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SILO PROJECT INDEPENDENT REVIEW TEAM DOCUMENTATION - MEETIN NOTES FROM FEBRUARY 11, 12 AND 13, 1997 MEETING - PATH FORWARD DECISION - DRAFT ASSESSMENT

02/21/97

MN:WMTSP(SP):97-0063
IRT IRT
75
MEETING

FEMP Silos Project
Path Forward Decision
Distribution List

Independent Review Team w/ Attachments
Gail E. Bingham, consultant
Gilles Chevrier, NUMATEC
Robert Cook, consultant
Jim Edmondson, consultant
Bob Lawrence, WVNS
Todd Martin, HEAL
Earl McDaniel, consultant
John Plodinec, WSRC
Bob Roal, consultant
Della Roy, consultant
Ben Smith, consultant

Decision Analysis Support Contractor
Lee Merkhofer, Applied Decision Analysis, Inc.
w/ Attachment

Fluor Daniel Fernald
John Bradburne w/o Attachments
Mike Connors w/o Attachments
Doug Daniels w/o Attachments
Yvonne Gale w/o Attachments
Terry Hagen w/o Attachments
Bob Heck w/ Attachments
Renee Holmes w/ Attachments
Richard L. Maurer w/o Attachments
Dennis Nixon w/o Attachments
Don Paine w/ Attachments
Tisha Patton w/ Attachments
Harry Robertson* w/ Attachments
Dennis Sizemore w/o Attachments
Jeff Stone w/o Attachments
Tricia Thompson w/o Attachments

Jeannie Foster w/ Attachments
Jill Oligee w/ Attachments

DOE-FN
Nina Akgunduz w/ Attachments
Jack Craig w/o Attachments
Glenn Griffiths w/o Attachments
Johnny Reising w/o Attachments
Gary Stegner w/o Attachments
David Yockman w/ Attachments

FRESH w/ Attachments
Lisa Crawford
Vicky Dastillung
Pam Dunn

Citizens Task Force
w/ Attachments
Gloria McKinley
Doug Sarno
Gene Willeke

FATLAC w/ Attachments
Robert Tabor
Rick Wilson

Building Trades w/ Attachments
Lou Doll

U.S. EPA-V
Gene Jablonowski
w/ Attachments
Jim Saric w/o Attachments

Ohio EPA
Kelly Kaletsky w/ Attachments
Tom Schneider w/o Attachments

Others w/ Attachments
Marc Fioravanti, IEER
Ben Rusche, MTR Inc.
Silos Project File 40000 -
Independent Assessment Team
Fernald Public Reading Room

*Author

2/21/97

MEETING NOTES MN:WMTSP(SP):97-0063

SUBJECT: Silos Project Path Forward Decision

MEETING DATE: February 11, 12 and 13, 1997

LOCATION: Fluor Daniel Fernald Office

Project File 40000 - Independent Assessment Team

ISSUE DATE: February 21, 1997 File Record Storage Copy 104.(35).5

DISTRIBUTION: Please refer to the attached Distribution List

1.0 PURPOSE

The meeting was the fourth in a series of working sessions to review and evaluate the path forward alternatives for the FEMP Silos Project. The meeting involved the Silos Project Independent Review Team (IRT) along with representatives of the FEMP Stakeholder groups, regulatory agencies, the Department of Energy and Fluor Daniel Fernald.

The meeting shifted focus from previous meetings in several ways. The first day was structured to be a series of presentations by Silos Project personnel to answer both specific and general questions raised in previous meetings. The second day followed the previous meeting format and consisted of review and discussion of the technical committee progress in developing performance measures for input to the decision logic tree. In the evening of the second day, the IRT participated in a Public Availability Session during which the public had an opportunity to ask questions and express their concerns to the IRT. The third day was spent largely by the IRT, in caucus, establishing the basis and manner in which they would begin to formulate their recommendations.

Two new IRT members joined the team and attended the meeting for the first time in February.

2.0 DISCUSSION

<u>Tuesday, February 11</u>

<u>Introduction</u> Bob Heck opened the meeting by introducing the two new IRT members. He explained that the IRT had requested the support of additional stabilization/cementation expertise to help in the evaluation of alternatives and that FDF had obtained the services of Dr. Della Roy, Professor of Material Science Emerita at the Pennsylvania State University,

MEETING NOTES - Continued

and Mr. Earl McDaniel, consultant and former technical advisor in the use of cement-based materials to several DOE sites while employed at the Oak Ridge National Laboratory.

Silos Project/VITPP Update Don Paine gave an update to the VITPP melter bottom drain incident. He described the results of the Incident Analysis Team and the information that had been gathered during the investigation. Lou Bogar followed with the Safety Review Team report and Nina Akgunduz with the Data Analysis Review Team report. The notes from all three incident team reports are attached to the minutes.

Open Actions/Technical Issues Mark Dehring introduced the session by describing the approach that had been taken. Based on comments and questions at the previous meeting a list of unanswered or incompletely answered questions was developed and a comprehensive and fundamental answer formulated for presentation to the IRT.

Feasibility of Cement Stabilization The first question related to the feasibility and implementation of cement stabilization of the Silos material. Earl McDaniel responded with a presentation titled "Use of Inorganic Minerals in the Science and Technology of Waste Solidification/Stabilization. Dr. Della Roy followed with a presentation on the fundamentals of the chemistry and physics of concrete. Their joint answer to the question of feasibility of cement stabilization of the Silos material was that, based on the information supplied (Feasibility Study for Silos Material), it appeared to be feasible. On the question of implementability, Earl McDaniel emphasized the need for a comprehensive experimental plan and the close integration of science, technology and engineering and the need to be conservative in waste loading goals.

The balance of the morning was spent discussing the issues of feasibility and implementability with respect to: waste form performance criteria, experience with cementation of similar materials, and experience with cementation in general (both within the DOE complex and in other applications). The impact of high sulfate levels, high concentrations of lead and the presence of radium and radon were also discussed. Since many of these issues had been raised before and were to be covered in subsequent presentations, the IRT adjourned at lunch time. The notes from both presentations are attached.

Health and Safety Requirements Doug Daniels presentation that followed lunch, covered the clarification of the Health and Safety requirements for the various aspects of the project. These included radiological requirements for processing including: fence line limits, silo emissions and interim storage, occupational exposure and personnel monitoring, and stack emissions. He also explained the disposal site (NTS) requirements and the approach for transportation. He pointed out that stack emissions were currently being negotiated with the EPA and that no radon emission limits were currently specified for transportation and that FDF was proposing to control to the same limits applicable to the disposal site.

MEETING NOTES - Continued

Long Term Effectiveness of Waste Forms Steve Beckman followed the Health and Safety Requirements with an evaluation of the long term effectiveness of glass versus cement with respect to the constituents of concern. He showed the comparison between the two waste forms for radionuclides, RCRA metals and radon emanation and how the disposal site performance assessment might address the issues of leaching, radon emanation and the inadvertent intruder scenario.

Waste Container Requirements Mike Smith gave a summary of DOT Hazard Classifications for Radioactive Material and where the Silos material would be classified relative to other radiological material. He also explained how the Silos material met this qualification and the margin of conservatism by which it met it. He went on to describe the development of the SEG Enduropak and its certification to transport the vitrified silos material. He then explained the options for radon emanating materials and the concept of using the SEG Enduropak container with polyurethane lining and epoxy coating as a conservative approach to shipment of cement stabilized silos material.

Transportation Comparison - Truck vs. Rail Following his presentation on container requirements, Mike Smith continued with a comparison of the cost and safety risks between truck and rail transportation. He began by showing that rail transportation was, in fact, intermodal, and that rail shipment would require truck shipment from some transfer point (currently assumed to be Salt Lake City). This required double handling and adversely impacted the rail economics. (The risk estimates did not include the increased material handling.) He emphasized that FDF will continue to evaluate transportation options to determine the safest and most cost effective mode.

Waste Loading Sensitivity Analysis From examination of the cost comparison between Alternative 2 and Alternative 3, it was apparently at the January meeting that assumptions of waste loading had a significant impact on the alternatives. Karen Wintz presented the results of an analysis that varied the waste loading assumptions for Alternative 3. She began by describing the basic assumptions of the study and followed with the impacts on volume of treated waste, number of waste shipments, estimated doses and disposal volume. It was clear that increases in waste loading could improve the cost and schedule for Alternative 3 if they could be achieved.

Blending of Silo Residues Mike Smith explained the regulatory reasons why it was not feasible to dispose of silos material with Operable Unit 1 pit materials.

Pretreatment Alternatives John Smets presented a status of studies to investigate the feasibility of pretreating Silos 1 and 2 material to remove certain constituents. For lead and sulfates, the feasibility does not appear promising. For bentonite removal, the feasibility is still being investigated.

MEETING NOTES - Continued

Niagara Experience John Smets continued with a status report on the investigation of the Niagara Falls experience with retrieval of material very similar to the Silos 1 and 2 material. The experience appears to be extremely valid and useful and will be incorporated into the silos project planning, including use of personnel with Niagara Falls experience as reviewers of the FEMP plans and designs.

Soil Waste Characterization Dennis Nixon presented the goals and results of the silos characterization activities carried out as part of the remedial investigations. He explained, with visual descriptions from the Remedial Investigation Report, the extent and details of the sampling and extent and details of the classification and analysis. He showed examples of the boring logs and the data limitations and recommended actions and described how the archive material was collected in a representative fashion.

Alternative Remediation Technologies As a means of addressing the question "should consideration be given to alternative remediation technologies," Dennis Nixon presented the initial screening of technologies and process options that was conducted during the remedial investigation/feasibility phase of the project. He showed that several of the alternative remediation technologies had been considered applicable. The IRT's review of these was held over to a session on Wednesday afternoon.

Assumptions and Technical Basis John Smets presented the expanded list of assumptions and technical basis. This included more details on the densities of various materials to establish the waste volume bases and more details on the container details for the same reason.

Approach to Technology Development John Smets presented the revised approach to melter technology development that came about from the IRT's suggestion to not consider use of the pilot plant for radioactive materials operations. Considerable discussion resulted from the review of the steps assumed in the revised schedule. The main issue of discussion centered around the three month time frame for one ton pilot scale testing with surrogate (activity 4AAC2150) preceding the full scale plant melter spec development and procurement. Opinion within the IRT differed on the adequacy of this time frame. It was agreed that Jim Edmondson would visit both West Valley and Savannah River melters to better reach agreement on the necessary pilot melter development time frames.

The notes for all the presentation materials are attached to these minutes.

Fernald Citizens Task Force Doug Sarno of the Fernald Citizens Task Force presented a letter from Chairman John Applegate with several key questions he requested the IRT to address in formulating their recommendations. The letter is attached to these meeting minutes.

MEETING NOTES - Continued

Wednesday, February 12

Introduction Bob Heck began the session with a summary of objectives and progress to date.

Draft Recommendations for Alternative 1 Harry Robertson presented a draft of a recommendation for Alternative 1 that was based on discussion at the January meeting. After a brief discussion a sub group of the IRT volunteered to redraft the recommendation. This was accomplished and is attached to the meeting minutes. This will be incorporated into the final IRT recommendations when these are completed.

Decision Analysis Process Update Lee Merkhofer presented the status of the input to the decision analysis process together with the responsibilities and committee tasks to complete the input. His slide is included with the minutes.

Cost and Schedule Committee Report - Base Case Mike Connors began addressing a list of questions from the IRT with respect to the base case cost and schedule presented at the January meeting. These included some issues that had already been answered by the presentations on Tuesday. He also showed a comparison of the cost breakdown for waste packaging, transportation and disposal between Alternative 2 and 3. He also explained the changes in costs between those presented in January and this meeting including the cost sensitivity study for Alternative 3 with 50 percent waste loadings based on the analysis presented by Karen Wintz on Tuesday. To complete the addition of information, he gave a more detailed summary of the assumptions used to develop the base case estimates of cost and schedule for both alternatives. The information used in his presentation is attached to these minutes.

Technical Issues Committee Report Harry Robertson summarized the results of the January meeting listing technical issues of concern. He showed that these could be evaluated by assuming a significant deviation from the design basis, assessing the impact of this significant deviation on cost, schedule and health and safety and applying a probability of occurrence (based on professional judgment). He presented this approach for the technical issues identified, and after some discussion, modified the probabilities to be used to reflect the IRT's judgment of these numbers. The off-spec issue was removed from consideration.

Health and Safety Committee Report Doug Daniels presented the definitions of the health and safety measures to be used in the base cases and the manner that deviations to the base case would impact these measures. These included both Industrial Safety and Radiological Safety. He then described the accident scenarios together with the frequency and consequences of these accidents. It was apparent that the accident of concern was silo dome collapse.

MEETING NOTES - Continued

Cost and Schedule Committee Report - Deviations from Base Case Mike Connors described the impacts to the cost and schedule of the three levels of funding together with the probabilities that had been assessed for these. He went on to describe the approach to the handling of technical issue impacts and the funding restraint impacts on the measures of health and safety.

Summary of Decision Framework Lee Merkhofer described the logic tree and its current state of development including the funding restraint, technical impact and accident scenario branches. He showed the probabilities that had been estimated by the various committees and how they influenced the likelihood of success. He then presented the preliminary, rough order of magnitude cost and schedule profiles that include the revisions made during the previous day. The results of this preliminary assessment are shown in the attachments to the minutes.

The IRT concluded that the cost differences were not sufficiently different and the range of costs had considerable overlap such that cost was not a primary reason to choose either alternative. The assessment of the schedule impact showed similar results but had an additional area of concern. Based on the significant accident frequency of 0.039 for this event, it was concluded that the schedule could be a discriminator. As this was heavily influenced by the high frequency number, this aspect should received further attention.

Literature Search Harry Robertson explained that a search of the literature through the databases had identified only 3 similar situations (cementation with lead sulfates and radon). However, Earl McDaniel had several publications that surveyed and summarized the literature of cementation. These are included in the attachments showing the table of contents of each.

Alternative Remediation Technologies As a follow up to the presentation by Dennis Nixon on Tuesday, Bob Heck facilitated a discussion on alternative remediation technologies. The attached list titled "Alternatives to Vitrification of Silo 1 and 2" reflects the outcome of the IRT's views and knowledge of the status of these potential options.

Public Availability Session At the request of FRESH, the IRT attended an evening session from 7 to 9 p.m. during which they were available to answer questions and learn the concerns of the local residents. A summary of the questions and discussion are given in the attachment titled "Notes from February 12 Public Availability Session with Silos Project IRT" and a memo from Arjun Makhijani to the Technical Review Panel.

MEETING NOTES - Continued

Thursday, February 13

Review of Public Availability Session
The IRT began by summarizing the public availability session on the previous evening. They requested that the notes taken at the session be distributed to them before the next meeting. The list of issues that resulted from their summary discussion is as follows:

- Some of the questions were predictable--local residents are concerned that things are being changed without their knowledge or involvement.
- Local residents have a longer "core memory" and experience of the situation than either the DOE or FDF.
- There needs to be a closer working relationship between the site and the community.
- The community is fearful of change. They were sold on vitrification and they want a vitrification plant.
- They take a long range view of the waste form (just meeting the requirements is not enough). The Nevada stakeholders views are important.
- There needs to be frank discussions with the stakeholders on cost and schedule.
- Lessons learned from previous projects and other sites must not be forgotten.
- There are concerns that the final report comes from FDF and not the IRT.
- Each IRT member is to provided a one page report on the IRT process--what worked and what didn't.
- Consider "out of the box thinking," such as privatization.
- Consider independent oversight of the project.
- Need to address whether abandoning vitrification is due to technical issues or inadequacy of design and project management.
- There is a concern about the high quality waste form and escalating costs.

Additional Open Issues Lee Merkhofer presented an analysis of the areas that would benefit most with reduced uncertainty. This lead to discussion on how to spend funds to

MEETING NOTES - Continued

reduce uncertainty in the most effective way since it appeared that some of the uncertain assessments of cementation may be a result of relative ignorance of this technology.

Plan for Documentation of IRT Recommendations The IRT held a session amongst themselves to establish the issues they needed to address and make assignments for developing position papers for each of these. At the end of the session, a list was generated, assignments made and it was agreed that these would be faxed to FDF as a distribution center on Friday, February 21, 1997. Harry Robertson would ensure that all IRT members would receive a copy of each paper faxed in.

Plan for Subsequent Meeting It was agreed that the meeting planned for the end of February should be expanded from two to four days. Those members who had conflicting commitments would attend for as many days a possible. FDF would provide clerical, copying and computer support during the four days.

HLR:kjc
Attachments

MEETING NOTES - Continued

LIST OF ATTACHMENTS

- Agenda
- Independent Review Team - Recommendation for Excluding Vitrification of Silos 1, 2 and 3 Together
- Preliminary Results of Decision Analysis Model
- Alternatives to Vitrification of Silos 1 and 2
- Memorandum from John Applegate to IRT
- Notes from Public Availability Session with Silos Project IRT
- Memorandum from Arjun Makhijani to IRT
- Literature Survey
- Radon Handling (Block Flow Diagrams)
- Parking Lot Issues
- Presentation Material

MEETING AGENDA

SUBJECT: FEMP Silos Project, Path Forward Decision
DATE: February 11, 12 and 13, 1997
LOCATION: FEMP Alpha Bldg., Fernald OH

Tuesday, February 11

8:00	**Opening**	R Heck
8:15	**Silos Project / VITPP Update**	D Paine
	• Incident Analysis Team	D Paine
	• Data Analysis and Path Forward Team	N Akgunduz
	• Safety Review Team	L Bogar
10:00	**Open Actions / Technical Issues**	
	• Feasibility of Cement Stabilization	D Roy / E McDaniel
	• West Valley Cementation Experience	R Lawrence
12:30	**Lunch**	
1:00	• Health and Safety Requirements	D Daniels
	• Long Term Effectiveness of Waste Forms	S Beckman
	• Waste Container Requirements and Basis	M Smith
	• Transportation Comparison - Truck vs. Rail	M Smith
	• Waste Loading Sensitivity Analysis	K Wintz
	• Feasibility of Pit 5 / Waste Mix Option	M Smith
3:00	• Pretreatment Alternatives	J Smets
	• Niagara Experience	J Smets
	• Alternative Remediation Technologies	D Nixon
	• Silo Waste Characterization	D Nixon
4:00	• Assumptions & Technical Basis	J Smets
	• Approach to Technology Development	J Smets
5:00	• Fernald Citizens Task Force	
	Key Questions to the Independent Review Team	D Sarno

Wednesday, February 12

8:00	**Introduction**	R Heck
9:00	**Draft Recommendation for Alternative 1**	H Robertson
10:00	**Decision Analysis Process Update**	L Merkhofer

11:00	**Cost & Schedule Committee Report - Base Case** - Review Incorporation of IRT Recommendations/Changes to "base case" - Update to base case estimates - Impact of funding availability to "base case"	M Connors
12:00	**Lunch**	
1:00	**Technical Issues Committee Report** - Significant Technical Impacts / Probabilities	H Robertson
2:00	**Health & Safety Committee Report** - Base Case Definition - Accident Scenarios - Impacts/Probabilities	D Daniels
3:00	**Cost & Schedule Committee Report - deviations from "base case"** - Technical Issues Impacts - Effect on Cost & Schedule - H&S Impacts - Effect on Cost & Schedule - Funding Availability Impacts	M Connors
4:00	**Summary of Decision Framework and Remaining Steps** - Model Costs/Schedules	L Merkhofer
4:30	**Literature Search - Summary** **Alternative Remediation Technologies**	H Robertson R Heck
7:00-9:00	**Public Availability Session**	IRT

<u>Thursday, February 13</u>

8:00	**Review of Public Availability Session**	All
9:00	**Additional Open Issues**	All
10:00	**IRT Recommendations** - Plan for Documentation of IRT Recommendations	IRT
	Working Lunch	
1:00	**Plan for Subsequent Meeting**	All
2:00	**Meeting Concludes**	

INDEPENDENT REVIEW TEAM RECOMMENDATION FOR EXCLUDING VITRIFICATION OF SILOS 1,2 &3 TOGETHER

The Silos Project Independent Review Team recommends that Alternative 1 (Vitrification of Silos 1,2, &3 together) should be eliminated from further consideration. Further, the Vitrification of Silo 3 material by itself should also be eliminated from further consideration.

The basis of the recommendation is as follows:

The design of a vitrification process for a combination of Silos 1, 2, &3 material would have to address two specific glass chemistry challenges:

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

and

The high and varying lead content in Silos 1 and 2 (without proper control, Pb may precipitate and compromise melter integrity).

Steps taken to alleviate one most likely will exacerbate the other. The difficulty of vitrifying this combination of wastes is high. While processes could be developed, the time and cost of developing a process tolerant of the inherent variability is likely to be high. Further immobilizing Silo 3 separately from Silo 1 and 2 would reduce the programmatic risk of vitrifying Silos 1 and 2. Thus, Silo 1, 2 and 3 should not be immobilized together.

While significant technical issues exist, it appears that Silo 3 residues can be stabilized/solidified in cement which will meet the technical requirements in a more timely manner than vitrification. Thus, vitrification of Silo 3 material should be eliminated from further consideration.

PRELIMINARY RESULTS

ALT	COST	SCHEDULE	PROB. OF DOME COLLAPSE*
II	$590M (380 – 820)	17 yrs (15 – 20)	0.53
III	$520M (240 – 730)	14 yrs (13 – 18)	0.43

*0.039/yr

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WASTE LOADING SENSITIVITY ANALYSIS FOR ALTERNATIVE III

	COST	SCHEDULE	PROB. OF DOME COLLAPSE
10% WASTE LOADING	$800M (560 – 1000)	17 yrs (16 – 21)	0.55
20% WASTE LOADING	$500M (240 – 730)	14 yrs (13 – 18)	0.43
30% WASTE LOADING			

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0004/005 A.D.A. INC. 703 893 6233 15:37 17:38 86/17/07

VALUE OF RESOLVING UNCERTAINTIES

FACTOR	ALT II	ALT III	BOTH
MELTER LIFE	~0		
WASTE LOADING	~0	11M	
PLANT CAPACITY	~0	~0	
ALL TECH SUCCESS FACTORS	~0	11M	
RESIDUAL COST UNCERTAINTY	27M	42M	<60M
ALL TECH COST UNCERTAINTY			<67M

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ALTERNATIVES TO VITRIFICATION OF SILOS 1 AND 2

Alternatives:

1. Cementation
   -Engineering proven tests in Belgium
   -Well developed equipment
   -Needs some technology development for formulation

2. Sulphur Polymerization
   -Earlier 80's
   -Molten sulphur incidents
   -Flammability
   -Bonding limitations
   -Elemental
   -Not proven in production

3. Bitumen (Asphalt)
   -Rejected by power industry
   -Flammability
   -Hydrocarbon release
   -IAEA document
   -Popular 20 years ago
   -Cogema/Numetec/BNEL -- not chosen

4. PE Encapsulation (micro encapsulation)
   -dry feed/no production yet
   -Development to do

5. Macro Encapsulation (other material)
   -Can't do due to regulatory restrictions/WAC

6. Thermal Setting Resins
   -Flammable
   -Extensive Development required
   -Cost is high -- Rocky Flats using for Hg salt & $Ca(oh)_2$ flyash

7. Ceramics
   -Much done for HLW -- development no advantage over glass
   -Forming brick cast/then heated in a furnace

8. Metal Matrix (Cermat)
   -Limited as throughput
   -Developer
   -Used in INEL -- died out

9. Insitu vit
-Failure at Oak Ridge explosion
-Fires at INEL and Hanford

10. Molten Metal Tech_____ Gas / Slag / Metal Required significant development
-Used for volume reduction with resins
-Partioning
-Throughput is restrictive 3mm sizing required

11. Ceramic Silican Foam
-Silican dimethyl -- Chernobyl
-micro encapsulation
-Development required - stahle - limitation on water
-Not adev'd base of vendors requires potential demo
-Needs catalyst
-Phosphate Abatement
-Not tolerant of variability -- Pb Metal -- BADT
Pb Salt -- char. Hazardous waste
BADT -- stab/solid
Re____ insoluble
LSAR - stab - 5mg/kg

--national capability
--IRT scrutiny of thoughts
--Conservative in cementation What's impact to the public?
--More proven technology
--Disposal site stand point waste Increased transportation
In ground is more favorable
Intruder plus inadvertent intruder Is it going to work?

FERNALD CITIZENS TASK FORCE

MEMORANDUM

TO: Members of the Silos Independent Review Team

FROM: John Applegate, chair

DATE: February 10, 1997

RE: Key Vitrification Questions

As you approach the final evaluation and reporting point of your activities, I would like to take this opportunity to share with you some of the significant concerns of the Fernald Citizens Task Force with regard to the silos remediation decisions. The full Task Force met on January 11 and the Waste Management Committee met on February 5 to discuss the IRT results to date and other issues surrounding silos remediation. As you know, the conclusions of the IRT will be used to help decide how to remediate the silos, and its conclusions will undoubtedly carry great weight. It is therefore of great importance that the IRT have sufficient time and information to reach its conclusions, and that it address the questions that will affect the decision.

Prior to seating of the IRT, the main concern of the Task Force and other local stakeholders was the pending decision regarding the treatment of silo 3 materials. In October, the Task Force's Waste Management Committee sent a request to DOE identifying some important information that would be required to conduct a fundamental assessment of the change of remedy for silo 3. This request outlined six major concerns:

1. the effectiveness of vitrification;
2. the legal and administrative ramifications of the change;
3. the impact of the change on total waste volumes;
4. the impact of the change on transportation and disposal risks;
5. the acceptability of the change to the stakeholders at the waste disposal facility;
6. the need for review by an independent panel of experts.

Since then, we have become increasingly concerned with the treatment option for silos 1 and 2 and want to be sure that the ultimate decision is based on as complete and accurate a set of information as possible. I have identified the additional information that we believe is necessary to reach this decision below.

<u>Issue 1: Vitrification of Silos 1 and 2</u>
What is the best technical approach to vitrification?
How much will it cost?
How long will it take?
How confident are we in our estimates and the ultimate success of vitrification?
What impact will the resource requirements for vitrification have on other remediation projects on site?

Issue 2: Alternatives to Vitrification of Silos 1 and 2
Are there *bona fide* alternatives to vitrification?
If so, what are they?
How do alternatives compare with vitrification in terms of cost, schedule, and overall protection of the public, workers, and the environment?
How confident are we in the information we have available for the alternatives?
How significant are the regulatory barriers associated with changing the selected remedy?

We recognize that not all of these issues are areas in which you will provide input, but we ask that you (a) answer as many as you can with as much certainty as possible, (b) clearly identify in your final report the issues that you have addressed and those you have not, and (c) identify issues on which more time or information is required.

I hope that these questions help you to understand some of the concerns and the perspective of the stakeholder community at Fernald. We are grateful for the work you are doing to help in this challenging decision.

SUMMARY OF INDEPENDENT REVIEW TEAM (IRT)
PUBLIC AVAILABILITY SESSION
February 12, 1997; 7:00 p.m. Alpha Building

In support of the Silos Project, DOE and Fluor Daniel Fernald assembled an independent technical team to offer advice and make recommendations concerning the treatment of the waste in Silos 1, 2, and 3. The team has been meeting monthly since November and each session has included representatives from FRESH and the Task Force. However, to give the general public the opportunity to meet the IRT on an informal basis, an Availability Session was offered. The nine-member IRT, plus two experts on stabilization, made up the panel. Others attending the meeting included reps from U.S. EPA, OEPA, Institute for Energy & Environmental Research (IEER), FRESH, Fernald Citizens Task Force, ATSDR, Rob Portman's Office, GCBCTC, FAT&LC, DOE and Fluor Daniel Fernald.

