation of the Panel indicates that the situation in Idaho requires DOE to assume full responsibility for whether or not the waste treatment processes are satisfactory for the task at hand.

It is not sufficient to say that success is the responsibility of the contractor. Nothing must be allowed to get in the way of selection, testing, implementation and deployment of a technology or technologies that, in this sensitive situation, will get the job done, while also demonstrating good faith to all parties with an interest in seeing that the job is getting done well. Commercial interests associated with a privatized project must not dictate the selection and testing of specific technologies; much more weight should be given to the major benefit flowing to the nation from a proven technology for this class of waste. For beyond the measures necessary to resolve the impasse that produced this Panel, there are the volumes of buried TRU waste that we addressed previously in this report, as well as other TRU waste across the complex, both from legacy and from on-going and future program and decommissioning activities. Some of this waste will need treatment.

Also in this regard, the Panel underscores its strong support for increased and continuing basic scientific and developmental work over the longer term on processes to deal with mixed waste. We are aware of and applaud the TMFA plans to deploy alternatives to incineration across the DOE complex by 2007. But the nation has what is often called 'a 50-year problem,' involving both legacy and ongoing waste generation. Breakthroughs in cost, convenience and safety of processes are possible only if pursued. A simple analogy may be useful: the end-all in air transport was thought to have been achieved by 1939, until proof of the jet engine changed the picture completely. In the mixed waste area, the huge costs contemplated across the nation reinforce the importance of continued search for more and better technological alternatives.

Finally, the Panel believes strongly that its budgetary recommendations should be supported with an infusion of new federal funds rather than internal transfers from other vital efforts to solve problems associated with mixed waste, buried wastes at INEEL and elsewhere, and high-level radioactive waste.

TECHNOLOGY INTEGRATION: DOE should make every reasonable effort to ensure that the Panel's recommended alternatives are included in the comparative and integration phases of its RDD&D process. DOE's emphasis on 'near ready' or 'mature' technologies should not preclude further evaluation of innovative alternatives, and the proposed RDD&D schedule almost certainly will have to be extended to allow full assessment of such technologies.

SYSTEMS APPROACH: In evaluating the most promising alternatives to incineration, the Panel urges the DOE to take a systems approach, and to consider the alternative technologies (especially the air effluent containment technologies) as a system under both normal and upset conditions. For example, under upset conditions, will fire suppression systems plug HEPA filters at a time when they are most needed? In particular, the Panel urges rigorous evaluation of whether the reliability and efficacy of the various effluent control systems will be sufficient to protect workers, the public, and the environment. In other words, will these systems meet appropriate standards after accounting for the probability of upset conditions as well as normal conditions? The Panel also urges DOE and other federal agencies independently to evaluate the air effluent containment systems with surrogate and alpha-emitting waste, to determine the appropriate decontamination factors.

TECHNOLOGY EVALUATION: DOE should use the Panel's seven criteria in evaluating alternative technologies in the comparative and integration phases of the RDD&D. The primary emphasis should be on the alternative's protection of the environment, safety, and health.

PUBLIC INVOLVEMENT: The DOE plan summarized in Section IV-A recognizes the need to develop and maintain full and meaningful public involvement throughout the RDD&D process, particularly in the evaluation and implementation of any technology for the INEEL TRU and mixed waste. Specifically, the Panel recommends that DOE should follow the example of the Army's chemical weapons disposal program by broadening stakeholder outreach beyond the agency's site-based Citizen Advisory Boards (CABs) by making sufficient, specific budgetary provision for technical assistance to committees of citizen advisors, and finally by ensuring ongoing involvement by those committees throughout the RDD&D process. These committees also should have a role in the peer review process that DOE uses to evaluate technology alternatives.

The Panel believes that citizen stakeholder involvement at all stages of the process is essential for successful deployment of waste treatment technologies. Citizen stakeholders should include people of various expertise from around the country and region.

The Panel encourages the Department in its attempts to involve the public and to include funds in its FY 2001 and later budgets for that purpose. Broad-based and meaningful public involvement requires both expenditures and a carefully thought out disbursement process. The Panel endorses a 2001 national conference on alternative technologies to incineration, and feels it is important and necessary for DOE to involve, in both the Steering Committee (see principles below) and the conference itself, not only the local CABs but also state, local and tribal governments, and national environmental, labor and other relevant policy groups with interests, commitment and expertise on the issues. Conference objectives should include public education, and discussion of an ongoing role for stakeholder groups in the RDD&D process. A third party facilitator and participation by interested companies and agencies are also recommended.

The Panel's recommendations for public involvement reflect these principles:

- The national conference on alternatives to incineration should be planned through a Steering Committee, as described above, which should be charged with ensuring that major stakeholders participate.

- Organization of the conference should include a group of public representatives from all of the regions where the alternative technologies to incineration may be candidates for use at DOE sites.

- Opportunities should be provided for ongoing public participation in periodically assessing the progress of the technology developments on alternatives, e.g., the peer review process.

- State and EPA regional regulators for DOE sites should be kept informed or invited to periodically attend information reviews on the technology alternatives.

- Financial assistance should be provided to reimburse expenses for ongoing public participation and to engage, as needed, independent experts responsive to the needs of the public representatives.

- Discussions of methods to organize and continue public participation at the national level should be a major topic at the 2001 conference.

NEXT STEPS FOR DOE AND SEAB: The Panel expects that the DOE draft RDD&D, outlined in Section IV-A, will change in response to the Panel's recommendations. The Panel's recommendations for technological development should be followed without arbitrariness in the early assignment of priorities among technologies and processes. In particular, DOE should first categorize in detail the wastes that need to be treated, then, link the actual wastes to processes in proposed work scopes. To simplify for emphasis: DOE must identify which processes are to treat what wastes.

DOE's initial selections of alternative technologies should be made on the basis of the Panel recommendations. The Panel is also vitally interested in the science-based portion of the DOE plan. Given the likelihood that the DOE plan itself will change in light of this report, the Panel asks the full SEAB to review progress and continue to advise the Secretary on these matters after the Department has had the opportunity to recast its initial proposal to reflect the Panel’s findings and recommendations.

