NEW REPORT ISSUED ON FERNALD'S MOST DIFFICULT WASTE-TREATMENT ISSUE

APRIL 23, 1997

**Efforts to demonstrate a new technology for treating radioactive waste at Fernald have proven more costly and difficult than expected. A new report by an independent technical review team provides helpful information on this issue. While most of the Fernald cleanup has been proceeding expeditiously and significant cost savings have been realized, this trial demonstation is one area that has not progressed on schedule or budget. Vitrification binds radioactive waste into glass beads. This technology has been proposed for use on the radioactive waste stored in concrete silos that together are known as Operable Unit 4. Vitrification technology has proven successful with radioactive waste at other locations. However, the chemical content of the waste at Fernald has caused complications. Difficulties with the technology have prompted a thorough review of the best way to deal with the waste in these silos. This new report contains the judgement of a panel of independent experts and helps identify problems and possible alternative solutions. The DOE is working closely with its citizen advisory board, the Ohio Environmental Protection Agency, the U.S. Environmental Protection Agency and interested citizens to find the best means to treat this waste. Additional information is still needed before a decision can be reached. Further study and deliberations with regulators and the interested public may take several months.**

# SILOS PROJECT

# INDEPENDENT REVIEW TEAM

# FINAL MAJORITY REPORT

APRIL 1997

## TABLE OF CONTENTS



000003

LIST OF TABLES

## EXECUTIVE SUMMARY

Fluor Daniel Fernald (FDF) convened the Silos Project Independent Review Team (IRT) in November 1996, to provide recommendations to FDF and the U.S. Department of Energy (DOE) as an aid in an internal decision making process. Specifically, the IRT was tasked to assist and advise FDF, the DOE, stakeholders and regulatory agencies in developing a recommended path forward for immobilization and disposal of the wastes contained in Silos 1, 2 and 3 in Operable Unit 4 (OU4) of the Fernald Environmental Management Project (FEMP).

The IRT was originally composed of nine members, having background and experience in several areas including vitrification, glass furnaces and glass making, projects and project management, process design, process engineering, regulatory and environmental affairs and safety. Later, two additional IRT members were added with experience in cementation. The IRT held the first team meeting on November 14 and 15, 1996, and the fifth and last meeting on February 25 through 28, 1997.

Based on the information provided through reports, discussions, presentations and tours, and supplemented by individual knowledge and study, the Team came to several unified recommendations and some observations:

- Silo 1, 2 and 3 wastes should not be vitrified together (proposed Alternative I). The waste contained in these silos has competing glass chemistry requirements, specifically, the high sulfate concentration in Silo 3, and the high and varying lead content in Silos 1 and 2 create competing requirements. Measures taken to alleviate one will most likely exacerbate the other;

- Silo 3 waste should be immobilized through a cementation process. This waste has been calcined and is dry and it contains high sulfate concentrations not conducive to vitrification. Other Fernald waste materials have been successfully cemented by FDF and, since Silo 3 waste lacks the hazard associated with the radium in Silos 1 and 2, cementation of this waste is appropriate.

- The vitrification pilot plant should not be used for further melter testing, but be evaluated for other uses such as waste retrieval optimization, feed stream preparation, and off-gas system testing.

- Additional characterization of the silos waste is needed to better understand what is in the silos, and to assist in developing treatment process recipes.

- Immediate attention should be given to silo waste retrieval and heel-removal. Little has been done to assure this effort will proceed safely, easily and at the rate anticipated to support the treatment processes.

- FDF should actively pursue some form of commercial involvement rather than in-house design, construction and operation of a new facility. Commercial involvement might include some form of turnkey subcontracting, similar to other successful FDF contracts.

- Cementation should be carried as a backup technology in the event vitrification fails. By recommending this, the IRT is not advocating an intense dual track development program with both cementation and vitrification. Rather, activities that maintain cement as a contingency should be of relatively low-cost and should not divert funds from the vitrification program.

The entire IRT agreed that vitrification of Silos 1 and 2 waste and stabilization of Silo 3 waste (Alternative II) could be successfully pursued to completion. However, the Team was unable to reach consensus upon a recommended treatment process for the Silos 1 and 2 waste. The majority of the IRT made the following recommendation:

Silos 1 and 2 waste should be immobilized through a low temperature (1150° C) vitrification process. There is no compelling reason to abandon vitrification of Silos 1 and 2 waste. It is important, however, that vitrification be implemented through a planned and successful phased development program.

## I. INTRODUCTION

FDF convened the IRT in November, 1996, as an advisory group and technical resource to assist FDF, the DOE, stakeholders and regulatory agencies in developing a path forward recommendation for immobilization and disposal of the waste contained in Silos 1, 2, and 3 in OU4 of the FEMP.

The initial meeting of the IRT with FDF, the DOE, stakeholders and regulatory representatives was held November 14 and 15, 1996, and consisted of an overview of Operable Unit 4 history, current status, and near-term plans. A tour of the operational pilot plant was also provided. Since then, the Team has met once each month to assist FDF with development of a decision analysis model, and to provide technical and programmatic recommendations based on information presented by FDF and the collective experience represented by the individual members of the Team. The Team was also briefed on details surrounding the Vitrification Pilot Plant (VITPP) melter failure and subsequent evaluations of that event.

In initial proceedings of the IRT, FDF provided the following "Overview of Objectives" to help focus the Team in its deliberations:

- The IRT will be providing advice/recommendations to FDF and the DOE as an aid in an internal decision making process. FDF and the DOE will evaluate this input internally in determining what, if any, modifications to our current path forward (i.e. vitrification of silos waste) should be formally proposed to the regulators and other stakeholders. Stakeholders are being asked for input during the internal decision making process in firm recognition of the vital importance of their acceptance if any path forward modifications are proposed formally.

- The IRT will aid in decision making by:
    - Reviewing current FDF and DOE recommendations to stabilize Silo 3 waste and reach consensus to agree with or suggest modifications to this direction.

- Assist with optimization of vitrification by:

  - Reviewing, commenting and providing advice on the upgrade plans for the Pilot Plant and evaluating the Pilot Plant operating results.

  - Providing reviews, comments, and advice, using lessons learned on the current technical approach to vitrification.

- In light of significant uncertainties in vitrification process reliability observed to date, and associated impacts on project schedule and like issues, FDF and the DOE would like advice/recommendations on whether to formally re-evaluate the selected OU4 remedy. FDF and the DOE would like the IRT to evaluate issues associated with vitrification implementation and identify and evaluate any potentially viable options to vitrification. In light of these evaluations, FDF and DOE would like input on the appropriateness of re-evaluating, through a formal public process, the current OU4 path forward. The IRT is not expected to advance a sole recommendation for a single alternative, but rather to perform an evaluation and provide advice based on their experiences for each alternative as an aid to our path forward evaluation.

- The alternatives to be considered (at a minimum) include:

| | |
|---|---|
| Alternative I | Vitrify all three silos waste (Record of Decision Remedy) |
| Alternative II | Vitrify Silos 1 and 2 waste and stabilize Silo 3 waste |
| Alternative III | Use stabilization in the form of some viable option(s) for all three silos waste |

For further clarification and understanding, the IRT developed its interpretation of Fernald's objective:

- The ultimate goal of the OU4 Project is to:

  - Immobilize the unique Fernald silos waste safely, efficiently, and cost effectively.

  - Package and safely transport the treated wastes, and store those wastes at an acceptable disposal site.

- All actions are to be performed with the DOE and regulator approval, public acceptance and within a reasonable time frame.

The IRT recommendations that follow are offered on the basis of Team member experience and information received in the monthly meetings, including studies and reports developed in response to Team questions. It is important to note that Fernald has developed much more experience and data for the vitrification alternative than for the cementation alternative, since vitrification is the path forward identified in the Record of Decision (ROD). Additionally, as is normally the case for this stage in the technical decision-making process, there are variations in the depth and quality of cost and schedule estimates for both alternatives. In this case, vitrification is more developed. On the other hand, there is an experience base in the U.S. and overseas for both vitrification and cementation of radioactive waste.

The Team is confident that sufficient knowledge and adequate technology exist to achieve successful immobilization of the silos waste if the Team's recommendations are adopted and followed through to completion. In this context, successful immobilization includes achieving a vitrified or stabilized waste form satisfying the DOE regulations and requirements for disposal at the Nevada Test Site (NTS).

The Team is aware of the FDF projection of cost and schedule growth for the Silos Project. As part of the IRT deliberation/decision process, the team reviewed and discussed in-depth the Silos Project cost and schedule information provided by FDF (see Table B.8-1). In general, the team believes the cost and schedule data appear reasonable. However, because of the lack of engineering data and the significant overlap in the cost estimate ranges, these estimates could not be used as a discriminator in the final IRT recommendation.

The Team considers it beneficial to the Silos Project that the following issues, because of their importance to the success of the program, continue to be recognized and not overlooked:

- Complete characterization of silo waste
- Obtain DOE and NTS approval of the disposal site WAC
- Complete a performance assessment which envelopes the characteristics of the Silos waste.
- Identify all regulatory requirements
- Identify all applicable DOE orders
- Identify and prepare applicable general specifications

To a limited extent, the Team has pursued, with FDF and the regulatory representatives who have participated in the Team's meetings, the anticipated impact on the ROD of various treatment alternatives. The Team concluded from these discussions that impacts to the ROD cannot be determined with confidence until a specific immobilization process recommendation is submitted for regulatory review. Additionally, in evaluating technical alternatives, the Team also considered surety of waste product acceptability, the vitrification pilot plant operating experience, safety, cost of the stabilization processes, and the time required to deploy alternative technologies.

## II. ALTERNATIVE I EVALUATION

### A. Background

The Team's focus on Alternative I was directed toward the feasibility and practicality of using a vitrification process to remediate a mixture of the wastes in Silos 1, 2 and 3 (K-65 waste and cold metal oxides) and the contents of the decant sump tank as stipulated in the OU4 ROD. In addition, the evaluation addressed concerns related to waste retrieval, radon treatment, waste packaging and shipping, and disposal of vitrified waste at the NTS.

000008

## B. IRT Recommendation

The entire IRT concluded that Alternative I (vitrification of all silos waste and decant sump tank waste) should be eliminated from further consideration.

There was a team consensus that any vitrification program designed to accommodate a mixture of wastes from all three silos would suffer from great uncertainty in implementation. The design of a vitrification process for any combination of Silos 1, 2, and 3 waste would have to simultaneously address two specific glass chemistry challenges:

- The high sulfate concentration in Silo 3 waste (sulfate has a low solubility in glass)

- The high and varying lead content in Silos 1 and 2 waste (without proper control, lead can precipitate in the melter and compromise the integrity of the melter's materials of construction)

Because of the high concentration of sulfates present in the Silo 3 waste (15 wt%), the entire IRT agrees and recommends that vitrification of Silo 3 waste should not be pursued. Based on the Team's background and experience, materials containing high sulfate concentrations are extremely difficult to control during vitrification and can result in foaming events causing potentially serious operational concerns. In addition, mechanisms used to control the foaming events (e.g., addition of reductants) could reduce waste loading in the glass matrix to an undesirable level. Again, although a process could be developed to accommodate these conditions, the time and cost to develop two independent melter designs (one for Silos 1 and 2 waste and one for Silo 3 waste) would not be practical nor warranted. The Team is confident that, based on the characteristics of the Silo 3 waste, sufficient knowledge and adequate stabilization technologies exist to produce an immobilized Silo 3 waste form that will satisfy presently applicable regulations and requirements for disposal at the NTS. Thus, the IRT recommends that Silo 3 waste not be vitrified either individually or in combination, but be stabilized through another process; e.g., cementation.

# III. ALTERNATIVE II and ALTERNATIVE III EVALUATION

## A. Background

Alternative II, vitrification of Silos 1 and 2 waste and stabilization of Silo 3 waste, is the current DOE-FEMP and FDF proposed remedy for OU4. The proposed remedy includes proceeding with:

- A testing program for vitrification of Silos 1 and 2 waste and the decant sump tank waste

- The design, construction, procurement and operation of a full-scale vitrification facility for Silos 1 and 2 waste

- Stabilization of Silo 3 waste with a nonvitrification process

000009

- Performance of these activities through turnkey subcontracting

In pursuit of this alternative, DOE-FEMP and FDF issued a Commerce Business Daily (CBD) announcement on December 11, 1996, to solicit vendor interest in stabilizing the Silo 3 waste. As a result of this announcement, seventeen (17) vendors responded with a variety of proposed treatment technologies. Based on these responses, on January 31, 1997, FDF developed a "List of Qualified Bidders" and is now preparing a draft Request for Proposal (RFP).

The technical bases and assumptions for Alternative II and Alternative III are presented in Table A-1, which was provided to the IRT by FDF.

## B. IRT Recommendations

The majority of the IRT concludes that there is no compelling reason to abandon vitrification of the Silos 1 and 2 waste and the decant sump tank waste, and therefore recommends that Alternative II (vitrification) be the selected remedy for the treatment and disposal of Silos 1 and 2 and decant sump tank waste. This recommendation is subject to confirmation through a planned and successful phased development program. If the key decision point cannot be successfully passed, then vitrification should be reconsidered.

In addition to the above, the majority of the IRT concludes and recommends that FDF proceed to implement a turnkey subcontract for the treatment and disposal of the Silo 3 waste. The IRT, based on their background, knowledge and experience, recommends a cementation process for stabilization of the Silo 3 waste. However, the IRT also recognizes the need to allow the turnkey/subcontractor to recommend proven, alternative stabilization processes.

Furthermore, the entire IRT also recommends that if vitrification is the selected remedy for Silos 1 and 2 waste, cementation should be developed as a backup. Cement could be pursued if, for some reason, the challenges associated with development of the vitrification technology cannot be successfully overcome within a reasonable time and at a reasonable cost; or, in the event conditions are encountered that are not conducive to vitrification.