A call-in line had been publicized for those unable to attend the session. The Nevada Community Advisory Board contacted DOE and planned to participate via conference call. However, due to scheduling conflicts and the time difference, they had to cancel.

Gary Stegner opened the meeting and asked the 11-member panel to briefly introduce themselves. Gail Bingham from the IRT gave a status summary of the team's progress to date. Following are some of the comments/questions that were directed to the team.

- The charter of the IRT should be limited to technical issues.
- The approach the United States takes to classification of radiological waste is not rational. Waste form determination should be guided by what is best in terms of protectiveness not by current requirements.
- The OU4 Record of Decision provides that the Silo waste shall be disposed of as a vitrified waste form. A glass waste form for the Silo residues is best. Until and unless, Fluor Daniel Fernald/DOE demonstrate that it is not technically possible to vitrify the Silo residues, no other waste form should be considered.
- Expressed the concern that the IRT does not currently have all the information necessary to make an assessment of the Silos Project. The IRT should be provided with all relevant data and take as long as necessary to make a recommendation.
- Expressed concern with respect to DOE/Fluor Daniel Fernald's understanding of the potential for Silo degradation and collapse especially with respect to the potential impact of waste removal activities.
- Has the IRT been provided with a copy of the FEMP Emergency Response Plan?
- Requested that in the event that the IRT concludes that there exists insufficient information to make a final recommendation at this time, that it will return when the information becomes available and make a recommendation at that time.

- Requested that whatever the outcome of the IRT recommendation and final direction, sufficient "additional expertise" be brought in to support the project and assure a success. Requested that the expertise be the best available and not be limited to Fluor Daniel Fernald or DOE.

- Interpreted the "ADS Tracking Report" provided to her by DOE as "claiming" that the IRT had attended a stakeholder meeting.

- Asked whether "privatization" of the project has been considered.

- Expressed the concern that vitrification is being rejected based on technical difficulties associated with sulfates in the residues, yet sulfates present similar problems for cement stabilization.

- Expressed concern that the team needs more information and time to make a sound recommendation.

- Isn't there knowledge from other sites? Is there no coordination of lessons learned or sharing of information?

- Considers vitrification of Silo residues as a legally binding requirement. Does not understand why alternate forms are being considered.

- Considers the "March 1 deadline" for an IRT recommendation as an arbitrary Fluor Daniel Fernald requirement. Recommended that it should be "scrapped".

- Expressed concern that the IRT does not adequately understand the implications of waste volumes in considering a recommendation.

- Expressed concern regarding the dramatic increases in projected project costs.

- Expressed concern that we are not considering the impact of NTS not accepting a waste form other than what is currently agreed to.

- Expressed concern that no satisfactory explanation has been provided to the Stakeholders with respect to why Campaign 3 was omitted from the Pilot Plant test program.

- Asked the IRT if they had been provided with a copy of the Dose Reconstruction Report?

- Requested assurance that the report documenting this effort would be an IRT report not a Fluor Daniel Fernald report.

- Requested that recommendations in the report not be limited to consensus issues. Dissenting opinions should also be included.

- Requested a one-pager from each member of the IRT addressing their "feelings" on the "process, results, ..."

FRESH sincerely thanked the panel for staying late to meet with them and for allowing them to express their feelings and concerns.

The IRT's next session will be February 25-28.

To: Technical Review panel, Fernald OU4
From: Arjun Makhijani
Subject: Conclusions and recommendations regarding silos 1,2, and 3 at Fernald.
Date: 12 February 1997

I want to thank you all for the patience with which you dealt with the many comments and questions that I had during your public meeting. I hope that I conveyed adequately that I am as eager as you to see a resolution of the issues in a manner that will protect the environment. Based on my review of the documents and the information that you provided me, I want to present my tentative conclusions to you for your consideration. These are not complete by any means, since I have not made as detailed an evaluation of the matter as you have.

Main findings and recommendations:

1. The problems encountered in the vitrification program so far are not related to vitrification technology as such but to design and management failures that could have been avoided and can be avoided in the future through sound design and management.

2. Separation of Silos 1 and 2 vitrification from Silo 3 management is desirable on technical grounds.

3. There is at present no identified essential technical obstacle to vitrifying the wastes in all three silos. Further work is necessary to address the question of the mixture of sulfates and lead in silo 3.

4. A modular approach to vitrification that addresses the different compositions of the silos and perhaps different compositions in different regions of the silos appears to be advisable.

5. Silo 1 and 2 waste should be vitrified.

6. For reasons of minimizing volume, reducing toxicity, reducing radon emanations, reducing risk of rejection of waste as unsuitable for disposal in Nevada and reducing the risk of illegal decisions to change the ROD without an appropriate process, it is desirable to put vitrification of Silo 3 waste ahead of any other approaches to stabilization of Silo 3 waste.

7. Characterization of Silo 3 waste should be accelerated ~~and~~ several small experimental melters should be tried both to address the sulfate/lead questions in all silos and processing rate and economics.

bad point

8. Oak Ridge National Lab experience with developing a melter that handles molten lead might be useful in designing Silo 3 vitrification.

9. Surface layer problems and high temperature problems might be addressed by considering different melters such as stirred glass

melters and cold crucible melters.

10. A decision to cement the wastes should be taken only after adequate experimentation and evaluation of Silo 3 vitrification has been competently carried out.

11. It is important to draw on the European experience and the experience in the rest of the DOE in cementation and vitrification in the experimental and design phases of the project.

12. A greater diversity of glass makers is desirable early in the process so that there is an adequate body of experience in understanding the vitrification issues involved.

13. Budget figures should be based on sound engineering estimates. Present budgets do not have enough justification.

ORNL/TM-12656

Chemical Technology Division

A LITERATURE REVIEW OF MIXED WASTE COMPONENTS: SENSITIVITIES AND EFFECTS UPON SOLIDIFICATION/STABILIZATION IN CEMENT-BASED MATRICES

C.H. Mattus
T.M. Gilliam

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CONTENTS

	Page
LIST OF TABLES	v
ABBREVIATIONS AND CHEMICAL SYMBOLS	vi
EXECUTIVE SUMMARY	ix
1. INTRODUCTION	1
2. HYDRATION MECHANISMS OF PORTLAND CEMENT	5
3. MECHANISMS OF RETARDATION AND ACCELERATION OF CEMENT SET-FACTORS AFFECTING THE DURABILITY OF WASTE FORMS	12
3.1 ACCELERATING ADMIXTURES	13
3.1.1 Admixtures Accelerating C_3S Hydration	13
3.1.2 Admixtures Accelerating C_3A Hydration	14
3.2 RETARDING ADMIXTURES	14
3.2.1 Admixtures Retarding C_3S Hydration	15
3.2.2 Admixtures Retarding C_3A Hydration	16
3.3 DURABILITY OF WASTE FORMS	16
4. REGULATORY LIMITS AS THEY APPLY TO MIXED WASTES	18
5. REVIEW OF INORGANIC SPECIES THAT INTERFERE WITH THE DEVELOPMENT OF CEMENT-BASED WASTE FORMS	22
5.1 ANIONIC SPECIES	22
5.1.1 Chloride	22
5.1.2 Carbonate	25
5.1.3 Sulfide, Sulfite, and Sulfate	26
5.1.4 Nitrate and Nitrite	31
5.1.5 Hydroxide	35
5.1.6 Silicate	36
5.1.7 Borate	37
5.1.8 Phosphate	38
5.1.9 Fluoride	40
5.2 HEAVY METALS	45
5.2.1 Zinc	45
5.2.2 Cadmium	49

CONTENTS (Continued)

	Page
5.2.3 Mercury	52
5.2.4 Chromium	54
5.2.5 Nickel	58
5.2.6 Lead	59
5.2.7 Arsenic	63
5.2.8 Copper	64
5.2.9 Other RCRA Metals: Barium, Selenium, and Silver	65
5.3 OTHER SPECIES	68
5.3.1 Calcium and Magnesium	68
5.3.2 Iron, Manganese, and Titanium	74
5.3.3 Thallium, Antimony, Beryllium, Vanadium, and Molybdenum	75
5.3.4 Aluminum	75
5.3.5 Sodium, Lithium, and Potassium	76
6. REVIEW OF RADIOACTIVE SPECIES THAT CAN BE IMMOBILIZED IN CEMENT-BASED WASTE FORMS	77
6.1 CESIUM	78
6.2 STRONTIUM	81
6.3 TRANSURANICS	82
6.4 COBALT	83
6.5 TECHNETIUM	83
7. REVIEW OF ORGANIC SPECIES THAT MAY INTERFERE WITH VARIOUS WASTE-FORM PROPERTIES	85
8. SUMMARY AND CONCLUSIONS	92
8.1 GENERAL CHARACTERIZATION	93
8.2 RCRA METALS	94
8.3 ADDITIONAL METALS/CADMIUM	95
8.4 ANIONS	95
8.5 U.S. DEPARTMENT OF TRANSPORTATION REGULATIONS	95
8.6 OFF-SITE DISPOSAL	97
8.7 ORGANICS	97
8.8 QUALITY ASSURANCE	98
8.9 FUTURE NEEDS	98
REFERENCES	102

000028

LIST OF TABLES

ES.1 Waste characterization data required to support the development of grout waste forms xiii

1. Summary data of anionic waste species 41

2. Summary data of metallic waste species 69

3. Waste characterization data required to support the development of grout waste forms 100

Earl W. McDaniel

EPA/530/R-93/012
June 1993

TECHNICAL RESOURCE DOCUMENT SOLIDIFICATION/STABILIZATION AND ITS APPLICATION TO WASTE MATERIALS

by

BATTELLE
Columbus Division
Columbus, Ohio 43201-2693

Work Assignment No. 0-15
Contract No. 68-C0-0003

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ABSTRACT

Stabilization/solidification (S/S) processes are effective in treating a variety of difficult to manage waste materials for reuse or disposal. S/S has been identified as the Best Demonstrated Available Technology for treating a wide range of Resource Conservation and Recovery Act (RCRA) non-wastewater hazardous waste subcategories. S/S has been selected as the treatment technology of choice for 26% of the remedial actions complete at Superfund sites through fiscal year 1992.

The standard bulk material handling and mixing equipment used in many S/S processes make the technology appear simple. However, there are significant challenges to the successful application of S/S processes. The morphology and chemistry of S/S-treated waste are complex. Selection of the binder requires an understanding of the chemistry of the bulk material, the contaminants, and the binder. The S/S user must be fully aware of the complex interactions among the various components to ensure efficient and reliable results.

Battelle, under the direction of the U.S. Environmental Protection Agency, has prepared this Technical Resources Document (TRD) as a resource for the S/S user community and a guide to promote the best future application of S/S processes. An extensive body of information is available describing the theory and practice of S/S processes. However, no one document existed combining theory, practice, and regulatory aspects of S/S application to RCRA, Superfund, and similar waste materials. This TRD pulls a diverse range of materials into one comprehensive reference.

The TRD is intended for site managers considering S/S as an option for treating hazardous wastes. It provides technology transfer to persons responsible for selection and design of S/S treatment methods. Information about S/S technology is presented in detailed text descriptions supported by summary tables, checklists, and figures. It gives the user a summary of current S/S technology. The technology areas covered are binders and their binding mechanisms, waste interferences with S/S processes, S/S treatment of organic contaminants, air emissions for S/S processes, leaching mechanisms, long-term stability, reuse and disposal of S/S-treated waste, and economics. Information is also provided to clarify the limitations of S/S technology and ongoing research to fulfill future development needs.

This TRD was submitted in fulfillment of Work Assignment 0-15 of Contract #68-C0-0003 with Battelle, Columbus, under sponsorship of the USEPA. It covers a period from 11/01/90 through 05/30/92.

CONTENTS

Page

NOTICE ii

FOREWORD iii

ABSTRACT iv

TABLES xv

FIGURES xvii

ACKNOWLEDGMENTS xviii

1 INTRODUCTION 1-1

1.1 BACKGROUND 1-2

1.1.1 Definition of Solidification and Stabilization 1-2
1.1.2 Position of S/S in the U.S. EPA Environmental Management Options Hierarchy 1-2
1.1.3 Application of Solidification/Stabilization 1-4

1.2 PURPOSE AND SCOPE 1-11

1.2.1 Objectives 1-11
1.2.2 Scope 1-13

1.2.2.1 Waste Types 1-13
1.2.2.2. Processes 1-13

1.2.3 Audience 1-14

1.2.3.1 CERCLA Applications 1-14
1.2.3.2 RCRA Applications 1-15

1.3 REGULATORY CONSIDERATION 1-15

1.3.1 Regulatory Framework 1-15
1.3.2 RCRA Land Disposal Restrictions 1-16
1.3.3 Application of Land Disposal Restrictions to CERCLA Sites 1-19
1.3.4 Toxic Substances Control Act 1-21
1.3.5 Other Environmental Regulations 1-22

2 SOLIDIFICATION/STABILIZATION (S/S) TECHNOLOGY SCREENING PROCEDURES . 2-1

2.1 INTRODUCTION 2-1

2.1.1 Overview 2-1
2.1.2 The Need for Treatability Studies 2-3

CONTENTS (Continued)

2.2 SITE-SPECIFIC BASELINE INFORMATION REQUIREMENTS 2-5

2.2.1 Waste Sampling 2-5

2.2.1.1 Composites vs. Hot Spots 2-5
2.2.1.2 Statistical Approaches 2-9

2.2.2 Waste Acceptance 2-12
2.2.3 Waste Characterization 2-13

2.2.3.1 Regulatory Framework 2-15
2.2.3.2 Contaminant Characteristics & Treatment Types . 2-16
2.2.3.3 Sampling and Analysis 2-21

2.2.4 Site Characterization 2-25
2.2.5 Quality Assurance/Quality Control 2-27
2.2.6 Guidance for Site-Specific Information Requirements . . 2-28

2.3 PERFORMANCE OBJECTIVES 2-28

2.3.1 Regulatory Requirements 2-33

2.3.1.1 CERCLA 2-34
2.3.1.2 RCRA 2-40

2.3.2 Technical and Institutional Requirements 2-43
2.3.3 Approach for Setting Performance Criteria 2-43

2.4 INITIAL TECHNOLOGY SCREENING 2-46

2.4.1 Technology Screening/Feasibility Study Process 2-47

2.4.1.1 CERCLA Technology Screening 2-47
2.4.1.2 Technology Screening at RCRA TSD Facilities . . 2-51

2.4.2 General Criteria for Not Using S/S 2-51
2.4.3 Outcome of Technology Screening 2-51

2.5 WASTE/BINDER COMPATIBILITY LITERATURE SCREENING 2-56

2.5.1 Identify Available Binders 2-56
2.5.2 Screening Process 2-56

2.5.2.1 Interferences and Chemical Incompatibilities . 2-58
2.5.2.2 Metal Chemistry Considerations 2-58
2.5.2.3 Organic Chemistry Considerations for Target Contaminants 2-59
2.5.2.4 Compatibility with the Disposal or Reuse Environment 2-59
2.5.2.5 Cost 2-60
2.5.2.6 Process Track Record 2-60

CONTENTS (Continued)

2.6 LABORATORY BENCH-SCALE SCREENING OF THE WASTE/BINDER MIXTURES . 2-61

2.6.1 Purpose 2-61
2.6.2 Approach 2-62

2.6.2.1 Experimental Design 2-62
2.6.2.2 Performance Testing 2-64

2.6.3 Technical Guidance 2-66

2.7 BENCH-SCALE PERFORMANCE TESTING/PROCESS OPTIMIZATION 2-66

2.7.1 Purpose and Objectives 2-66
2.7.2 How Much Performance Testing? 2-70

2.7.2.1 Levels of Risk 2-70
2.7.2.2 Levels of Performance Testing 2-70
2.7.2.3 Tests for Specific Binding Agents 2-74
2.7.2.4 Acceptance Criteria 2-74
2.7.2.5 Process Optimization 2-75

2.7.3 Technical Guidance 2-76

2.8 PILOT-SCALE AND FIELD DEMONSTRATIONS 2-76

2.8.1 The Need for Process Scale-Up 2-76
2.8.2 Scale-Up Issues 2-81

2.8.2.1 Waste Excavation and Handling 2-82
2.8.2.2 Stabilizing Agent Storage 2-83
2.8.2.3 Pretreatment of Waste 2-83
2.8.2.4 Mixing and Curing 2-83
2.8.2.5 Stabilized Waste Disposal 2-85

2.8.3 Sampling and Analysis of the Treated Waste 2-85

3 S/S PROCESS PERFORMANCE TESTS 3-1

3.1 PHYSICAL TESTS 3-1

3.1.1 General Property Tests 3-2

3.1.1.1 Moisture Content 3-2
3.1.1.2 Particle Size Analysis 3-2
3.1.1.3 Specific Gravity 3-2
3.1.1.4 Suspended Solids 3-8
3.1.1.5 Paint Filter Test 3-8
3.1.1.6 Liquid Release Test (LRT) 3-8
3.1.1.7 Atterberg Limits 3-8
3.1.1.8 Visual Observation 3-9

000034

CONTENTS (Continued)

3.1.2 Bulk Density Tests 3-9
3.1.3 Compaction Tests 3-9
3.1.4 Permeability (Hydraulic Conductivity) Tests 3-9
3.1.5 Porosity Tests 3-10
3.1.6 Strength Tests 3-10

3.1.6.1 Unconfined Compressive Strength (UCS) 3-10
3.1.6.2 Immersion Compressive Strength 3-11
3.1.6.3 Triaxial Compression 3-11
3.1.6.4 Flexural Strength 3-11
3.1.6.5 Cone Index 3-11

3.1.7 General Concrete/Soil-Cement Tests 3-12
3.1.8 Durability Testing 3-12

3.2 LEACHING/EXTRACTION TESTS 3-13

3.2.1 Toxicity Characteristic Leaching Procedure (TCLP) . . . 3-19
3.2.2 Extraction Procedure Toxicity (EP Tox) Test 3-20
3.2.3 TCLP "Cage" Modification 3-20
3.2.4 California Waste Extraction Test (Cal WET) 3-20
3.2.5 Multiple Extraction Procedure (MEP) 3-21
3.2.6 Synthetic Acid Precipitation Leach Test 3-21
3.2.7 Monofilled Waste Extraction Procedure (MWEP) 3-22
3.2.8 American Nuclear Society Leach Test (ANSI/ANS/16.1) . . 3-22
3.2.9 Dynamic Leach Test (DLT) 3-22
3.2.10 Shake Extraction Test 3-23
3.2.11 Equilibrium Leach Test (ELT) 3-23
3.2.12 Sequential Extraction Test (SET) 3-23
3.2.13 Sequential Chemical Extraction (SCE) 3-23
3.2.14 Static Leach Test Method (Ambient- and High-Temperature) 3-24
3.2.15 Agitated Powder Leach Test Method 3-24
3.2.16 Soxhlet Leach Test Method 3-24

3.3 CHEMICAL TESTS AND ANALYSES 3-25

3.3.1 pH 3-25
3.3.2 Oxidation/Reduction Potential (Eh) 3-25
3.3.3 Major Oxide Components 3-30
3.3.4 Total Organic Carbon (TOC) 3-30
3.3.5 Oil and Grease 3-30
3.3.6 Electrical Conductivity 3-30
3.3.7 Acid Neutralization Capacity (ANC) 3-31
3.3.8 Alkalinity 3-31
3.3.9 Total Dissolved Solids (TDS) 3-31
3.3.10 Reactive Cyanide and Sulfide 3-32
3.3.11 Reactivity of Silica Aggregates 3-32
3.3.12 Metal Analysis 3-32
3.3.13 Volatile Organic Compounds 3-32
3.3.14 Base, Neutral, and Acid (BNA) Organic Compounds 3-33

CONTENTS (Continued)

3.3.15 Polychlorinated Biphenyls (PCBs) 3-33
3.3.16 Other Contaminant Analyses 3-34
3.3.17 Anion Measurements 3-34
3.3.18 Interferants Screen 3-34

3.4 BIOLOGICAL TESTS 3-34
3.5 MICROCHARACTERIZATION 3-36

3.5.1 X-Ray Diffraction 3-37
3.5.2 Fourier Transform Infrared (FTIR) Spectroscopy 3-37
3.5.3 Scanning Electron Microscopy (SEM) and Energy-Dispersive X-ray Analysis (EDXA) 3-38
3.5.4 Nuclear Magnetic Resonance (NMR) Spectroscopy 3-38
3.5.5 Optical Microscopy 3-38

4 STATUS OF SOLIDIFICATION/STABILIZATION TECHNOLOGY 4-1

4.1 S/S PROCESSES AND BINDERS 4-2

4.1.1 Inorganic Binders 4-3

4.1.1.1 Cement Processes 4-4
4.1.1.2 Pozzolanic Processes 4-7
4.1.1.3 Ettringite Formation Effects 4-8

4.1.2 Organic Binders 4-9

4.1.2.1 Thermoplastic Processes 4-11
4.1.2.2 Thermosetting Processes 4-12

4.1.3 Additives 4-12
4.1.4 Pretreatment 4-14

4.1.4.1 Adjustment of Physical Characteristics 4-14
4.1.4.2 Pretreatment of Inorganic Constituents 4-14
4.1.4.3 Pretreatment of Organic Constituents 4-15
4.1.4.4 Treatment Trains Involving S/S 4-15

4.2 IMMOBILIZATION MECHANISMS 4-16

4.2.1 Physical Mechanisms 4-16
4.2.2 Chemical Mechanisms 4-18

4.2.2.1 Inorganic Wastes 4-18

4.2.2.1.1 Basic Chemical Equilibria 4-18
4.2.2.1.2 Effect of Alkaline Conditions . . . 4-21
4.2.2.1.3 Effect of Redox Potential 4-22

000036

CONTENTS (Continued)

4.2.2.1.4 Metal Silicates 4-25
4.2.2.1.5 Other Low Solubility Phases 4-26

4.2.2.2 Organic Wastes 4-27

4.2.3 Concept of Surface Sealing 4-28

4.3 POTENTIAL INTERFERENCES 4-29

4.3.1 Interferences with Solidification 4-30
4.3.2 Interferences with Stabilization 4-30

4.4 ISSUES DEALING WITH THE STABILIZATION OF ORGANIC WASTES AND OF MIXED ORGANIC AND INORGANIC WASTES 4-39

4.4.1 Introduction 4-39
4.4.2 S/S Additives Compatible with Organics 4-40
4.4.3 Approach to Evaluating Feasibility of S/S for Wastes Containing Organics 4-45

4.4.3.1 Destructive or Removal Technologies Versus S/S 4-48
4.4.3.2 Volatile Organic Contaminants 4-48
4.4.3.3 Nonpolar Organic Contaminants 4-49
4.4.3.4 Degradation and By-Product Formation 4-50

4.5 AIR EMISSIONS AND CONTROL 4-50

4.5.1 Volatile Organic Compounds 4-51
4.5.2 Particulates and Other Emissions 4-52
4.5.3 Controlling Air Emissions 4-52
4.5.4 Significance of the Amended Clean Air Act 4-53

4.6 LEACHING MECHANISMS 4-54

4.6.1 Leaching Associated with Inorganic S/S Processes 4-55
4.6.2 Leaching Associated with Organic S/S Binders 4-58
4.6.3 Leaching Models 4-58

4.6.3.1 Dissolution/Diffusion Kinetics 4-58

4.6.3.1.1 Nonporous Solid 4-59
4.6.3.1.2 Porous Solid 4-61

4.6.3.2 Examples of Existing Models 4-63
4.6.3.3 The Moving Boundary or Shrinking Core Model . . 4-66

CONTENTS (Continued)

4.7 LONG-TERM PERFORMANCE 4-66

4.7.1 Field Studies 4-67
4.7.2 Laboratory Studies 4-68
4.7.3 Modeling 4-69

4.8 USE/REUSE VERSUS DISPOSAL 4-70

4.8.1 Alternatives 4-70
4.8.2 Limitations 4-73
4.8.3 Compatibility With the Disposal Environment 4-73

4.9 COST INFORMATION 4-74

4.9.1 Treatability Study Costs 4-75

4.9.1.1 Waste Characterization and Establishing Performance Objectives 4-75
4.9.1.2 Bench-Scale Testing and Analysis 4-75

4.9.2 Full-Scale Remediation Costs 4-77

4.9.2.1 Planning 4-77
4.9.2.2 Mobilization and Demobilization 4-78
4.9.2.3 Treatment 4-78
4.9.2.4 Final Disposal 4-82

4.9.3 Estimates of Stabilization Costs 4-82
4.9.4 Case Study 4-84

5 TECHNOLOGY SHORTCOMINGS AND LIMITATIONS 5-1

5.1 PROCESS/BINDER CONSIDERATIONS 5-1

5.1.1 Hierarchy of Waste Management 5-1
5.1.2 Scale-Up Uncertainties 5-1
5.1.3 Proprietary Binders 5-1
5.1.4 Binder "Overkill" 5-2

5.2 WASTE FORM/CONTAMINANT ISSUES 5-2

5.2.1 Complications of Physicochemical Form of the Target Contaminants 5-2
5.2.2 Interferences and Incompatibilities 5-2
5.2.3 Volatile Organic Contaminants 5-3
5.2.4 Multicontaminant Wastes 5-4

000038

CONTENTS (Continued)

5.2.5 Weaknesses of Cement-Based Waste Forms 5-4
5.2.6 Sample Heterogeneity 5-5

5.3 TREATABILITY AND PERFORMANCE TESTING ISSUES 5-5

5.3.1 Testing Limitations 5-5
5.3.2 Long-Term Performance 5-7
5.3.3 Reproducibility 5-8
5.3.4 Limitations in S/S Treatability Reference Data 5-8

6 CURRENT RESEARCH AND FUTURE DEVELOPMENT NEEDS 6-1

6.1 CURRENT RESEARCH 6-1

6.1.1 Binders 6-1

Experimental Study of S/S Treatment of Hazardous Substances 6-1
Improvement in S/S Treatment of Hazardous Inorganic Wastes by Silica Fume (Microsilica) Concrete . 6-1
Physical and Chemical Aspects of Immobilization 6-1
Evaluation of Solidification/Stabilization of RCRA/CERCLA Wastes 6-2

6.1.2 Mechanisms 6-2

Review and Analysis of Treatability Data Involving S/S Treatment of Soils 6-2
Morphology and Microchemistry of S/S-Treated Waste . . . 6-2
Fate of PCBs in Soil Following Stabilization with Quicklime 6-3
S/S Treatment of Salts of As, Cd, Cr, and Pb 6-3
The Nature of Lead, Cadmium, and Other Elements in in Incineration on Residues and Their Stabilized Products 6-3

6.1.3 Interferences 6-4

Factors Affecting the S/S Treatment of Toxic Waste . . . 6-4
Effects of Selected Waste Constituents on S/S-Treated Waste Leachability 6-4

6.1.4 Organics and Air Emissions 6-4

Roles of Organic Compounds in Solidification/Stabilization of Contaminated Soils 6-4
Measurement of Volatile Emissions from S/S-Treated Waste 6-5

000039

CONTENTS (Continued)

Field Assessment of Air Emissions from Hazardous Waste S/S Processing 6-5
S/S Treatment of Metal Wastes Contaminated with Volatile Organics 6-5
Immobilization of Organics in S/S Waste Forms 6-5

6.1.5 Test Methods 6-5

Method Development 6-5
Investigation of Test Methods for Solidified Waste . . . 6-6
Critical Characteristics of Hazardous S/S-Treated Waste 6-6
Advanced Test Methods 6-6
Assessment of Long-Term Durability of Solidified/Stabilized Hazardous Waste Forms — Lab Component and Field Component 6-7