# APPENDIX I
# Terms of Reference

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Secretary of Energy Advisory Board
Panel on Emerging Technological Alternatives to Incineration

## Terms of Reference

**Objectives and Scope of Activities**:
To evaluate and recommend emerging nonincineration technologies efforts for treatment and disposal of mixed waste on which the Assistant Secretary of Environmental Management's Office of Science and Technology should focus efforts for development, testing, permitting and deployment. The Panel will evaluate the technologies according to the criteria set forth in this charter.

**Background**:
Secretary Bill Richardson established the Panel to assess and recommend technological initiatives that the department should pursue to establish alternatives to incineration. The Panel was an important component of the Secretary's decision to postpone construction of an incinerator to treat nuclear waste stored at the Departments Idaho National Engineering and Environmental Laboratory (INEEL).

**Description of the Panel's Duties**:
The SEAB Panel on Emerging Technological Alternatives to Incineration will evaluate and recommend emerging nonincineration technologies for treatment and disposal of mixed waste on which the Assistant Secretary of Environmental Management's Office of Science and Technology should focus efforts for development, testing, permitting, and deployment.

The Panel will evaluate technologies to treat low-level, alpha low-level and transuranic wastes containing polychlorinated biphenyls (PCBs) and hazardous constituents, including the up to 14,000 cubic meters of such wastes that the DOE had planned to incinerate in the Advanced Mixed Waste Treatment Facility (AMWTF) at INEEL.

The Panel will also evaluate whether these technologies could be implemented in a manner that would allow the department to comply with all the legal requirements, including those contained in the Settlement Agreement and Consent Order signed by the State of Idaho, DOE, and the Navy in October 1995. That agreement requires the Department to remove 65,000 cubic meters of waste at the INEEL from Idaho by the end of 2018. The evaluation should also address the technical concerns raised by the public about the incinerator DOE has proposed as part of the AMWTF.

As a Subpanel of the Secretary of Energy Advisory Board, the Panel's final document will be a report that will be presented in a public forum. A copy of the report will be posted on the web site and made available to the public prior to its presentation to allow the public to prepare questions and comments. Opportunities for public comment will be made throughout the process.

**Reporting**:
The Panel should complete its evaluation and provide recommendations and a report to the Secretary through the SEAB no later than December 15, 2000. Results of the Panel's evaluation and recommendations will be shared with the Governors of Idaho and Wyoming and the public.

**Estimated Number and Frequency of Meetings**:
The Panel is expected to meet at least four times before December 15. Meetings will be scheduled as the Panel deems necessary to accomplish its duties and purposes.

**Membership**:
The Panel will consist of nine members who have expertise and experience in the management of hazardous wastes and related treatment technologies. DOE has nominated five members. The Governors of Idaho and Wyoming have nominated one each. The Panel will also include two representatives nominated by public interest groups.

**Chair of the Panel**:
The Secretary of Energy, in consultation with the Governors of Idaho and Wyoming, will select the Chair.

**Working Groups**:
To facilitate the functioning of the Panel, it may establish working groups on its own initiative. Working groups would undertake fact finding and analysis on behalf of the Panel with respect to matters within the charter of the Panel. Given the broad range of issues to be considered, the Panel may ask working groups to explore certain issues in greater detail. For example, the Panel may ask smaller groups of two or three individuals to review various categories of technologies or specific problems in greater detail. Working groups will report back to the full Panel.

The Chair (or Co-chairs), in consultation with the department, will appoint members of any working groups established by the Panel. Working groups may include members who are not members of the Panel in order that the Panel may obtain additional expertise. Working groups will meet as the Panel deems appropriate.

**Duration and Termination Date**:
This charter shall expire on December 15, 2000 subject to extension or dissolution by the Secretary of Energy.

## APPENDIX II
## Biographical Summaries of Panel Members

## APPENDIX II
## Biographical Summaries of Panel Members

**Ralph Cavanagh,** Chairman, is a senior staff attorney at the San Francisco office the Natural Resources Defense Council (NRDC), a nonprofit environmental-advocacy organization. Prior to rejoining NRDC, Mr. Cavanagh served as an attorney-advisor to the U.S. Department of Justice. He has held appointments as a lecturer at Stanford and Harvard Law Schools and visiting professor of law at the University of California at Berkeley (Boalt Hall). He served on the Energy Engineering Board of the National Academy of Sciences (1987-93), and as vice chair of the Coalition on Energy Efficiency and Renewable Energy Technologies (CEERT). Mr. Cavanagh has also served on the Energy Subcommittee of the President's Commission on Environmental Quality and the Advisory Council of the Electric Power Research Company. He received his undergraduate and law degrees from Yale University.

**Dr. Mario Molina,** Vice-Chairman, is Institute Professor at the Massachusetts Institute of Technology. He was awarded the Nobel Prize in Chemistry in 1995 for the discovery of the theory that fluorocarbons deplete the ozone layer of the stratosphere. He was a Jet Propulsion Lab Senior Research Scientist for the California Institute of Technology. In addition, he has been a researcher, and associate professor at the University of California. He received his Bachelors degree from the Universidad Nacional Autonoma de Mexico and a doctorate in physical chemistry from the University of California at Berkeley.

**Dr. Carl Anderson** is currently the manager of the Wyoming Department of Environmental Quality's hazardous waste permitting and corrective action program, which he helped develop and implement in 1995. He has broad experience in all aspects of hazardous waste permitting and corrective action, including remedial technologies. Dr. Anderson received Bachelors and Masters degrees in geology from Idaho State University and a doctorate in geology from the University of Wyoming.

**Andrew Athy, Jr.** is a partner in the Washington, D.C. law firm of O'Neill, Athy and Casey. In January 1999, Secretary Richardson named Athy chairman of the Secretary of Energy Advisory Board. From 1978 to 1981, he served as counsel to the U.S. House of Representatives Energy and Commerce Subcommittee on Energy and Power; from 1976 to 1978, he was an attorney in the Office of General Counsel of the Federal Election Commission; and from 1973 to 1975, Athy was Assistant Attorney General in the Criminal Division of the Commonwealth of Massachusetts. Mr. Athy received an undergraduate degree from the University of Pennsylvania and a law degree from the Georgetown University Law Center.