In developing these recommendations, the IRT considered the following items as potential discriminators between vitrification and cementation for Silos 1 and 2:

- Regulatory Commitments
- Stakeholder interests and input
- Fernald vitrification experience
- Technology development and application
- Radon control during waste processing and storage
- Waste packaging and transportation
- Waste form durability and long-term performance
- Cost and schedule

000020

Table A-1

## TECHNICAL BASIS & ASSUMPTIONS - Rev 1, April 1997

| | Alternative I Vitrify 1,2 & 3 | Alternative II Vitrify 1 & 2, Cement 3 | | Alternative III Cement 1, 2 & 3 | |
|---|---|---|---|---|---|
| | Vitrification | Vitrification | Cementation | Cement | Cement |
| Feed Basis | Silo 1,2, 3 mixture | Silo 1 & 2 mixture | Silo 3 | Silo 1 & 2 mixture | Silo 3 |
| Plant Capacity | 18 MT/day + 2 MT/day(VITPP) | 12 MT/day + 2 MT/day(VITPP) | 119 MT/day | 85 MT/day | 119 MT/day |
| Melter Temperature | 1350°C | 1150°C | - | - | - |
| Operating Basis | 24 hrs/day 7 days/week | 24 hrs/day 7 days/week | 8 hrs/day 5 days/week | 8 hrs/day 5 days/week | 8 hrs/day 5 days/week |
| Operating Period [1] | 3 years | 3 years | 4 months | 3 years | 4 months |
| Waste Loading | 60% (dry weight) | 60% (dry weight) | 45% (dry weight) | 20% (dry weight) | 45% (dry weight) |
| Waste Form | Gems | Gems | Monolith | Monolith | Monolith |
| Waste Packaging | SEG Concrete Boxes | SEG Concrete Boxes | Half Height White Metal Boxes | SEG Concrete Boxes | Half Height White Metal Boxes |
| Volume of Treated Waste | 8,700 $yd^3$ | 6,600 $yd^3$ | 6,100 $yd^3$ | 33,500 $yd^3$ | 6,100 $yd^3$ |
| Disposal Volume (with container) | 26,500 $yd^3$ | 18,500 $yd^3$ | 9,000 $yd^3$ | 101,400 $yd^3$ | 9,000 $yd^3$ |
| No. of Waste Containers | 5,500 | 3,800 | 2160 | 20,700 | 2,160 |
| No. of Waste Shipments | 2,750 | 1,900 | 540 | 10,350 | 540 |
| Transportation | Truck | Truck | Truck | Truck | Truck |
| Disposition of Silo Residues | NTS | NTS | NTS | NTS | NTS |
| Disposition of D&D Materials | Onsite Cell | Onsite Cell | Onsite Cell | Onsite Cell | Onsite Cell |

Notes: 1 Excludes treatment of OU4 soils
2 MT = metric tonnes

Quanties are averages and numbers are rounded.

### B.1 Regulatory Commitments

The possible impacts of changing the OU4 ROD have been carefully considered by the IRT. Significant time and effort was expended by DOE-FEMP and FDF in cooperation with stakeholders and regulatory agencies to get the current ROD approved with a selected remedy that was acceptable to all involved parties. Although ROD modifications are a recognized part of the CERCLA process, modifications can result in delaying remedial activities, delaying abatement of risks, and increasing costs to potentially unacceptable levels should acceptance of the ROD modification meet resistance. This concern is exacerbated in the case of OU4 since both Ohio and Nevada stakeholders and regulatory agencies could be impacted by a ROD modification. The majority of the IRT is certain that vitrification of Silos 1 and 2 waste can be accomplished with a greater cost and schedule certainty through the elimination of Silo 3 waste from the process and greater technical certainty through the use of a turnkey subcontracting approach. Therefore, since it appears that the Silo 3 stabilization alternative may be adequately addressed through the "Explanation of Significant Difference" (ESD) regulatory process (instead of opening the ROD to a full amendment), Alternative II appears to offer the preferable path forward for addressing the Regulatory Commitment issue. However, the ESD approach is still subject to regulatory confirmation. This is further supported by the fact that the regulatory agencies have informally indicated that a ROD Amendment, not an ESD, would be required if Alternative III were the selected remedy for the path forward.

### B.2 Stakeholder Interests and Inputs

Reevaluation of the OU4 path forward has demonstrated to the IRT the value of a continued stakeholder involvement. The stakeholders represent a valuable "corporate memory" resource, especially given the turnover of DOE and contractor personnel. Stakeholders are also effective in keeping the project focused on both risk reduction and cost-effective solutions. There is a keen stakeholder awareness that any appropriated funds which are not spent efficiently may ultimately represent a measure of community risk reduction foregone. As part of the IRT deliberations, FDF and the DOE scheduled two evening meetings between the IRT and Fernald stakeholders, principally represented by members of the Citizen's Task Force and FRESH. These meetings were held for the IRT to gain insight into stakeholder concerns and for the stakeholders to hear the IRT recommendations and bases. Strong feelings were expressed by a number of stakeholder representatives although no consensus for a path forward was evident.

Both Alternative II and Alternative III are a diversion from Alternative I, the remedy currently identified in the ROD. A full and open accounting of the data which led to these recommendations, and an avenue for stakeholder input into future decisions will be essential to both the success and the credibility of the program.

### B.3 Fernald Vitrification Experience

In selecting Alternative II as the recommended remedy, the IRT recognizes that FDF has gained invaluable information with regard to the vitrification process through: a) lab scale testing on surrogates and actual silos waste; b) mini-melter testing on surrogate waste; c) VITPP testing on surrogate waste; and d) operation of the complete VITPP. Although not yet complete, experience to date has demonstrated that glass recipes can be formulated that will meet waste acceptance requirements. FDF has experienced numerous issues at the VITPP with regard to the operability of waste feed and off-gas systems, glass gem production and melter design. All will prove useful in proceeding with the vitrification facility design, construction and operation. The IRT offers the following advice to help ensure project success:

The majority of the IRT recommends a subcontracted, turnkey approach (e.g., process development, design, construction, operation, and dismantlement) to vitrification of the Silos 1 and 2 waste. (Within this recommendation, proper consideration must be given to existing FDF labor agreements.)

The experience the FDF Silos Project Team gained from operation of the VITPP will also provide a valuable knowledge base from which to integrate FDF's and the subcontractor's efforts. In addition, however, FDF staff qualified in subcontract management will be required to ensure project success.

Because recruiting a staff qualified to support this project will require more than a few months, the IRT strongly suggests a turnkey subcontracting procurement strategy. This procurement approach would require that the selected subcontractor possess all the capabilities necessary to design, construct, operate and close the waste treatment facility.

In addition, however, the IRT recommends FDF consider the following in developing and implementing a turnkey procurement approach:

### B.3.1 Technical Capabilities

In addition to the selected vendor capabilities, the project needs to acquire and maintain the services of qualified engineers and scientists with the following specific knowledge and experience:

a) Vitrification chemistry; glass formulation (recipe) development; melter types and their operation and maintenance; and, melter parameters to be measured and controlled.

b) Design and operation of radiochemical process systems including liquid/solids separations, slurry transport, process vessel ventilation and confinement, and process control.

c) Design and fabrication of glass melters, and especially materials of construction.

d) Developing process flowsheets, process control plans, and defining technical data and parameters necessary to design and operate the process.

e) Packaging low specific activity materials, and optimizing transportation, temporary storage and disposal activities.

000013

Were the decision made to immobilize Silos 1 and 2 waste by cementation (Alternative III), FDF expertise similar to that required for cementation of Silo 3 waste would be required: cementation chemistry, process design, equipment and facility design, and facility operation and maintenance.

### B.3.2 Project Management

A subcontracted turnkey approach will influence the extent and type of project management required. For example, a turnkey subcontractor will require less Fernald Site project management than an in-house effort. As programmatic responsibility shifts from the site to a vendor, project management requirements will be reduced. However, regardless of the contracting approach, some level of Fernald project management involvement will always be required.

Solid project management is the linchpin in a publicly credible program. Poor project management leads to poor credibility and an impression that the program is stumbling. Effective project management increases credibility. Setbacks are not viewed as mistakes by the public, but as expected difficulties in a complicated and vexing problem. Sound project management, and the increased credibility it brings, are critical to success in the silos project.

Several project management deficiencies have manifested themselves as problems in the vitrification pilot plant. In general, the project management deficiencies led to problems in design control, process control, effective contracting, contractor oversight, and contractor accountability.

Most of the pilot plant problems that were encountered could have been avoided had the following project management been in place:

- Design criteria, design integration, design control, and technically sound process flowsheets
- A Safety Analysis Report developed in conjunction with design
- Effective monitoring, tracking, reporting and control of cost and schedule growth
- A Project Management Plan that identifies management roles, responsibilities, and authorities
- Thorough and frequent design reviews which involve independent experts

Given the management challenges associated with the OU4 project, the Team offers the following suggestions which will increase the likelihood of project success:

- Significant thought and preparation should be given to preparation of the statement of work, selection criteria, and evaluation and selection of a turnkey subcontractor. Specific attention should be given to:

- Past successful waste processing experience, both vitrification and stabilization
- Past DOE project experience
- Extent and depth of technical experience and expertise

- Without exception, projects are optimistic in estimating what can be accomplished in a given time for given resources. Experience has shown that optimism is good, but realism is essential when preparing cost estimates and schedules, especially when pursuing research and development activities. The Team recommends that FDF and DOE provide sufficient contingency in both cost estimates and schedules to accommodate uncertainties, both known and unforeseen. Data gathering efforts directed at reducing the uncertainties are important both in resolving the uncertainties and in refining cost and schedule estimates.

- Adequate funding is crucial to the success of the Silos Project. In addition, proposed funding and project life cycle funding should reflect a "typical" project life cycle funding profile and must be fully supported by DOE. Failure to provide planned funding will result in increases in total funding requirements and in total project lifetime.

Experienced project management will ensure that the variety of challenges and constraints affecting the project are resolved expeditiously. Without sound project management the Silos Project will continue to be susceptible to cost growth, basic design deficiencies and oversights, schedule delays, contractor disputes, and persistent operating problems. With this in mind, the Team sees fulfilling the intent of DOE Order 4700.1 (before it was amended by Order 430.1) as important to success. In addition, a list of suggested areas for attention are included as Attachment 1.

### B.4 Technology Development and Application

Given the current state of the VITPP, the IRT recommends the following:

The vitrification pilot plant should not be used for further melter testing. It should be evaluated for other uses such as waste retrieval optimization, feed stream preparation, and off-gas system testing.

Timely development and deployment of a successful vitrification process is crucial to minimizing the cost of the OU4 remediation effort, and expeditiously reducing the risks associated with the Silos 1 and 2 waste.

In order to assist in achieving successful vitrification of Silos 1 and 2 waste, the Team suggests high priority be given to:

- Use of a low temperature (1150° C) vitrification process allowing for proven melter designs in the facility.

000015

- Retrieval and characterization of additional Silos 1 and 2 waste to support validation of surrogate testing

- Identification of radioactive waste melters that have proven successful in treating similar waste

- Development of recipes and processes using best available surrogate formulation

- Assurance that subcontractor selection criteria include successful experience in vitrification process development, melter operation, and management of a comparable project

With a focus on the above items, the majority of the IRT recommends that FDF and DOE begin implementation of the following steps designed to reduce the technical uncertainties associated with vitrification. Such steps have proven to lead to success in similar waste treatment efforts.

- Complete waste characterization including chemical composition, organic content and radionuclide inventory and the expected variability in each, and rheological characteristics. This effort should also include a determination of whether the bentonite layer requires treatment prior to disposal. If not, an inexpensive bentonite removal (e.g., flotation) and disposal process should be explored.

- Development of a detailed flowsheet, including all material flows and mass balances throughout the process. A key result of this step is that required process design data are identified, and a plan is developed to obtain those which are missing.

- Formulation of glass compositions (recipes) that are based on the process flowsheet, and which reflects expected variability in waste composition. Testing should be performed with both waste surrogates and actual Silos 1 and 2 waste. Additional waste sampling will probably be required to facilitate testing by the turnkey subcontractor.

- Determine melter materials of construction (e.g., electrodes, refractory) appropriate for the expected glass formulations.

- Demonstration of the viability of the low temperature vitrification process through mini-melter testing. Use of actual waste would be highly desirable.

- Demonstrate the viability of the entire low temperature vitrification process, using surrogate waste in an off-site, currently operating melter of sufficient capacity (i.e., 1 MT/day). If possible, test feed compositions should be varied over the same range as that expected during silo waste processing.

- Testing should include characterization of the product, and, more importantly, of the process. If at all possible, the feed should be varied over as wide a range as expected during silo waste processing. A key output is the waste loading which can actually be achieved with the process flowsheet. Testing will also confirm flowsheet chemistry.

At this stage in the Silos Project, a decision point is recommended: if the vitrification process cannot be successfully demonstrated using Silos 1 and 2 waste, then the decision to vitrify these materials should be reconsidered. However, if the process is confirmed, the following steps are applicable and should be included in the turnkey subcontractor's scope of work:

- Selection of a melter design using proven design concepts. The melter design must tolerate molten metal formation because of the likelihood that some Pb metal phase will form in the melter during melter operation. Experienced, independent personnel should participate in the melter selection process.

- Consideration of constructing and operating an integrated engineering-scale system (feed prep, melter, off-gas, product packaging) designed to facilitate melter scale-up and confirm process integration. Feed compositions should be varied over the range expected during silo waste processing.

- After three-six months of aggressive testing, a detailed examination of the engineering-scale melter should be performed. Any evidence of unexpected "wear" should be noted. This will help establish the size and other design parameters of the production unit.

- Consideration should be given to maintaining the engineering-scale unit in an operational state throughout the production facility design period to allow testing of auxiliary equipment concepts, confirmation of design life, validation of flowsheet modifications and development of operating procedures.

- The IRT has previously provided detailed suggestions for the production facility design phase. However, the IRT also wishes to emphasize the importance of thorough, competent and frequent technical reviews of design assumptions and outputs.

- For construction and startup of the production facility, the basic principles of effective project management apply. Startup testing should include three-six months of integrated cold testing of the entire immobilization system before initiation of radioactive operation.

The majority of the IRT wishes to emphasize the feasibility of the program outlined above. DWPF, West Valley, M-Area and foreign experience all indicate that the immobilization facility can be operating effectively within three months of the start of radioactive operations, if a thorough testing program is carried out. A thorough testing program must include operation of the facility by the operating staff. Further, M-Area clearly demonstrates that the entire process from formulation through startup testing can be accomplished in three years, if a technically competent and effective organization is in place to carry it through.