6.1.6 Leaching and Transport Models 6-7

Contaminant Profile Analysis 6-7
The Binding Chemistry and Chemical Leaching Mechanism of Hazardous Substances in Cementitious S/S Binders 6-7
Development of a Numerical Three-Dimensional Leaching Model 6-8
Acid Leaching Rate and Advancement of Acid Front in S/S-Treated Waste 6-8
Leaching Test Methods and Models 6-8
Review and Analysis of Treatability Data Involving Solidification/Stabilization of Soils 6-9

6.1.7 Compatibility with Disposal or Reuse 6-9

Assessment of Long-Term Durability of S/S-Treated Waste 6-9
Effect of Curing Time on Leaching 6-9
Field Performance of S/S-Treated Waste 6-10
Utilization and Disposal 6-10

6.1.8 Treatability Tests and S/S Process Application 6-10

Superfund Innovative Technology Evaluation (SITE) Program 6-10
Municipal Waste Combustion Residue S/S Program 6-10
Leaching Mechanisms and Performance of S/S-Treated Hazardous Waste Substances in Modified Cementitious and Polymeric Matrices 6-12
Stabilization Potential of Lime Injection Multistage Burner (LIMB) Product Ash

000040

CONTENTS (Continued)

Used with Hazardous Distillation Residues . . . 6-12
Stabilized Incinerator Residue
in a Shore Protection Device 6-12

6.2 FUTURE DEVELOPMENT 6-13

6.2.1 Binders 6-13
6.2.2 Mechanisms 6-13
6.2.3 Interferences 6-14
6.2.4 Organics and Air Emissions 6-14
6.2.5 Test Methods 6-14
6.2.6 Leaching and Transport Models 6-15
6.2.7 Compatibility with Disposal or Reuse 6-15
6.2.8 Treatability Tests and S/S Application 6-16

7 REFERENCES 7-1

APPENDIX A: SOLIDIFICATION/STABLILIZATION TECHNOLOGY
SCREENING WORKSHEETS A-1

APPENDIX B: DRAFT REPORT: SAMPLING AND ANALYTICAL PROCEDURES B-1

APPENDIX C: GLOSSARY C-1

CONTENTS (Continued)

TABLES

TABLE 1-1. RCRA WASTES FOR WHICH SOLIDIFICATION/STABILIZATION IS IDENTIFIED AS BEST DEMONSTRATED AVAILABLE TECHNOLOGY (BDAT) 1-5

TABLE 2-1. GENERAL INDUSTRIAL WASTE CATEGORIES 2-14

TABLE 2-2. EXAMPLES OF SOME METAL WASTES TESTED FOR SOLIDIFICATION/STABILIZATION TREATMENT 2-17

TABLE 2-3. EXAMPLES OF SOME METAL AND ORGANIC MIXED WASTES TESTED FOR SOLIDIFICATION/STABILIZATION TREATMENT 2-19

TABLE 2-4. EXAMPLES OF SOME ORGANIC MIXED WASTES TESTED FOR SOLIDIFICATION/STABILIZATION TREATMENT 2-20

TABLE 2-5. EXAMPLES OF OTHER INORGANIC WASTES TESTED FOR SOLIDIFICATION/STABILIZATION TREATMENT 2-22

TABLE 2-6. GUIDANCE FOR COLLECTING BASELINE INFORMATION 2-29

TABLE 2-7. ALTERNATIVE TREATMENT LEVELS FOR SOIL AND DEBRIS CONTAMINATED WITH RESTRICTED RCRA HAZARDOUS WASTES 2-36

TABLE 2-8. EXAMPLES OF REGULATORY ARARs 2-40

TABLE 2-9. TOXICITY CHARACTERISTIC CONSTITUENTS AND REGULATORY LEVELS 2-41

TABLE 2-10. EXAMPLES OF TREATABILITY PERFORMANCE OBJECTIVES BASED ON NONREGULATORY FACTORS 2-44

TABLE 2-11. APPLICABILITY OF SOLIDIFICATION/STABILIZATION TO SITE-SPECIFIC WASTE 2-54

TABLE 2-12. BENCH-SCALE BINDER SCREENING GUIDANCE 2-67

TABLE 2-13. RISK FACTORS FOR EVALUATING LEVELS OF PERFORMANCE TESTING 2-71

TABLE 2-14. LEVELS OF PERFORMANCE TESTING AND EXAMPLE TESTING REQUIREMENTS 2-73

TABLE 2-15. GUIDANCE FOR BENCH-SCALE PERFORMANCE TESTING 2-77

TABLE 3-1. PHYSICAL TESTS 3-3

TABLE 3-2. LEACHING/EXTRACTION TESTS 3-14

000042

CONTENTS (Continued)

TABLE 3-3. EXTRACTION CONDITIONS 3-16

TABLE 3-4. CHEMICAL TESTS 3-26

TABLE 3-5. BIOLOGICAL TESTS 3-35

TABLE 3-6. MICROCHARACTERIZATION TESTS 3-37

TABLE 4-1. pK_{sp} VALUES FOR SELECTED METAL PRECIPITATES 4-19

TABLE 4-2. pK_{sp} VALUES FOR SELECTED As AND Se PRECIPITATES 4-24

TABLE 4-3. SUBSTANCES THAT MAY AFFECT CEMENT REACTIONS: INHIBITION AND PROPERTY ALTERATION 4-31

TABLE 4-4. SUMMARY OF FACTORS THAT MAY INTERFERE WITH SOLIDIFICATION/STABILIZATION PROCESSES 4-33

TABLE 4-5. POTENTIAL CHEMICAL INCOMPATIBILITIES BETWEEN BINDER AND WASTE CONSTITUENTS 4-38

TABLE 4-6. S/S PROCESSES TESTED ON OR APPLIED TO ORGANIC-CONTAINING WASTES 4-41

TABLE 4-7. COSTS OF TYPICAL ANALYTICAL TESTS OF UNTREATED AND TREATED WASTES 4-76

TABLE 4-8. COSTS OF TYPICAL STABILIZATION CHEMICALS 4-79

TABLE 4-9. COMPARISON OF MAJOR COST ELEMENTS OF SOLIDIFICATION/STABILIZATION WITH CEMENT 4-80

TABLE 4-10. ESTIMATED TREATMENT COSTS MENTIONED IN THE RODs FOR SUPERFUND SITES WHERE STABILIZATION HAS BEEN SELECTED AS A COMPONENT OF THE REMEDIAL ACTION 4-83

TABLE 4-11. STABILIZATION COSTS FOR AN 1,800-CUBIC-YARD SITE CONTAMINATED WITH LEAD 4-85

TABLE 6-1 SUPERFUND INNOVATIVE TECHNOLOGY EVALUATION PROGRAM: SOLIDIFICATION/STABILIZATION TECHNOLOGIES 6-11

TABLE A-1 SOLIDIFICATION/STABILIZATION TECHNOLOGY SCREENING WORKSHEETS A-4

TABLE A-2 SUMMARY SHEET A-23

CONTENTS (Continued)

FIGURES

FIGURE 1-1. U.S. ENVIRONMENTAL PROTECTION AGENGY'S HIERARCHY OF HAZARDOUS WASTE MANAGEMENT 1-3

FIGURE 2-1. S/S TECHNOLOGY SCREENING 2-2

FIGURE 2-2. INFORMATION COLLECTION STEPS IN THE TECHNOLOGY-SCREENING PROCESS 2-6

FIGURE 2-3. GENERAL TECHNOLOGY SCREENING PROCEDURE 2-50

FIGURE 2-4. DETERMINING WHETHER S/S IS APPLICABLE AT A RCRA TSD FACILITY 2-52

FIGURE 2-5. S/S DECISION TREE AT A RCRA TSD FACILITY 2-53

FIGURE 2-6. WASTE/BINDER COMPATIBILITY LITERATURE SCREENING 2-57

FIGURE 2-7. LABORATORY SCREENING OF WASTE/BINDER MIXTURES 2-63

FIGURE 2-8. BENCH-SCALE PERFORMANCE TESTING OF SELECTED WASTE/BINDER MIXTURES 2-68

FIGURE 2-9. PILOT-SCALE TEST SCREENING 2-80

FIGURE 4-1. PROGRESS OF CEMENTATION REACTIONS 4-10

FIGURE 4-2. GENERAL DECISION TREE FOR S/S APPLIED TO ORGANIC CONTAMINANTS. 4-46

FIGURE 4-3. SCHEMATIC ILLUSTRATION OF CONCENTRATION PROFILES, $C(x)$, CHARACTERISTIC OF SPECIES DISSOLVING FROM A NONPOROUS SOLID INTO AN AQUEOUS MEDIUM, WITH x BEING THE DISTANCE INTO THE SOLUTION MEASURED FROM THE SOLID/LIQUID INTERFACE. THE TWO RATE-LIMITING CASES AND AN INTERMEDIATE CASE ARE SHOWN 4-62

FIGURE 4-4. ILLUSTRATION OF SPECIES DISSOLUTION WITHIN A POROUS SOLID. DISSOLUTION ACROSS A PORE WALL IS SHOWN, COUPLED WITH TRANSPORT THROUGH THE SOLUTION-FILLED PORE TO THE EXTERNAL SURFACE 4-64

000044

ORNL/TM-12657

Chemical Technology Division

EVALUATION OF SULFUR POLYMER CEMENT AS A WASTE FORM FOR THE IMMOBILIZATION OF LOW-LEVEL RADIOACTIVE OR MIXED WASTE

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CONTENTS

LIST OF FIGURES v
LIST OF TABLES vii
ACRONYMS AND INITIALISMS ix
EXECUTIVE SUMMARY xi
1. INTRODUCTION 1
2. MATERIAL AND TECHNIQUE 3
3. ADVANTAGES AND DISADVANTAGES OF SULFUR POLYMER CEMENT OR SULFUR CONCRETE AS DESCRIBED IN THE LITERATURE 7
3.1 ADVANTAGES 8
3.1.1 Physical and Chemical Properties 8
3.1.2 Operational Characteristics 9
3.1.3 Waste Stream Compatibility and Waste Loading 10
3.1.4 Immobilization of Hazardous Wastes in SPC 14
3.1.5 NRC Requirements for SPC Waste Forms 15
3.1.6 Engineering Developments Related to SPC Full-Scale Testing 18
3.1.6.1 Test performed in 1991 18
3.1.6.2 Test performed in 1992 19
3.1.6.3 Test performed in 1993 20
3.2 DISADVANTAGES 22
3.2.1 Temperature Control 22
3.2.2 Waste Stream Limitations 23
3.2.3 Durability of SPC Waste Forms 25
3.2.4 Operational Disadvantages 30
3.2.5 Safety Considerations 30
3.2.6 Cost Considerations 31
4. CONCLUSIONS 32
REFERENCES 34

000040

LIST OF FIGURES

Figure		*Page*
1	Stability field diagram for the S-H_2O System at 25°C	28
2	Schematic representation of elemental sulfur degradation due to sulfate formation and bacterial activity	29

LIST OF TABLES

Table		*Page*
1	Composition and properties of sulfur polymer cement	4
2	Properties of typical sulfur concrete and portland cement concrete	4
3	Industrial testing results of sulfur concrete materials	6
4	Summary of maximum waste loadings for modified sulfur cement waste forms achieved during process development studies	11
5	Comparison of optimal recommended waste loadings for modified sulfur cement and portland cement based on processing and waste form performance considerations	12
6	Comparative solubilities of metal hydroxides and sulfides	16
7	Sulfur polymer cement and portland cement: advantages and disadvantages	33

000048

ORNL/TM-12759

FINAL WASTE FORMS PROJECT: PERFORMANCE CRITERIA FOR PHASE I TREATABILITY STUDIES

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CONTENTS

TABLES v

ACRONYMS vii

PREFACE ix

ABSTRACT xi

1. INTRODUCTION 1

2. RATIONALE FOR SELECTION OF PERFORMANCE CRITERIA 3

3. RESOURCE CONVERSATION AND RECOVERY ACT AND SUBSEQUENT REAUTHORIZATION AND AMENDMENTS 4
   3.1 SPENT SOLVENTS AND DIOXIN WASTES 5
   3.2 CALIFORNIA LIST WASTES 5
   3.3 LISTED WASTES 9
      3.3.1 Treatment Standards 9
      3.3.2 Organics 14
   3.4 CHARACTERISTIC WASTES 14
   3.5 CONTAMINATED DEBRIS 21
      3.5.1 Debris Containing Listed Waste with Specified Treatment Technologies as Treatment Standards 24
      3.5.2 Debris Containing Listed Wastes with Specified Concentration-Based Treatment Standards 24
      3.5.3 Debris Contaminated with Characteristic Waste 25
      3.5.4 Impact on Phase I Performance Criteria 26

4. TOXIC SUBSTANCES CONTROL ACT 27
   4.1 PCB LIQUIDS 27
   4.2 PCB SOLIDS 28
   4.3 PCB SPILL CLEANUP POLICY REQUIREMENTS 28
   4.4 PCB-CONTAMINATED DEBRIS 29
   4.5 IMPACT ON PERFORMANCE CRITERIA 30

5. NUCLEAR REGULATORY COMMISSION REGULATIONS 31
   5.1 LLW CLASSIFICATIONS 31
      5.1.1 General Description 31
      5.1.2 Technical Definitions (10 CFR 61.55) 33
   5.2 REQUIRED LLW WASTE FORM CHARACTERISTICS 35
      5.2.1 Requirements for All LLW Classifications 35
      5.2.2 Waste Form Stability Requirements 36
      5.2.3 Requirements Particular to Cement Waste Forms 38
      5.2.4 Summary of NRC Waste Form Requirements 41
   5.3 IMPACT ON PHASE I WASTE FORM PERFORMANCE CRITERIA ... 41

000050

6. SUMMARY 43

7. REFERENCES 46

8. ACKNOWLEDGMENTS 48

Appendix A. TREATMENT STANDARDS FOR LISTED WASTES 50

Appendix B. TECHNOLOGY CODES USED IN APPENDIX A 115

Appendix C. TREATMENT STANDARDS FOR DEBRIS 123

TABLES

1 Treatment standards for spent solvent wastes (nonwastewater) 6

2 Treatment standards for dioxin wastes (nonwastewater) 8

3 Treatment standards for listed wastes (nonwastewater) based on stabilization as BDAT 11

4 TCLP treatment standards based on stabilization as BDAT for treatment residues of listed wastes (nonwastewater) 12

5 Treatment standards for characteristic wastes (nonwastewater) 15

6 TCLP concentration standards for characteristic wastes based on stabilization as BDAT 20

7 NRC radionuclide concentrations used to classify low-level radioactive wastes: long-lived radionuclides 32

8 NRC radionuclide concentrations used to classify low-level radioactive wastes: short-lived radionuclides 32

9 Known problematic wastes 41

10 Stability criterion vs test procedures 42

11 Comparison of EPA and NRC waste form evaluation methods 44

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Revision 2

Waste Form Performance Criteria and Testing Methods for Low-Level Mixed Waste

Draft

May 1994

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U.S. Department of Energy
Under Contract No. DE-AC02-76CH00016

000053

TABLE OF CONTENTS

Page

1. INTRODUCTION 1
   1.1 Need for Waste Form Performance Criteria 1
   1.2 Mixed Waste 2
   1.3 Waste Form 2

2. WASTE FORM MATRIX MATERIALS 4
   2.1 Hydraulic Cements 4
   2.2 Modified Sulfur Cement 4
   2.3 Glass 5
   2.4 Organic Polymers 5
   2.5 Asphalt (Bitumen) 6
   2.6 Crystalline Ceramics, Glass-Ceramics, and "Chemically-Bonded" Ceramics 6
   2.7 Metals 6

3. UTILITY AND APPLICATIONS OF TESTS 10
   3.1 Demonstration of Regulatory Compliance 10
   3.2 Development of Waste Forms 10
   3.3 Determination of Acceptability - Quality Control 10
   3.4 Comparison of Waste Form Types 11
   3.5 Input Data for Site Performance Assessments 11

4. APPLICABLE REGULATIONS 14
   4.1 EPA Regulations 14
      4.1.1 Identification of Hazardous Wastes 14
      4.1.2 Environmental Performance Standard for New TSD Facilities 15
      4.1.3 Land Disposal Restrictions and Best Demonstrated Available Technology (BDAT) 16
   4.2 Federal Facility Compliance Act of 1992 (FFCA) 17
   4.3 DOE Order 5820.2A, Chapter III 18

5. WASTE FORM PERFORMANCE CRITERIA AND PERFORMANCE ASSESSMENT MODELS 20
   5.1 Radiological Performance Assessment 21
   5.2 RCRA Metals Performance Assessment 22

000054

TABLE OF CONTENTS (Continued)

Page

6. PROPOSED CRITERIA AND TESTS 23
   6.1 Basis for Criteria 24
   6.2 Release of Radionuclides from Solidified Mixed Waste 25
   6.3 Release of RCRA Regulated Constituents from Solidified Mixed Waste . . 29
   6.4 Physical Integrity of Solidified Mixed Waste 31
   6.5 Waste Form Stability in Water 32
   6.6 Radiation Stability on Solidified Mixed Waste 33
   6.7 Freeze/Thaw Stability of Solidified Mixed Waste 34
   6.8 Wet/Dry Cycling Stability of Solidified Mixed Waste 36

7. LONG-TERM PERFORMANCE OF WASTE FORMS 40

8. RECOMMENDATIONS FOR FUTURE WORK 46

APPENDIX A: Review of NRC Low-Level Waste Form Criteria and Tests . . . . A-1 - 23

APPENDIX B: DUST Calculations Applied to Toxic Metals. . . . . B-1 - 7

APPENDIX C: Non-U.S. Low-Level and Mixed Waste Solidification/Stabilization Criteria and Testing Requirements. . . . . C1 - 12

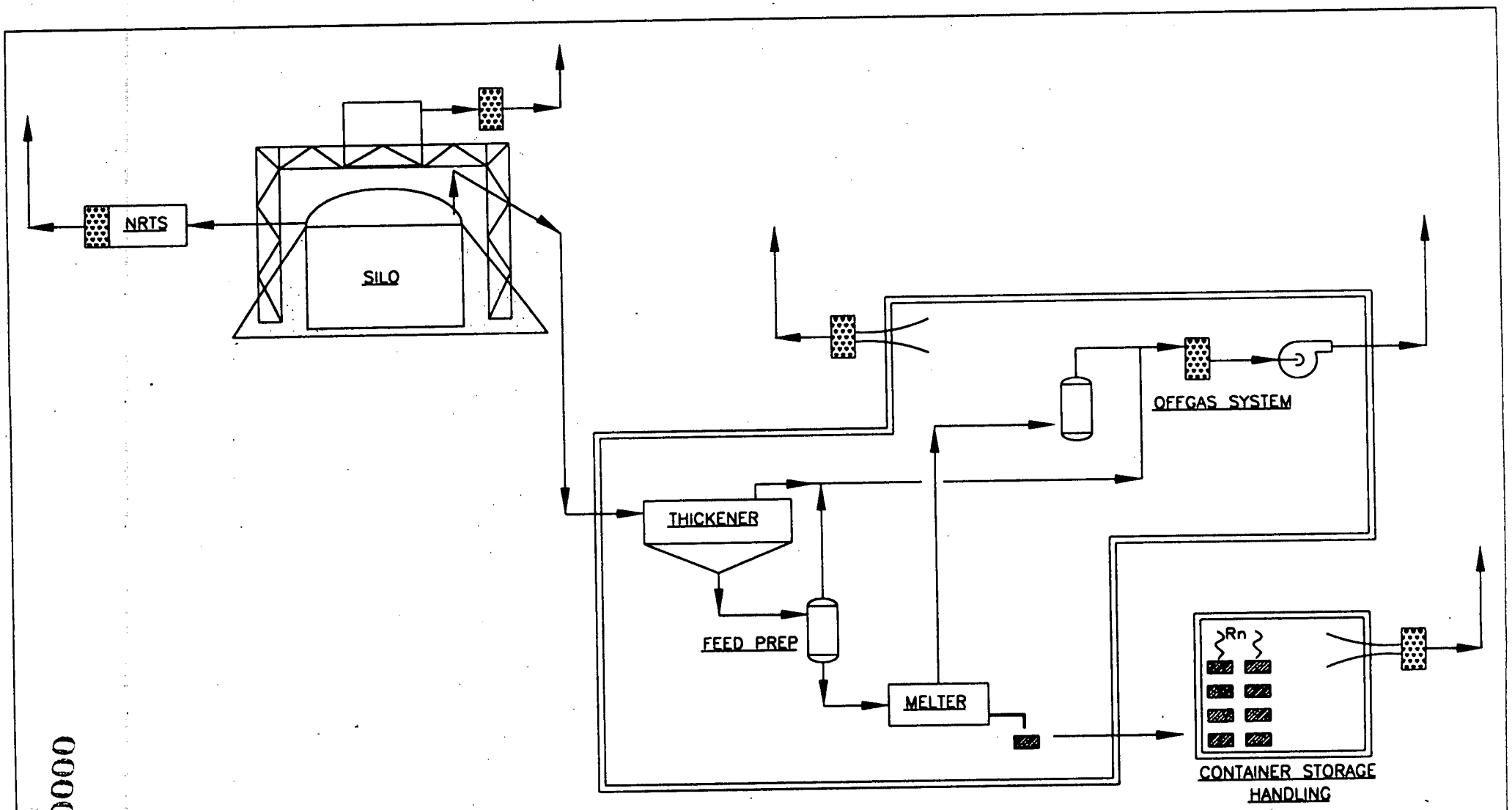
APPENDIX D: Rationale in Support of Table 6.2 - A Semi-Quantitative Ranking System for Radionuclide Wastes. . . . . D-1 - 7

APPENDIX E: Accelerated Leach Test for Diffusive Releases from Solidified Waste. . . . . E-1 - 16

APPENDIX F: Nondestructive Testing. . . . . F-1 - 5

APPENDIX G: Radiation Stability of Low-Level Radioactive Waste Forms. . . . . G-1 - 22

RADON HANDLING



VITRIFICATION

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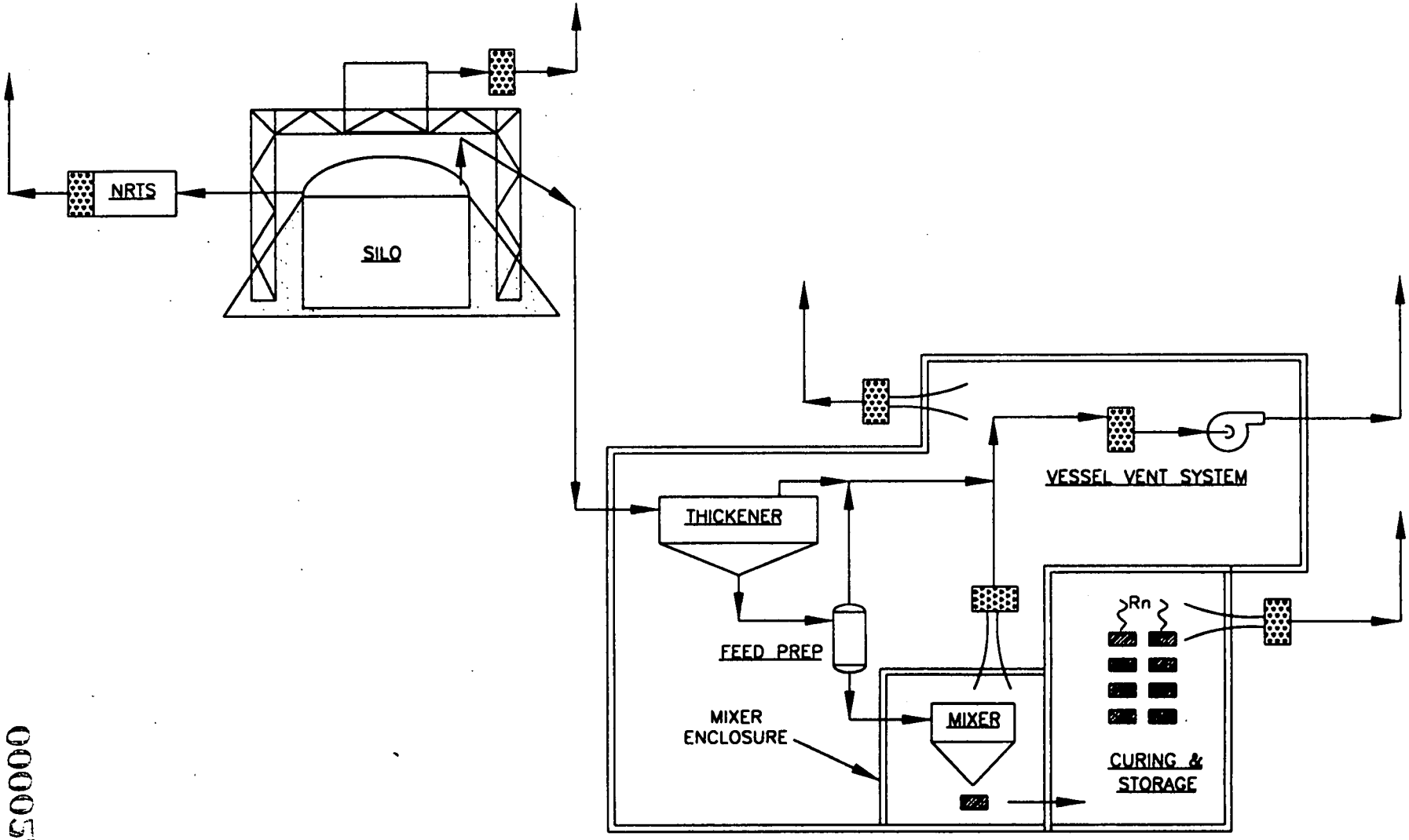
RADON HANDLING



CEMENT STABILIZATION

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PARKING LOT ISSUES

Optimization of Alternatives 2 & 3 (Brainstorming)
Melter Process Development - approach to gain sufficient confidence

Cost/Assumptions Comparison for Feasibility Study Alternatives

Literature Search - make summary report (stabilization)
    Wast Loading with similar experience

Approach to radon exposure during cement stabilization treatment operations
    (Block Flow.)

Salvage Value of Pilot Plant

Radon emanation minimization with cement formulation

Open Data Requirement
Points to be addressed - subgroup on draft positions

INCIDENT ANALYSIS TEAM

DON PAINE

FEBRUARY 11, 1997

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VITRIFICATION PILOT PLANT INCIDENT INVESTIGATION

- Bubbler Tube #3 had corroded below the Monofrax K-3 surface refractory through the AZS sub-layer refractory to the castable layer.
- Initial breakout was a small stream passing through the annular space between the remaining bubbler stub and castable refractory block.
- Glass stream became a coherent conductor to ground at the inner shell causing the temperature to rise, glass viscosity to lower, mass flow rate to increase, and remaining bubbler assembly to dislodge.
- Current flow through the grounded leak stream was enhanced due to ground paths at bottom drains Nos. 1, 2, and 3.
- Transition glass, batch BO9, was a less viscous glass causing the glass flow to increase all the more rapidly.