**Paul Bardacke** is a founding partner in the New Mexico law firm of Eaves, Bardacke**,** Baugh, Kierst & Kiernan. He was previously a partner in the law firm Sutin, Thayer & Browne. Mr. Bardacke served as Attorney General for the state of New Mexico (1983 to 1986) and was appointed Special U.S. Attorney for the District of New Mexico (1984 to 1985). He is a Fellow of the American College of Trial Lawyers and is also a member of the American, New

Mexico and California Bar Associations. In his legal career, Mr. Bardacke has addressed a number of environmental cases, including cases involving the safety and regulatory requirements of hazardous waste incineration. He received a Bachelors degree cum laude from the University of California at Santa Barbara and a law degree from the University of California at Berkeley.

**Robert J. Budnitz** is President of Future Resources Associates Inc. in Berkeley, California. Previously, he served as Deputy Director and Director of the U.S. Nuclear Regulatory Commission's Office of Nuclear Regulatory Research, and he also held several management positions at the Lawrence Berkeley Laboratory of the University of California. His professional expertise and interests have focused on the environmental impacts, hazards, and safety analysis of nuclear materials, particularly of the nuclear fuel cycle. He has been prominent in the field of nuclear reactor safety assessment and waste-repository performance assessment, including probabilistic risk assessment. Dr. Budnitz has served on numerous investigative and advisory panels of scientific societies, government agencies, and committees of the National Research Council. His most recent National Research Council service was with the Board on Radioactive Waste Management Committee on Buried and Tank Wastes and the Committee on Technical Bases for Yucca Mountain Standards. He received a Bachelors degree from Yale University and a doctorate degree in physics from Harvard University.

**Gretchen Long Glickman** is a resident of Jackson, Wyoming. She is Chairman of the Board of Trustees of the Institute of Ecosystem Studies based in Millbrook, N.Y. She also serves as the Vice Chairman of the National Parks Conservation Association; Chairman of the Murie Center in Jackson, Wyo.; a Trustee of the Teton Science School in Jackson, Wyo.; and a Trustee of the D.C.-based Rails to Trails Conservancy. Ms. Long Glickman is a graduate of Harvard Business School and was a professional executive search consultant during her business career. She is the past Vice Chairman of Environmental Defense and the past Chairman of National Outdoor Leadership School (NOLS) and past Chairman of the Greater Yellowstone Coalition.

**Dr. Marvin Resnikoff** is Senior Associate at Radioactive Waste Management Associates in New York City and has concentrated exclusively on radioactive waste issues since 1974. He was formerly Research Director of the Radioactive Waste Campaign, during which time he authored Living Without Landfills, the Campaign's book on ‘low-level’ waste, and co-authored Deadly Defense, A Citizen Guide to Military Landfills. He is an expert in nuclear waste management and has testified often before State Legislatures and the U.S. Congress. Dr. Resnikoff has prepared numerous reports on incineration of radioactive materials, transportation of irradiated fuel and plutonium, reprocessing, and management of low-level radioactive waste. He has conducted studies on the remediation and closure of the leaking Maxey Flats, Kentucky, radioactive landfill, the Wayne and Maywood, New Jersey, thorium superfund sites and on proposed low-level radioactive waste facilities at Martinsville (IL), Boyd County (NE), Wake County (NC), Ward Valley (CA), and Hudspeth County (TX). He has conducted studies on transportation accident risks and probabilities for the State of Nevada and is currently technical consultant to the State of Utah on the proposed dry cask storage facility and proposed storage/transportation casks. Dr. Resnikoff is a 1965 graduate of the University of Michigan with a Doctor of Philosophy in Theoretical Physics.

**Dr. Charles Till** served as the Associate Laboratory Director for Engineering Research, Argonne National Laboratory from 1980 to 1998. In this role he directed all fission reactor work, along with fusion, non-nuclear energy supply R&D, chemical engineering, and applied materials technology, programs which comprised about half of all scientific activities at the Laboratory. An internationally recognized expert in matters dealing with nuclear power, nuclear waste, and nuclear safety, he was Chairman of the Nuclear Energy Agency Committee on Reactor Physics from 1978 to 1980, which coordinated such development worldwide. He was Technical Director of the Fast Reactor Working Group for U.S. participation in the International Nuclear Fuel Cycle Evaluation, whose purpose was to limit proliferation risk from civilian reactor activities. He received his Ph.D. in nuclear engineering from the Imperial College, University of London, England. He is a member of the National Academy of Engineering and a Fellow of the American Nuclear Society.

# APPENDIX III
## Request For Information (RFI), Commerce Business Daily (CBD) Announcement and List of Responders

## APPENDIX III
## Request For Information (RFI), Commerce Business Daily (CBD) Announcement and List of Responders

[Commerce Business Daily: Posted in CBDNet on August 25, 2000][Printed Issue Date: August 29, 2000] From the Commerce Business Daily Online via GPO Access [cbdnet.access.gpo.gov]

SUBJECT: REQUEST FOR DATA AND INFORMATION ON ALTERNATIVE TECHNOLOGIES TO INCINERATION FOR MIXED TRANSURANIC AND ALPHA LOW-LEVEL WASTE

DESCRIPTION: Request for Information DEPARTMENT OF ENERGY

The U.S. DOE is seeking information on emerging technologies as alternatives to incineration for review by the Secretary of Energy Scientific Advisory Board, Blue Ribbon Panel on Emerging Technological Alternatives to Incineration. This is not a solicitation announcement for proposals and no contract will be awarded as a direct result of the information provided. No reimbursements will be made for any costs associated with preparation of responses to this request.

ACTION: Request for data and information on alternative technologies to incineration for mixed transuranic and alpha low-level waste.