Were a decision made to immobilize Silos 1 and 2 waste by cementation (Alternative III), a similar development program would be necessary, including:

- Waste characterization
- Flowsheet development
- Waste recipe formulation
- Pilot testing
- Construction and start-up testing

### B.5 Radon Control during Process, Storage, and Transportation

The IRT considered the radon characteristics of both the vitrified waste form and the cement waste form for Silos 1 and 2 waste. Because of the low radium content of the Silo 3 waste, radon is not deemed a discriminating factor. For Silos 1 and 2 waste, however, the radon flux from the glass matrix is reduced by 99% when compared to the untreated waste, while the radon flux from the cement matrix is only reduced by 80%. The vitrified glass performance is well below the interim storage and final disposal cell radon flux regulatory limit of 20 $pCi/m^2$-sec, therefore, no additional packaging would be required to control radon emanation. However, additional engineered features would be required for storage, packaging, and transportation of the cement waste form. Although not a major discriminator between the two alternatives, the characteristic of the vitrified glass matrix to contain radon favors and supports the majority IRT recommendation of Alternative II as the remedy of choice.

The ability of vitrified waste to effectively contain radon also provides another margin of safety and comfort: were future waste storage requirements to become more stringent (e.g., 10 CRF 61), glass (because of its conservatism) is much more likely than concrete to meet future, potentially more, stringent requirements.

### B.6 Packaging and Transportation

The single greatest discriminator between vitrification and cementation is the resultant disposal volume. Excluding Silo 3, vitrification of Silos 1 and 2 would result in 18,500 cubic yards of waste and 1,900 shipments. In contrast, and also excluding Silo 3, cementation of Silos 1 and 2 would result in 101,400 cubic yards of waste and 10,350 shipments. In short, cementation would result in over five (5) times as many waste shipments as vitrification. Therefore, the majority of the IRT concludes that for this discriminating factor Alternative II is superior to Alternative III.

### B.7 Waste Form Durability and Long-term Performance

DOE Order 5820.2A requires preparation of a Performance Assessment (PA) of DOE waste disposal sites. A draft PA for the NTS has been prepared, and its current status (final draft) was discussed with the IRT. While the Team has reasonably high confidence that the silos waste can be vitrified or cemented to a recipe that would meet current NTS waste acceptance criteria, long-term performance of the resultant waste form may not be assured simply by meeting waste recipe criteria. In order to provide the appropriate level of assurance that the

000028

public and the environment are adequately protected from the long-term radiological and chemical hazards presented by the silos wastes, a Performance Assessment that envelopes the characteristics of the silos wastes needs to be completed for the NTS. DOE needs to take action to complete the Performance Assessment and resolve this uncertainty, including an effort to reach agreement among all interested parties on the specification and conduct of the Performance Assessment.

### B.8 Cost and Schedule

The majority of the IRT concludes that because of the high degree of uncertainty in the cost/schedule estimates prepared by FDF, these criteria do not definitively discriminate between the two alternatives.

The cost estimates and schedules developed by FDF and presented to the IRT appear to be reasonable and of the correct order of magnitude. However, the IRT recognizes there is limited engineering in support of Alternative II data, and essentially no engineering in support of the Alternative III data. FDF has made comparisons to other similar facilities; e.g., Weldon Springs, West Valley, Hanford, and Savannah River. However, without flowsheets, equipment data sheets, space allocation drawings, etc., specific to the Fernald application, such estimates and comparisons must be considered very preliminary. Due to the pre-conceptual nature of the cost information, the cost ranges presented were very broad and overlapped to the extent that they could not be used to discriminate between alternatives. However, the Team believes both alternatives could ultimately prove less costly than shown in Table B.8-1.

The IRT offers the following observations on the FDF cost and schedule estimates:

- The estimates were generated by FDF. The IRT did not prepare any independent cost or schedule estimates.
- Even though critical path schedules were provided, the schedules were mostly based on pre-conceptual engineering assumptions for sequencing, duration and resource loading.
- The cost estimates do not include contingency; only ranges of uncertainty.
- The vitrification cost estimate is based on limited engineering and pilot plant construction and operating experience.
- The cementation estimate is based on pre-conceptional engineering only, e.g., comparisons, extrapolations.
- The cost estimates appear to be of the correct order of magnitude.
- The cost and schedule estimates are based on a large, new project, constructed and operated by the site manager, not a turnkey subcontracting approach.

000019

## Table B.8-1

FLUOR DANIEL FERNALD COST ESTIMATES
FINAL REMEDIATION ALTERNATIVES
FUNDING (IN MILLION DOLLARS)

| | Alternative II | | | Alternative III | | |
|---|---|---|---|---|---|---|
| UNCONSTRAINED FUNDS Note 1 | Low | Expected | High | Low | Expected | High |
| Capital Costs (retrieval, design & construction) | 152 | 202 | 241 | 85 | 100 | 124 |
| Operating & Maintenance | 50 | 75 | 90 | 25 | 29 | 38 |
| Shipping & Disposal | 72 | 80 | 94 | 120 | 198 | 227 |
| Total Silos 1 & 2 | 274 | 357 | 425 | 230 | 327 | 389 |
| Total Silo 3 | 22 | 25 | 29 | 22 | 25 | 29 |
| Project Management | 46 | 54 | 57 | 43 | 45 | 50 |
| D & D | 34 | 40 | 52 | 30 | 36 | 45 |
| Total OU4 Silos | 376 | 476 | 563 | 325 | 433 | 513 |
| Impact of Escalation | | | | | | |
| Unconstrained Funds | | 186 | | | 182 | |
| Constrained Funds Note 2 | | 222 | | | 218 | |
| Severely Constrained Funds Note 3 | | 250 | | | 228 | |
| Key Milestones | | | | | | |
| Start Operations | | 2006 | | | 2003 | |
| Complete D & D | | 2011 | | | 2008 | |

* Completion of D & D is impacted by funding constraints.

Note 1 Annual funding is at a level desired for efficient implementation of the project.
Note 2 Constrained funding is defined as $25 million per year from 1997 to 2001, $50 million per year from 2002 through 2005 and unconstrained thereafter.
Note 3 Severely constrained funding is defined as the level presented in the current FY97 plan.

000020

- The vitrification cost estimate is driven primarily by development and capital costs.

- The cementation cost estimate is driven primarily by waste loading, packaging, transportation, and disposal.

- Efforts to effect cost reductions should focus on development and capital costs for Alternative II, and waste loading, packaging, transportation and disposal for Alternative III.

## C. Immobilization Options for Silos 1 and 2 Residues

In developing a recommendation for immobilization of Silos 1 and 2 waste, the Team reviewed screening information on a variety of technologies with an interim goal of reducing the choices to two -- vitrification and some other non-vitrification stabilization technology. In evaluating non-vitrification alternatives, the IRT considered such factors as:

- Maturity of alternative technologies
- Waste form acceptability
- Technical viability

The IRT concluded that following vitrification, cementation is the preferred option among potential alternatives, and the technology selection should be between vitrification and cementation.

This recommendation resulted from the evaluation of the following technologies:

- Sulfur Polymerization
- Macro Encapsulation
- Bitumen (Asphalt)
- Poly Encapsulation (micro encapsulation)
- Thermal Setting Resins
- Ceramics (forming a brick cast/then heating in a furnace)
- Metal Matrix (Cermet)
- Insitu vitrification
- Molten Metal Technology
- Ceramic Silican Foam (Silican dimethyl)
- Cementation

Based on the broad knowledge and experience of the IRT, and further supported by the fact that FDF in the RI/FS demonstrated cementation as an acceptable alternative, the IRT concluded that after vitrification, cementation should be the preferred option among immobilization alternatives.

000021

## D. Additional IRT Concerns

The IRT, during the review of the Silos Project, identified two other areas which should be emphasized to ensure a successful project completion:

- Silo waste retrieval and heel removal
- On-site interim storage capability

### D.1 Silo Waste Retrieval and Heel Removal

FDF does not have experience with mobilization and transfer of the materials contained in the silos. Since current plans do not include intermediate storage tanks for retrieved silo material, any immobilization facility will be directly impacted by the rate at which material transfers can be accomplished. In order to minimize uncertainties and potentially serious future impacts, the Team recommends that a high priority be given to developing and demonstrating waste retrieval capability, including heel removal.

### D.2 On-site Interim Waste Storage Capability

The Team recommends that interim storage capability for immobilized waste be emphasized due to the large volume of packaged waste that will be produced. To accommodate possible interruption of shipping, the facility design should permit ready expansion of interim storage capacity. The facility should also interface with the selected transportation mode. For example, were unit trains and sea/land containers determined to be the most desirable transportation scheme, an interim storage concept that uses sea/land containers and the existing Fernald Facility railroad spur should be considered.

**SIGNATURES**

G. E. Bingham 4/14/97
G. E. Bingham Date

M. John Plodinec 4/14/97
M. John Plodinec Date

G. Chevrier 4/14/97
Gilles P. Chevrier Date

R. C. Roal 4/14/97
R. C. Roal Date

R. E. Lawrence 4/14/97
R. E. Lawrence Date

Ben S. Smith 4/14/97
Ben Smith Date

4/14/97
Todd Martin Date

000023

# ATTACHMENT 1

# LESSONS LEARNED

## ATTACHMENT 1

### LESSONS LEARNED ON PAST PROJECTS

1. Assign one, totally responsible Project Manager to the project. This person needs to be experienced in project management. The Project Manager also needs to be very familiar with the project construction site, the DOE site personnel, the DOE and contractor rules, requirements, orders, and procedures that apply to the site.

2. The Project Manager must be delegated all of the authority needed to manage the project. Typically, the Project Manager needs more authority than most people think is required.

3. Authority should be verified in writing with appropriate DOE and contractor managers being made aware of the assignment.

4. The Project Manager should report at a high enough level within the organization to demonstrate: 1) the project is important; 2) senior management supports the project; and 3) the Project Manager has adequate access to senior management to resolve problems and obtain resources. The reporting level also establishes the Project Manager's ability to access and work directly with other senior staff personnel.

5. A Memorandum of Understanding (MOU) should be prepared between the contractor Project Manager and the DOE Project Manager outlining authorities and responsibilities of each. This becomes very important as the project progresses through design and construction; there cannot be two Project Managers providing guidance and direction to contractors and subcontractors.

6. Clear lines of communication should be established between the project, DOE, subcontractors, suppliers, and other support organizations.

7. Establish a strong cost/schedule control organization and a strong configuration management/records management organization. Also prepare and issue detailed procedures for these organizations.

8. Develop and implement a change control procedure early in the project along with a project change control board. Establish reasonable change control limits. Change requests should be well documented, justified, approved, and recorded. Justification should include all impacts of the change including schedule, cost, technical, design, procurement, construction, startup, operation, and maintenance.

9. Change board membership should include representatives from the contractor safety, technical, engineering, operations and maintenance organizations.

10. As a minimum, the following should be placed under change control as soon as approved versions are available: project design criteria, cost estimates, schedules, specifications and drawings.

11. All personnel supporting the project should report to the Project Manager. If matrix support is necessary, then those matrix personnel providing support to the Project should understand they report to the Project Manager.

12. All project funding must be under the control of the Project Manager. Authorization to spend project funds must be through approved GWA's, work authorizations, etc.

13. If support is required from matrix organizations (technical/R&D), these organizations should prepare a scope of work, a cost estimate and a schedule for the support to be provided. The schedule should contain meaningful, measurable quarterly milestones.

14. All tasks, planning packages, work packages should consist of a scope of work, a cost estimate and a schedule.

15. Consider organizing project engineering personnel as "subproject managers." That is, organize and assign project work efforts into subprojects, again, each having scopes, resource leaded schedules and cost estimates. For the vitrification facility typical subproject assignments could include the melter, off-gas system, feed retrieval system, electrical system, emergency electrical system, DCS, instrumentation system, glass gem forming system, HVAC, etc. Anything which can be described as a discrete work effort, and for which funding, authority and responsibility can be assigned.

    The second and most important aspect of this arrangement is assigning the responsible engineer total authority and responsibility for the assigned system(s). This includes preparation of conceptual design criteria; preparation of design criteria; drawing and specification preparation; design reviews and design review comment resolution; preparation of procurement documents and equipment procurement, including inspections and installation; preparation of CC tests and oversight of performance; preparation of SO tests including selection and training of SO test team and serving as SO test team leader; preparation, review and approval of operating manuals and procedures; training of operators and maintenance personnel; review and approval of appropriate vendor data; resolution of field problems; and, providing expert support during facility startup and cold operation.

    The responsible engineers would be the responsible work package mangers which includes budget authority and responsibility, monthly budget analysis and variance analyses and explanation.

    The value that flows from such an organizational arrangement is total responsibility, authority and most importantly ownership. In addition, the project manager is fully aware of who the responsible persons are, and can immediately obtain needed information and data.

000026

A secondary benefit of such an organization is that the project is continually training future project managers.

16. Assure all project personnel are fully aware that annual performance reviews, promotions and salary increases are totally based on performance.

17. Perform at least three "team reviews" of the facility design, if possible, at the AE's facility: conceptual, Title I and Title II. If a facility model is available, make the model a key part of the review. The review teams should include operations and maintenance personnel as well as safety, QA and technical and field/construction engineering.

18. Require timely responses to all vendor data submittal and design review comments.

19. Locate all project personnel and essential support personnel (e.g., operating manual technical writers) in the same facility if possible to maximize communication and increase the feeling of belonging to the project team. If common building location is not possible, then certainly a common area becomes essential.

20. Establish a field/construction engineering group to provide construction interface and problem resolution, safety oversight, daily and weekly construction meetings, and constructability reviews.

21. All design review packages should be reviewed by all involved organizations: safety, QA, technical, operations and maintenance. Establish strict review times and respond to all review comments.

22. Encourage (strongly) that responsible system engineers frequently overview construction activities to respond to questions, participate in and respond to field problems; and remain fully familiar with the facility to simplify drawing walkdowns; training of operations and maintenance personnel; accelerate equipment, line and valve tagging; and simplify CC and SO test procedure preparation and performance.