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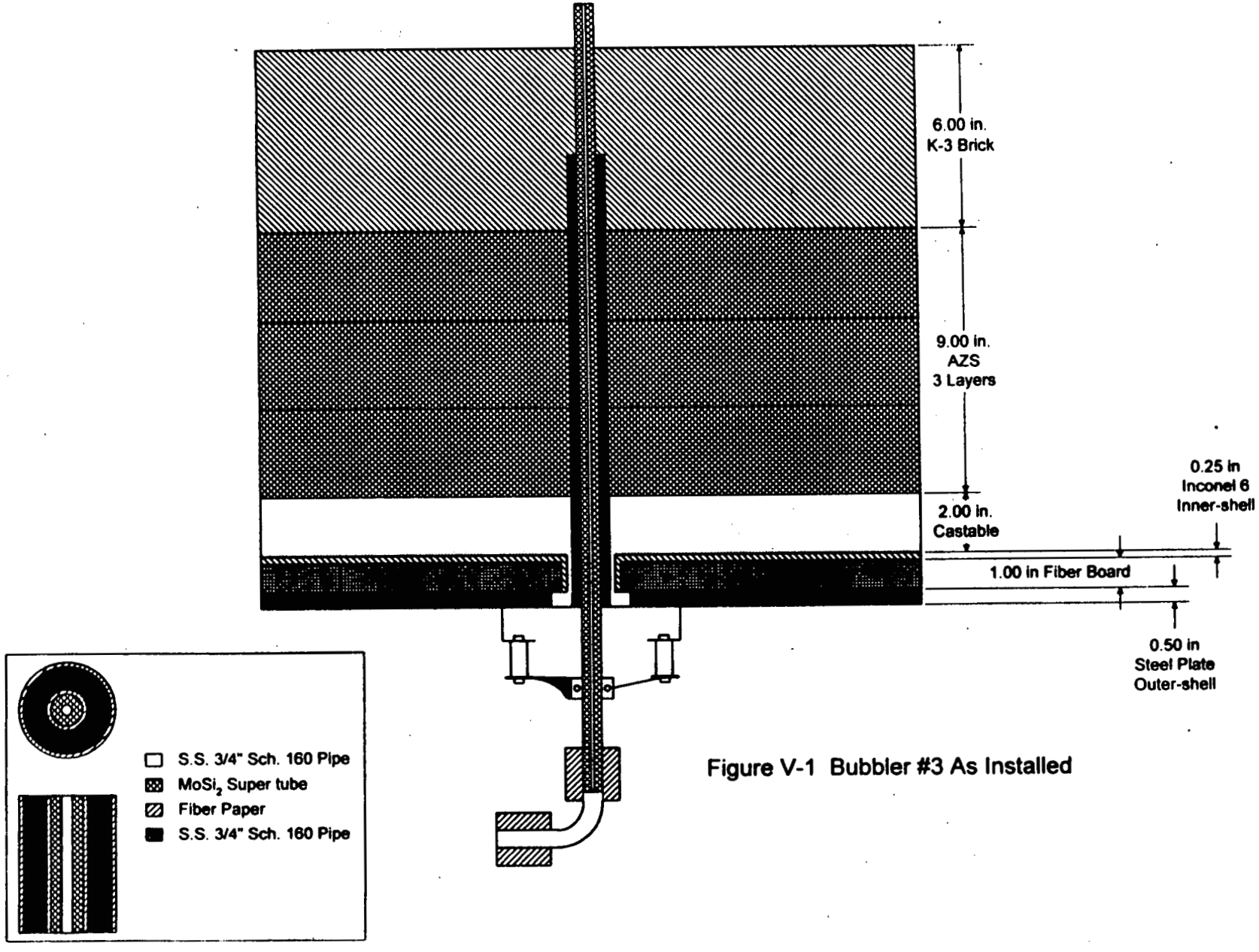

Figure V-1 Bubbler #3 As Installed

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Silos Project

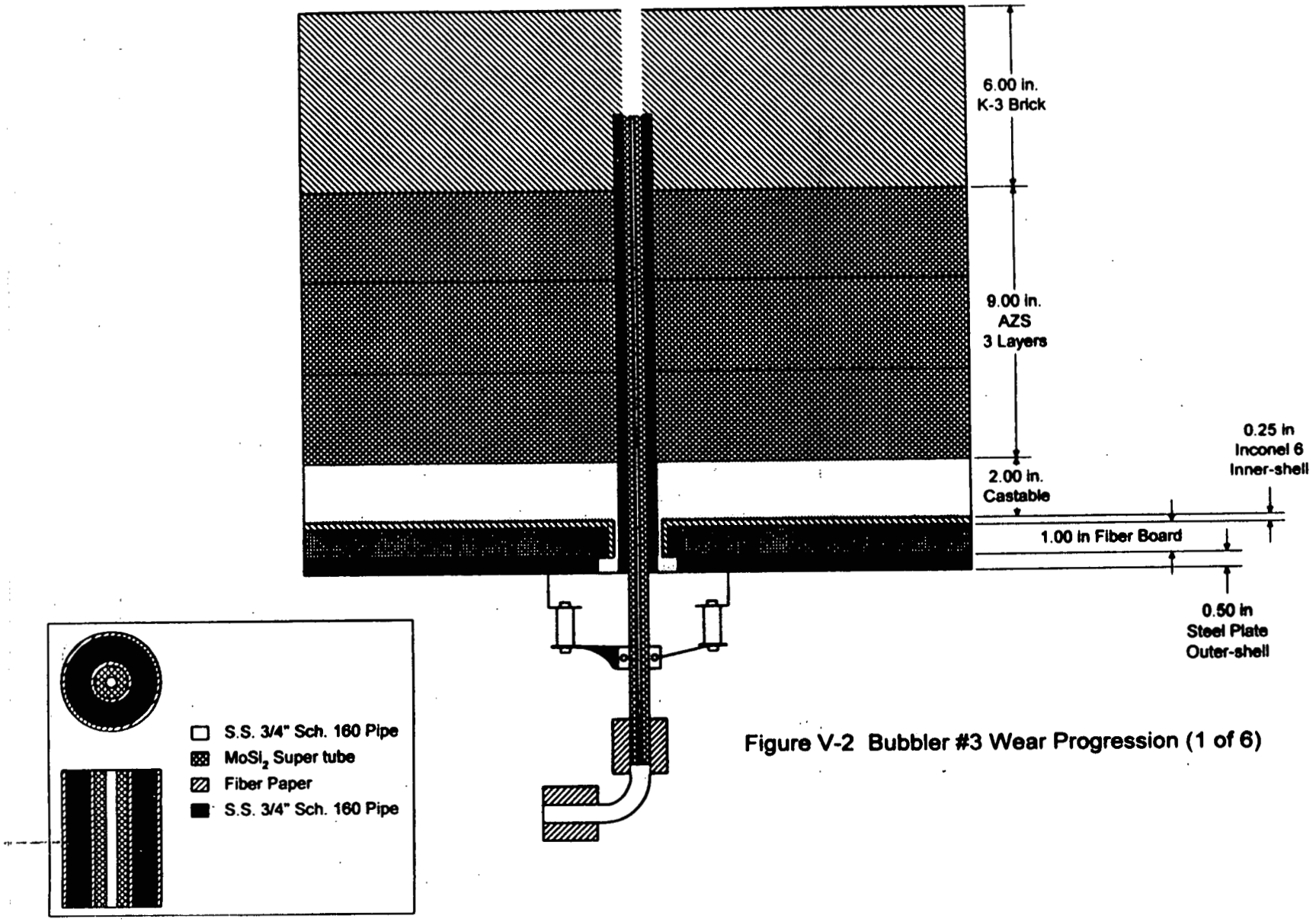

Figure V-2 Bubbler #3 Wear Progression (1 of 6)

Silos Project

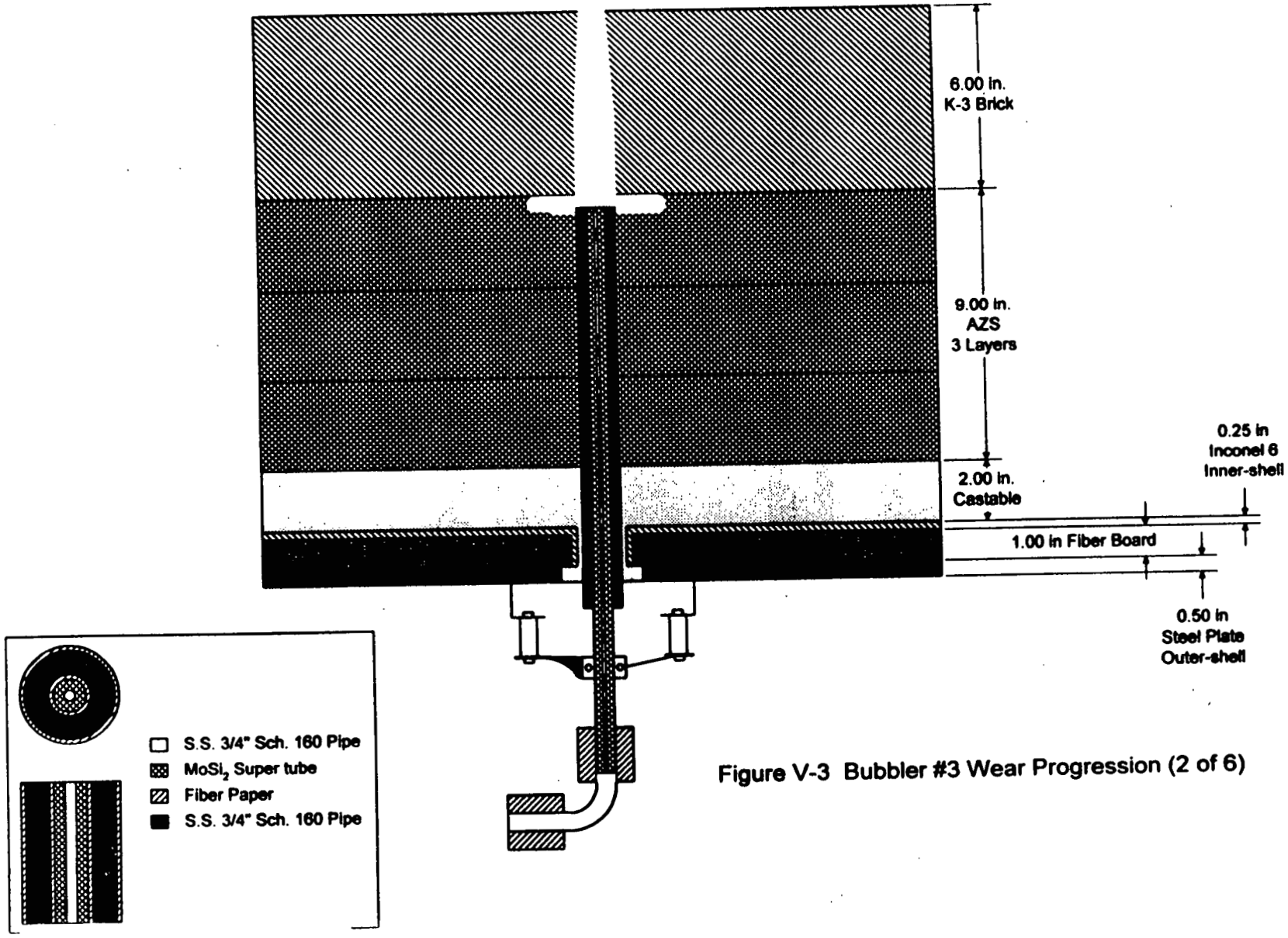

Figure V-3 Bubbler #3 Wear Progression (2 of 6)

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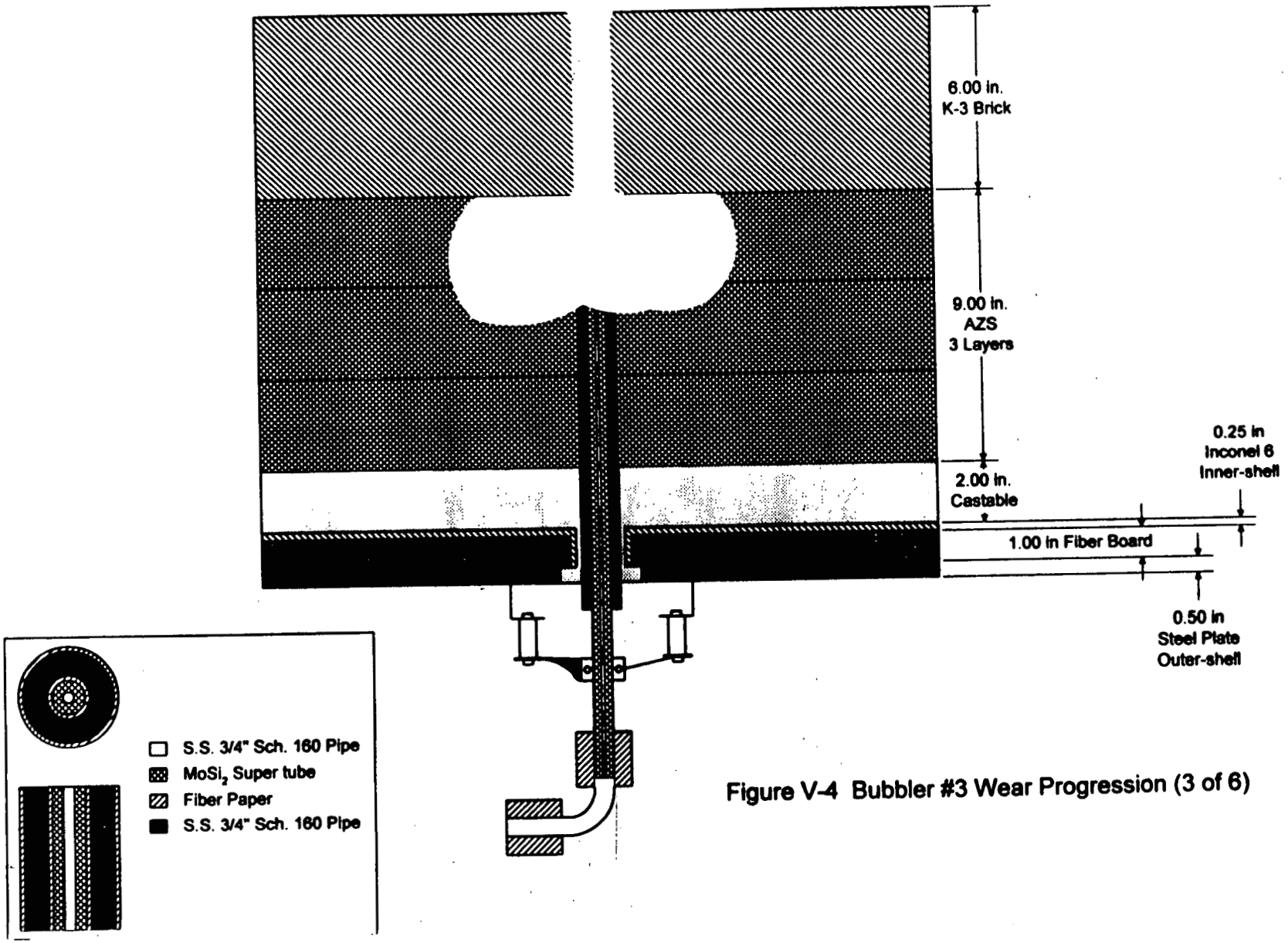

Figure V-4 Bubbler #3 Wear Progression (3 of 6)

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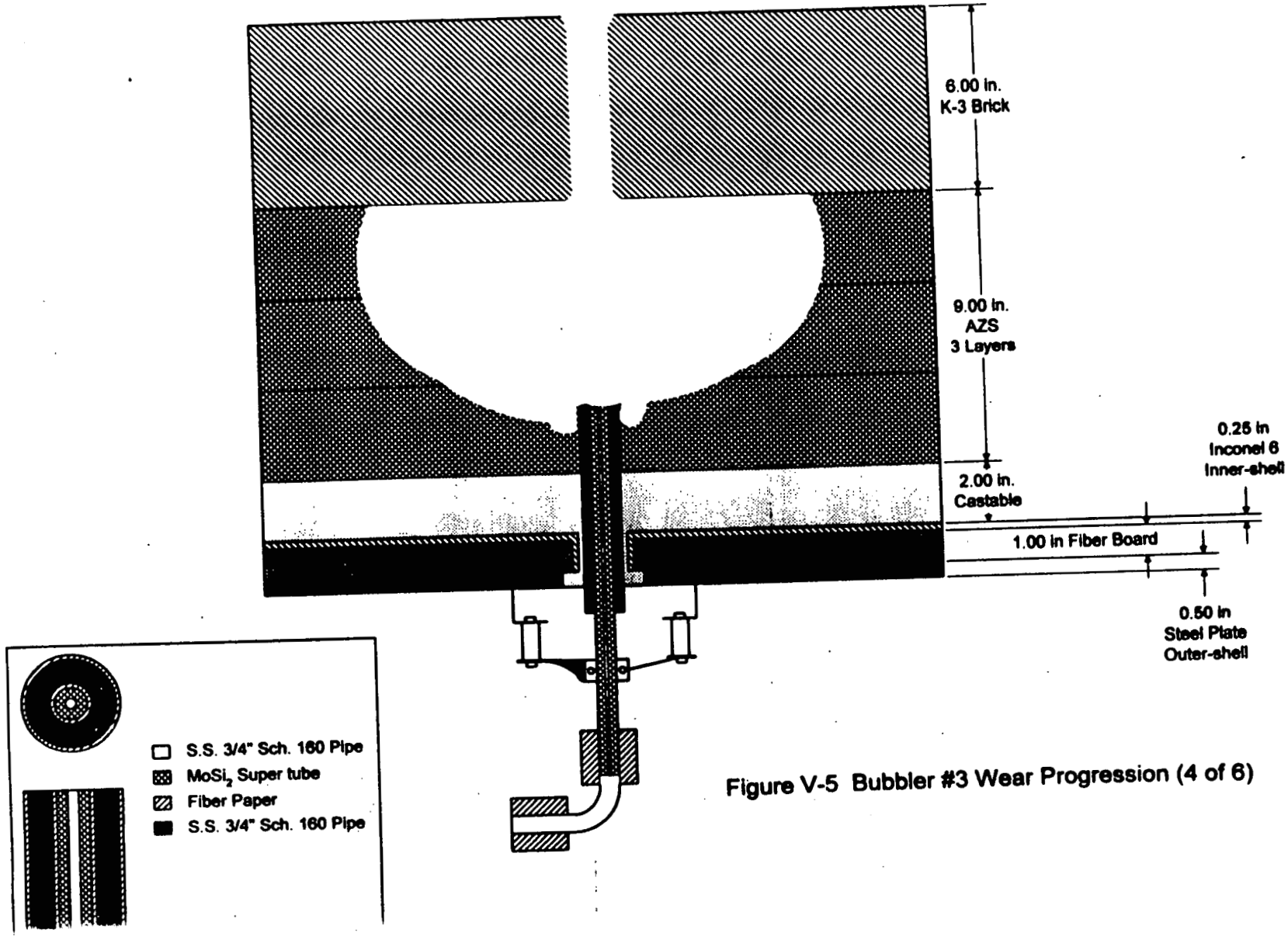

Figure V-5 Bubbler #3 Wear Progression (4 of 6)

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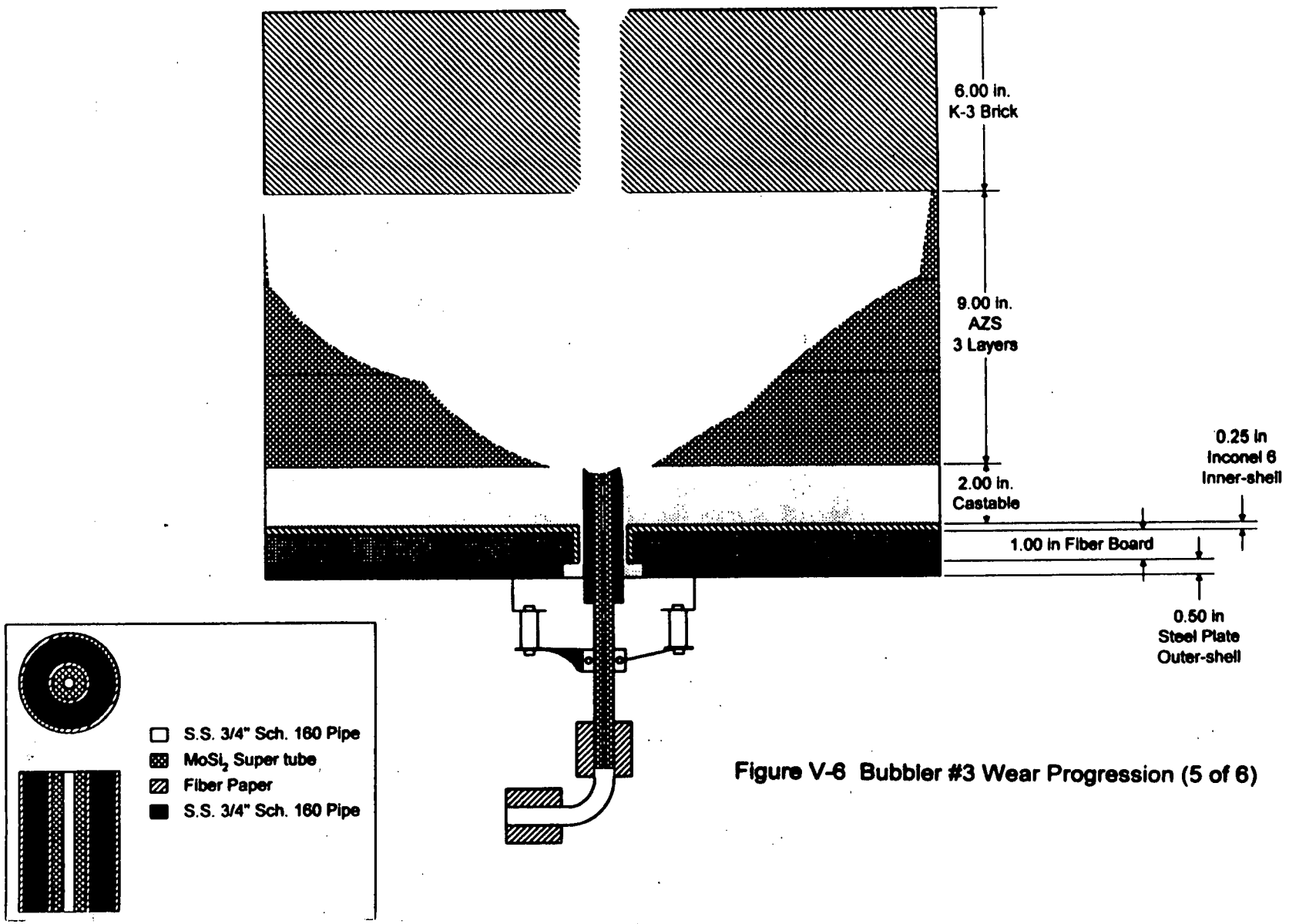

Figure V-6 Bubbler #3 Wear Progression (5 of 6)

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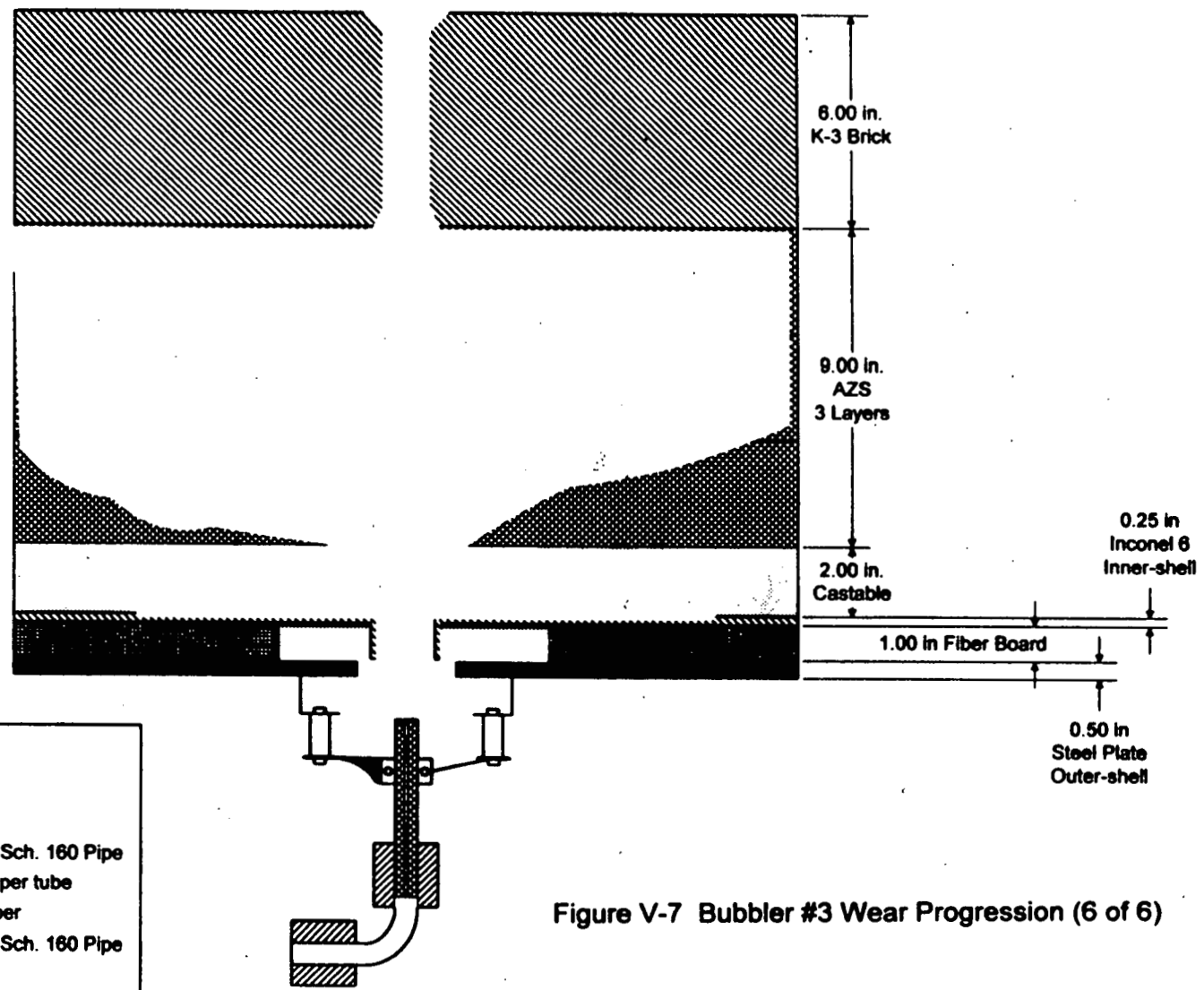

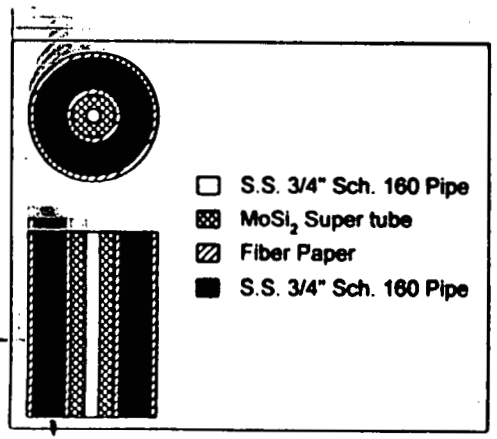

Figure V-7 Bubbler #3 Wear Progression (6 of 6)