SUMMARY: The Department of Energy (DOE) seeks information from firms and organizations with capabilities and interest in existing and emerging non-incineration technologies for the treatment of Mixed Alpha and Mixed Transuranic (TRU) waste currently being stored at the Idaho National Engineering and Environmental Laboratory (INEEL). The information is sought to inform the Blue Ribbon Panel on Emerging Technological Alternatives to Incineration. The Panel, as part of the Secretary's Energy Advisory Board, is a duly constituted advisory committee under the Federal Advisory Committee Act (FACA) governed by the Act's rules.

DATES: Submit data and information within 30 days of this announcement.

ADDRESSES: All responses should be in writing and be provided to the Executive Director of the Secretary of Energy Advisory Board, Mary Louise Wagner, US Department of Energy, Forrestal Building, 1000 Independence Avenue, Washington D.C. 20585. It should be marked Attention:  Blue Ribbon Panel on Alternatives to Incineration.

SUPPLEMENTARY INFORMATION

**Background:**  INEEL is one of DOE's primary centers for research and development activities on reactor performance, materials testing, environmental monitoring, natural  resources research and planning, and waste processing. In addition to nuclear reactor research, INEEL supports reactor operations; processing and storage of high-level waste (HLW), low-level mixed waste (LLMW), and low-level waste (LLW); the disposal of LLW; and, storage of TRU waste generated by defense program activities. DOE has been storing TRU waste at the INEEL since the early 1970s.

The Settlement Agreement and Consent Order signed by the State of Idaho, DOE, and the Navy requires the removal of this waste by 2018. To treat the TRU and alpha contaminated mixed waste at INEEL, the Department is planning an Advanced Mixed Waste Treatment Project (AMWTP) to be constructed and operated at INEEL. Although incineration was initially proposed as part of this facility, the Secretary has chosen to postpone the incinerator and await the recommendation of the Blue Ribbon Panel on emerging technological alternatives that may be capable of treating the waste. Accordingly, the Department has requested the State of Idaho and EPA only proceed with regulatory approval of the non-incineration components of the AMWTP. Currently, DOE is committed to the goal of identifying environmentally sound alternatives to incineration.

The Secretary of Energy has appointed the Panel to evaluate and recommend new technology initiatives that the Department should consider as alternatives to incineration of mixed transuranic and mixed alpha bearing waste that include shipment of the TRU waste to the Waste Isolation Pilot Plant in New Mexico. In particular, the Panel will assess emerging technologies that could treat such wastes contaminated with polychlorinated biphenyls (PCBs) and other hazardous constituents. The Panel is then to make recommendations to the DOE by December 15, 2000 regarding alternatives.

**Request for Data and Information:** Information provided in response to this RFI will be the sole source made available from industrial and academic organizations to the Panel as the means by which the Panel can review and consider alternatives from the industrial and public perspective. The Panel seeks information that may not be under the purview of the Department of Energy and associated laboratories and contractors. This request for information is voluntary and solely for the purposes of the Panel review. No individual response back to the providers of the information is planned but rather the Panel report will reflect consideration of the input received from responses to this RFI.

Although the Panel would prefer to review non-proprietary information, proprietary information will be accepted. If you wish to include proprietary information in your response, the title page of the response must be marked with the following legend:

Use and Disclosure of Proprietary Information This document includes proprietary information that shall not be disclosed outside the Panel and shall not be duplicated, used, or disclosed--in whole or in part--for any purpose other than review by the Panel. This restriction does not limit the right of the Panel, its members, or the Government to use information contained in the proprietary information if they are obtained from another source without restriction. The information subject to this restriction is contained on pages [insert page numbers].

You shall also mark each page containing proprietary information with the following legend:

"Use or disclosure of information contained on this page is subject to the restriction on the title page of this document."

The Panel will use the information provided to evaluate and recommend approaches and focus to be taken by the Department concerning the development, testing, permitting, and deployment of emerging non-incineration technologies.

This RFI is not an opportunity or obligation to provide goods or services to DOE. All information provided is strictly voluntary without expectations of remuneration from the Department. Responses to this RFI should address each of the criterion listed on the following page. Limit responses to no more than a total of 35 typed pages using a font size of no less than 10 point, Arial or similar. Responses must include a one-two page overview of the technology or system, as well as a one-page table that summarizes the key characteristics for each of the seven individual criteria. To be considered, all responses are due within 30 calendar days of the date of this RFI notice.

The Panel has selected criteria as guidelines for making recommendations to the Department on emerging alternative technologies. Information supplied in response to this RFI should indicate the status data, knowledge, testing, and operating experience relative to following criteria:

1. Environmental, Safety and Health (ES&H) Risk Considerations (Describe the safety of the system, potential ES&H risks and the difficulty in designing and constructing a system to meet the safety and environmental health requirements in radioactive service.)

2. Stakeholder and Regulatory Interests (Describe the degree to which there may be resistance or delays in implementing the technology or system due to either public concerns or regulatory requirements.)

3. Functional and Technical Performance (Describe the technical performance of the treatment process to include destruction efficiency, volume reduction capability, secondary waste generation, robustness and flexibility of the system to process diverse types of waste, final waste form performance & characteristics, and its capability to be shipped.)

4. Operational Reliability (Describe the reliability and availability of the treatment process, its complexity, and the potential exposure to maintenance workers.)

5. Pre- and Post-Treatment (Describe the pre-treatment and post-treatment requirements of the waste including expected amounts and the requirements for treating

the effluents from the process.)

6. Economic Viability (Describe the total life-cycle cost of the system, the cost per unit volume of waste treated, the market for the technology, and the potential that the technology will be commercially available to treat the waste.)

7. Maturity (Describe the level of development of the technology, field experience with the technology in radioactive service, and whether the technology will be available in the time frame required, i.e., removal of this waste by 2018.)

Most of the waste treated at the AMWTP will be packaged for shipment offsite for disposal at the Waste Isolation Pilot Plant (WIPP) near Carlsbad, New Mexico. Alpha LLMW must be treated to comply with RCRA land disposal restriction (LDR) standards and the mixed TRU waste must be treated to meet the WIPP waste acceptance criteria (WAC). WIPP WAC physical properties include: Free liquid content is less than 1 volume percent of external container; or less than 1 inch or 2.5 cm in bottom of internal containers; no sealed containers greater than 4 liters.