23. Establish a single, well organized records management/configuration management center. Establish a computerized records identification and tracking system using bar coding where possible. Assure the records system maintains copies of <u>all</u> project records until facility turnover. If space is a problem, consider microfilming the older records. Also, keep copies of all design review comments and responses. Also maintain a complete, easily retrievable vendor data system including all past versions and all review comments and resolutions.

24. As part of all procurement contracts, include sufficient hold-back to guarantee receipt of all vendor data. That is, make non-submittal painful for the vendor.

25. Prepare and maintain a detailed WBS. Tie all project activities to the WBS. Make the WBS flexible enough so that additional activities can be added with minimal disruption. Along with the WBS, prepare and distribute a WBS Dictionary.

000027

26. Establish numerous, smaller work packages so that the responsible engineers can provide adequate attention to cost and schedule management.

27. Assure the cost/schedule group provides adequate monthly performance data so that analysis and explanation can be provided for the monthly project performance reports.

28. Hold monthly project review meetings for contractor and the DOE management. Review all significant project areas including problem areas and recommended corrective actions. If possible, have the responsible engineers present their own area of responsibility.

29. Maintain a continuous contingency usage log to provide a continuous track record of contingency usage. Establish the log as soon as capital funds are received and maintain the log, throughout the life of the project. As part of the log, include change order identifiers and explanations of approvals and reasons for contingency usage. Maintain a continuous plot of contingency usage and provide copies to all interested parties, especially senior contractor and the DOE management.

30. Establish and maintain an action item log so that actions are documented along with responsible parties and due dates. Include the architect-engineer, the construction manager and the DOE.

31. Prepare and maintain schedules that roll-up from the work package level to the project master schedule. All schedules should be time phased, resource loaded and include frequent, meaningful and measurable milestones and a critical path.

32. Prepare either a change request or as a minimum impact studies of DOE directed changes. Especially those that change standards, requirements, orders, agreements, etc.

33. Train all project personnel in the cost/schedule system, the reporting system, the configuration control system and the records management system.

34. For major procurements, assign a resident engineer at the vendor's shop. Also provide a resident engineer at the AE's offices during the design period.

35. For engineered procurements, when a resident is not assigned, assure the responsible engineers visit the supplier frequently enough to confirm reported progress and schedule and cost status, and to validate reported problems and solutions.

36. For off-site activities, use QA auditors to examine, evaluate and report potential problems.

37. Use cost/schedule curve extrapolation to project anticipated future costs and progress. Early notification of potential problems can be obtained through curve projections and mathematical calculations.

38. Prepare and distribute a Project Approval Authority Matrix outlining the authority and responsibility of each manager and engineer assigned to the project.

39. Train all engineers and technical personnel assigned to the project to avoid making verbal commitments or providing inadvertent work direction (changes) to suppliers and subcontractors.

40. Establish "reasonable" variance thresholds. That is, establish thresholds that are related to the risk involved.

41. Initiate CC, SO, operating manuals and procedures, ORR, and startup activities very early in the project, i.e., during Title I.

# SILOS PROJECT

# INDEPENDENT REVIEW TEAM

# MINORITY FINAL REPORT

APRIL 1997

TABLE OF CONTENTS



000031

## MINORITY MEMBER SIGNATURES

(SEE APPENDIX F FOR PROFESSIONAL BIOGRAPHICAL INFORMATION)

4/14/97
F. R. Cook Date

4/14/97
E. McDaniel Date

4/14/97
James N. Edmondson Date

4-14-97
Della M. Roy Date

4/14/97
G. E. Bingham Date

000632

## 1.0 EXECUTIVE SUMMARY

A Minority of five members of the eleven member Independent Review Team (IRT) hereafter referred to as the "Minority" concludes that the most expedient and cost effective alternative for accomplishing the Fernald Silos Project objectives is to stabilize the waste in all three silos by cementation, package the wastes in sealed containers to control radon where necessary and to ship packaged waste by unit trains and/or trucks to an acceptable government disposal facility for defense waste.

Cementation is consistent with the Silos Project Alternative III remediation scheme, stabilization of wastes in all three silos. This alternative was included in the Silos Project Remedial Investigation/Feasibility Study (RI/FS). The Minority considers that the existing Record of Decision (Alternative I of the RI/FS) to mix and vitrify the wastes in all the silos should be modified accordingly .

These recommendations are based on a qualitative comparison of key features of vitrification and cementation technologies pertinent to deciding the appropriate application for the Silos Project. This evaluation, which is included in Appendix B, reflects a total consensus of the experts recommending Alternative III and making up the Minority.

Their technical backgrounds are described in Appendix F. Their combined experience and knowledge is directly pertinent to the evaluation they accomplished and the recommendations of this report. Each Minority member has over 30 years of experience in technical fields pertinent to the Silos Project alternatives paths forward. The basic agreement of the Minority hinged on their common perception of the technical complexity and project uncertainty with silo waste vitrification compared to cementation and the acceptability and desirability of a cement waste form for disposal.

Several other recommendations for FDF relative to the Silos Project that are independent of the decision to vitrify silo wastes are held in common with the Majority of the IRT. These common recommendations are also identified in this report.

000033

## 2.0 INTRODUCTION

### 2.1 HISTORICAL BACKGROUND

Fluor Daniel Fernald (FDF) convened the Silos Project Independent Review Team (IRT) in November, 1996, as an advisory group and technical resource to assist FDF, U.S. Department of Energy (DOE), stakeholders and regulatory agencies in developing a path forward recommendation for immobilization and disposal of the material contained in Silos 1, 2, and 3 in Operable Unit 4 (referred to as "OU4" or the "Silos Project") of the Fernald Environmental Management Project (FEMP).

The group of eleven team members after three months of project review and discussion could not come to a consensus on their advice for FDF. Alternative actions considered by the team for resolving disposition of the OU4 wastes included actions which were also identified by the CERCLA regulatory procedural evaluation or RI/FS. The alternatives to be considered by the IRT at a minimum were:

| | |
|---|---|
| Alternative I-- | Vitrify all three silos |
| Alternative II-- | Vitrify Silos 1 and 2 and cement solidify Silo 3 |
| Alternative III-- | Use a stabilization process (selected from among viable options) for all three silos. |

A Majority members of the IRT decided that Alternative II (see the Majority Report) should be pursued. The Minority members (hereinafter referred to as the "Minority") concluded that Alternative III was preferable. This Minority recommendation together with identification and discussion of its bases and other Silos Project related recommendations and bases are contained in the "Recommendations" section of this report.

The initial meeting of the IRT with FDF, DOE, stakeholder and regulatory representatives was held November 14 and 15, 1996, and consisted of an overview of Operable Unit 4 history, current status, and near term plans. A tour of the operational Vitrification Pilot Plant (VITPP) was included. Since then, the Team met four more times to develop technical and programmatic recommendations based on information presented by FDF and the collective experience represented by the individual members of the Team.

In January the IRT was briefed on facts and FDF evaluations surrounding the VITPP melter failure that occurred in late December, 1996.

### 2.2 IRT MISSION

In the IRT's job description or charge FDF provided the following "Overview of Objectives" to focus the Team in its deliberations.

1. The IRT will be providing advice and recommendations to FDF and DOE as an aid in an internal decision making process. FDF and DOE will evaluate this input internally in determining what, if any, modifications to our current path forward (i.e. vitrification of Silos waste) should be formally proposed to the regulators and other stakeholders. Stakeholders are being asked for input during the internal decision making process in firm recognition of the vital importance of their acceptance if any path forward modifications are proposed formally.

2. The IRT will aid in decision making by:

   - Reviewing current FDF and DOE recommendations to cement solidify Silo 3 and reach consensus to agree with or suggest modifications to this direction.

   - Assisting with optimization of vitrification by:

     - Reviewing, commenting and providing advice on the upgrade plans for the Pilot Plant and evaluating the results from the existing Pilot Plant.

     - Providing reviews, comment, and providing advice on current technical approach to vitrification using lessons learned.

3. In light of significant uncertainties in the vitrification process reliability observed to date and associated impacts on project schedule and like issues, FDF and DOE would like advice and recommendations on whether to formally re-evaluate the selected OU4 remedy. FDF and DOE would like the IRT to evaluate issues associated with vitrification implementation and identify and evaluate any potentially viable options to vitrification. In light of these evaluations, FDF and DOE would like input on the appropriateness of re-evaluating, through a formal public process, the current OU4 path forward. It is not expected that the IRT will advance a sole recommendation for a single alternative, but rather to return evaluation and advice based on their experiences for each alternative as an aid to our path forward evaluation.

For further clarification and to focus the group interactions, the IRT developed its interpretation of Fernald's objective as follows:

The ultimate goal Silos Project is to:

1. Immobilize the unique Fernald silo wastes safely, efficiently, and cost effectively.

2. Package and safely transport the treated wastes, and store those wastes at an acceptable disposal site.

3. Obtain DOE and regulatory approval, public acceptance and complete remediation within a reasonable time frame.

000035

## 3.0 RECOMMENDATIONS

## 3.1 ALTERNATIVE I EVALUATION

**Recommendation**

Eliminate Alternative I (vitrification of all silos waste and decant sump tank waste) from further consideration and proceed with the cementation of Silo 3 wastes as soon as possible.

**Discussion**

The entire IRT's initial focus on Alternative I was directed toward the feasibility and practicality of using a vitrification process to remediate a mixture of the wastes in Silos 1, 2 and 3 (K-65 waste and cold metal oxides) and the contents of the decant sump tank as stipulated in the OU4 ROD. In addition, the evaluation addressed concerns related to waste retrieval, radon treatment, waste packaging and shipping, and disposal of vitrified waste at the NTS.

The entire IRT reached a consensus that any vitrification program designed to accommodate a mixture of wastes from all three silos would suffer from great uncertainty in implementation. The design of a vitrification process for any combination of Silos 1, 2, and 3 waste would have to simultaneously address two specific glass chemistry challenges:

1. The high sulfate concentration in Silo 3 waste (sulfate has a low solubility in glass).

2. The high and varying lead content in Silos 1 and 2 waste (without proper control of oxidizing conditions in the melt, lead can precipitate in the melter and compromise the integrity of the melter's materials of construction).

It was pointed out by the Minority Group members that vitrification of the calcined wastes in Silo 3 could probably be readily accomplished, if the sulfate were removed by pre-processing or degassed during vitrification, and the wastes were not mixed with the high content lead wastes in Silos 1 and 2. However, the Minority considered that vitrification was not warranted (see Recommendation at 3.2 below) consistent with the Majority recommendation. This position recognized that there was no regulatory requirement to vitrify Silo 3 waste and that the risk associated with handling the wastes whether or not they would be further immobilized was low.

**Conclusion**

Thus, the entire IRT concluded that Silos 1, 2 and 3 wastes should not be mixed together and vitrified.

**Discussion**

In developing a recommendation for immobilization of Silo 1 and 2 wastes, the entire IRT reviewed screening information on a variety of technologies with an interim goal of reducing the choices to two—vitrification and another stabilization technology. In evaluating these non-vitrification alternatives, the IRT considered factors such as:

1. Maturity of the alternative technologies
2. Waste form acceptability
3. Technical viability.

The entire IRT early in its deliberations concluded that cementation was the preferred option among the potential alternatives, and thus the technology selection should be between vitrification and cementation.

**Conclusion**

The Minority still agrees with this conclusion.

## 3.2 ALTERNATIVE II VS ALTERNATIVE III

**Recommendation**

Modify the Silos Project path forward to stabilize Silos 1, 2 and 3 in a grout or cementation process. Cancel all work on vitrification of wastes at Fernald. Initiate a formal change in the Record of Decision for the Project to obtain regulator approval of Alternative III.

**Discussion**

Since November 1996, the 11 member Independent Review Team (IRT) has been heavily involved in evaluating the history and status of the Fernald Operable Unit 4 (OU4) cleanup effort. The specific purpose of this review was to recommend to Fluor Daniel Fernald (FDF) the path forward for treatment and disposal of the silos waste.

As a result of the IRT efforts several u .nimous decisions were reached by the Team: Elimination of Alternative I, cementation of the Silo 3 waste and an agreement that both waste forms (vitrification and cementation) would meet presently applicable waste acceptance criteria applicable to Silo 3 waste. However, a unified decision was not reached by the Team concerning treatment and disposal of the Silos 1 and 2 waste. In this case, the IRT was essentially evenly divided with Majority members recommending vitrification and Minority members recommending cementation.

The five "dissenting" members of the IRT feel strongly that vitrification should not be used for the Silos 1 and 2 waste for the following (most important) reasons:

1. An IRT consideration was to identify whether there was a compelling" reason for abandoning vitrification. The minority group believes there is a compelling reason: the potentially long and costly path forward, including another melter development effort, and the design, construction and operation of a large, new facility. The "turnkey" subcontractor as envisioned by the Majority and advocated in its report is unknown and probably does not exist. No one to the knowledge of the Minority has ever successfully melted lead glass in commercial quantities while using sulfate containing raw materials.

2. The Vitrification Pilot Plant (VITPP) design, construction, operation and eventual melter failure clearly demonstrated some of the difficulties associated with vitrification and vitrification facilities in general and reinforced the well known rules in the Industry for making lead glass:

   (a) Use oxidizers, not reducing agents, in the batch,
   (b) Use no raw materials containing sulfates.

3. Although the vitrification pilot plant experience may have been enlightening to FDF, little, if any new knowledge was contributed to the general body of glass making expertise.

Additional problems and uncertainties relative to potential vitrification of silo wastes are presented in **Appendix A**. This Appendix was prepared by James Edmondson and was reviewed and endorsed by the Minority.

The magnitude and number of issues identified, remaining unresolved after several years of vitrification process development at Fernald, is the basis for the Minority's pessimism regarding the prospects for this technology being successfully implemented for the Silos Project.

The stabilization cost estimate was based on only pre-conceptual engineering development. Therefore, because of some of the assumptions used to develop this estimate, there are several opportunities for major cost savings, examples of which follow:

1. Waste Loading. The estimate was based on an average waste loading (by weight) of 20%. Cementation experts stated that waste loading of 40%

could probably be achieved, and that 50% might be attained. The implications of this change include shorter processing times, greatly reduced waste volumes, reduced numbers of wastes boxes and transportation casks, and reduced number of waste shipments. All of these items lead to significant cost savings, since packaging, transportation and disposal is the single major item in the stabilization option cost estimate.