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Silos Project

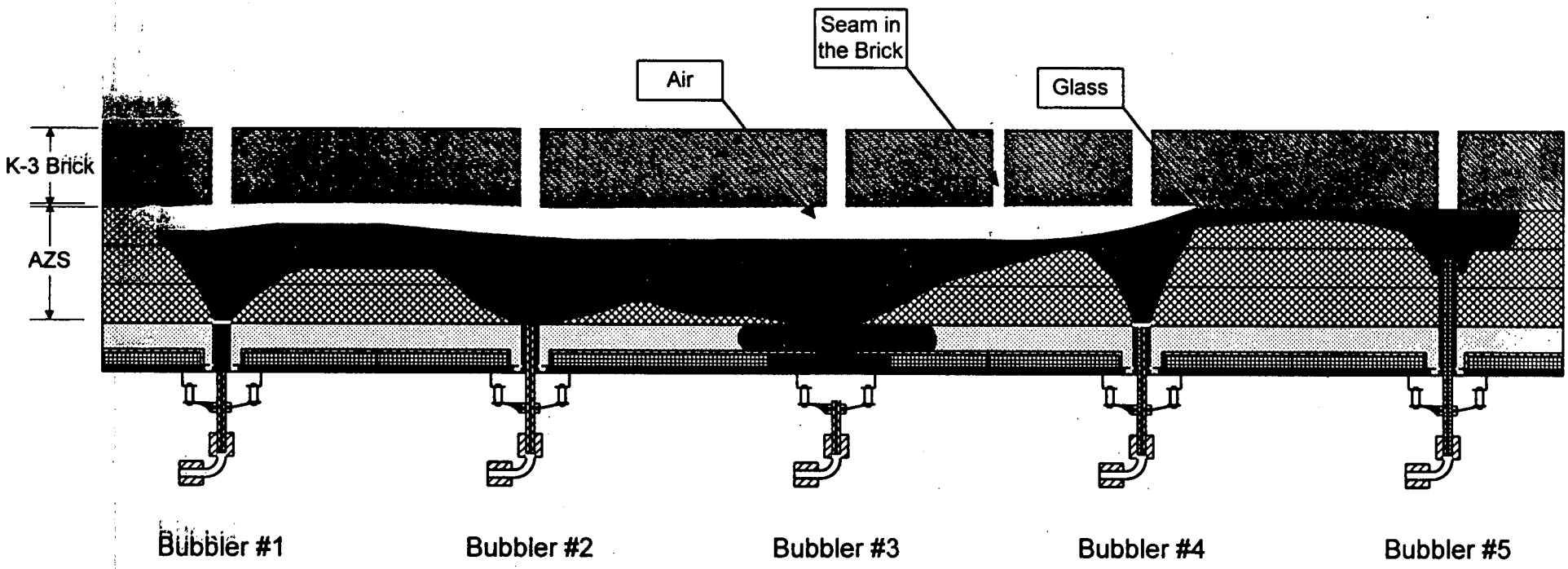

Figure V-8 Glass Infiltration in the Air Bridge

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Hazard

Conse

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Cause

Mitig

INPUT FOR

SAFETY REVIEW TEAM

LOUIS C. BOGAR

FEBRUARY 11, 1997

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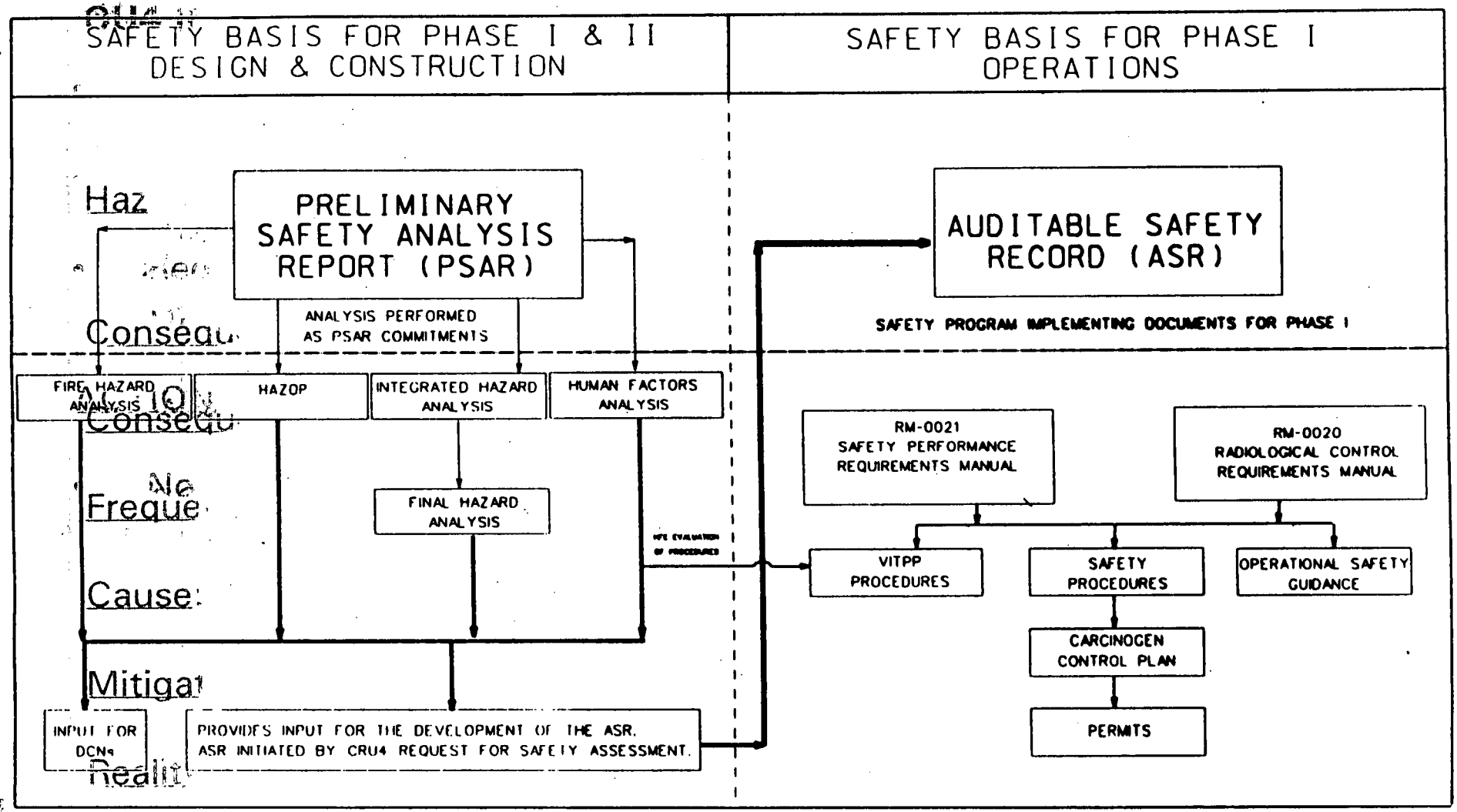

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OU4 IN

OU4 INTEGRATED HAZARD ANALYSIS EVALUATION

Ref: Final Hazard Analysis, September 1995

Hazard: Leak or spill of molten glass or heavy metals from furnace

Consequence: Fire; potential worker death/serious injury

Consequence Class: Moderate

Frequency Class: Unlikely (10^{-2} - 10^{-4}/Year)

Cause: Material defect; installation error

Mitigators: Bottom Container, Acceptance Testing

Reality: Bottom Container Volume Inadequate

OFF-NORMAL SCENARIOS AND TEST CORRECTIONS

Melter Incident
Safety Review Team

CONCERNS:

- Erosion and Corrosion
- Redox Potential in Melt
- Reduced Metals

ACTIONS:

- No Monitoring Plan

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Melter Incident
Safety Review Team

ENVIRONMENTAL IMPACTS

- Potential Pathways Evaluated:
  - No Impact
- Worker Exposure to Pb Evaluated by Medical Surveillance:
  - Workers not exposed to significant fume levels
- Worker Exposure to Noxious Gasses
  - SO_x & NO_x Exposures Inconsequential

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LESSONS LEARNED AND RECOMMENDATIONS

Safety Assessments and Hazard Analyses

Lesson I:

The safety assessments and hazard analysis processes for the VITPP inadequately assess the potential for casualties resulting rom incompletely understood wastage in the melter.

Recommendation I:

Project management must assure that periodic independent technical review and direction is provided during all phases of the project. Include safety, design and operational considerations, be available during early phases of the project.

Recommendation II:

Because of the technical complexity of this project, project management must assure that a thorough, detailed hazard assessment is performed by an integrated team with adequate technical resources to establish the safety basis, and that this safety basis is revised as new data and facts become available.

LESSONS LEARNED AND RECOMMENDATIONS

Design Change Control

Lesson 2:

The existing Design Change Control process at Fluor Daniel Fernald (FDF)is ineffective to assure that changes are adequate to maintain operations within the safety basis.

Recommendation 3:

Project management must ensure that management control processes are in place throughout the life of the project to maintain the integrity of the safety basis.

000025

638

LESSONS LEARNED AND RECOMMENDATIONS

Emergency Response

Lesson 3:

Good emergency response to casualty conditions requires good design, disciplined operations, and continuous training.

Recommendation 4:

The discipline gained from all aspects of operational experience and personnel training ensured that the incident resulted in no personnel injuries. Project management must ensure that such training is a continuing requirement for a project of this complexity.

Recommendation 5:

Project management must ensure that there are appropriate designs and/or effective administrative controls and/or project procedures to mitigate and confine the consequences of a potential breach of the melter which could spill molten glass onto the floor of the melter room, as well as, the consequences resulting from emergency response.

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DATA ANALYSIS REVIEW TEAM

NINA AKGÜNDÜZ

FEBRUARY 11, 1997

FLUOR DANIEL FERNALD

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DATA ANALYSIS AND PATH FORWARD TEAM RECOMMENDATION

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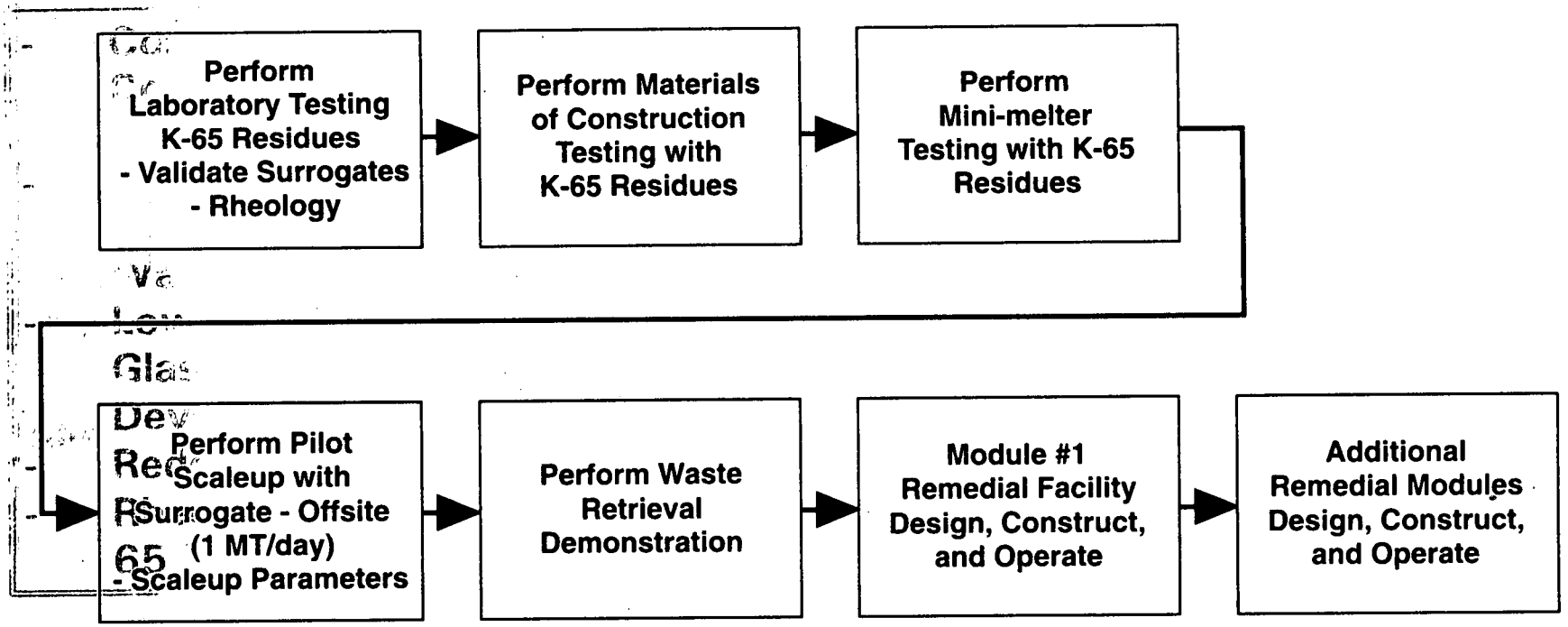

Graphics 4437L.1 2/97

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Laboratory Scale (approx. 6 mo.)	Mini Melter Scale (approx. 14 mo.)	Pilot Scale (4 to +7 mo)
- Corrosion Rates of Construction Material - Comparing Surrogate to Actual Waste - Low Temperature Glass Formula Development - Redox Study - Rheology of the K-65 Residues	- Radioactive Glass Properties - Off-Gas Composition (Rn, NOx, SOx, Solids carryover) - Dose Rates	- Melter Throughput Rate for Sizing of the Full-Scale Melter - Validation of Low Temperature Glass Formula

000029

RECOMMENDATIONS

Not to Re-Start the VitPP Melter

Perform Waste Retrieval Demonstration using VitPP to Extent Possible

Perform Laboratory Testing of K-65 Residues to
1) Validate Surrogate Material Properties
2) Rheology Testing

Perform Materials of Construction Testing with K-65 Residues (Melter Design)

Perform Mini-Melter Testing with K-65 Residues

Perform Pilot Scale-Up with Surrogate (Off-site)

Module #1 Remedial Facility Design, Construct, and Operate

Additional Remedial Modules Design, Construct, and Operate

000030

WVDP CEMENTATION OF PRETREATED LIQUID HLW

R. E. Lawrence

0000081

638

CHRONOLOGY

1982 - WVDP COMMENCES
- HLW PROGRAM PUT ON "FAST TRACK"
- DECISION TO INSTALL NEW SYSTEMS IN OLD PLANT
- CEMENT SYSTEM DESIGN CRITERIA DEVELOPED
  - HIGH SHEAR MIXING
  - REMOTE OPERATION
  - 55-GAL. DRUMS

1984 - CONSTRUCTION, TRAINING, TESTING

1985 - URANYL NITRATE PROCESSING
- PROCESSING DIFFICULTIES
  - PLUGGING
  - HEATS OF NEUTRALIZATION, HYDRATION

280000

CHRONOLOGY (Continued)

1986 - FLUSHING CAMPAIGNS & REDESIGN
- SWITCH TO 71-GALLON SQUARE DRUMS
- REVISED DRUM HANDLING
- REVISED MIXING PROGRAM

1987 - REDESIGN FOR SUPERNATANT PROCESSING
- NEW RECIPE 37-41% TDS (TOTAL DISSOLVED SOLIDS)
- PROCESS CONTROL PLAN

1988 - SUPERNATANT PROCESSING BEGINS

1990 - SUPERNATANT PROCESS ENDS
- 10,394 DRUMS (71-GALLON)
- CLASS C LOW LEVEL WASTE

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CHRONOLOGY (Continued)

1991-93 - SLUDGE WASH TESTING & RECIPE DEVELOPMENT

- TYPE I CEMENT 19-21% TDS
- TYPE V CEMENT 27-33% TDS

1993-94 - SLUDGE WASH PROCESSING

- 6,582 DRUMS (71-GALLON)
- CLASS A LOW LEVEL WASTE

1994-95 - THOREX WASH TESTING & RECIPE DEVELOPMENT

- TYPE V CEMENT
- 18-22, 26-29% TDS

1995 - THOREX WASH PROCESSING

- 1,450 DRUMS (71-GALLON)
- CLASS A LOW LEVEL WASTE

480000

RECIPE DEVELOPMENT

WASTE REQUIREMENTS 10CFR 61.56.(a)

- PACKAGING
- LIQUIDS
- FREE LIQUIDS
- REACTIVITY
- GAS GENERATION
- PYROPHORICITY
- GASEOUS WASTE
- HAZARDOUS WASTE

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RECIPE DEVELOPMENT (Continued)

RECIPE
FOAMP

STABILITY REQUIREMENTS 10CFR61.56(b)

- COMPRESSIVE STRENGTH
- RADIATION RESISTANCE
- BIODEGRADATION
- LEACHABILITY
- IMMERSION
- THERMAL CYCLING
- FREE LIQUIDS
- FULL-SCALE SPECIMENS
- TEST SPECIMENS
- PROCESS CONTROL PROGRAM

TEST SP

NRC BRANCH TECHNICAL POSITION (1991)

980000

STAR
SVE/1968JAE
Super

START-UP EXPERIENCE:
Supernatant Recipe

FOAMING
- CHANGE MIXER SPEED
- ANTIFOAM ADDITIVE

GELATION FAILURE
- USE OF PRE-SOLIDIFICATION CUBE SAMPLE
- SODIUM SILICATE ADDITIVE (ADDED TO MIXER)
- CALCIUM NITRATE ADDITIVE (BLENDED WITH CEMENT)

HEAT OF HYDRATION
- THERMOCOUPLED DRUMS

TEST SPECIMENS VS. FULL-SCALE TESTING
- CUBE SPECIMENS PER ASTM C-109

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START-UP EXPERIENCE:
Sludge Wash Recipe

RECIPE DEVELOPMENT
- PLACKETT-BURMAN SCREENING TESTS

INCREASED SULFATES
- DECONTAMINATED WASTE WITH SULFATE SPIKE

IMMERSION TEST FAILURE
- EVALUATION OF WASTE pH
- CHANGE IN IMMERSION TEST VOLUME-TO-SURFACE AREA
- SULFATE ATTACK
- MEETINGS WITH NATIONAL EXPERTS
- SWITCH TO TYPE V CEMENT

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START-UP EXPERIENCE:
THOREX Wash Recipe

RECIPE DEVELOPMENT WHILE PROCESSING SLUDGE WASH

- USE OF SURROGATE THOREX WASTE MADE FROM DECONTAMINATED SLUDGE WASH SOLUTION

LABORATORY SPECIMENS VS. FULL-SCALE WASTE FORM

- ALL QUALIFICATION SAMPLES CORED FROM FULL-SCALE DRUMS

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LONG-TERM TESTING PROGRAMS

- COMPRESSIVE STRENGTH TESTING PER ASTM C-39
  - SUPERNATANT DRUMS
    - COMPRESSIVE STRENGTH INCREASES FROM 750 TO 1770 PSI OVER 5 YEARS
  - SLUDGE WASH DRUMS
    - FOR TYPE I CEMENT: COMPRESSIVE STRENGTH AVERAGE >1700 PSI OVER 3 YEARS
    - FOR TYPE V CEMENT: COMPRESSIVE STRENGTH AVERAGES >1200 PSI OVER 3 YEARS
  - THOREX DRUMS
    - TESTING NOT STARTED

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LONG-TERM TESTING PROGRAMS - (Continued)

HAZARDOUS WASTE TESTING

TOXICITY CHARACTERISTIC LEACHING PROCEDURE (TCLP)

- SUPERNATANT DRUMS
  - NONHAZARDOUS
- SLUDGE WASH DRUMS
  - NONHAZARDOUS
- THOREX WASH DRUMS
  - NONHAZARDOUS

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SUPERNATANT RECIPE DEVELOPMENT

CRITERIA	SUPERNATANT
Weight % Solids	37-41 wt%
pH	10
SO_4 (% of total salts)	4%
water-to cement ratio	0.61-0.63
NRC Branch Technical Position	
Compressive Strength > 60 PSI	74 days cure: average 890 PSI
Compressive Strength following 90-day immersion >60 PSI	650 PSI
Homogeneity: 10 samples each from the top, middle, and bottom section of the drum	TOP: 7.65E-03 μCi/g 1 std. dev. 7.7E-04 MIDDLE: 8.15E-03 μCi/g 1 std. dev. 1.3E-03 BOTTOM: 7.60E-03 μCi/g 1 std. dev. 3.2 E-04
Radionuclide Leach Indices > 6.0	CS-137 > 6.5 Tc-99 > 6.6 Sr-90 > 9.4 α-Pu > 15.2

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SLUDGE WASH RECIPE DEVELOPMENT

CRITERIA	TYPE I RECIPE	TYPE V RECIPE
weight-%-solids	19-21% TDS	26-33 wt%
pH	> 12.0	12.6
SO_4 (% of total salts)	< 0.11 gm/gm salt	< 0.115 gm/gm salt
water-to-cement-ratio	0.64 to 0.68	0.49 to 0.55
NRC Branch Technical Position		
Compressive Strength > 500 PSI	1497 PSI	average 1230 PSI
Compressive Strength following 90-day immersion > 500 PSI and > 75% or pre-immersion	average 1230 PSI 82% of pre-immersion	1590 PSI 129% of pre-immersion
Compressive Strength following 30 thermal cycles > 500 PSI		Average 2200 PSI 160% of pretest strength
Radionuclide Leach Indices > 6.0	Cs-137 > 7.1 Tc-99 > 7.1 Sr-90 > 10.9 α-Pu > 13.7	CS-137 > 8.1 Tc-99 > 8.3 Sr-90 > 9.6 α-Pu > 9.6

THOREX WASH RECIPE DEVELOPMENT

METAL CRITERIA	TYPE V CEMENT	TYPE V CEMENT
weight % solids	18-22% TDS	26-29 wt%
pH	> 12.2	12.3
SO_4 (% of total salts)	4.2%	4.0%
water-to-cement ratio	0.55 to 0.65	0.53 to 0.58
NRC Branch Technical Position		
Compressive Strength > 500 PSI	average 2360 PSI	average 1830 PSI
Compressive Strength following 90-day immersion > 500 PSI and > 75% of pre-immersion	average 2520 PSI 107% of pre-immersion	1760 PSI 96% of pre-immersion
Compressive Strength following 30 thermal cycles > 500 PSI	average 2460 PSI 104% of pretest strength	average 2430 PSI 130% of pretest strength
Radionuclide Leach Indices > 6.0		Cs-137 > 7.4 Tc-99 > 7.3 Sr-90 > 6.5 α-Pu > 7.4

LEACHABILITY OF HAZARDOUS METALS

SVE/1968JA

METAL	REGULATORY LIMIT	CONCENTRATION IN WASTE	SUPERNATANT	SLUDGE WASH	THOREX WASH
Arsenic	5.0 PPM	< 1 PPM	< 0.8 PPM	< 0.10 PPM	ND
Barium	100 PPM	< 1.5 PPM	0.653 PPM	< 1.0 PPM	1.12 PPM
Cadmium	1.0 PPM	< 1 PPM	ND	< 0.10 PPM	ND
Chromium	5.0 PPM	up to 360 PPM	2.47 PPM	1.7 PPM	1.6 PPM
Lead	5.0 PPM	< 0.1 PPM	< 0.2 PPM	< 0.05 PPM	ND
Selenium	1.0 PPM	< 1.5 PPM	0.019 PPM	< 0.10 PPM	ND
Silver	5.0 PPM	< 0.067 PPM	< 0.06 PPM	< 0.05 PPM	ND
Mercury	0.2 PPM	<0.075 PPM	0.00118 PPM	< 0.005 PPM	ND

ND - Not Detected

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638

Page

INTRODUCTION
OPEN ACTIONS/TECHNICAL ISSUES

MARK DEHRING

FEBRUARY 11, 1997

960096

OPEN ACTIONS / TECHNICAL ISSUES

What has been the experience of cement stabilization projects with materials similar to the Silo waste?

How realistic are the assumptions for waste loading (20% for Silos 1 & 2, 45% for Silo 3)?

What waste loading has been achieved for wastes similar to the Silo residues?

Define radon related requirements for waste treatment operations, transportation and disposal.

Clarify relevant health & safety requirements.

Provide an evaluation showing how alternative waste forms perform with respect to the constituents of concern?

Address the ability of a waste container to contain radon.

Provide a comparison of waste transportation by rail and truck.

Perform a sensitivity analysis with respect to the waste loading assumptions.

Is it feasible to dispose of Silo waste by mixing with FEMP pit materials?

What is the potential for removing lead prior to waste treatment?

Can we benefit from the experience at Niagara?

OPEN ACTIONS / TECHNICAL ISSUES

Should we give consideration to alternative remediation technologies? Perform a literature survey.

What is the effectiveness of alternative technologies with respect to radon emissions?

Silo Waste Characterization Issues

Optimize the approach to melter development in Alterative 2

Address technology development requirements for Alternative 3

Evaluate the impact of alternatives on health and safety of operations.

USE OF INORGANIC MINERALS IN THE SCIENCE AND TECHNOLOGY OF WASTE SOLIDIFICATION/STABILIZATION

By
Earl W. McDaniel
a Retiree of
Oak Ridge National Laboratory
Chemical Technology Division
Oak Ridge, Tennessee 37831

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EXAMPLES OF INORGANIC MINERALS:

- Fly Ash
- Blast Furnace Slag
- Sand
- Silica Fume
- Clays
  - gel clays
  - non-smelling
- Portland Cement

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CHEMICALS OF INTEREST

- Fluidizers
- Set Regulators
- Special Applications Chemicals
  a) precipating agents
  b) reducing agents
  c) oxidizing agents

WASTE STREAM CHEMISTRY

- What are the Impacts of Waste Stream Composition on Materials to be Used to Stabilize Waste?

- Long Term Waste Form Chemistry

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MIX DESIGN (FORMULATION DEVELOPMENT)

- Determine Regulatory Requirements
- Identify Parameters that Impact Regulatory Requirements
- Identify Materials
- Develop Experimental Plan

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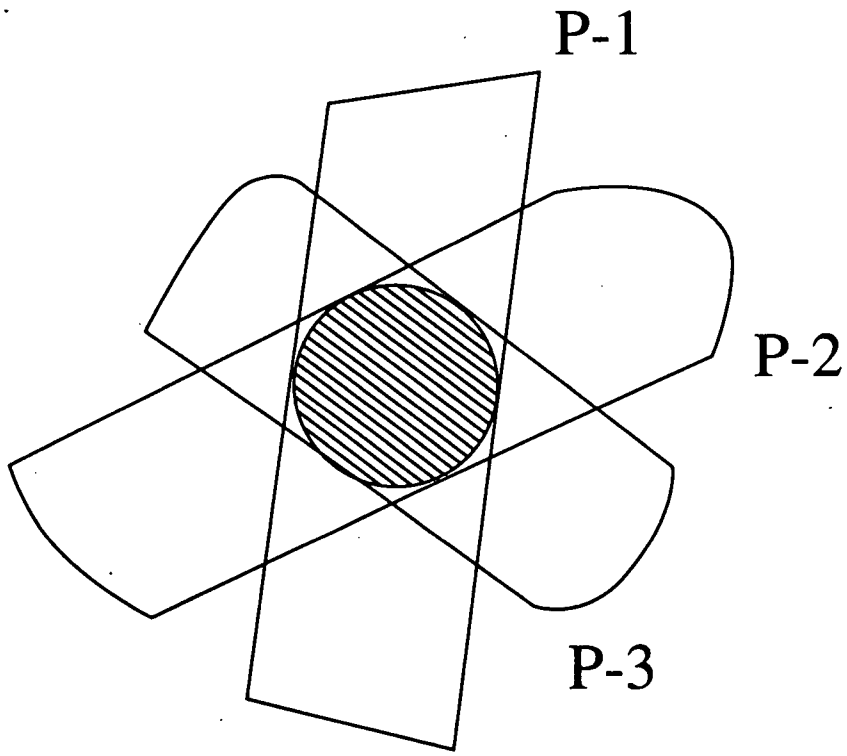
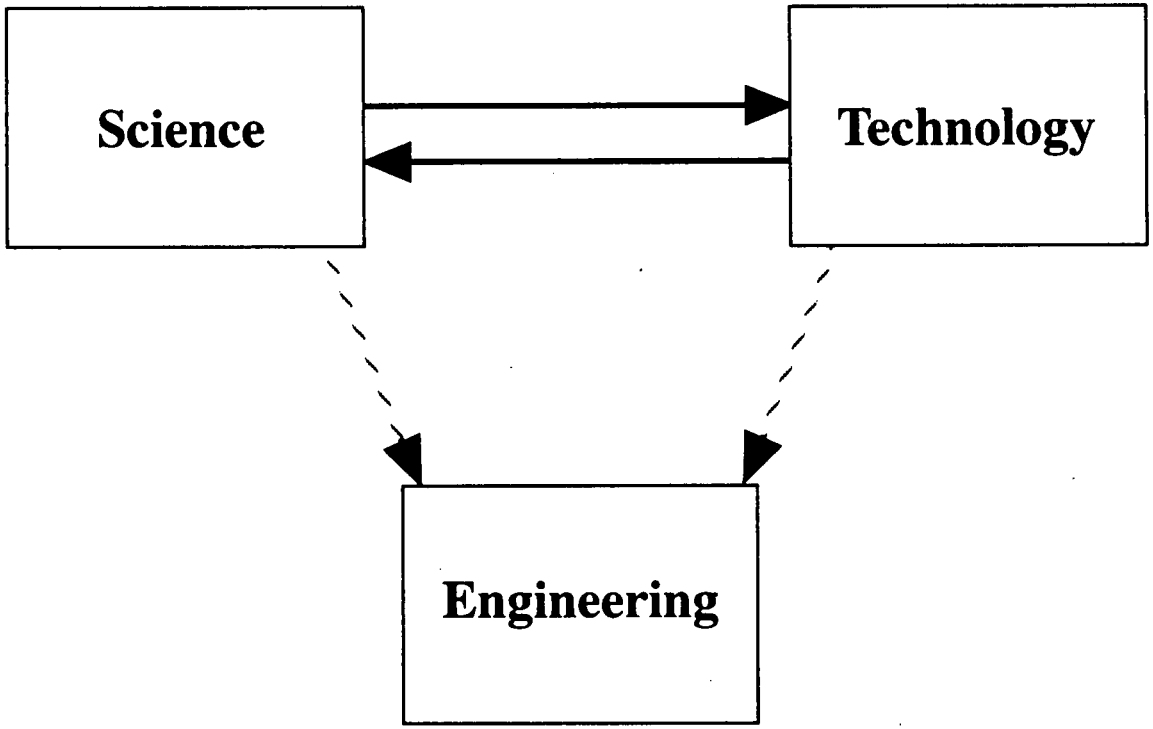
DEVELOPMENT OF OPERATING WINDOW



- Quality Final Waste Form



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ADVANTAGES

- Low Temperature Process
- Locally Available Materials
- Process Equipment Well Developed
- Forgiving Process

DISADVANTAGES

- Volume Increase
- Porous Final Product

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OUTLINE

Introduction

Perspective

Principal Uses

Design of Waste Form

Overall Composition

Chemistry

Pore Fluid Composition

Microstructural Characteristics

Physical Properties

Inter-relationships

Leaching and Transport of Radionuclides and other Species

Examples

Conclusions

SOLIDIFICATION

Soluble Species → Cementing → Physical Containment

↑ Concentration

↓

Disposal

↑

↓

APPLICATION AREAS

Application	Desirable Characts.
Matrix Mat.	Potential to condition E_h and pH. Resistance to aggressive disposal conditions.