WIPP WAC chemical properties are: less than 1percent radionuclide pyrophorics, no non-radionuclide pyrophorics; hazardous waste characterized in accordance with approved site-specific criteria limited to RCRA hazardous waste codes as listed in WIPP WAC Table 3.5.2; no chemicals or materials that are incompatible; no explosives, corrosives or compressed gases; PCB concentration less than 50 ppm; wastes containing asbestos should be identified; every container headspace will be sampled for volatile organic compounds. Additional information on WIPP WAC should be reviewed at http://www.wipp.carlsbad.nm.us/wipp.htm.

Suitable non-incineration technology must be available in time to complete the treatment and shipment of a minimum of about 3000 cubic meters of INEEL TRU waste. Certain wastes will require alternative treatment prior to shipment to WIPP or land disposal if incineration is not used. Such wastes may contain the following contaminants:

Polychlorinated biphenyls (PCBs) in concentrations equal to or greater than 50 parts per million (ppm), Containers with a potential for a flammable concentration of gas in the headspace due to the presence of volatile organic compounds (VOCs) or from significant hydrogen gas generation due to radiolysis, Containers with free liquids, Reactive or pyrophoric materials. Bulk composition of these wastes includes paper, oils and other organics, cloth, metals, glass, empty bottles and absorbent, and process sludges.

## LIST OF RESPONDERS

1. AEA Technology Eng. Services
2. ATG
3. CerOx Corporation
4. Clean Technology Int'l
5. Commodore Advanced Sciences
6. Delphi Research Inc
7. DURATEK
8. Electro-Pyrolysis, Inc
9. Environmental Technology
10. Environmental Waste International
11. General Atomics
12. High Mesa Technologies
13. Integrated Environmental Tech.
14. MicroBasix
15. Nukem Nuclear Technologies
16. Perma-Fix
17. RACE, LLC
18. SAIC
19. SEPRADYNE Corp.
20. STUDSVIK, Inc.
21. Westinghouse Plasma Corp.

# APPENDIX IV
# Waste Streams Potentially Requiring Treatment at AMWTP, by Charles Till

**APPENDIX IV**
**Waste Streams Potentially Requiring Treatment at AMWTP, by Charles Till**

# Waste Streams Potentially Requiring Treatment at AMWTP

| IDC | Name | D001 | D002 | Volume ($m^3$) | Comment |
|---|---|---|---|---|---|
| 003 | Organic setups; oil soils | | X | ~ 1425 | A fraction of this waste is expected to be contaminated with PCB's in excess of 50 ppm, the current WIPP limit. The organic setups waste were produced from treatment of liquid organic wastes generated by various plutonium and nonplutonium operations. The organic wastes were mixed with calcium silicate to form a grease paste-like material. Small amounts of oil-dri absorbent were usually mixed with the waste.<br><br>Organic wastes such as degreasing agents (primarily trichloroethane), lathe coolant (machining oil and carbon tetrachloride), and hydraulic were are generated primarily by plutonium fabrication operations. Other organic wastes include carbon tetrachloride; trichloroethylene; hydraulic, gearbox, and spindle-oils; and trace concentrations of miscellaneous organic laboratory wastes. (organophosphates, nitrobenzene, etc.) In addition, unknown volumes of oil containing polychlorinated biphenyls (PCB) were processed with other organic wastes until 1979. Degreasing solvents generated by operations are contaminated with beryllium. A typical 55 gal drum contains approximately 30 gal of organic waste and 100 lb of calcium silicate.<br><br>This stream is a major contributor to the wastes requiring treatment either as a result of PCB contamination or because of the presence of flammable VOCs. BNFL Inc. believes that approximately 80percent of the waste in this category will require treatment, with PCB contamination driving the treatment of a few hundred $m^3$ of the waste. |

| Waste Streams Potentially Requiring Treatment at AMWTP | | | | | |
|---|---|---|---|---|---|
| **IDC** | **Name** | **D001** | **D002** | **Volume ($m^3$)** | **Comment** |
| 203 | Paper, metal, and glass | | X | 26.3 | This waste stream is listed in the HWMA/TSCA permit application as a PCB waste stream. This waste stream, generated at Battelle Columbus Laboratories, contains a mixture of combustible and noncombustible items in roughly equal proportions. Combustible items include paper and paper products. Noncombustibles are primarily metal and some glass.<br><br>The organic content is about 9 lb/ft3 in drums and about 5 lb/ft3 in bins. Combustibles, including packaging, may exceed 25 volume percent. The levels of dispersible fines should be within WIPP-WAC limits. No sludges or free liquids should be present. No explosive or pyrophoric materials should be in this waste.<br><br>This IDC is a relatively low volume stream but 203 carries a code for PCBs and thus requires treatment. The PCB contamination is contained in 1-gallon metal cans (estimated at 20 1-gallon metal cans.) |

# Waste Streams Potentially Requiring Treatment at AMWTP

| IDC | Name | D001 | D002 | Volume ($m^3$) | Comment |
|---|---|---|---|---|---|
| 001 | First stage sludge | | X | 2888.7 | This waste consists of a wet sludge produced from treating aqueous process wastes, such as ion exchange column effluent, distillates, and caustic scrub solutions generated by Plutonium Recovery Operations at Rocky Flats (Building 771). Portland cement was added to the waste package for absorption of free liquids. Waste drums may periodically contain surgeon's gloves.<br><br>Since the fall of 1979, first-stage sludge (IDC 001) and Second stage sludge (IDC 002) were combined into Content Code 1 - Combined sludge.<br><br>Sludge was produced by treating aqueous wastes by the carrier precipitation process. Aqueous wastes were made basic, if necessary, with sodium hydroxide. Radioactive elements such as plutonium and americium were chemically precipitated from the liquid waste. Treatment chemicals included ferric sulfate, calcium chloride, magnesium sulfate, and flocculating agents. The treatment process produced a precipitate of the hydrated oxides of iron, magnesium, aluminum, silicon, etc., which also carried the hydrated oxides of plutonium and americium. The precipitate or slurry was filtered to produce a sludge containing 50 to 70 weight percent water.<br><br>Materials in this waste group (IDCs 001, 002 and 800) may meet the definition of corrosivity as defined in 40 CFR 261.22 to the presence of caustic free liquids. Free liquids were identified in some sludge drums. Analysis...indicates a pH range of 8 to 12. Although the pH does not meet the definition of corrosivity these results are limited and may not be representative of the entire inventory. According to (RFETS Bldg. 774) log books, the liquids treated were consistently above pH=12.5.<br><br>BNFL believes that the presence of corrosive liquids cannot be discounted, and further that there is some possibility of flammable VOCs being present. BNFL estimates that up to 25percent of the combined volume of IDC 001 and IDC 002 may require treatment either to remove the free liquids or to deal with flammable VOCs. |