A note of interest was that the FDF estimate made for vitrification was based on waste loading of 60% with the only dilution stemming from additions of boria, alumina, calcia and alkalis, all to achieve a composition believed to be processable and stable. However, it can be reasonably speculated that stability in both composition and processing, if at all achievable, will come about only by gross dilution of the K-65 material to lower sulfate concentration by a factor of 10 or more. Such would greatly increase boxes and shipments, required glass pulls, and time and cost to achieve. Such circumstances could of course be a great discriminator favoring cementation.

2. Processing facility operating strategy. The cementation estimate was based on the facility operating 8 hours/day, 5 days/week. This is not a realistic operating schedule for a production facility. An alternative study showed that the overall waste processing time could be reduced by more than 2 years by simply applying the same operating parameters to the cementation facility that were applied to the vitrification facility, i.e., 24 hours/day, 7 days/week. This approach matches the operating philosophy planned for Alternative II and used at both WVDP and DWPF. Around-the-clock facility operation for both vitrification and cementation, however, is based on the assumption that feed material, waste packaging, on-site temporary storage, and on-and-off-site transportation would impose no limitations. Limitations in any of these areas; e.g., inability to use unit trains, could dictate the facility operating schedule. If no problems are encountered, the Minority believes these potential problems can be resolved, thus resulting in a potential total schedule differential between Alternatives II and III of up to six years, to the clear advantage of Alternative III.

3. Privatization. The minority group's background and experience leads to the conclusion that a cementation facility would probably be easier, quicker and cheaper to design, construct and place in operation than a vitrification facility. In addition, a cementation facility would appear to be better suited than vitrification to turnkey subcontracting and the implementation of competitive pricing because of the larger base of experienced, commercial vendors. The Minority did not know of any qualified commercial vitrification firms that would be expected to bid on the Project. This does not say that unqualified firms would avoid bidding.

000039

A stabilization facility is inherently safer to operate and maintain than a vitrification facility. Stabilization does not include high temperatures, high electrical currents and voltages, or stored energy.

The potential of a catastrophic failure is much less with a cementation facility than a vitrification facility; e.g., the recent VITPP melter failure. In addition, recovery is expected to be more rapid because of an anticipated "heavier" involvement of more oversight agencies in a melter accident; e.g., DNFSB, DOE-HQ, DOE-Ohio, DOE-FEMP and independent accident review teams. Whether the perception is justified or not, failure of a high energy source, dumping hot glass, creating smoke, starting fires and evacuating personnel are viewed as inherently less safe and higher risk than spilling ambient temperature concrete.

## 3.3 RECOMMENDATIONS ESSENTIALLY REFLECTING THE MAJORITY

### 3.3.1 DISPOSAL FACILITY PERFORMANCE ASSESSMENT

**Recommendation**

Specify and accomplish promptly a Performance Assessment of Long Term Hazards (Radiological and Chemical) at an appropriate Disposal Site.

**Discussion**

DOE Order 5820.2A requires performance assessment of DOE waste disposal sites. To the best of the Minority's knowledge, such an assessment has not been completed to support disposal of Silos wastes at the NTS. While the Minority has reasonably high confidence that Silos wastes can be cemented to a recipe that would meet current NTS waste acceptance criteria, long term performance of the resultant waste form may not be assured simply by meeting these criteria. In order to meet Order requirements and provide the appropriate level of assurance that the public and the environment are adequately protected from the long-term radiological and chemical hazards presented by the Silos wastes, a performance assessment that envelopes the characteristics of the Silos wastes must be performed for the NTS or other disposal facility selected for these wastes. DOE should take action to complete the performance assessment to remove this uncertainty. Removing this uncertainty should include an effort to find agreement among all interested parties on the conduct of the performance assessment.

The issue of the long-term hazard of high radium bearing wastes was addressed by the DOE in its Final Environmental Impact Statement- Long-Term Management of the Existing Radioactive Wastes and Residues at the Niagara Falls Storage Site, DOE/EIS-0109 (DE86008418). This EIS addressed management of K-65 wastes similar to those in Silos 1 and 2. The New York State Department of Health and Environmental Protection and the U.S. Environmental Protection Agency (EPA) expressed concern over DOE's plans for the waste in an exchange of letters with DOE (letters are included in Appendix K of DOE's EIS.)

The central point of these letters is that the concentration of Radon-226 in the K-65 residues is so high, the 40 CFR 192 disposal standards for thorium and uranium mill tailings were not applicable; therefore, the 40 CFR 191 standards for management and disposal of spent nuclear fuel, high-level and transuranic radioactive wastes should be followed.

An additional assessment of the impacts associated with disposal of the K-65 residues is contained in a 1995 National Research Council report, "Safety of the High-Level Uranium Ore Residues at the Niagara Falls Storage Site, Lewiston, New York". The evaluation in this report was used by the Minority to evaluate issues associated with handling and disposal.

Relative to the performance assessment for near surface disposal, for example the NTS Site, the Minority considers radon control will not be a concern during the time institutional controls are maintained at the Site. However, following the period when institutional controls can be reliably anticipated, a cemented waste form has an advantage over a vitrified form, because of its lower concentration of radium and resulting lower gamma source from entrained short-lived radon daughters. Any vitrified waste that remains in tact for intruders to contact would present a substantial gamma radiation hazard from the entrained radon daughters. Only after devitrification and continuous radon release occurs will the gamma radiation hazard be mitigated. For these reasons the Minority does not believe a vitrified waste form is desirable for disposal near the surface for intruder scenarios. For deep geologic disposal a low-volume waste form is favored from the stand point of cost, however, performance is insignificantly affected by the waste form. Considering potential to add substantial diluting glass constituents, it cannot be decided with an absolute certainty at this time which form, glass or cement, will be the lower volume.

The disposal site performance evaluation also made it apparent that as the radium is diluted, the hazard in the long-term after the waste forms deteriorate suffered by intruders is reduced.

A substantial body of data exists relative to performance assessments for DOE's uranium mill tailings remedial action (UMTRAP) sites. These assessments indicate a substantial long-term hazard from radon emanation to intruders.

As recognized by the State of New York and the U.S. EPA (see the discussion above) Silos I and II (K-65 wastes), because of their extremely high original uranium ore concentration and resulting radium concentration, are substantially more hazardous than the UMTRAP low-grade uranium ore mill tailings.

**Conclusion**

Therefore, the Minority considers plans for cementing the Silos I and II wastes should anticipate potential disposal in a deep repository, for example, the WIPP facility. This facility is selected in lieu of the prospective Yucca Mountain Repository, since it has a

000041

reasonable likelihood of beginning operation early and is under the control of DOE's Environmental Management Office.

### 3.3.2 WASTE RETRIEVAL PRIORITY

**Recommendation**

Give high priority to development and demonstration of silo waste and heel removal.

**Discussion**

Fernald does not have direct experience with retrieval and transfer of the bulk materials contained in the Silos. Current plans do not include intermediate storage tankage for retrieved silo material, so the immobilization plants will be directly impacted by the rate at which transfers can be accomplished. In order to minimize uncertainties in this regard the Team recommends that a high priority be given to development and demonstration of retrieval capability.

### 3.3.3 INTERIM STORAGE

**Recommendation**

Provide substantial on-site interim storage capability.

**Discussion**

The Minority considers that capability for interim storage of immobilized Silo wastes should be planned for the Silos Project. For example, in order to provide for a possible interruption of shipping, the design of the storage facility should allow for ready expansion of capacity to accept all cemented wastes that could be accumulated over a 6 month period. An additional design feature should be that the facility interface with the transportation mode selected. For example, if unit trains with sea/land containers are determined to be the most desirable transport scheme, an interim storage concept that makes use of sea/land containers and existing Fernald Facility railroad tracks should be planned.

### 3.3.4 STAKEHOLDER INVOLVEMENT

**Recommendation**

The Minority recommends that DOE and FDF continue support of strong stakeholder involvement in the remediation of the Fernald facility. It is recommended that stakeholders pay particular attention to the valid determination of cost effective operations, valid performance assessment for disposal sites and technically qualified project management.

**Discussion**

Reevaluation of the OU4 path forward has demonstrated the value of intensive and continuing involvement of the stakeholders. Without this involvement, it is doubtful this current IRT evaluation of alternatives would have happened.

The Fernald Site stakeholders represent a valuable corporate memory resource, especially given the turn-over of DOE and contractor personnel. Stakeholders are effective in keeping the project focused on risk reduction and on cost-effective solutions which have enduring value. There is a keen stakeholder awareness that any appropriated funds which are not spent efficiently may ultimately represent a measure of community risk reduction foregone.

The Minority agrees with this apparent stakeholder concern and has recommended Alternative III because it considers it to be the only cost effective solution of the three alternatives considered. In addition the Minority also considers that Alternative III will minimize risk to the public health and safety and the environment as a result of potential operational and subsequent disposal exposure to the hazardous materials in the wastes.

## 3.4 ADDITIONAL SUPPORTING INFORMATION

The Appendices listed below provide additional pertinent information supporting these recommendations and include additional general advice and observations pertinent to the Silos Project.

Appendix A--Comments on sampling, characterization, and vitrification
Appendix B--Qualitative comparison of the two treatment methods
Appendix C--Consistency of path forward recommendations with the Ten-Year Plan (TYP)
Appendix D--A specific IRT Minority member recommendation regarding project management issues.
Appendix E--Fluor Daniel Fernald Cost Estimates for Final Remediation
Appendix F--Minority Team Members Professional Experience

000043

# APPENDIX A

## COMMENTS ON SAMPLING, CHARACTERIZATION AND VITRIFICATION

Objective

The objective of this attachment is to summarize for the IRT data which helps characterize the waste in Silos 1, 2 and 3, and comment on the reliability and usefulness of these data for planning further study or piloting of treatability processes. A second purpose of this paper is to provide a critique of the vitrification treatability efforts of FDF, Pacific Northwest Laboratories (PNL) and Vitreous State Laboratory-Catholic University of America (VSL-CUA).

Information was obtained from the documents distributed to the IRT and from conversations with several FDF personnel. There were discrepancies and gaps in the information provided. However, most if not all of the missing information is probably on record, and explanations of discrepancies are most likely also available. If so, the information should be supplied to the IRT.

Silo Sampling

Refer to presentation handout at the February 12, 1997 IRT meeting on Silo Waste Characterization.

All the 80 ft. diameter silos were sampled by core boring through the crust. Silo 3 was sampled in May 1989; Silos 1 and 2 in July and August 1991, before the bentonite clay was added (November 1991). Details were provided for Silos 1 and 2, but nothing other than a date for Silo 3. Sketches indicate that silo domes have round openings at the center and at four locations equally spaced on a circle of unspecified diameter and identified by compass locations SE, SW, NE, and NW. Copies of the boring contractor's logs indicated that a vibra core drill with a 3 in. I.D. was used. These logs show the location of the so called zones, the sample size recovered from each zone, the samples' physical appearance, and some radiological characteristics. Listed below is the length of the 3 in. diameter slug and its weight for each sample retained:

| | | Location | | | |
|---|---|---|---|---|---|
| Silo | Zone | SE | NE | NW | SW |
| 1 | A | 56" - 10027 gms | 60" - 10856 gms | 21" - 3938 gms | no data presented |
| 1 | B | 61" - 10684 gms | 69" - 8543 gms | 37" - 6861 gms | no data presented |
| 1 | C | 58" - 9855 gms | 53" - 8261 gms | 37" - 6312 gms | no data presented |
| 2 | A | 44" - 7736 gms | 12" - 1992 gms | 0 - 0 | no data presented |
| 2 | B | 89" - 10689 gms | 61" - not shown | 0 - 0 | no data presented |
| 2 | C | 46" - 7838 gms | 64" - not shown | 54 - not shown | no data presented |

As can be noted, no data were supplied for a boring at the SW location of either silo. It was stated that borings were made but there was no explanation for lack of information. Furthermore, we were informed that four borings were made, one at each manway of Silo 3, and the slugs obtained, unlike those for Silos 1 and 2, were the full depth of the silo's content. Each of these Silo 3 slugs were composited and identified as Samples 1, 2, 3, and 4.

Disposition of all samples is unclear. We were told records do exist. We understand that for Silo 3 aliquots of composite of each of the four core (Samples 1, 2, 3, and 4) were given to PNL for analysis and treatability study. However, for the K-65 material of Silos 1 and 2 either an aliquot or the complete samples from a single location were used by PNL for analysis and study. The implication of all this is that the Silo 3 analyses will indicate horizontal but not depth variations, and the Silos 1 and 2 analyses may indicate some depth variations but no horizontal.

000045

For several reasons discussed at the IRT meetings, more samples need to be taken from the silos. Some thought should be given to a plan that results in samples truly capturing both horizontal and vertical variations. In devising such a plan, consideration needs to be given to how materials were loaded into the silos, and any available records concerning loading methods should be perused for any insight they may offer. For example, if Silo 1 and 2 waste were all dumped as sludges through the center dome hole and allowed to spread by gravity flow, it can be visualized that multiple samples on a single concentric circle might not capture lateral variations whereas multiples along a radial line might do so. If material were charged through one or several of the four manways, a more complicated problem arises.

Knowledge of waste composition is of importance in making concrete and a cemented waste, and it is of paramount importance if vitrification is to be pursued. The first rule for successful glass making is to control the batch. To do so requires up-front knowledge of any raw material variation so that suitable adjustments are made prior to furnace charging--afterwards is too late to prevent disaster.

In conclusion, given the stakes involved, more resources should be assigned toward obtaining samples of the silo waste both for characterization and for piloting immobilization processes.

Characterization - Silo Materials

Refer to Appendix C - Summary of Cement Stabilization, Chemical Extraction and Vitrification Studies.