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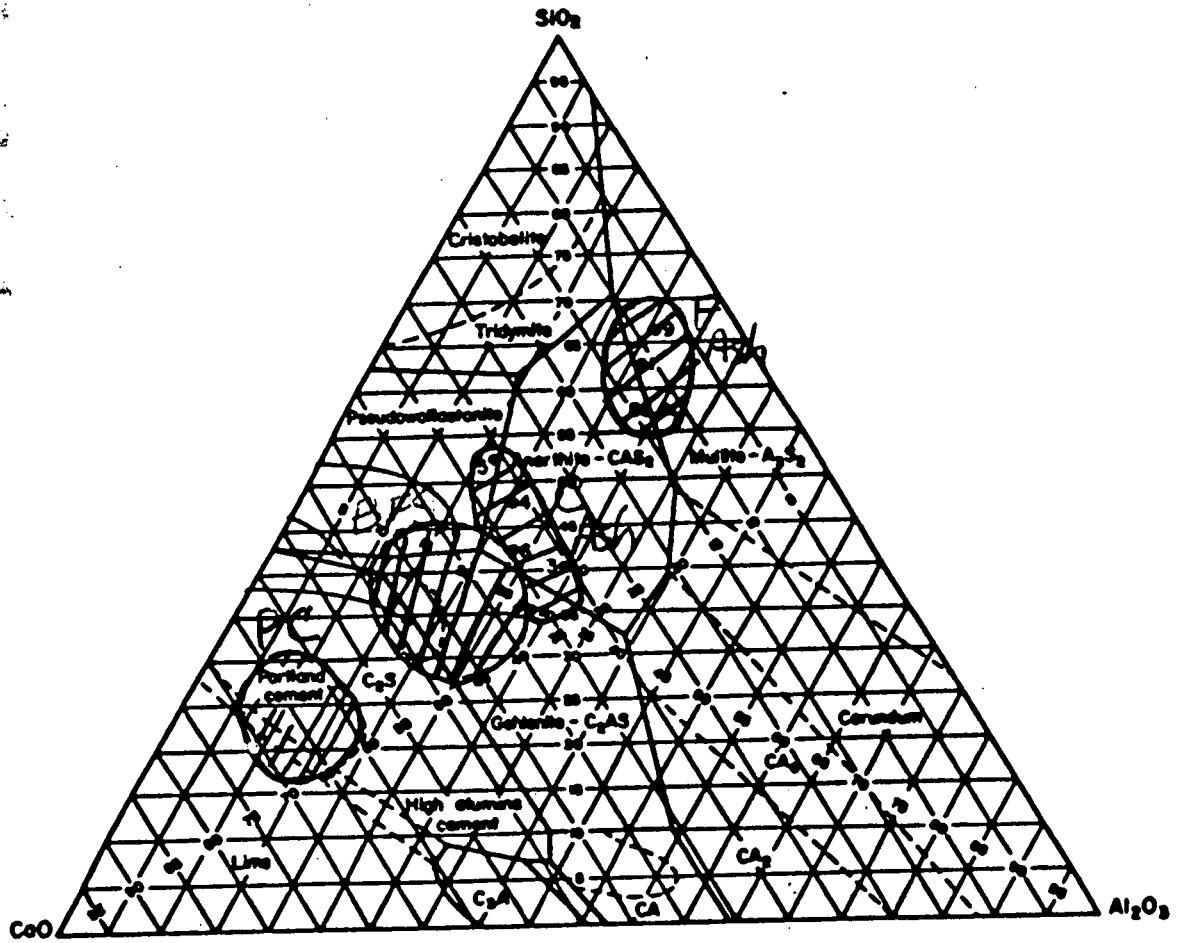
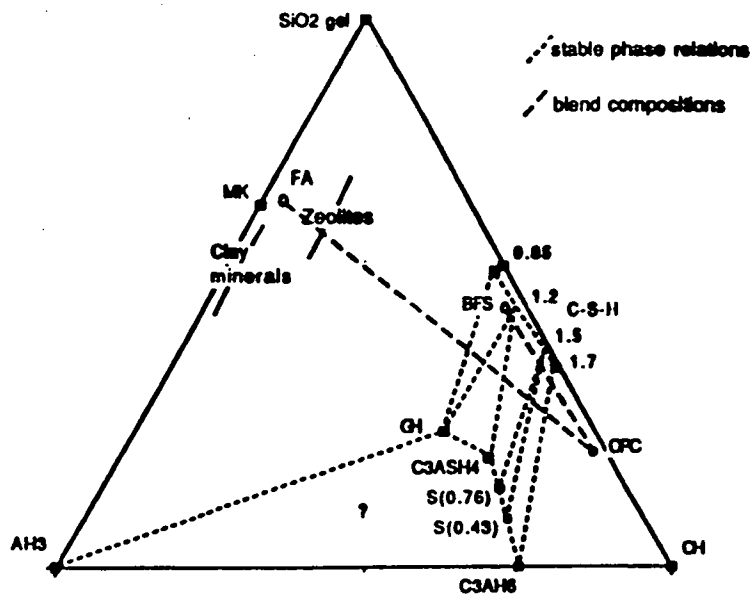
The System CaO-SiO_2-Al_2O_3



Phase	Constitution	Notes
Crystalline		
Ettringite	$C_3A.3CS.32H$ $3CaO.Al_2O_3.3CaSO_4.32H_2O$	Potential substitution of Fe for Al, and various anions for S.
Monosulphate	$C_3A.CS.12H$ $3CaO.Al_2O_3.CaSO_4.12H_2O$	As above.
Hydrogarnet	C_3AH_6 $3CaO.Al_2O_3.6H_2O$- $3CaO.Al_2O_3.SiO_2.4H_2O$	Potential substitution of Fe for Al and SiO_2 for H_2O.
Portlandite	$Ca(OH)_2$ CH	
Hydrotalcite	$4MgO.Al_2O_3.10H_2O$	Potential substitution of various anions for $(OH)_2$.
Amorphous		
C-S-H	(0.9-1.7) $CaO.SiO_2.xH_2O$	Ca/Si ratio ~1.7 in OPC, but less in siliceous blends. Anion sorption increases with increasing Ca/Si ratio. Converse for cations.

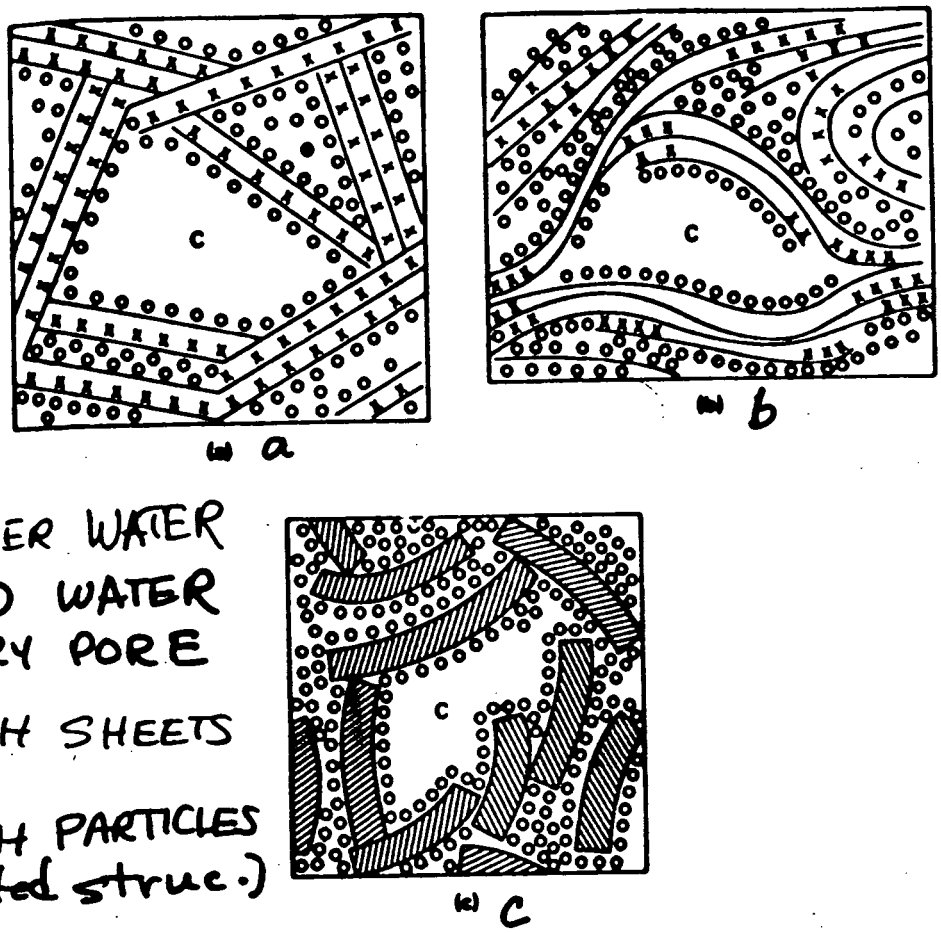
Cement hydrate phases: composition and properties.



Phase relations in the water saturated portion of the C-A-S system at 25°C

Colloidal properties
Porosimetry
Reversibility / irreversibility of mech

Models of C-S-H Structure

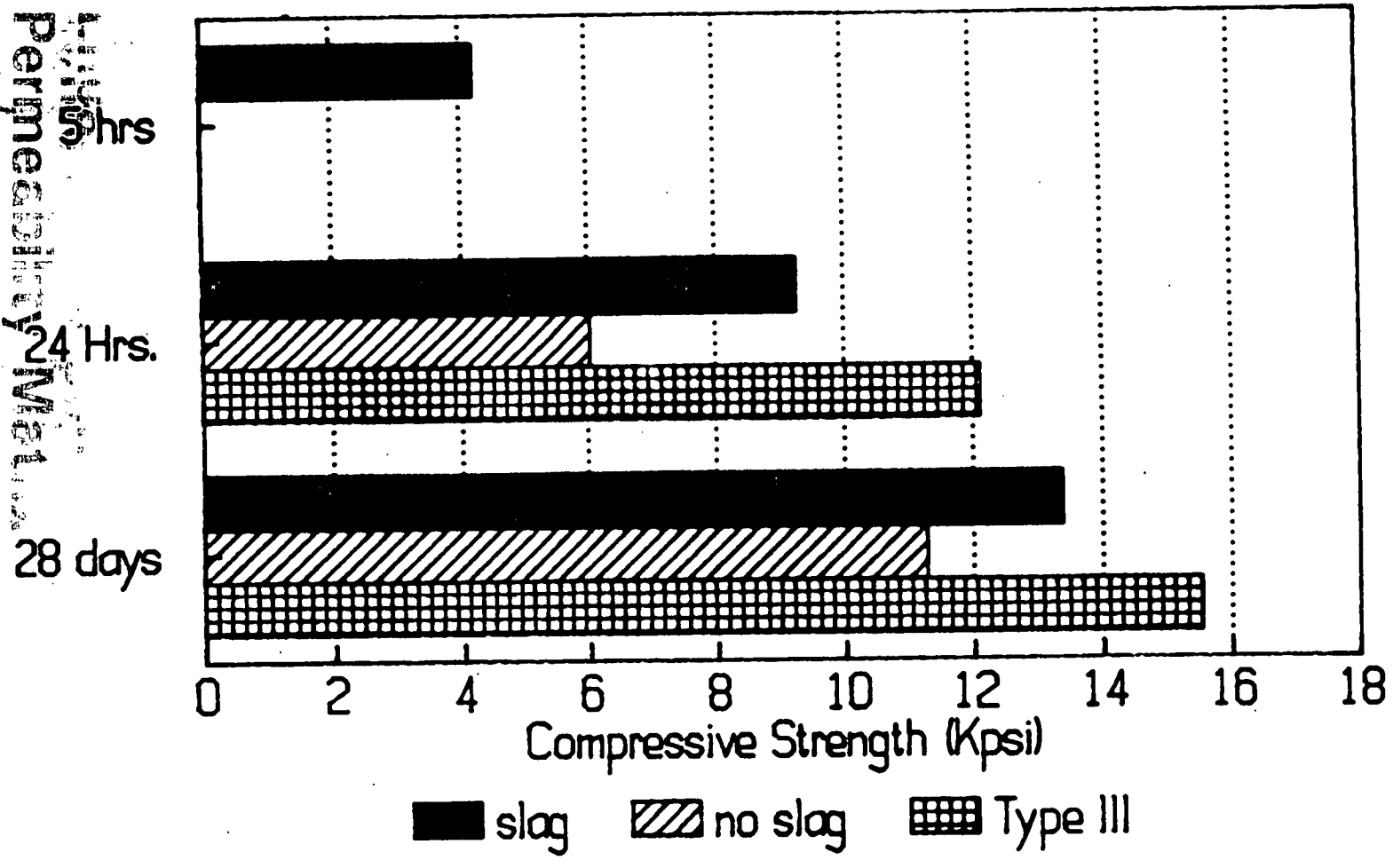


× INTERLAYER WATER
o ADSORBED WATER
C CAPILLARY PORE
—— C-S-H SHEETS
▨ C-S-H PARTICLES (no designated struc.)

(a) Powers-Brunauer (b) Feldman-Sereda
(c) Munich-Wittmann

(In cement paste, crystalline $Ca(OH)_2$ and AFm $C_4A\bar{S}H_{12}$, AFt $C_6A\bar{S}_3H_{32}$, etc. ← anhydrous cement grains interspersed).

Tools to study structure physically
BET, surface characterization
Colloidal properties
Porosimetry
Reversibility / irreversibility of mech. props.

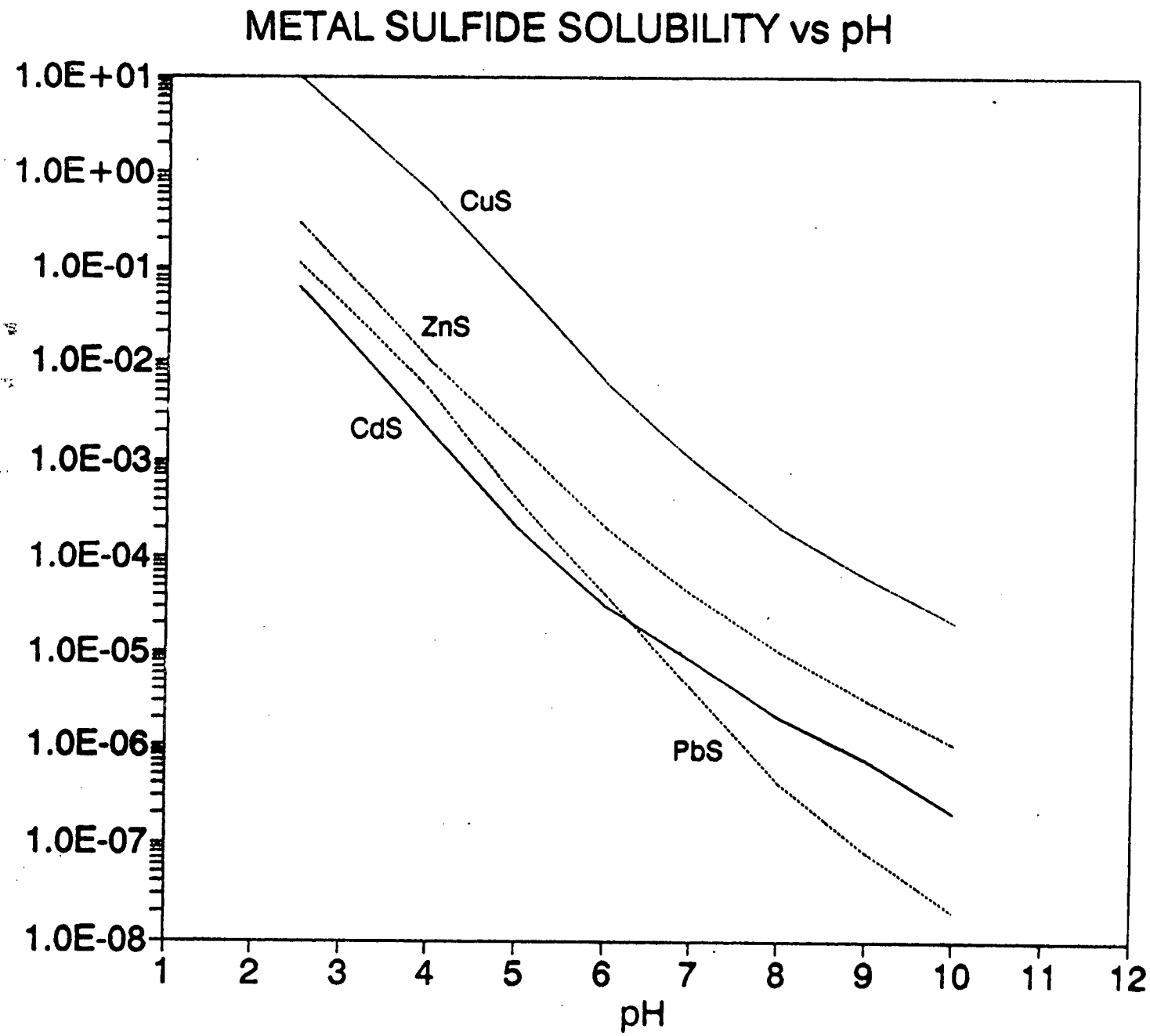

5hrs
24 Hrs.
28 days
0
2
4
6
8
10
12
14
16
18
Compressive Strength (Kpsi)
slag
no slag
Type III

METALS ARE IMMOBILIZED BY....

- Reducing Their Solubility In A Water Environment
- pH Control To Minimum Solubility Zone
- Reaction To A Less Soluble Form
- Control Of ORP
- Adsorption
- Reducing Access of Water To Them
- Coating Of The Particle Surface
- Encapsulating In A Low Permeability Matrix

STEPS IN METAL SOLIDIFICATION/STABILIZATION

1. Control excess acidity/alkalinity by neutralization
2. Eliminate reactivity as necessary
3. Destroy metal complexes as necessary
4. Control oxidation state as necessary
5. Immobilize metals by converting to least soluble species
6. Form a solid matrix with solidification agents


METAL SULFIDE SOLUBILITY vs pH
Metal Solubility (mg/l)
1.0E+01
1.0E+00
1.0E-01
1.0E-02
1.0E-03
1.0E-04
1.0E-05
1.0E-06
1.0E-07
1.0E-08
1
2
3
4
5
6
7
8
9
10
11
12
pH
CuS
ZnS
CdS
PbS

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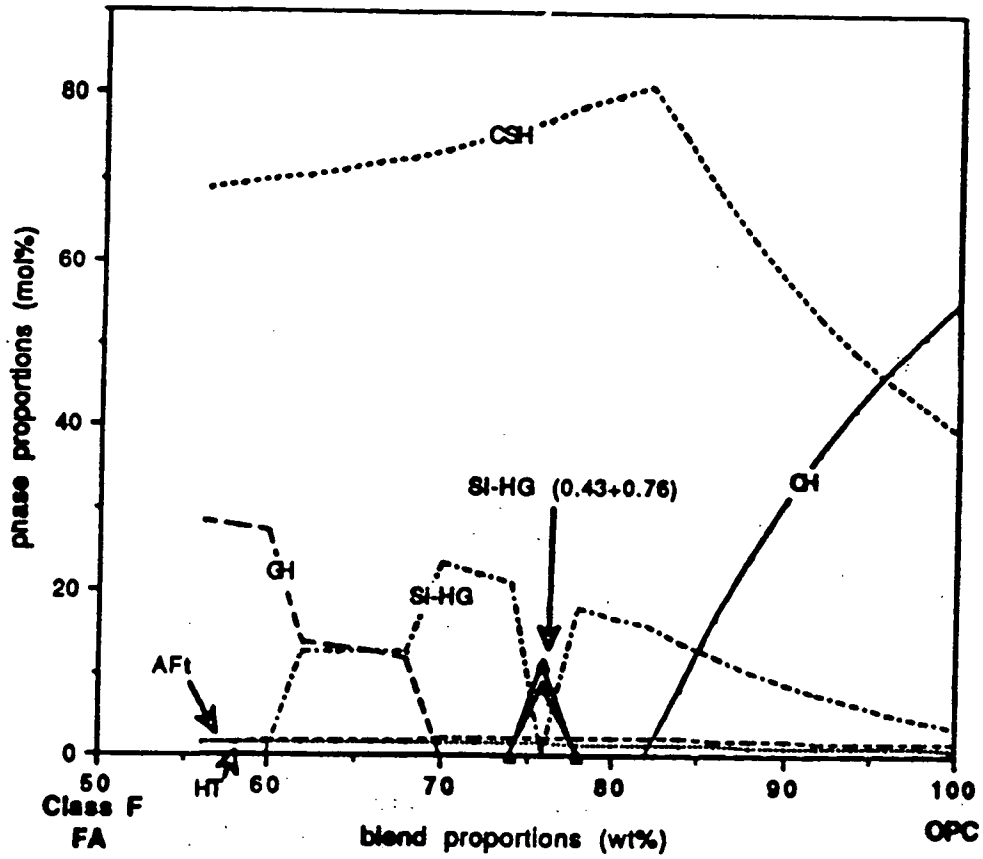
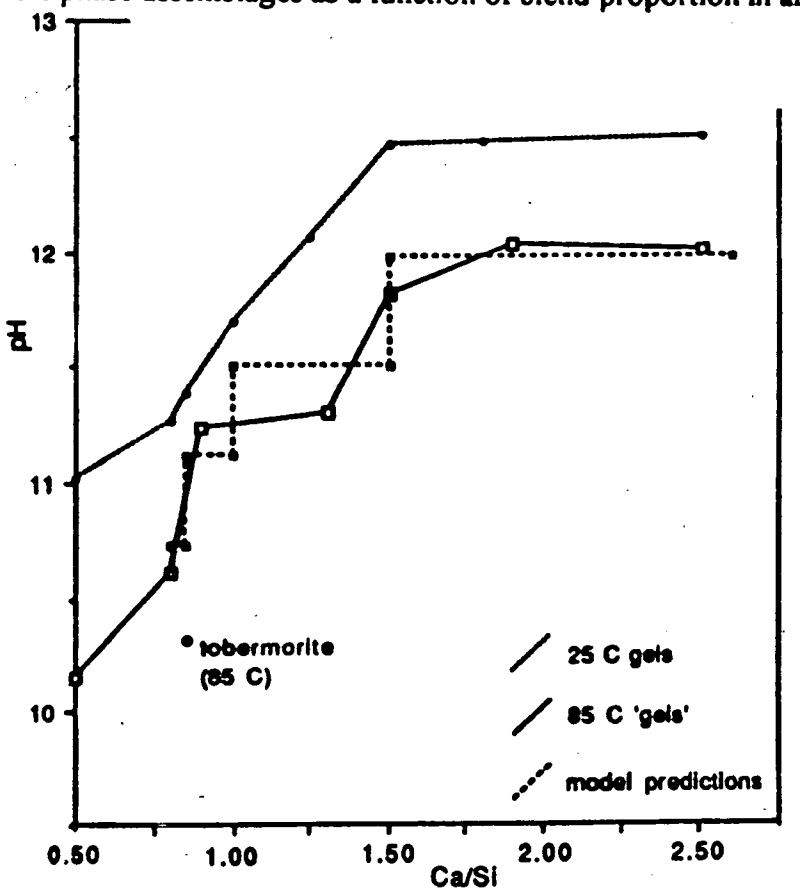
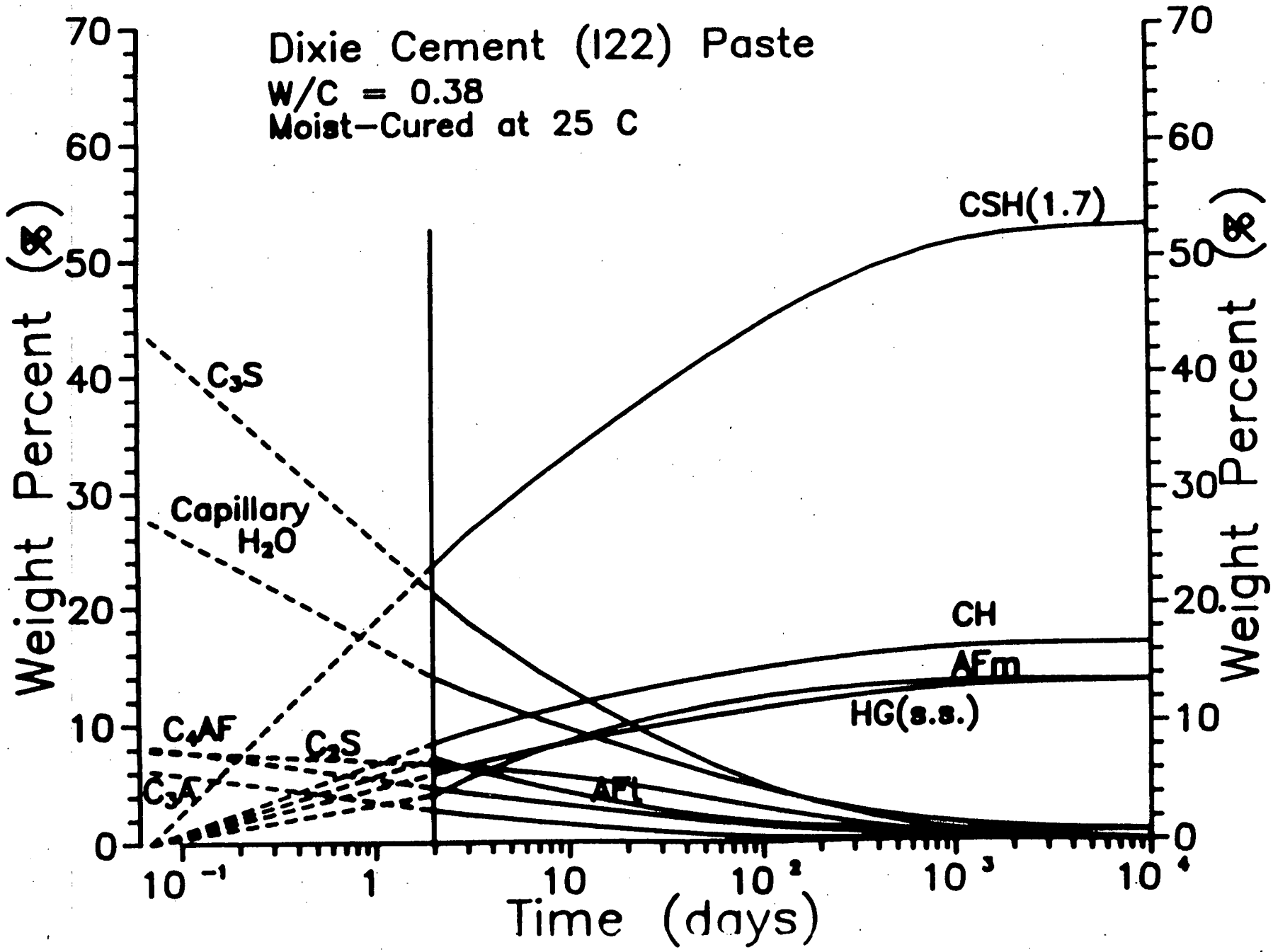
Chemically- Controlled