| Waste Streams Potentially Requiring Treatment at AMWTP | | | | | |
|---|---|---|---|---|---|
| **IDC** | **Name** | **D001** | **D002** | **Volume ($m^3$)** | **Comment** |
| 002 | Second Stage sludge | | X | 2555.7 | This waste consists of wet sludge produced from treatment of all other plant radioactive and/or chemical contaminated wastes and further treatment of the first-stage effluent. Portland cement was added to the waste package for absorption of free liquids.<br><br>Second-stage sludge drums packaged prior to 1973 may contain other waste such as electric motors, bottles of chemical (usually liquid) wastes, mercury and lithium batteries, and small amounts of contaminated mercury in pint bottles. Radioactive sources were also periodically included in second-stage drums through 1979.<br><br>See also additional comments (“Sludge was produced.....”and following) under IDC 001. |

| Waste Streams Potentially Requiring Treatment at AMWTP | | | | | |
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| **IDC** | **Name** | **D001** | **D002** | **Volume ($m^3$)** | **Comment** |
| 800 | Solidified Sludge | | X | 326.4 | The process that produced solidified sludge from Rocky Flats Building 774 (IDC 800) was very similar to IDC 001. The sludge was co-fed into a drum with a diatomite and Portland cement mixture which formed a solid monolith after curing. IDC 800 was generated from 1986 until March 1991.<br><br>See also additional comments ("Materials in this waste group...") under IDC001.<br><br>The BNFL analysis of this waste stream indicated that the process used in its generation involved an immobilization technique that might be expected to limit the occurrence of free liquids. BNFL therefore assumes that the probability of this stream requiring treatment is low, and that it will not contribute materially to the overall volume requiring treatment in this group. |

| Waste Streams Potentially Requiring Treatment at AMWTP | | | | | |
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| **IDC** | **Name** | **D001** | **D002** | **Volume ($m^3$)** | **Comment** |
| 007 | Dried Sludge | | X | 1097.9 | Rocky Flats solidified sludge consists of immobilized low-level mixed waste materials from decontamination-precipitation and neutralization processes in the Building 374 Liquid Waste Treatment Facility. The wastewater treatment operation included neutralization, radioactive decontamination (precipitation), filtration, evaporation, spray drying, salt immobilization, and filtrate sludge immobilization. The sludge from the rotary drum vacuum filter had a dry appearance but was still very moist. The dried sludge was transferred from the dryer directly into a 55-gallon drum. The resulting waste consisted of dispersible fines and was assigned IDC 007.<br><br>Materials in this group (IDCs 007, 803 and 807) may meet the definition of corrosivity due to the presence of caustic free liquids...it is suspected bypass sludge generated before April 1986 may have dewatered. Free liquids..were identified in 4 drums of IDC 007...Analysis of the liquids indicate of pH range of 7 to 12. Although the pH does not meet the definition of corrosivity, these results are limited and may not be representative of the entire inventory. According to generator knowledge and Rocky Flats Bldg. 374 treatment log books, the pH of liquids treated was as high as 14 and was consistently above 12.5.<br><br>BNFL notes that this is a relatively large waste stream and that liquids have been detected in some drums. Although modest pH values of 7-12 were noted, perhaps due to reaction with $CO_2$, the possibility of high alkalinity free liquids cannot be precluded. In the BNFL view, there is a high likelihood that these wastes may require treatment, and possibly up to 75percent might fall into the treatment category. |

| Waste Streams Potentially Requiring Treatment at AMWTP | | | | | |
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| **IDC** | **Name** | **D001** | **D002** | **Volume ($m^3$)** | **Comment** |
| 803 | Wet sludge-cemented | | X | 33.6 | This waste consists of sludge dried in a dryer, and mixed with Portland cement and water, which cured to form a solid monolith.<br><br>See additional comments ("This materials in this waste group..." and following) under IDC 007.<br><br>In the BNFL analysis, IDC 803 and 807 wastes were considered together with IDC 007 as a group. See the comments on waste volume under IDC 007. |
| 807 | Solidified bypass sludge | | X | 267.1 | This waste consists of sludge that bypassed the dryer and was mixed with diatomite and Portland cement. IDC 807 sludge is the same as the IDC 007 sludge generated using the bypass system.<br><br>See additional comments ("The materials in this waste group...." and following) under IDC 007.<br><br>In the BNFL analysis, IDC 803 and 807 wastes were considered together with IDC 007 as a group. See the comments on waste volume under IDC 007. |

| Waste Streams Potentially Requiring Treatment at AMWTP | | | | | |
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| **IDC** | **Name** | **D001** | **D002** | **Volume ($m^3$)** | **Comment** |
| 440 | Glass | X | | 508.2 | This waste consists of glass generated by plutonium production, recovery, treatment, laboratory and maintenance operations at many locations at Rocky Flats. The waste consists of items such as bottles, vials, light bulbs, labware, glovebox windows, and process equipment.<br><br>These materials may meet the definition of ignitable due to the presence of ignitable free liquids. The materials themselves are not liquid, and absorbents were added to wastes having the potential of generating free liquids (e.g. glass vitals containing liquid). However, free liquids were identified in a few drums of glass waste. Headspace gas analysis indicates that the liquids contain cycolhexane; an ignitable liquid.<br><br>BNFL assumes that there is a moderate possibility of this stream requiring treatment. It is estimated that up to 50percent of the volume could fall into the treatment category. |
| 441 | Raschig rings, unleached | | X | 348.2 | This waste consists of Raschig rings (borosilicate glass rings) used to maintain subcritical conditions in fissile solution storage tanks that were not safe by dimension. Unleached Raschig rings may meet the definition of corrosivity due to the presence of acid or caustic free liquids. The material in this group is not a liquid, and absorbents were added to wastes having the potential of generating free liquids. However, unleached raschig rings removed from tanks that contained acids or bases could potentially contain corrosive fuel liquids.<br><br>BNFL believes it unlikely that these wastes will make a significant contribution to the treatment category. |