- Various analyses and property determinations performed by PNL are recorded in this document:
  - Table C.3-1 Physical Properties of Untreated K-65 and Silo 3 Materials
  - Table C.3-2 Radon Emanation from Untreated K-65 Materials
  - Table C.3-3 Inorganic Composition of Silo 1 Material
  - Table C.3-4 Inorganic Composition of Silo 2 Material
  - Table C.3-5 Inorganic Composition of Silo 3 Material
  - Table C.3-6 Isotopic Content of Silo 1 Material
  - Table C.3-7 Isotopic Content of Silo 2 Material
  - Table C.3-8 Isotopic Content of Silo 3 Material
  - Table C.3-16 TCLP Leachate Concentration from Untreated K-65 Silo 3 Material
  - Table C.3-17 TCLP Fractional Release from Untreated K-65 Silo 3 Material

In additional to the above, a list of trace organics found in the materials is given in Table 4-3 of Proposed Plan for Remedial Action at OU4 (February 1994). For Silos 1 and 2, thirty-one materials are listed, but only two for Silo 3.

Of major concern for treatability is chemical composition. Acceptance of the validity of the analyses as representing all the waste in the silos should be tempered by knowledge of the sampling procedures as discussed previously. It should also be noted that on Tables C.3-3, C.3-4 and C.3-5 the waste is assumed to be oxides except for halogens. Recognition is given to possible presence of phosphate, carbonate, sulfate, nitrate, and nitrite anions by including P, C, S, and N as $P_2O_5$, $CO_2$, $SO_3$ and $N_2O_5$. The non-presence of water is assumed by listing components as "dry weight %." In spite of this, the sum of all components is only 86% for Silo 1, 81% to 88% for Silo 2, and 81% to 90% for Silo 3. No explanation is given which of course is not an exactly tolerable situation. In discussing this with FDF, I learned that "dry weight" was determined by drying at 160°C. Since many hydrates retain their waters well above this temperature, and since the K-65 materials were sludges with free water of 26% to 35%, this may very well explain the discrepancy. Silo 3 waste is, however, another story, since it supposedly was calcined prior to storage.

Another concern about the analyses is that though the presence of anions was recognized, no attempt was made to assign what anion to what cation. Knowing this is highly desirable when trying to plan treatability strategy. The importance of this for sulfates has been impressed on the FDF glass melt personnel.

In conclusion, when and if further attempts are made at characterizing the silo waste, emphasis should be given to determining exact species which are present.

Vitrification Efforts

Refer to:
- Appendix C - Summary of Treatability Studies, February 1994
- Vitrification Testing for Fernald CRU4 Silo Wastes, May 1996
- Operable Unit 4 VPP Campaign 2 Report, December 1996
- Vitrification Pilot Plant Melter Incident, February 1997

By perusing these documents, one can get a general feel for the efforts expended and the reasons why certain avenues were explored. For a glass technologist, however, the lack of detail concerning experimental parameters frustrates one's ability to judge validity of conclusions drawn and the wisdom of succeeding actions. In discussing this with FDF, they suggested reading primary source documents which they will supply. However, at the risk of having to later retreat, the following comments are offered.

The first concern is simply--do the cognizant engineers understand the waste they are dealing with. As pointed out previously, both sampling procedure and analytical results aren't reassuring. A good example of why analysis should be of concern is a statement in the Campaign 2 report pointing out that in December 1996 someone realized that Silos 1

000047

and 2 probably contained $BaSO_4$ rather than $CaSO_4$ used by CUA as surrogate in all their experiments. This is an important detail that needs be settled. Another example for why sampling procedure is a worry--it was reported in the same source that FDF's lab found samples from Silos 1 and 2 to contain twice as much sulfate as found by PNL in the original samples.

The initial efforts involving crucible melts at PNL was a worthwhile endeavor. They used actual silo waste and adding other materials made small 100 gram melts, measured properties, adjusted batch, and tried again. After a number of iterations, they arrived at a composition with reasonable ease of melting and satisfied required properties or performance criteria.

VSL-CUA's laboratory's challenge was more complex and their efforts were clouded by:

(1) Silo 3 waste had to be part of the mix recipes which greatly complicated and diluted those efforts.

(2) All crucible and mini-melter experiments used surrogates of questionable compositional validity (discussed previously).

(3) All experiments were designed to arrive at a composition suitable for a preselected process (i.e., three-chamber melter/gems).

In retrospect including Silo 3 was a poor decision because of its high sulfate, high phosphate waste. To consider combining it with the high lead, Silo 1 and 2 waste, is even worse. Considering the results of the simple series C & D PNL melts (C = Silo 3, D = Silo 1, 2 and 3) which exhibited such extreme volatility should have served as a warning.

For point (3) the problem as I see it is someone had a really clever idea for circumventing the well known moly-PbO reaction which discourages use of moly electrodes for lead glasses. The three chamber furnace with the conducting barrier wall is a fascinating concept. However, as FDF learned the hard way, there were and are many problems to solve. It seems to me that handling radioactive materials both upstream and downstream is sufficiently challenging that the simplest treatment process should be chosen. Another type of melter is definitely in order if one is to pursue vitrificatio CUA, however, had to spend much effort toward using the melter. This involved getting the relative conductivities and densities for two different glasses correctly adjusted. In addition, they also had t worry about glass workability for a gem making process!

All this diluted their efforts which should rightly had been directed toward the real problem. That is how to make a glass relatively high in PbO but with raw materials containing several percent sulfates whose cation is either an alkali or an alkaline earth or both.

The dilemma here is that the highly oxidizing conditions required for lead glass induces $SO_3$ to enter the structure to the extent that the glass becomes "super saturated" and various conditions will cause sudden release of $SO_2$ gas. This sometimes causes violent and catastrophic foaming.

Thus it has been known by all lead glass makers that sulfates should be avoided, and most who have been around for awhile will have stories to tell about how dangerous it is.

There are three rules for making lead glass:

(1) Don't disturb the surface to minimize volatiles.
(2) Never use moly electrodes--use tinoxide
(3) Load the batch with oxidizers (niter, antimony, manganese).

It is interesting to note that the piloting effort by FDF violated all three!

In concluding, we offer the opinion that a substantial development effort is needed to devise a viable process for vitrifying K-65 material.

000049

# APPENDIX B

## QUALITATIVE COMPARISON OF THE TWO TREATMENT METHODS

To quote the Fluor Daniel Fernald charge to the IRT:

> "The Independent Review Team (IRT) will be providing advice/recommendations to Fluor-Daniel Fernald (FDF) and the Department of Energy (DOE) to aid in an internal decision process."
>
> "In light of significant uncertainties in vitrification process reliability observed to date and associated impacts on project schedule and like issues, FDF and DOE would like advice/recommendations on whether to formally re-evaluate the selected OU4 remedy. FDF and DOE would like the IRT to evaluate issues associated with vitrification implementation and identify and evaluate any potentially viable options to vitrification. In light of these evaluations, FDF and DOE would like input on the appropriateness of re-evaluating, through a formal public process, the current OU4 path forward."

A significant portion of the IRT meetings held to date have, because of necessity, been directed towards and centered upon technical information and facts underlying the vitrification and stabilization processes. In these discussions and exchanges, the IRT has gained considerable information concerning the Fernald Site history and background, details concerning the decisions of how to treat the Fernald wastes, backgrounds and histories of vitrification and stabilization, operating details (good and bad) of both vitrification and stabilization facilities, details concerning potential discriminators between vitrification and stabilization (treatment, waste form, packaging, transportation, disposal, safety, etc.), and the successes and failures of the VITPP project. This information has been in the form of studies, reports and presentations, and has been thorough, understandable and important.

However, as valuable and important as technical information is to any decision-making process, there are also practical aspects associated with the same decision. To this end, a matrix of practical items has been prepared, based on providing large, new, on-site treatment facilities.

Although the matrix is qualitative, and no attempt has been made to weigh the factors, the matrix did assist the minority group in evaluating the two treatment alternatives by considering non-technical but nevertheless important items. The minority group opinion is that this matrix favors stabilization rather than vitrification.

The terms used to rate or describe the various factors are non-specific; e.g., high-low, yes-no, and many different terms could be selected. In addition, both the terms and their application are subjective. Therefore, the matrix should be used judiciously and only as originally intended: a qualitative tool.

TREATMENT METHOD EVALUATION FACTORS

(*The Minority recommends that the stabilization process be cementation)

| FACTOR | VITRIFICATION | CEMENTATION |
|---|---|---|
| TECHNOLOGY: | | |
| KNOWN | YES | YES |
| WELL DEVELOPED | NO | YES |
| DEMONSTRATED | YES | YES |
| WIDE APPLICATION | NO | YES |
| EASILY UNDERSTOOD | NO | YES |
| WIDELY ACCEPTED | NO | YES |
| COMPLEX | YES | NO |
| COSTLY | YES | NO |
| ROBUST | NO | YES |
| LONG OPERATING EXPERIENCE | NO | YES |
| APPLICABLE PRIOR EXPERIENCE | LIMITED | YES |
| DEVELOPMENT TIME REQUIRED | 3 YEARS + | 1 YEAR |
| SPECIAL DEVELOPMENTAL NEEDS | UNIQUE ELECTRIC MELTER | NONE |
| TECHNICAL SUPPORT: | | |
| EXPERTS AVAILABLE | YES | YES |
| LARGE TECHNICAL BASE | NO | YES |
| INDUSTRIAL SUPPORT BASE | LIMITED | YES |
| FACILITY/PROCESS: | | |
| NUMEROUS UNIT OPERATIONS | YES | LESS |
| COMPLEX UNIT OPERATIONS | YES | NO |
| EASILY CONTROLLED | NO | YES |
| EASILY MAINTAINED | NO | YES |
| EASILY OPERATED | NO | YES |
| PROCESSING RATE | LOW | HIGH |
| REPLACEMENT PROCESSOR | MADE TO ORDER | AVAILABLE |
| PROCESSOR LIFETIME | 1/2-3 YEARS | 10 YEARS + |
| PROCESSOR MATERIALS OF CONSTRUCTION | MADE TO ORDER | STANDARD |
| MISTAKES/ERRORS | LESS FORGIVING | FORGIVING |
| SHUTDOWN/UPSET RECOVERY | SLOW | RAPID |
| SECONDARY WASTE STREAMS | SEVERAL | FEW |
| MIX RECIPES | DEVELOPMENTAL | DEVELOPMENTAL |
| PROCESS UPSETS | UNFORGIVING | FORGIVING |
| PRIVATIZATION POTENTIAL | LOW | HIGH |

| FACTOR | VITRIFICATION | CEMENTATION |
|---|---|---|
| ROBUST | NO | YES |
| PROTECTS PUBLIC, WORKERS, ENVIRONMENT | YES | YES |
| LATENT HAZARDS | TEMPERATURE, HEAT, ELECTRICAL | NONE |
| RECOVERY FROM MELTER/MIXER FAILURE | LENGTHY | RAPID |
| D&D IMPACTS | HIGH | MODERATE |
| SUPPORT: | | |
| OPERATING TEAM SIZE | MODERATE | MODERATE |
| SUPPORT TEAM SIZE | MODERATE | MODERATE |
| LABORATORY SUPPORT | LARGE | MODERATE |
| R&D NEEDED | EXTENSIVE | LIMITED |
| OPERATING SCHEDULE: | | |
| BASELINE FACILITY OPERATING SCHEDULE | 24 HR/DAY, 7 DAYS/WK | 8 HR/DAY, 5 DAYS/WK |
| LIKELIHOOD OF IMPROVING OPERATING SCHEDULE | LOW | HIGH |
| PROCESSOR ACCIDENTS: | | |
| POTENTIAL | MODERATE | LOW |
| IMPACT | HIGH | MODERATE |
| RECOVERY TIME | LENGTHY | MODERATE |
| RECOVERY COSTS | HIGH | MODERATE |
| UNIQUE HAZARDS | TEMPERATURE VOLTAGE UNSTABLE GLASS | NONE |
| UNCONTROLLED MELT PROCESSING | MODERATE | NONE |
| SECONDARY IMPACTS | SMOKE, FIRE | NONE |
| PROBABILITY OF EXTERNAL OVERSIGHT GROUPS | HIGH | MODERATE |
| CONSTRUCTION: | | |
| MELTER/MIXER | MADE-TO-ORDER | OFF-THE-SHELF |
| COST | VERY EXPENSIVE | RELATIVELY CHEAP |

| FACTOR | VITRIFICATION | CEMENTATION |
|---|---|---|
| CURRENT FDF COST ESTIMATES | OPTIMISTIC | PESSIMISTIC |
| CURRENT FDF SCHEDULES | OPTIMISTIC | PESSIMISTIC |
| PROBABILITY OF COST/SCHEDULE IMPROVEMENT | FAIR | GOOD |
| WASTE FORM: | | |
| PRODUCT | GEMS/MONOLITH | BLOCK |
| WASTE LOADING | HIGH (MAYBE) | MODERATE |
| RADON RETENTION | EXCELLENT | FAIR |
| RADIATION LEVELS | MODERATE | LOW |
| DISPOSAL CRITERIA | MEETS | MEETS |
| DISPOSAL SITE | NTS | NTS |
| TRANSPORTATION CRITERIA | MEETS | MEETS |
| PACKAGING | SEG BOX | SEG BOX |
| WHITE METAL BOX | | |
| NUMBER OF WASTE BOXES | MODERATE | HIGH |
| NUMBER OF TRUCK SHIPMENTS | MODERATE | HIGH |
| NUMBER OF RAIL SHIPMENTS | LOW | LOW |
| RECOVERY FROM OFF-SPEC MTL. | RAPID | RAPID |
| LATENT DEFECTS | NON-HOMO-GENEITY, PHASE CHANGE HIGH STRESS OFF-SPEC | OFF-SPEC |
| ACTIVITIES AT RISK: | | |
| COST: ALT. II, LIFE CYCLE, $490M VIT; $430M STABIL. | APPEARS ACHIEVABLE | APPEARS ACHIEVABLE AT LESS COST |
| PROJECT COMPLETION SCHEDULE: 2011 VIT; 2008 STABILZ. | APPEARS UNACHIEVABLE | ACHIEVABLE WITH POSSIBLE 3 YEAR IMPROVEMENT |
| TYP REQUIREMENTS | CANNOT BE MET | MIGHT BE MET |
| MEETS EM 30 VISION | NO | NO |
| MEETS OHIO FO VISION | NO | NO |
| MIX RECIPES | HIGH RISK | NO RISK |
| PROCESSOR DEVELOPMENT SUCCESS | HIGH RISK | NO RISK |
| OTHER: | | |
| UNIQUE REGULATORY REQ. | NONE | REVISE ROD |
| COST REDUCTION OPPORTUNITIES | FEW | MANY |

000053

## APPENDIX C

## INCONSISTENCY OF CURRENT PATH FORWARD DECISION WITH THE TEN YEAR PLAN (TYP)

The Ten-Year Plans (TYPs) submitted to DOE-HQ in July 1996 by the 11 major DOE sites have been reviewed for important assumptions and issues that could influence the Fernald waste treatment decision. Those assumptions and issues specifically related to the Ohio Field Office have been identified separately and are attached, as are those applicable to Fernald and to OU4.