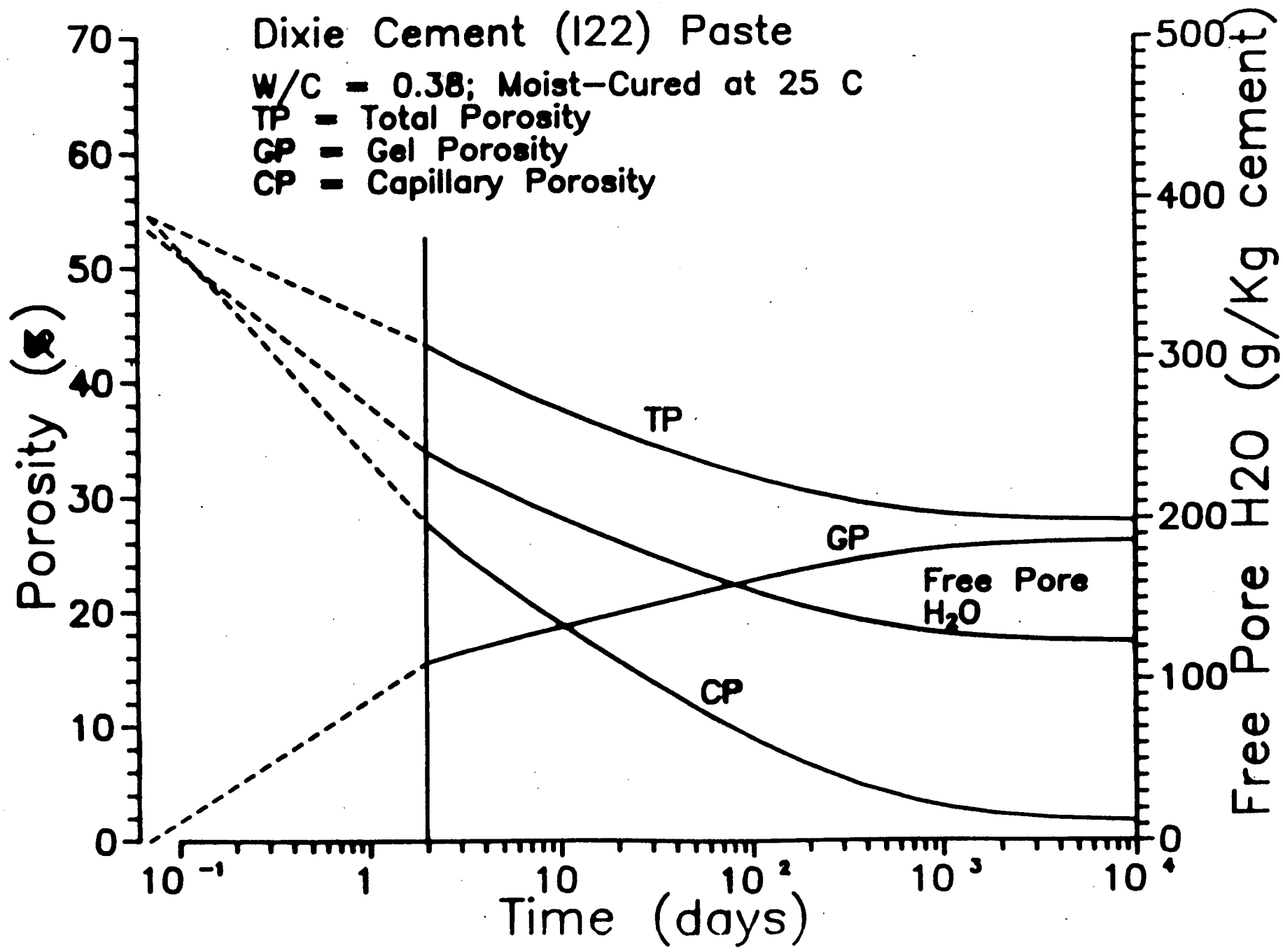


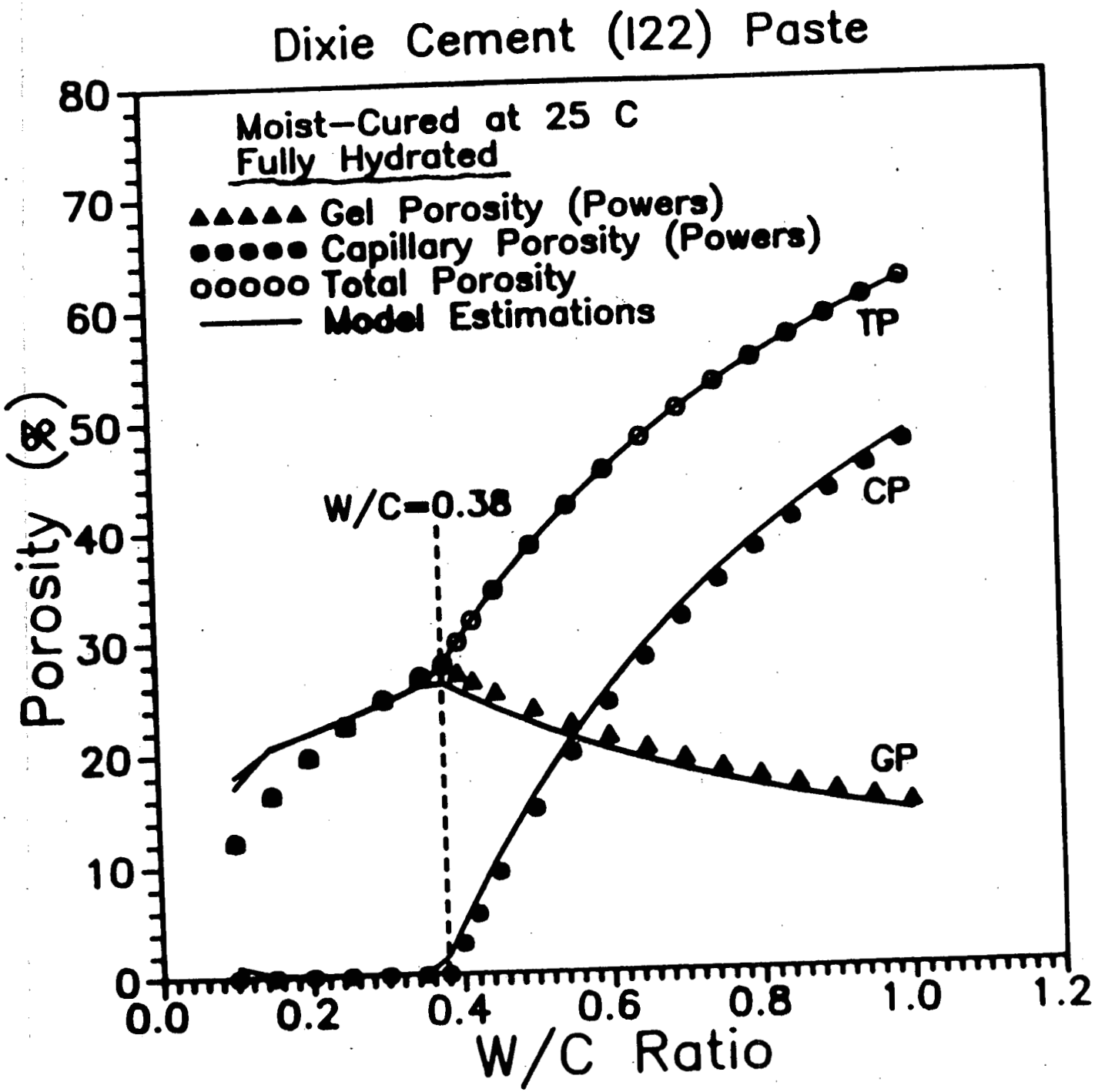
Predicted stable phase assemblages as a function of blend proportion in an example



pH as a function of Ca/Si ratio in the C-S-H system.


Dixie Cement (I22) Paste
W/C = 0.38
Moist-Cured at 25 C
Weight Percent (%)
Time (days)
CSH(1.7)
CH
AFm
HG(s.s.)
AFt
C3S
Capillary H2O
C4AF
C2S
C3A
0
10
20
30
40
50
60
70
10 -1
1
10
10 2
10 3
10 4


Dixie Cement (I22) Paste
W/C = 0.38; Moist-Cured at 25 C
TP = Total Porosity
GP = Gel Porosity
CP = Capillary Porosity
Porosity (%)
Free Pore H2O (g/Kg cement)
Time (days)
TP
GP
CP
Free Pore H2O
70
60
50
40
30
20
10
0
500
400
300
200
100
0
10 -1
1
10
10 2
10 3
10 4


Dixie Cement (I22) Paste
Moist–Cured at 25 C
Fully Hydrated
Gel Porosity (Powers)
Capillary Porosity (Powers)
Total Porosity
Model Estimations
W/C=0.38
TP
CP
GP
Porosity (%)
W/C Ratio
0
10
20
30
40
50
60
70
80
0.0
0.2
0.4
0.6
0.8
1.0
1.2

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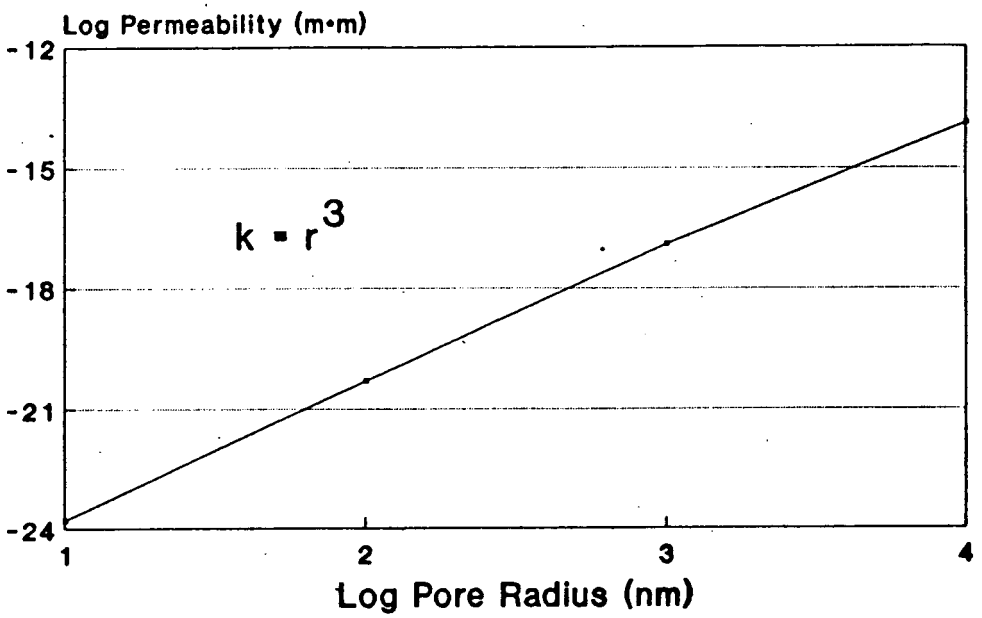
PENNSTATE

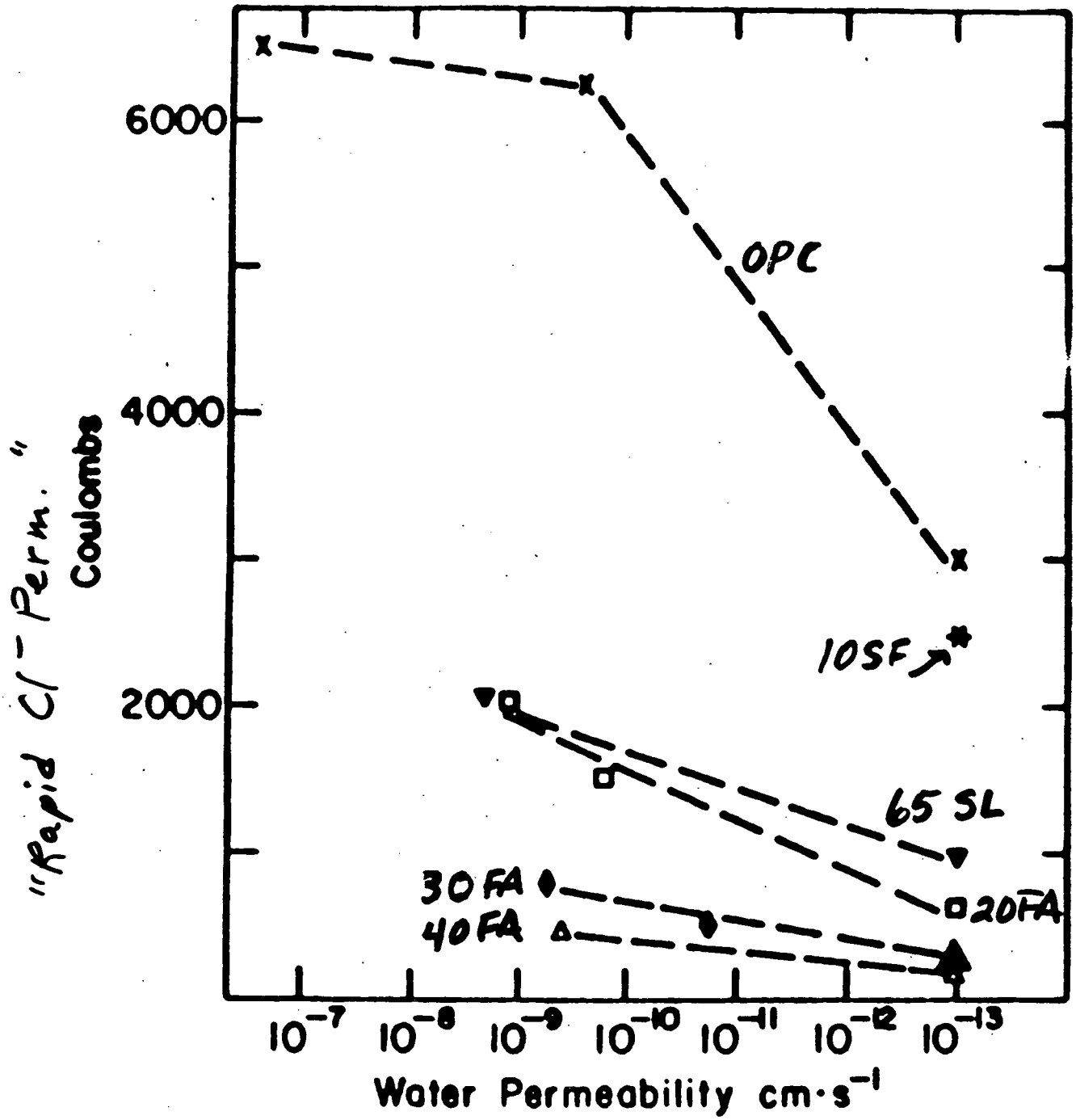
PERMEABILITY vs. POROSITY

OPC pastes



(Atkinson and Hearne, 1984)

Cl "Diffusion/Permeability"



Typical

Corrosion Rates for Magnox Swarf in BFS/OPC

BFS/OPC Ratio	Water/ Cement Ratio	Tempera- ture (°C)	Corrosion Rate (% Corrosion/yr)			
			3 Days	3 Months	1 Year	3-4 yrs
all Scale Non-active						
3:1	0.38	20	0.7	0.02	0.01	<0.01
3:1	0.35	(a)	30.0	0.09	0.04	<0.01
3:1	0.31	20	1.0	0.07	0.01	<0.01
9:1	0.35	20	2.0	0.02	0.01	<0.01
all Scale Active						
3:1	0.31	20	3.0	0.11	0.04	<0.01
3:1	0.35	20	2.5	0.22	0.08	<0.01
3:1	0.31	20(b)	3.0	0.12	0.02	<0.01
3:1	0.31	(c)	2.1	0.22	0.05	0.02(d)
ll Scale Non-active						
3:1	0.33	20	-	0.03	-	<0.01
7:3	0.33	20	-	0.01	-	<0.01
9:1	0.33	20	-	-	<0.01	<0.01

[a] 80°C at 3 days, 40°C at 3 months and 1 year, 20°C 3 years.
[b] Cured at 80°C for 2 days, then 20°C.
[c] 80°C for 2 days then 35°C.
[d] 1.75 years.

SUMMARY, continued

Physical constraints:

- Low permeability
- Mechanical stability
- Fine interwoven solid/pore structure

Environmental factors:

- Near equilibrium state may be attained (especially if elevated temperatures).

SUMMARY

Cementitious waste forms developing widespread use. Chemical factors important in controlling effectiveness:

- Adsorption of ions
- Precipitation of insoluble (thermodynamically stable) phases
- Incorporation of waste species in stable crystalline solutions
- Maintain pH/.Eh

SUMMARY, continued

Environmental factors, continued:

- Steady state pore fluid composition
- Rates of change critical in determining effectiveness.
- Combination of chemistry and micro/pore structure important in minimizing release of undesirable species.

CONCLUSIONS

- Long term performance places demands on waste form
- Combination of physical / chemical factors important in cementitious waste form design
- Inherent "cement paste" composition, microstructural, and environmental exposure conditions combine to control performance
- Many compositional varieties may be devised
- Prediction of performance needs:
  - -control of "fresh state"
  - -development of properties / factors
  - -protection, control during "curing" or development of properties
- Knowledge of operable mechanisms of degradation / rate processes
- Versatile waste forms

H&S REQUIREMENTS

Define radon related requirements for waste treatment operations, transportation and disposal

Clarify relevant health & safety requirements

Doug Daniels

000128

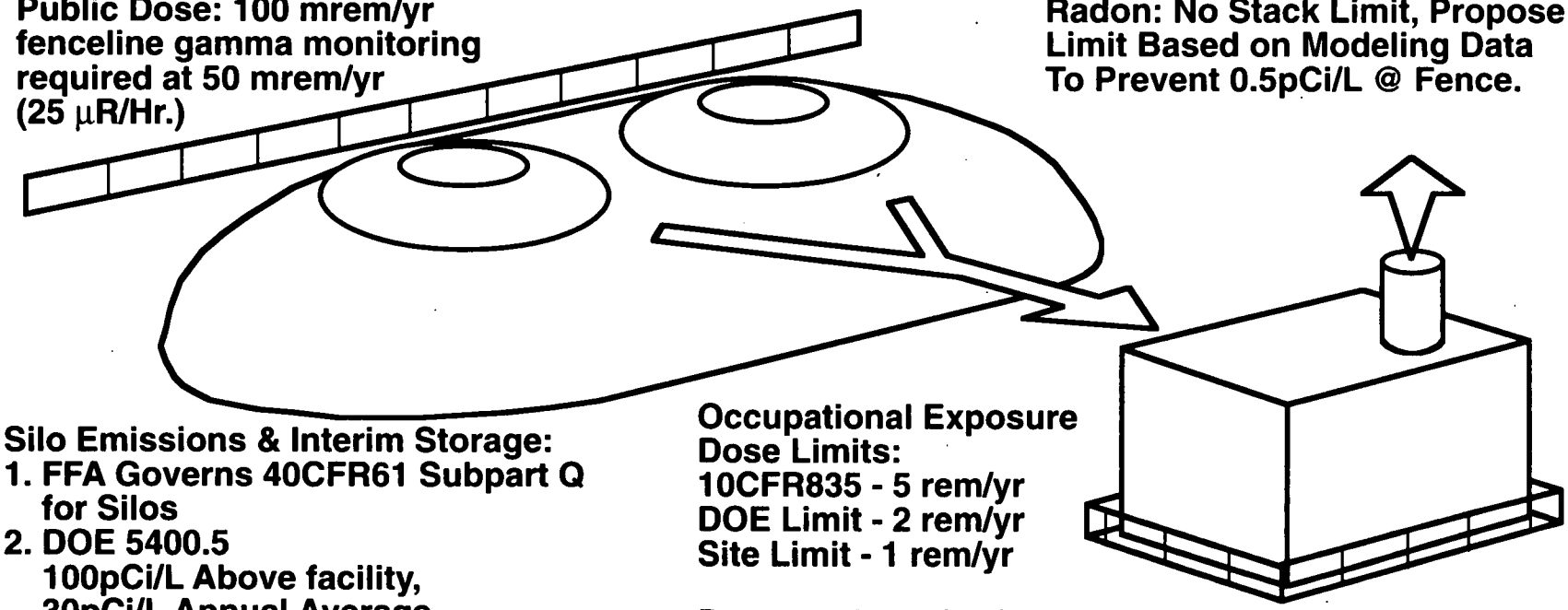
RADIOLOGICAL REQUIREMENTS FOR PROCESSING

FERNALD

Fenceline Limits:
DOE 5400.5 3pCi/L annual avg.
10CFR834 (Draft) 0.5pCi/L annual avg.

Public Dose: 100 mrem/yr
fenceline gamma monitoring
required at 50 mrem/yr
(25 μR/Hr.)

Stack Emissions:
40CFR61 Subpart H
Particulate <10 mrem/yr
(Monitor at 0.1 mrem/yr
Radon: No Stack Limit, Propose
Limit Based on Modeling Data
To Prevent 0.5pCi/L @ Fence.



Silo Emissions & Interim Storage:
1. FFA Governs 40CFR61 Subpart Q for Silos
2. DOE 5400.5
   100pCi/L Above facility,
   30pCi/L Annual Average
   3pCi/L Fenceline Annual Average

Occupational Exposure Dose Limits:
10CFR835 - 5 rem/yr
DOE Limit - 2 rem/yr
Site Limit - 1 rem/yr

Personnel Monitoring Required for:
External Dose Potential - 100 mrem/yr
Internal Dose Potential - 100 mrem/yr
Radon Exposure Potential - 500 mrem/yr (~5pCi/L)

Graphics #4437A.1 2/97

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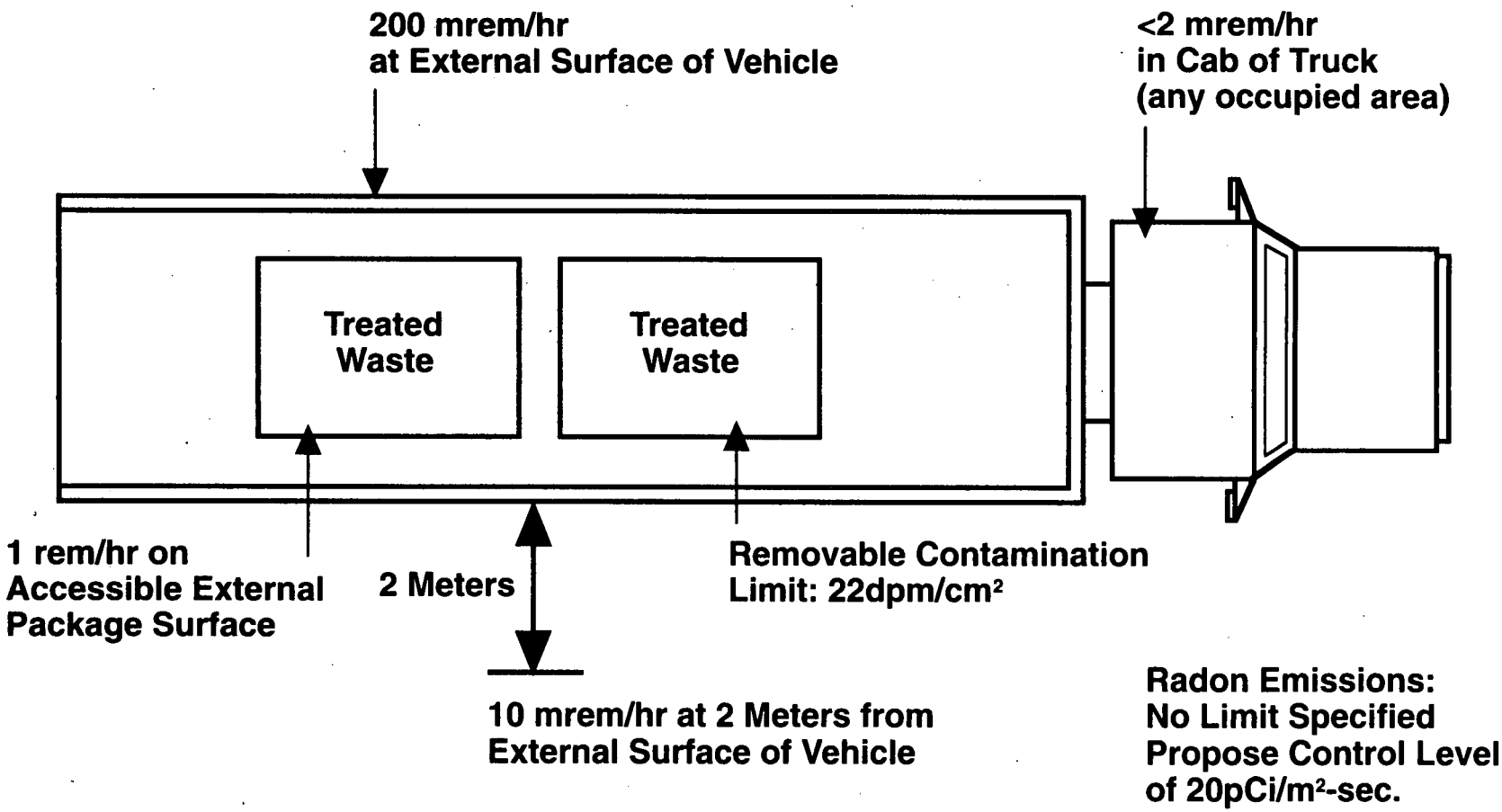
EXCLUSIVE USE, CLOSED TRANSPORT 49CFR173

FERNALD



Radon Emissions:
No Limit Specified
Propose Control Level
of 20pCi/m²-sec.