| Waste Streams Potentially Requiring Treatment at AMWTP | | | | | |
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| **IDC** | **Name** | **D001** | **D002** | **Volume ($m^3$)** | **Comment** |
| 290 | Sludge filter | | X | 1 | This waste stream, generated at Rocky Flats Plant, consists of only one (1) drum of wet sludge from the incinerator off-gas system, recovery building filter plenums, pumps, etc. Content Code 290 was replaced with Code 292 in 1974.<br><br>This waste contains free liquids. Organic content is less than 14 lb/ft3. No explosive, pyrophoric, or corrosive materials should be in the waste.<br><br>The filter sludge was packaged in 1-quart ice cream cartons. Each carton was sealed. It is believed that each carton was bagged and sealed in a Vollrath 8802 stainless steel can. Cans were assayed and then placed in groups of 20 to 25 in prepared 55-gallon drums. |

| Waste Streams Potentially Requiring Treatment at AMWTP | | | | | |
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| **IDC** | **Name** | **D001** | **D002** | **Volume ($m^3$)** | **Comment** |
| 292 | Cemented Sludge | | X | 135.8 | Incinerator sludge (IDC 292) packaged prior to 1977 was placed in a polyvinyl chloride bag and sealed with tape. The bag was then double-contained in plastic and placed in a 1-gallon metal paint can containing Portland cement. Additional cement was added to the top of the waste before the paint can lid was closed. Beginning in 1977, the sludge was collected in 2-or 4 liter Nalgene bottles. Portland cement was added in layers as the bottled filled with sludge. The sludge was capped with cement, the bottle lid was installed, and the bottle was double-bagged. The sludge may also be packaged in several plastic bags within the drum. Each individual package was bagged out of the glovebox and placed in two plastic bags that were sealed with tape. The packages were assayed and placed into a 55-gallon drum. Up to 25 cans or 20 bottles were placed in a drum depending on assay. IDC 292 may exhibit the characteristic of corrosivity due to the presence of caustic free liquids.<br><br>In BNFL's view, this waste stream has a moderate probability of contributing to the treated waste, perhaps as much as 75percent of the volume of IDC 290 and 292. |

| Waste Streams Potentially Requiring Treatment at AMWTP | | | | | |
|---|---|---|---|---|---|
| **IDC** | **Name** | **D001** | **D002** | **Volume ($m^3$)** | **Comment** |
| 105 | Empty bottle and absorbent | | | 0.7 | This waste stream consists of PE and glass bottles used to transport liquids wastes. The organic content is around 5 lb/ft3. The levels of dispersible fines should be within WIPP-WAC limits. No sludges or free liquids should be present, except for small quantities of wet vermiculite. No explosive or pyrophoric materials should be in the waste.<br><br>BNFL notes that this is a very small waste steam with a very low likelihood of requiring treatment. |
| 802 | Solidified Lab Waste | X | | 16.3 | IDC 802 is not identified in the AK document as a characteristic waste. This waste stream was generated at Mound Laboratory and consists of neoprene gloves, neoprene O-rings, and lead-lined gloves. Limited amounts of waste from Mound content codes 801, 804, and 812 may be included.<br><br>BNFL analysis is that IDC 802 is a small volume that has a low chance of containing cyclohexane, and that this waste stream will make no significant contribution to the treatment category. |

| Waste Streams Potentially Requiring Treatment at AMWTP | | | | | |
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| **IDC** | **Name** | **D001** | **D002** | **Volume ($m^3$)** | **Comment** |
| 005 | Evaporator Salts | X | | 8.0 | This waste consists of a salt residue generated from concentrating and drying liquid waste from concentrating and drying liquid waste from solar evaporator ponds. The approximate chemical makeup is 60percent sodium nitrate, 30percent potassium nitrate, and 10percent 'miscellaneous'. Limited amounts of other wastes such as surgeons gloves, paper, rags, and metal may be found. Portland cement was added to damp or wet salt when necessary.<br><br>Noting that the drum may contain both liquids and nitrates, BNFL believes that up to 75percent of this low-volume stream may require treatment. |
| 834 | High Level Acid | X | X | 187.7 | This waste comes from Mound Laboratory. It consists of acid liquids, mainly nitric, absorbed onto a clay called Florco. The Florco is then placed in a drum bag in a drum lined with a 90-mil poly liner. Analytical assay values are available for each drum.<br><br>For both IDC 834 and 835, the BNFL view is that both streams were extensively sorbed and are not expected to exhibit free liquids. Neutralization of caustic and buffering by the clay also would tend to reduce the extremes of pH. |
| 835 | High Level Caustic | | X | 348.8 | This waste comes from Mound Laboratory. It consists of caustic waste and neutralized waste liquids, absorbed onto a clay called Florco. The Florco is then placed in a drum bag in a drum lined with a 90-mil poly liner. Analytical assay values are available for each drum.<br><br>See BNFL comments above under IDC 834. |

| Waste Streams Potentially Requiring Treatment at AMWTP | | | | | |
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| **IDC** | **Name** | **D001** | **D002** | **Volume ($m^3$)** | **Comment** |
| 811 | Evaporator and Dissolver sludge | X | | 0.8 | This waste stream, generated at Mound Laboratory, consists of dry evaporator and dissolver sludge and insoluble residue. The consistency ranges from powder to sand-like particles. Limited amounts of other noncombustible wastes including Content Codes 803, 805, 810, 813, 814, 826, and 832 may be included. A few containers may have limited amounts of beryllium-contaminated wastes including glass, paper, gloves, and sample precipitates.<br><br>The drums contain free liquids. The expected organic content in the drums is less than 14lb/ft3. No explosive, pyrophoric, or corrosive materials should be in the waste.<br><br>BNFL comments that this is a very low volume waste stream unlikely to contribute significantly. |
| 430 | Resin, Ion Column unleached | X | | 12.7 | This waste, generated at the Rocky Flats Plant, consists of anionic and cationic exchange resins used in the purification and recovery of plutonium and americium, respectively. The anionic resins were DOWEX 1-X4 and the cationic resins were DOWEX 50W-X8, both being polystyrene-divinylbenzene copolymers.<br><br>BNFL notes that this small-volume stream might require 10percent of the stream volume to be treated. |