Mr. Al Alm's vision of what EM will accomplish by FY 2006 included the statement that "within a decade, the Environmental Management Program will complete cleanup at most sites." As indicated, most DOE sites (including all Ohio sites) will be complete with active waste cleanup by FY 2006. Mr. Hamric's letter transmitting the Ohio TYP includes a commitment to ".... declare total victory on September 30, 2005." Mr. Hamric's letter also outlines some of the challenges in meeting TYP commitments: funds availability, flat funding, needed cost savings, and between-site funding flexibility.

The Ohio Field Office Strategic Plan, projects a steady decrease in employment for Fernald starting in FY 1997 and continuing through FY 2005.

When the goals and objectives presented in the TYPs' and the Strategic Plan are compared to the Silos Project estimated costs and schedules, the Project clearly cannot meet TYP objectives regardless of the waste treatment method. These conclusions, however, are based on large, new on-site treatment facilities. Turnkey subcontracting or some form of privatization may offer the potential of significantly reducing costs and schedules.

The issue of compatible project funding and schedules is important because of the potential for the DOE-HQ to transfer funding from offices that are not meeting and cannot meet TYP commitments to offices that are meeting and can meet 10 year plan commitments. Since the Silos Project as presently envisioned and estimated (Alternative I) will not meet TYP goals or objectives, this possibility exists overall funding would be cut. The same situation would prevail, if Alternative II were selected.

**Comment**

The Minority considers that Alternative III provides an acceptable, expedient path forward that can be accomplished within the ten year planning period.

### OHIO FIELD OFFICE ASSUMPTIONS CONTAINED IN THE TEN-YEAR PLAN

- Optimum regulatory flexibility.
- Anticipated 20% reduction in annual funding.

- Savings will balance funding reductions.
- Level funding for future years.
- Between-site funding flexibility.
- All LLW/MLLW disposed at commercial or other DOE sites.

## FERNALD TEN-YEAR PLAN ASSUMPTIONS

- Allocated funds are 10% below needs.
- Creativity will balance funding reductions.
- Wastes will continue to be shipped to NTS.
- Other DOE sites will accept LLW, mixed legacy waste and nuclear material inventory.
- Nuclear materials inventory will either be sold or sent to another site, i.e., no disposal costs.
- Will achieve success in obtaining regulatory relief for on-site waste disposal.
- Privatization is an opportunity for a) the waste pit remedial action and b) portions of the Silos Project.

## FERNALD ASSUMPTIONS APPLICABLE TO OU4

- Funds allocation; 10% reduction.
- Shipment of wastes to NTS.
- Privatization of portions of OU4.
- Implementation of cost savings.
- Regulatory relief for on-site waste disposal.

000055

## APPENDIX D

## LESSONS LEARNED ON PAST PROJECTS

PREPARED BY GAIL BINGHAM, MINORITY GROUP MEMBER.

(The following lessons learned are NOT a consensus position or recommendation of the Minority.)

1. Assign one, totally responsible Project Manager to the project. This person needs to be experienced in project management. The Project Manager also needs to be very familiar with the project construction site, the DOE site personnel, DOE and contractor rules, requirements, orders, and procedures that apply to the site.

2. The Project Manager must be delegated all of the authority needed to manage the project. Typically, the Project Manager needs more authority than most people think is required.

3. Authority should be verified in writing with appropriate DOE and contractor managers being made aware of the assignment.

4. The Project Manager should report at a high enough level within the organization to demonstrate: 1) the project is important; 2) senior management supports the project; and 3) the Project Manager has adequate access to senior management to resolve problems and obtain resources. The reporting level also establishes the Project Manager's ability to access and work directly with other senior staff personnel.

5. A Memorandum of Understanding (MOU) should be prepared between the contractor Project Manager and the DOE Project Manager outlining authorities and responsibilities of each. This becomes very important as the project progresses through design and construction; there cannot be two Project Managers providing guidance and direction to contractors and subcontractors.

6. Clear lines of communication should be established between the project, DOE, subcontractors, suppliers, and other support organizations.

7. Establish a strong cost/schedule control organization and a strong configuration management/records management organization. Also prepare and issue detailed procedures for these organizations.

8. Develop and implement a change control procedure early in the project along with a project change control board. Establish reasonable change control limits. Change requests should be well documented, justified, approved, and recorded. Justification

should include all impacts of the change including schedule, cost, technical, design, procurement, construction, startup, operation, and maintenance.

9. Board membership should include representatives from the contractor safety, technical, engineering, operations and maintenance organizations.

10. As a minimum, the following should be placed under change control as soon as approved versions are available: project design criteria, cost estimates, schedules, specifications and drawings.

11. All personnel supporting the project should report to the Project Manager. If matrix support is necessary, then those matrix support to the Project should understand they report to the Project Manager.

12. All project funding must be under the control of the Project Manager. Authorization to spend project funds must be through approved GWA's, work authorizations, etc.

13. If support is required from matrix organizations from matrix organizations (technical/R&D), these organizations should prepare a scope of work, a cost estimate and a schedule for the support to be provided. The schedule should contain meaningful, measurable quarterly milestones.

14. All tasks, planning packages, work packages should consist of a scope of work, a cost estimate and a schedule.

15. Consider organizing project engineering personnel as "subproject managers." That is, organize and assign project work efforts into subprojects, again, each having scopes, resource leaded schedules and cost estimates. For the vitrification facility typical subproject assignments could include the melter, off-gas system, feed retrieval system, electrical system, emergency electrical system, DCS, instrumentation system, glass gem forming system, HVAC, etc. Anything which can be described as a discrete work effort, and for which funding, authority and responsibility can be assigned.

The second and most important aspect of this arrangement is assigning the responsible engineer total authority and responsibility for the assigned system(s). This includes preparation of conceptual design criteria; preparation of design criteria; drawing and specification preparation; design reviews and design review comment resolution; preparation of procurement documents and equipment procurement, including inspections and installation; preparation of CC tests and oversight of performance; preparation of SO tests including selection and training of SO test team and serving as SO test team leader; preparation, review and approval of operating manuals and procedures; training of operators and maintenance personnel; review and approval of appropriate vendor data; resolution of field problems; and, providing expert support during facility startup and cold operation.

The responsible engineers would be the responsible work package mangers which includes budget authority and responsibility, monthly budget analysis and variance analyses and explanation.

The value that flows from such an organizational arrangement is total responsibility, authority and most importantly ownership. In addition, the project manager is full aware of who the responsible persons are, and can immediately obtain needed information and data.

A secondary benefit of such an organization is that the project is continually training future project managers.

16. Assure all project personnel are fully aware annual performance reviews, promotions and salary increases are totally based on performance.

17. Perform at least three "team reviews" of the facility design, if possible, at the AE's facility: conceptual, Title I and Title II. If a facility model is available, make the model a key part of the review. The review teams should include operations and maintenance personnel as well as safety, QA and technical and field/construction engineering.

18. Require timely responses to all vendor data submittal and design review comments.

19. Locate all project personnel and essential support personnel (e.g., operating manual technical writers) in the same facility if possible to maximize communication and increase the feeling of belonging to the project team. If common building location is not possible, then certainly common area becomes essential.

20. Establish a field/construction engineering group to provide construction interface and problem resolution, safety oversight, daily and weekly construction meetings, and constructability reviews.

All design review packages should be reviewed by all involved organizations: safety, QA, technical, operations and maintenance.

Establish strict review times and respond to all review comments.

22. Encourage (strongly) that responsible system engineers frequently overview construction activities to respond to questions, participate in and respond to field problems; and to remain fully familiar with the facility to simplify drawing walkdowns; training of operations and maintenance personnel; accelerate equipment, line and valve tagging; and simplify CC and SO test procedure preparation and performance.

000058

23. Establish a single, well organized records management/configuration management center. Establish a computerized records identification and tracking using bar coding where possible. Assure the records system maintains copies of all project records until facility turnover. If space is a problem, consider microfilming the older records. Also, keep copies of all design review comments and responses. Also maintain a complete, easily retrievable vendor data system including all past versions and all review comments and resolutions.

24. As part of all procurement contracts, include sufficient hold-back to guarantee receipt of all vendor data. That is, make non-submittal painful for the vendor.

25. Prepare and maintain a detailed WBS. Tie all project activities to the WBS. Make the WBS flexible enough so that additional activities can be added with minimal disruption. Along with the WBS, prepare and distribute a WBS Dictionary.

26. Establish numerous, smaller work packages so that the responsible engineers can provide adequate attention to cost and schedule management.

27. Assure the cost/schedule group provides adequate monthly performance data so that analysis and explanation can be provided for the monthly project performance reports.

28. Hold monthly project review meetings for contractor and DOE management. Review all significant project areas including problem areas and recommended corrective actions. If possible, have the responsible engineers present their own area of responsibility.

29. Maintain a continuous contingency usage log to provide a continuous track record of contingency usage. Establish the log as soon as capital funds are received and maintain the log, throughout the life of the project. As part of the log, include change order identifiers and explanations of approvals and reasons for contingency usage. Maintain a continuous plot of contingency usage and provide copies to all interested parties, especially senior contractor and DOE management.

30. Establish and maintain an action item log so that actions are documented along with responsible parties and due dates. Include the architect-engineer, the construction manager and the DOE.

31. Prepare and maintain schedules that roll-up from the work package level to the project master schedule. All schedules should be time phased, resource loaded and include frequent, meaningful and measurable milestones and a critical path.

000059

32. Prepare either change request or at as a minimum impact studies of DOE directed changes. Especially those that change standards, requirements, orders, agreements, etc.

33. Train all project personnel in the cost/schedule system, the reporting system, the configuration control system ad the records management system.

34. For major procurements, assign a resident engineer at the vendor's shop. Also provide a resident engineer at the AE's offices during the design period.

35. For engineered procurements, when a resident is not assigned, assure the responsible engineer visit the supplier frequently enough to confirm reported progress and schedule and cost status, and to validate reported problems and solutions.

36. For off-site activities, use QA auditors to examine, evaluate and report potential problems.

37. Use cost/schedule curve extrapolation to project anticipated future costs and progress. Early notification of potential problems can be obtained through curve projections and mathematical calculations.

38. Prepare and distribute a Project Approval Authority Matrix outlining the authority and responsibility of each manager assigned to the project.

39. Train all engineers and technical personnel assigned to the project to avoid making verbal commitments or providing inadvertent work direction (changes) to suppliers and subcontractors.

40. Establish "reasonable" variance thresholds. That is, establish thresholds that are related to the risk involved.

## APPENDIX E

## FLUOR DANIEL FERNALD COST ESTIMATES FINAL REMEDIATION ALTERNATIVES--FUNDING (IN MILLION DOLLARS)

| | Alternative II | | | Alternative III | | |
|---|---|---|---|---|---|---|
| UNCONSTRAINED FUNDS Note 1 | Low | Expected | High | Low | Expected | High |
| Project Management | 46 | 54 | 57 | 43 | 45 | 50 |
| Capital Costs (retrieval, design & construction) | 152 | 202 | 241 | 85 | 100 | 124 |
| Operating & Maintenance | 50 | 75 | 90 | 25 | 29 | 38 |
| Shipping & Disposal | 72 | 80 | 94 | 120 | 198 | 227 |
| D & D | 34 | 40 | 52 | 30 | 36 | 45 |
| Total Silos 1 & 2 | 354 | 451 | 534 | 303 | 408 | 484 |
| Total Silo 3 Costs | 22 | 25 | 29 | 22 | 25 | 29 |
| OU4 Silos | 376 | 476 | 563 | 325 | 433 | 513 |
| Impact of Escalation | | | | | | |
| Unconstrained Funds | | 186 | | | 182 | |
| Constrained Funds Note 2 | | 222 | | | 218 | |
| Note 2 Severely Constrained Funds | | 250 | | | 228 | |
| Key Milestones | | | | | | |
| Start Operations | | 2006? | | | 2003? | |
| Complete D & D | April 2011 + 2, +3* | | | February 2008 +2, +3* | | |

* Completion of D & D is impacted by funding constraints.

Note 1 Annual funding is at a level desired for efficient implementation of the project.

Note 2 Constrained funding is defined as $25 million per year from 1997 to 2001, $50 million per year from 2002 through 2005 and unconstrained thereafter. Severely constrained funding is defined as at the level of the current FY97 plan.

000061

## IRT OBSERVATIONS ON FLUOR DANIEL FERNALD COST ESTIMATES

The cost estimates and schedules developed by FDF, assuming development of an acceptable vitrification process could be accomplished in the time allotted (the Minority considered this assumption was invalid) appeared to be reasonable and of the correct order of magnitude. The Minority recognized there is limited engineering support for Alternative II and essentially no engineering to support Alternative III cost estimates. FDF has made comparisons to other similar facilities, i.e., Weldon Springs, West Valley, Hanford, and Savannah River to arrive at their estimates. However, without flowsheets, equipment data sheets, and space allocation drawings for the Fernald application, these estimates must be considered very preliminary.

A summary of the Minority observations follow:

- The estimates are FDF generated. The IRT has not performed any independent cost estimates.
- The costs are not supported with resource loaded, critical path schedules.
- The estimates assume FDF managed a new project.
- The cost estimate do not include contingency; only ranges of uncertainty.
- The vitrification estimate is based on limited engineering and pilot plant experience.
- The cementation estimate is not supported by engineering; it is based on comparisons.
- The cost estimate appears to be in the current order of magnitude.
- The vitrification cost estimate is primarily influenced by development and capital costs.
- The cementation cost estimates are primarily influenced by waste loading, packaging, transportation, and disposal.
- Efforts at cost reductions should focus on the identified cost drivers.
- Opportunities that exist for reducing ultimate costs and schedule include:
  - Increased waste loading above the 20% assumed for cement.
  - Optimized packaging and shipping. (FDF used the same assumption for both cases with no effort to optimize.)

000062

- Modified cementation facilities operating philosophy (i.e., 24 hr./day, 7 days/wk. instead of 8 hr./day, 5 days/wk.)

000063

## APPENDIX F

## MINORITY GROUP MEMBER PROFESSIONAL EXPERIENCE

### JAMES N. EDMONDSON

### EDUCATION

B.S. in Chemical Engineering with Distinction and Honors
University of Delaware, 1950

### EMPLOYMENT HISTORY

Mr Edmondson was a professional employee of the General Electric Co. (GE) from 1950 through 1989.

Mr. Edmondson served as Chemical Engineer, Service Engineer, Senior Engineer, and Supervisor-Melting Equipment Engineering. He also served as Manager of the following GE groups: Manufacturing Technology, Melting Equipment Engineering, Melting Systems, Glass Technology, Glass Engineering, and Glass Melting Systems.

Mr. Edmondson's combination of world renowned experience in glass making technology resulted in many technological breakthroughs in GE's Lighting Products Division. He designed and modified many furnaces and glass manufacturing process lines to suit specific electrical component products. Mr. Edmondson was also a pioneer in pursuit of glass furnace energy reduction and emission reduction programs at GE.

Mr. Edmondson received the company's distinguished Charles P. Steinmetz Award in 1987 for his wide ranging innovation in manufacturing of GE's glass based electrical components. GE reports he was responsible for dramatic improvements in quality and productivity that helped GE gain an edge in an era of intense world competition.

Since retiring, Mr. Edmondson has worked as a part-time consultant for GE Lighting, Philops (N. America) Lighting, Venture Lighting, APL Materials, Iwasaki Electric (Tokyo), Lim Kim Hai Holdings (Singapore), Vortec Corp., Toledo Engineering, and Westinghouse Hanford Corp.

## F. ROBERT COOK

### EDUCATION

Nuclear Engineering , Bettis Atomic Power School, Pittsburgh, PA, 1964-1965

Graduate Study in Molecular Biology, Washington University, St. Louis, MO, 1961-1962

A.B. in Physics, Washington University, St. Louis, MO, 1961

### EMPLOYMENT HISTORY

Mr. Cook was a Nuclear Power Engineer from 1963-1980 with the Naval Ships System Command/Division of Naval Reactors U.S. Navy Department/Atomic Energy Commission.

Mr. Cook directed technical activities involved in designing, producing, installing and operating reactor equipment for four classes of nuclear powered ships. Performed extensive and detailed reviews of naval reactor technology, contractor procurement specifications and requirements, management schemes involving the government and contractors, large Navy-DOE/ERDA/AEC budget preparations and reactor operating procedures, including refueling and fuel transportation and storage procedures.

He managed technical aspects of naval reactor research and development programs at two U.S. government laboratories, including development of a comprehensive design control system for reactors. Work was focused on advanced reactor cores, advanced fuel systems, new reactor structural materials, and included development analyses for structural, thermal-hydraulic, shock and vibration, reactor chemistry and metallurgical evaluations.

He was responsible for the design, installation, operation, maintenance, and overhaul of reactor fluid systems for two classes of Navy Surface ships. This included design cognizance of loss of coolant accident considerations, and radiological shields.

Mr. Cook was Chief, Material Section, from 1980 - 1983 and Senior On-Site Licensing Representative, DOE Hanford Site, from 1983 - 1988 for the High Level Waste Licensing Branch U.S. Nuclear Regulatory Commission (NRC).

From 1980 to 1983 he supervised the NRC's program to determine acceptable high-level nuclear waste immobilization and packaging requirements and to provide a basis for repository performance analyses. This included the direction of NRC sponsored research regarding short-term and long-term performance of borosilicate waste glass, including its stability properties and its fabrication. His work included reviewing DOE research and development programs directed at reliability analyses for high-level waste forms and waste packages. His responsibility included designs of universal storage/shipping/disposal containers for commercial spent fuel. He participated in the development of quality assurance requirements in NRC's high-level waste disposal rules, other rule making policy issues and the preparation of Staff Technical Positions relative to disposal of high-level waste.

From 1983 to 1988 Mr. Cook was responsible for managing NRC's oversight activities of DOE and DOE contractor's work on the Basalt Waste Isolation Project (BWIP). His work included investigating and identifying problems associated with the high-level waste site and DOE/DOE contractor actions related to future licensing by NRC. He interacted directly with Federal, State, and Tribal officials, the public, and the media. Development and implementation of quality assurance systems of DOE and its contractors and technical problems associated with site characterization were the focus of his actions during this time. He retired from Federal service in 1988.

Mr. Cook was an Instructor from 1989 - 1990 for Washington State University, providing OSHA hazardous waste safety training to Hanford workers handling hazardous substances at the Department of Energy Hanford facilities. Instructions complied with 29 CFR 1910.120--the OSHA rule covering worker safety.

Mr. Cook has been a technical analyst from 1991 to the present for the Yakama Indian Nation's Environmental Restoration/Waste Management Program.

Mr. Cook is currently responsible for reviewing all technical matters of interest to the Yakama Indian Nation with respect to Department of Energy operations at their Hanford Site. Prime areas of concern relate to environmental, safety, cultural and regulatory matters. Specific projects of interest are the tank safety problems, waste disposal facility designs, waste management facility development, systems integration, vitrification plant justification, monitored retrievable storage for high-level radioactive wastes, waste minimization and waste volume reduction, spent fuel disposition, N-reactor decommissioning, cultural resource preservation and public involvement.

In the past he has participated in advisory groups and panels, including the Hanford Future Site Uses Working Group, the Keystone Federal Facility Environmental Restoration Dialogue Committee, a Federal advisory committee concerning public involvement with government cleanup actions, the State and Tribal Government Working Group (a federal advisory committee for Department of Energy) the Hanford Site Technology Coordinating Group, the Hanford Tank Waste Remediation System Task Force, and the Hanford Advisory Board.

**DELLA M. ROY**
Professor of Materials Science (Emerita)
Intercollege Materials Research Laboratory
The Pennsylvania State University
University Park, PA 16802

## EDUCATION

Ph.D., Mineralogy, minor in Ceramic Science, The Pennsylvania State University, 1952; M.S., Mineralogy, minor in Chemistry, The Pennsylvania State University, 1949; B.S., Chemistry, University of Oregon, 1947

## PROFESSIONAL EXPERIENCE

The Pennsylvania State University
- Professor of Materials Science Emerita, 1992
- Professor of Materials Science, 1975-91
- Associate Professor of Materials Science, 1969-75
- Senior Research Associate, Research Associate, Research Assistant, 1952-69
- Graduate Assistant-Mineralogy, 1947-49; 1950-52
- Teaching Assistant (as undergraduate), Chemistry and Physics, University of Oregon, 1945-47

## PROFESSIONAL ASSOCIATIONS AND UNIVERSITY SERVICES

American Ceramic Society (Fellow); American Concrete Institute (Fellow); Mineralogical Society of America (Fellow); American Association for the Advancement of Science (Fellow); Materials Research Society; ASTM; Geochemical Society; Transportation Research Board; Clay Minerals Society; Concrete Society; American Nuclear Society; Society of Women Engineers. Director, Consortium on Chemically Bonded Ceramics and Low-Temperature Materials.

## RESEARCH INTERESTS

Materials synthesis, preparation and characterization in inorganic, ceramic, cement and mineral systems; chemically bonded ceramics–low temperature materials; cement hydration, surface chemistry, electrokinetic phenomena, rheology; characterization, concrete microstructure, high performance concrete, very high strength low porosity cement composites, special cements; science of nuclear and chemical waste management; phosphates, apatite bioceramics; hydrothermal and high temperature reactions; chemical and mineral admixtures; phase equilibria.

000C7

## HONORS AND AWARDS

Elected: National Academy of Engineering (1987); Honorary Fellow, Institute of Concrete Technology (1987); Member, (Intl.) Academy of Ceramics (1991); American Ceramic Society: Jeppson Medal (1982), Copeland Award (1987), Trustee; ACI/CANMET Award for Outstanding Contributions to Fundamental Properties of Blast-Furnace Slag (1989); Phi Beta Kappa; Sigma Xi; Tau Beta Pi; Founding and Council Member, Materials Research Society; Founding Editor and Editor-in-Chief, Cement and Concrete Research (1971-); Transportation Research Board, NAS, Executive Committee (1991-94); NAS Board on Radioactive Waste Management (1994, several committees).

## PUBLICATIONS

(Total of 375; 8 edited books; 45 major reports to government agencies; 4 patents)

## SPECIAL EXPERIENCE

Since 1974: Extensive experience in the science and technology of radioactive waste management, especially in the applications of cementitious materials in waste solidification, isolation, and underground repository development: ORNL/Union Carbide 1974-77 Borehole Plugging and Waste Properties; Borehole and Shaft Sealing Systems (Office of Nuclear Waste Isolation; Rockwell Hanford; Sandia 1977-1980); Tailored Ceramic and Cement Waste Forms (DOE/Rockwell International); Geochemistry of Cement-based Borehole Plugging/Shaft Sealing Systems (DOE/ONWI 1979-82), Materials for Repository Sealing, Backfilling (Los Alamos, Sandia, 1982-86) Repository Performance: Salt Repository (DOE/SAIC/ONWI) (1986-87); Thermal Properties of Concrete (SAIC/NRC); Saltstone Characterization (DuPont - SRL 85-88); Anhydrite-Grout Interface Studies (DOE/Sandia 88-89); Characterization of Tumulus Concrete (ORNL/MMES 89-95). Consulting and Advisory Committees various sites and organizations 1988-97 (including National Academy of Sciences).

000068

**GAIL E. BINGHAM**
Engineering Consultant

**EDUCATION**

Masters Business Administration, University of Idaho, 1973
BS Chemical Engineering, Oregon State University, 1956

**PROFESSIONAL EXPERIENCE**

Cost Schedule Control System Criteria (CSCS/C)
Project Management
OSHA Requirements Training
Operational Readiness Review and Risk Assessment
Process Plant Startup
Design Review Process
Environmental Assessment Workshop
Construction Contract Litigation
Design Review Process
MORT (Risk Analysis)
Quality Assurance (TQM)

**POSITIONS**

| | |
|---|---|
| 1995 to present: | Independent Consultant |
| 1993 - 1995: | Manager, Strategic Planning, Westinghouse Idaho Nuclear |
| 1990 - 1993: | Manager, Major Projects Department, Westinghouse Idaho Nuclear |

**EXPERIENCE**

Fernald: Comprehensive Vitrification Project Review Team; VITPP Value Engineering Team; VITPP RAM Analysis; Melter Failure Incident Analysis Team; Silos Project Independent Review Team (IRT)

DOE Headquarters: Federal Facility Compliance Act; DNFSB 90-2 (S/RIDs); Baseline Environmental Management Report; Ten-Year Plan

Westinghouse, et al (INEL): Project Manager: New Waste Calcining Facility ($90M), FPFU ($45M), IFSF ($4M), UFSF ($250K), FPR ($350 M); Manager of Projects: FPR ($350M); New Tank Farm ($300M); FDP Upgrade ($500M); FDP Rerack ($50M)

000069

**EARL W. McDANIEL**
Independent Consultant

**EXPERIENCE**

Earl W. McDaniel retired from Oak Ridge National Laboratory (ORNL) April 1, 1996, after a career of over 36 years. For the past 22 years, he has specialized in the use of concrete, cement and inorganic mineral admixtures such as fly ash, blast furnace slag, and clays to terminally store and dispose of both radioactive and hazardous wastes. These efforts included evaluation of raw materials, mix design, testing and evaluation. Mix design and material selection were in support of the Borehole Plugging Program. This program was responsible for the evaluation and testing of materials that would be used to seal boreholes and mine shafts in deep geological repositories. Mr. McDaniel served as Oak Ridge National Laboratory's principal investigator (PI) in this activity for three years. During this period, he developed skills in performing American Concrete Institute (ACI). American Society of Testing and Materials (ASTM) and American Petroleum Institute (API) standard test procedure. In addition to standard procedures, Mr. McDaniel designed and built a device based on API procedures to determine both liquid and gas permeability of materials in the micro Dary range. This device was used to support the Department of Energy's (DOE) efforts at placing an experimental plug in a borehole at the Bell Canyon Test Site in Southeastern New Mexico as part of the early development of the Waste Isolation Pilot Plant (WIPP) Project . Working solutions for permeability measurements were saturaged solutions of brine and sulfate to simulate New Mexico ground water.

Mr. McDaniel has experience in designing mixes and testing of material to be used in construction of vaults used to store and dispose of low-level wastes. This effort required knowledge of ACI, ASTM, and API materials specifications, quality assurance and quality control of processing materials.

Mr. McDaniel has developed skills in the fixation of both radioactive and hazardous waste in cementitious matrices. This activity required much knowledge of the chemistry of cement, concrete and the interactions of chemicals in waste solutions with the cementing materials. In many cases, wastes were ionic solutions containing chloride, sulfate, fluoride, phosphate and nitrate salts. Evaluation involved the determination of the migration of these ions.

Mr. McDaniel has been involved in the design, construction, and operation of several waste (grout) stabilization facilities.

000670

During his career at ORNL, Mr. McDaniel maintained a very close working relationship with the Materials Research Laboratory of the Pennsylvania State University and the U.S. Army Corps of Engineers Waterways Experiment Station. Both facilities are considered outstanding in the field of applied cement and concrete technology.

Mr. McDaniel has served on many international committees and working groups in support of applied cement and concrete technology as a viable waste fixation medium. He has visited many research and waste management facilities and given lectures and invited seminars in Europe, the former Soviet Union, Japan, South Korea, and Thailand. On two occasions, he was invited to lecture in the People's Republic of China, but was unable to accept the invitations.

Mr. McDaniel is author or co-author of over 50 publications on the use of cementitious materials in waste fixation. He is a member of the editorial advisory board of *Nuclear Technology*. He is a member of the American Institute of Chemical Engineers, the American Nuclear Society, and a past member of the American Chemical Society and the American Ceramic Society.

Mr. McDaniel received his technical education at Catawba College, North Carolina State University, and the University of Tennessee.

000071