[1] **The volumes listed are not indicative of the amount of waste that requires treatment--the volumes indicated are the totals for the stream.**

# APPENDIX V
## Executive Summary
## Transuranic and Mixed Waste Focus Area,
## Alternatives to Incineration: Preliminary Research, Development, Demonstration and Deployment (RDD&D) Plan
## October 2000

**APPENDIX V**
**Executive Summary**
**Transuranic and Mixed Waste Focus Area,**
**Alternatives to Incineration: Preliminary Research, Development, Demonstration and Deployment (RDD&D) Plan**
**October 2000**

For over ten years, the Department of Energy (DOE) has successfully incinerated a variety of the organic-based mixed wastes that were generated from its past and present nuclear energy, waste remediation, and weapons missions. However, some of these waste streams are not amenable to efficient incineration since they contain transuranics, mercuric compounds, explosives, and/or reactives. Additionally, public concern over incinerator emissions, and the recently mandated Environmental Protection Agency (EPA) requirements to enhance monitoring and treatment of these emissions, has caused the DOE to consider closure of all three of its mixed waste incinerators complex wide. As a result, the DOE's Transuranic and Mixed Waste Focus Area (TMFA) has established a new plan for developing, and deploying the cost effective and timely alternative technologies necessary for replacing the role of incineration. [11]

The strategy presented in the plan is most applicable to those wastes that will be generated in the out years as a result of extensive remediation and DOE site closure activities. The majority of the legacy mixed waste volumes immediately displaced as a result of near –term incineration closure may be treated through the private sector and may not be, except in specific cases, impacted by the plan.

The preliminary plan to develop these alternative methods requires a broad range of efforts over the various stages of development, including those of basic science research and full-scale integrated demonstrations. To be successful, the specific development and deployment plan to be initiated in FY 2001 by DOE's Transuranic and Mixed Waste Focus Area (TMFA) must include regulatory and public input, in addition to the traditional technical component. The regulatory issues are to be addressed by working directly with the various State and Federal agencies (e.g., the Environmental Protection Agency/EPA) throughout the alternatives development process. Through communication with these agencies, various developers will be informed of the data needed to ensure permitting, and will be notified of pending regulatory changes that may effect the future applicability of their alternative technology. Likewise stakeholder and public issues will be addressed by presenting the strategy, as well as periodic

[11] A budget for the plan has also been prepared and it provides recommended estimates of resources for the next four fiscal years. This budget is presented as a Table in Section IV A. Overview of the Evolving DOE Plan. As indicated by the table, the present TMFA allocated FY2001-2002 budgets are tabulated along with a recommended plus-up budget required to address the proposed plan.

status reports to established stakeholder groups. As a result of the presentations, stakeholders will play an active role in the process by providing criteria for selecting and testing alternatives. Additionally, public perception will be gauged through the presentations and various efforts of the alternatives development plan will be redirected, altered, or terminated as appropriate.

Technical issues will be addressed through a development effort involving a side-by-side comparative study of emerging alternative methods to incineration. Based, in part on an independent peer review, methods selected for the study will include near ready or relatively mature technologies. The comparative study will involve collecting the necessary performance, design, scale-up, and permitting data for each selected technology. Testing with identical waste surrogates and actual wastes will ensure that each alternative technology generates comparable data. Starting in FY 2001, the TMFA will prepare the required facilities for housing the comparison tests and issue the appropriate competitive calls to initiate the testing program in FY 2002.

DOE’s Western Environmental Technology Office (WETO) in Butte MT will support the majority of the comparison testing and will be equipped with the required additional monitoring and analytical equipment in FY2001. Based on the competitive solicitation issued in 2001, three to five primary alternative treatment processes will be selected for comparison testing at WETO in FY 2002. The current strategy is to select enough processes to represent the three general classes of alternatives: thermal, aqueous based chemical oxidation (including dehalogenation), and separations. In addition to the primary alternative test units to be located at WETO, on-going tests of other alternative methods at other locations will be leveraged and altered in a manner to make them consistent with the comparative studies at WETO. A number of these leveraged alternative methods will involve on-going TMFA funded projects already addressing specific DOE issues in regard to both mixed low-level and transuranic waste. In addition to surrogate waste testing at WETO and alternative sites, demonstrations using actual wastes of interest will be performed on selected technologies with the highest potential for success. Additionally, if the requested budget levels are obtained for FY-2001, limited testing on selected technologies will be initiated as early as FY-2001.

The scheduled three-year long comparative study of near ready or mature alternatives will be supplemented with a series of basic science research efforts, as well as with development activities to optimize the ancillary systems required for completely integrated alternative methods. The efforts in basic science research will span three years and, at a minimum, will include extensive studies in material research, off –gas pollutant formation, and long-term waste form stability, as well as on new concepts for organic separation and destruction. Ancillary system testing will include activities involving pretreatment, waste feed pre-sizing, off –gas monitoring, and residue stabilization. Upon completion of the comparison testing in FY-2004, two to three of the higher performing alternatives will be selected for integrated prototype testing, starting in early FY2006. The selection will be based on an additional peer review by an independent consulting panel as well as on any feedback received from the established public stakeholder groups. If appropriate, the current plan is to conduct this final test phase at a single location. This integrated testing is expected to last at least two years, culminating with deployments by 2007.