Graphics #4437A.3 2/97

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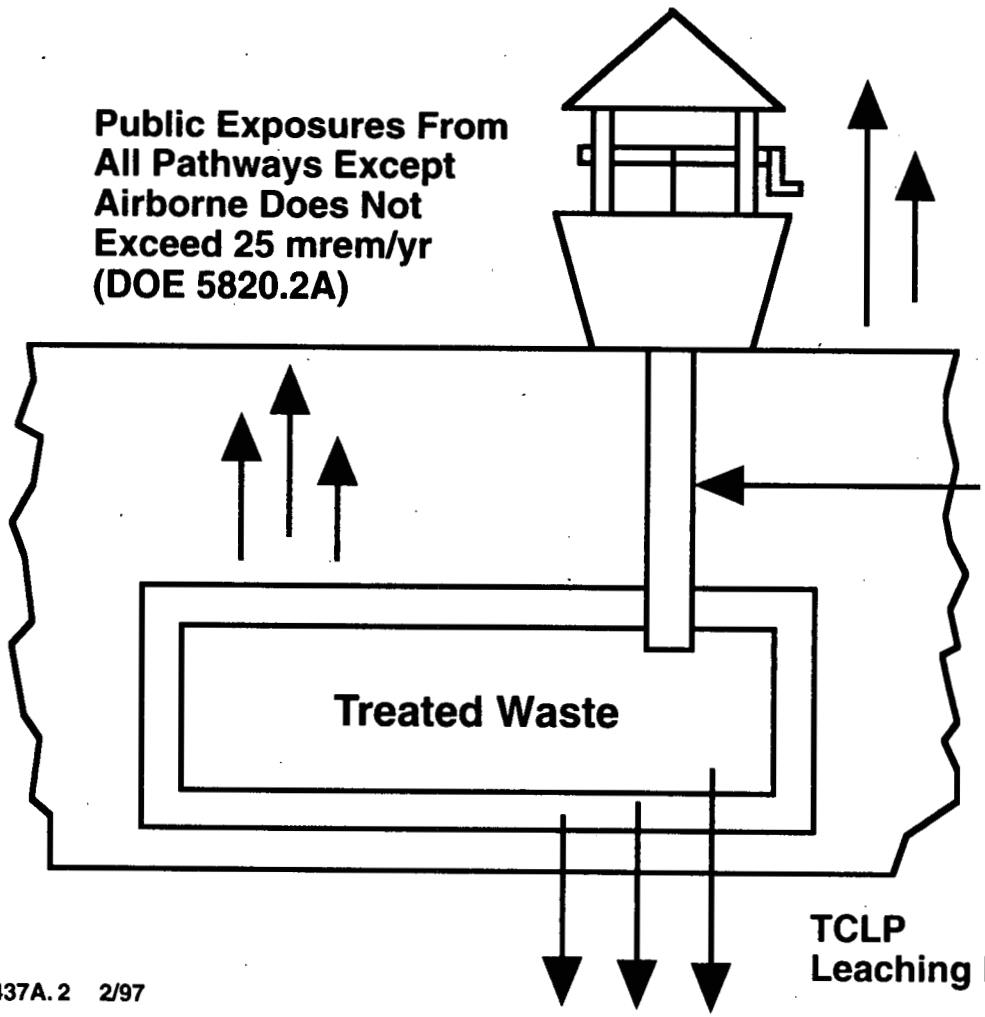
RADIOLOGICAL REQUIREMENTS DISPOSAL SITE (DOE)

FERNALD



Public Exposures From All Pathways Except Airborne Does Not Exceed 25 mrem/yr (DOE 5820.2A)

Air:
40CFR61

Radon
NESHAP Subpart Q
20pCi/m²-sec

Other Particulate
NESHAP Subpart H
(10 mrem/yr Off-Site)

Inadvertent Intrusion
Will Not Exceed 100 mrem/yr
Continuous or 500 mrem
Acute Exposure
(DOE 5820.20A)

TCLP
Leaching Limits

Graphics #4437A. 2 2/97

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LONG TERM EFFECTIVENESS OF WASTE FORMS

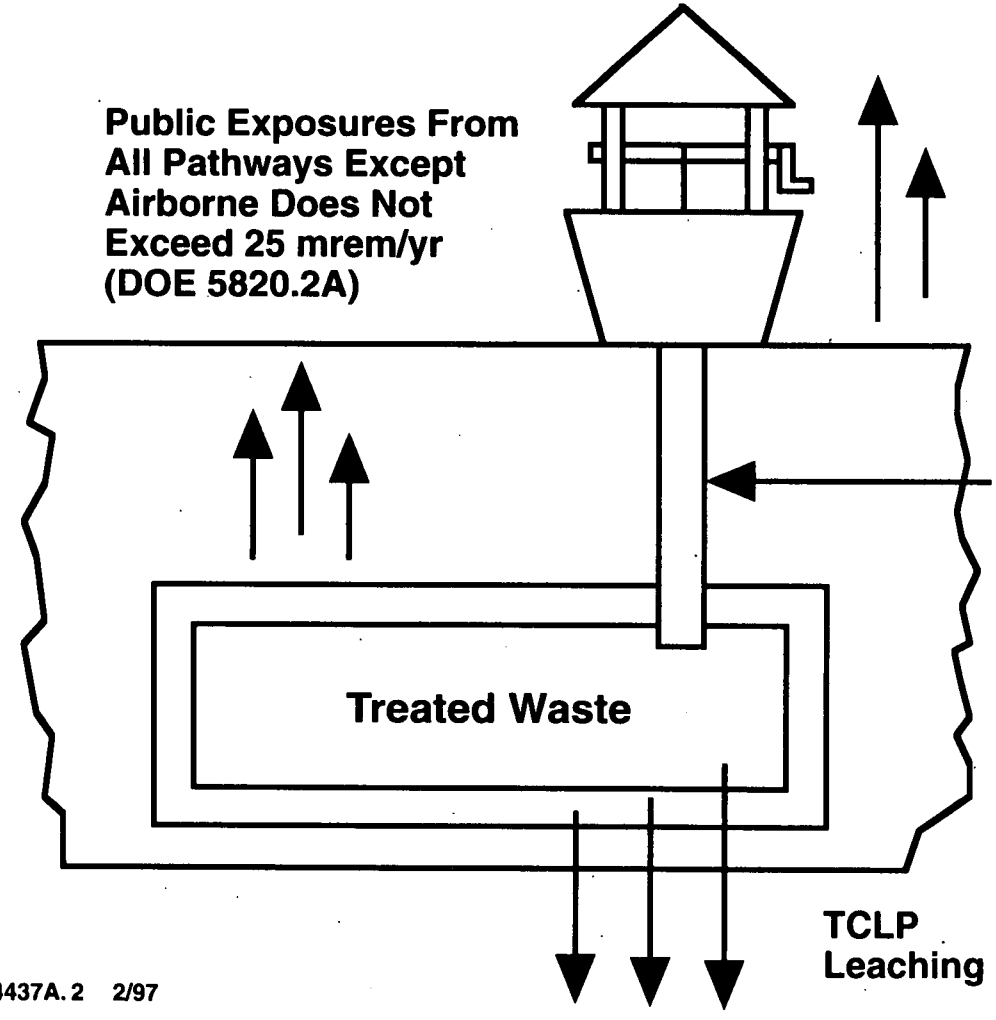
Provide an evaluation showing how alternative waste forms perform with respect to the constituents of concern.

Steve Beckman

Graphics 4437G.2 2/97

RADIOLOGICAL REQUIREMENTS DISPOSAL SITE (DOE)

FERNALD



Public Exposures From All Pathways Except Airborne Does Not Exceed 25 mrem/yr (DOE 5820.2A)

Air:
40CFR61

Radon
NESHAP Subpart Q
20pCi/m²-sec

Other Particulate
NESHAP Subpart H
(10 mrem/yr Off-Site)

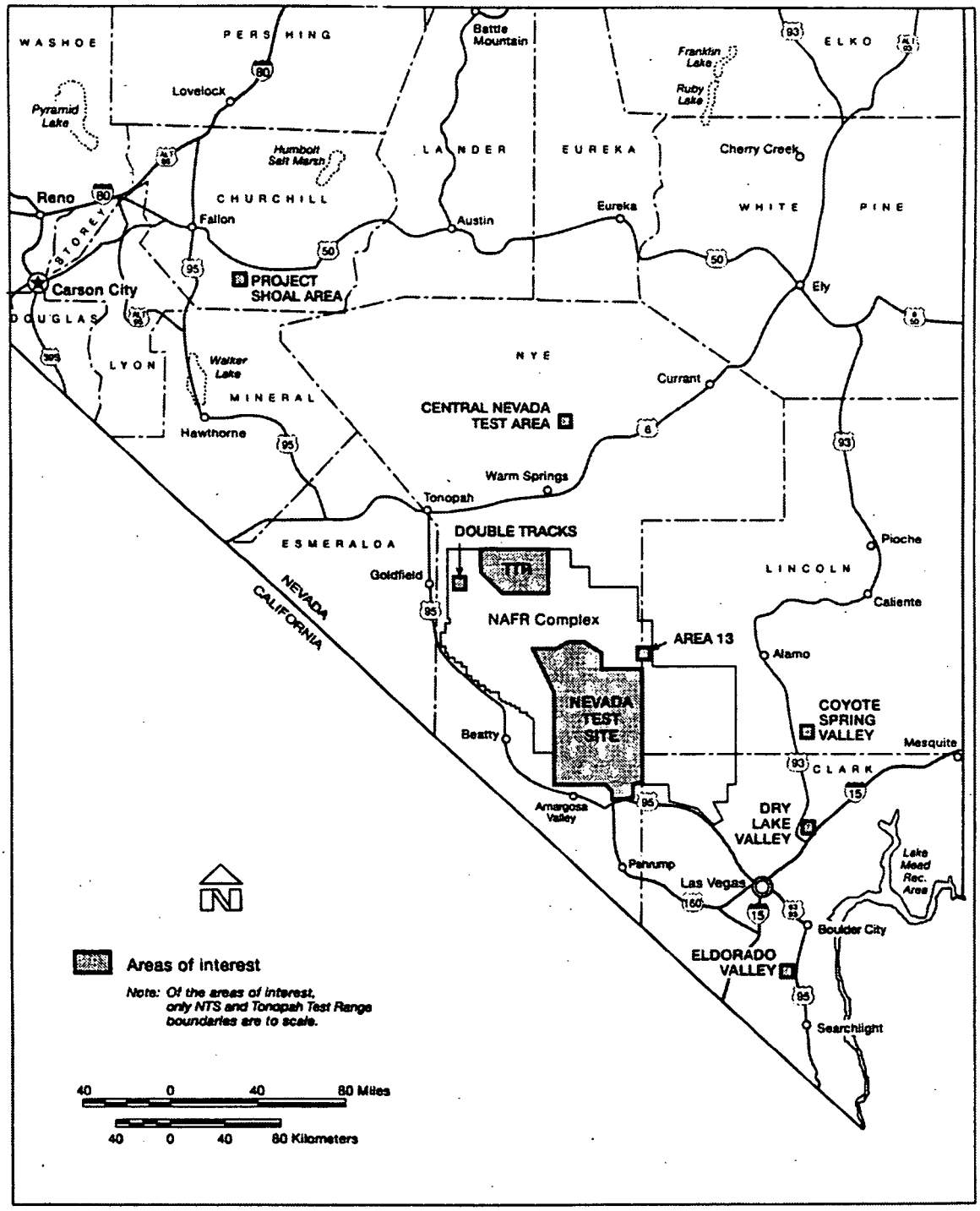
Inadvertent Intrusion
Will Not Exceed 100 mrem/yr
Continuous or 500 mrem
Acute Exposure
(DOE 5820.20A)

TCLP
Leaching Limits

Graphics #4437A. 2 2/97

LOCATION OF NTS

FERNALD

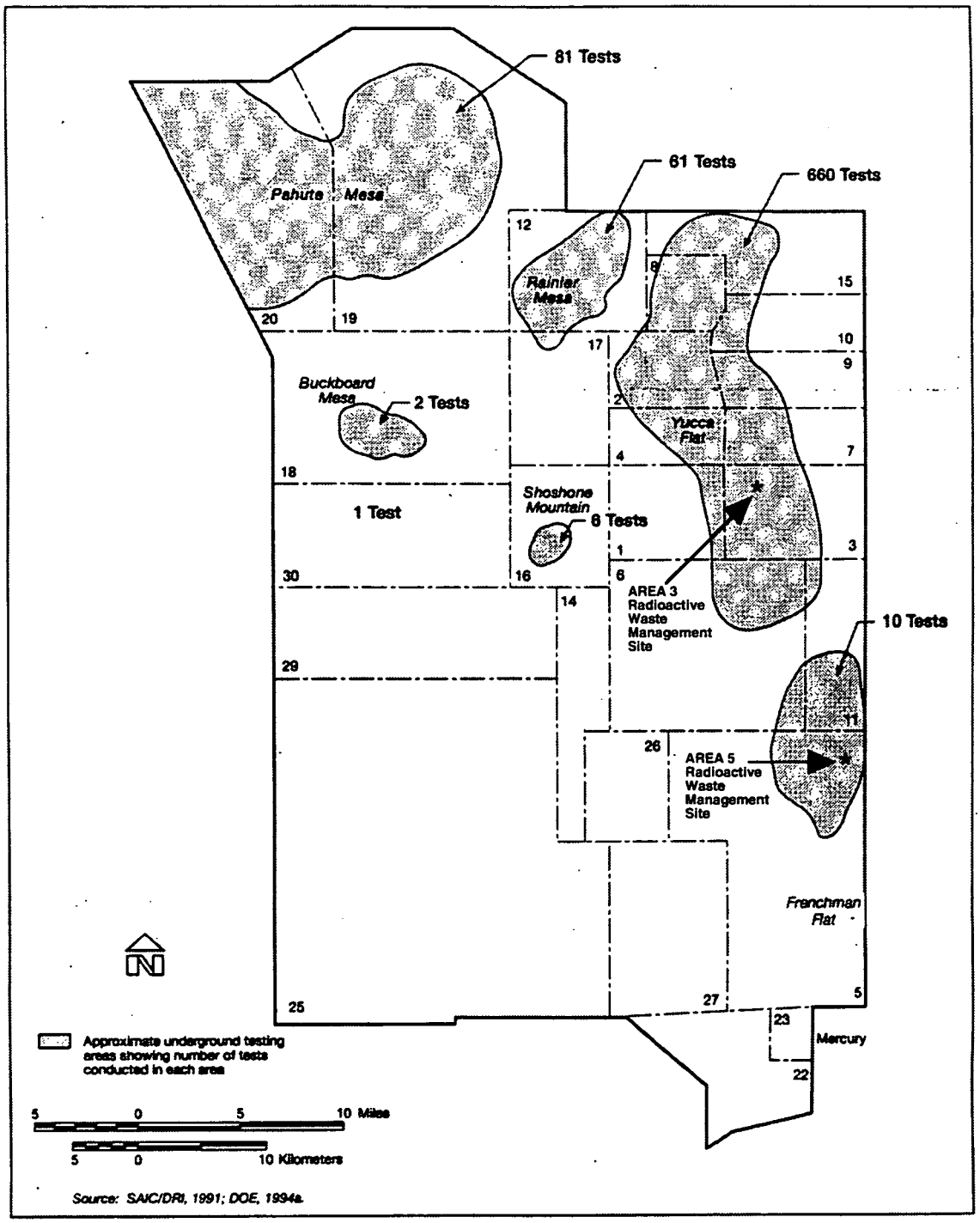


LONG-TERM EFFECTIVENESS

Graphics 4437B.7 2/97

NTS MAJOR FEATURES

FERNALD



Source: SAIC/DRI, 1991; DOE, 1994a.

LONG-TERM EFFECTIVENESS

Graphics 4437B. 8 2/97

AERIAL VIEW OF YUCCA FLAT

FERNALD

Graphics 3974B. 6 2/97

LONG-TERM EFFECTIVENESS

RADIONUCLIDES RCRA METALS

FERNALD

Radionuclides
All Concentrations are = pCi/L

	Regulatory Limit	Untreated	Vitrified	Stabilized (Cement)
Radium - 226	None	53,194	4,415	4,850 - 48,600
Lead - 210	None	763,694	3,470	80 - 495
Thorium - 230	None	272	502	5 - 45
Uranium - 238	None	1623	13	.7 - 3

RCRA Metals

Lead	5mg/L	630mg/L	1mg/L	0.183 - 0.0045mg/L

LONG-TERM EFFECTIVENESS

Graphics 4437B.2 2/97

RADON EMANATION:

FERNALD

Vitrified Waste

- 99% Reduction in Radon Flux
- Radon Emanation (Treated Waste) = .059 pCi/m²/sec
- Regulatory Limit of 20pCi/m²/sec for packaged waste can be met

Stabilized Waste

- 80% Reduction in Radon Flux
- Radon Emanation (Treated Waste) = 1,400 pCi/m²/sec
- Regulatory Limit of 20pCi/m²/sec for packaged waste can be met

LONG-TERM EFFECTIVENESS

Graphics 4437B.1 2/97

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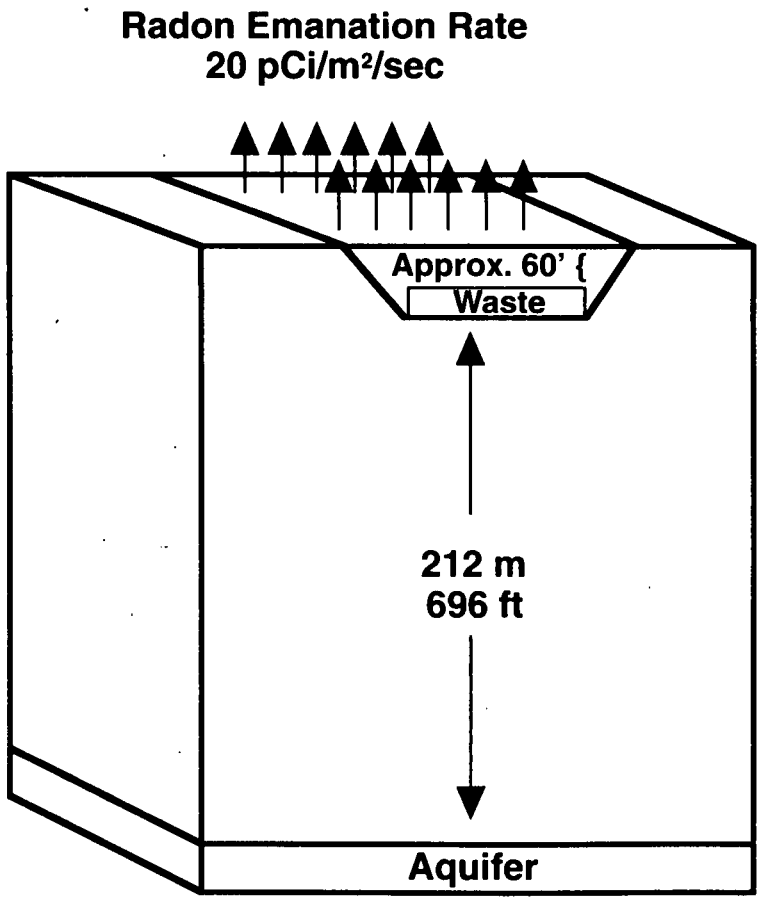
LONG-TERM EFFECTIVENESS

FERNALD

Performance Assessment Considers:

- All exposure pathways
- Conservative assumptions for intrusion



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CONCLUSIONS

FERNALD

- RADON EMANATION - Not an issue; limits will be met by burial depth

- INTRUDER SCENARIO - Cement waste form is more effective due to reduced source concentration

- LEACHING
  - Both glass & cement waste form meet NTS WAC
  - Cement is more effective than glass with respect to lead

- Long-term effectiveness of glass and cement waste forms should not represent a discriminator with respect to treatment technology decision

LONG-TERM EFFECTIVENESS

Graphics 4437C

WHY BLENDING (as a substitution for treatment) IS NOT PERMITTED FOR THE SILO RESIDUES

FERNALD

- Silo Residues are Classified as 11(e)(2) Byproduct Material
- RCRA is a "Relevant and Appropriate" Requirement Due to Their Hazardous Characteristics
- CERCLA Mandates Compliance with Substantive Requirements of RCRA (ie. Treatment of Residues to Eliminate Hazardous Characteristics) for Onsite Activities
- "Blending" or Dilution Cannot be Used as the Treatment Method Where Other Viable Methods Exist Under RCRA

BLENDING SILO 3 RESIDUES WITH MATERIAL FROM WASTE PIT 5

This fact sheet evaluates the concept of blending Silo 3 residues with material from Waste Pit 5 for final disposal at Envirocare of Utah.

SILO 3 WASTE DEFINITION

- Silo 3 residues are waste material produced from the extraction and concentration of uranium bearing ore. The Atomic Energy Act (AEA) of 1954, Section 11(e)(2), as amended, defines the Silo 3 residues as byproduct material.

- As 11(e)(2) byproduct material, the Silo 3 residues are specifically exempt from regulation as solid waste under the Resource Conservation and Recovery Act (RCRA) 40 CFR § 261.4(a)(4).

- Silo 3 residues cannot be disposed of at Envirocare of Utah, as 11(e)(2) byproduct material because a few of the radionuclides, including lead-210, radium-226, and thorium-230, exceed the 11(e)(2) byproduct material license criteria of 2,000 pCi/g for radionuclides in the uranium series.

- It is the opinion of Fluor Daniel Fernald that blending Silo 3 residues with either soil or other waste (i.e., Waste Pit 5) would result in Silo 3 residues losing their classification as 11(e)(2) byproduct material. In addition, the intent to blend Silo 3 residues with either soil or other waste with the knowledge that the residues would be reclassified as low level waste would require the residues to be classified and managed as low level waste prior to blending. Because the Silo 3 residues exhibit the toxicity characteristic, classification as low level waste would require management as a mixed waste in accordance with all RCRA requirements including the land disposal restrictions (LDRs).

- Silo 3 residues can be managed as 11(e)(2) byproduct material at the Nevada Test Site (NTS) as small volume. However, the residues must be treated to meet the NTS waste acceptance criteria.

SILO 3 UNDER RCRA

- Silo 3 residues contain heavy metal contaminants that were present in the natural ore, and that were unintentionally extracted from the parent ore along with the uranium during the process of extraction. Leachate from the Silo 3 residues exceed the toxicity characteristic limits established under 40 CFR § 261.24 for four of these metals: arsenic, cadmium, chromium, and selenium.

- If it were not for the exemption from RCRA afforded Silo 3 residues for being AEA 11(e)(2) byproduct material, the Silo 3 residues would be classified as mixed hazardous waste due to exhibiting the characteristic of toxicity and the presence of radionuclides in the waste.

- Treatment is defined under 40 CFR § 260.10 as "any method, technique, or process, including neutralization, designed to change the physical, chemical, or biological character or composition of any hazardous waste so as to neutralize such waste, or so as to recover energy or material resources from the waste, or so as to render such waste nonhazardous, or less hazardous; safer to transport; store, or dispose of; or amenable for recovery, amenable for storage, or reduced in volume".

SILO 3 UNDER CERCLA

- Silo 3 residues are being remediated in accordance with the Comprehensive Environmental Response Compensation and Liability Act (CERCLA). Section 121(d) of CERCLA requires that, at the completion of remedial action, the site should achieve a level of control that complies with federal and state environmental laws that are applicable or relevant and appropriate requirements (ARARs) for the hazardous substances, pollutants, or contaminants that remain on site.

- Because Silo 3 residues are exempt from RCRA, the requirements under RCRA are not considered "applicable" to the remediation of the Silo 3 residues. Silo 3 residues are considered to be sufficiently similar to hazardous waste, due to exhibiting the toxicity characteristic for arsenic, cadmium, chromium, and selenium. Therefore, certain requirements under RCRA are considered "relevant and appropriate" to the remediation of Silo 3 residues.

- "Relevant and appropriate" requirements that are identified for alternatives involving off-site disposal activities must be met for only the onsite (activities at the FEMP) portions of those alternatives. In addition, onsite remedial actions are required to comply only with substantive parts of the ARARs. Therefore, only the substantive parts of RCRA requirements identified as ARARs need to be met for the alternatives that identify onsite treatment of Silo 3 residues followed by off-site disposal.

- Reclassification of Silo 3 residues to low level mixed waste would result in requirements under RCRA becoming "applicable" to the remediation of the residues. Onsite remedial actions would still only be required to comply with the substantial parts of the RCRA requirements. In addition, off-site remedial action would only have to comply with "applicable" requirements, however, the remedial actions would have to comply with both the substantive and administrative parts of the "applicable" RCRA requirements. [illegible] of the residues. This would [illegible] identified as "a blending [illegible] being c[illegible]d an option for management [illegible] the residues [illegible] blending from is not recognized as a substitute for adequate treatment. is not recogniz

- The treatment of the Silo 3 residues would be considered a substantial part of the RCRA requirements. Although the AEA 11(e)(2) byproduct material can be blended with other nonhazardous waste material through its exclusion from RCRA requirements, the relevance and appropriateness of RCRA requirements to the Silo 3 residues preclude the use of blending as a treatment option to remove a characteristic, since RCRA and CERCLA do not recognize blending as a substitute for adequate treatment.

- Blending Silo 3 residues with material from the Waste Pits would not be consistent with CERCLA section 121(b)(1) preference for a remedial alternative that "permanently and significantly reduces the volume, toxicity, or mobility of the hazardous substances or contaminated materials". This section further states, "The off-site transport and disposal of hazardous substances or contaminated materials without such treatment should be the least favored alternative remedial action where practicable treatment technologies are available".

- Blending Silo 3 residues with material from the Waste Pits would neither reduce the mobility of the heavy metal contaminants, nor destroy the heavy metal contaminants to reduce the toxicity. Blending would merely dilute the heavy metal contaminants through an increase in total volume to eliminate the toxicity characteristic under RCRA. Practicable stabilization technologies are available for treating the Silo 3 residues that would reduce the mobility of the heavy metal contaminants and eliminate the toxicity characteristic under RCRA.

CONCLUSION

The Silo 3 residues are classified as 11(e)(2) byproduct material as defined by the AEA of 1954, as amended. The NTS can accept the Silo 3 residues as "small volume" 11(e)(2) byproduct material for disposal if the residues meet the NTS waste acceptance criteria (WAC). However, the NTS WAC requires treating the residues to immobilize the heavy metal contaminants to remove the toxicity characteristic.

At this time, Silo 3 residues cannot be disposed of at Envirocare of Utah as 11(e)(2) byproduct material. For Envirocare of Utah to accept Silo 3 residues for disposal, either Envirocare's 11(e)(2) byproduct material license criteria for radionuclides would have to be raised by a factor of 30 or the Silo 3 residues would have to be reclassified as low level mixed waste.

Identification of "relevant and appropriate" requirements that reference the dilution prohibition under RCRA prohibit blending Silo 3 residues, without further treatment, with any material with the expectation of removing the hazardous characteristic. In addition, if Silo 3 residues were reclassified as low level mixed waste, RCRA requirements would be identified as "applicable" to the remediation of the residues. This would also preclude blending from being considered an option for management of the residues, since blending is not recognized as a substitute for adequate treatment.

Graphics 4437G

PRETREATMENT ALTERNATIVES

What is the potential for removing lead prior to waste treatment?

John Smets

Graphics 4437G. 7 2/97

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Reduce Compl
of Melter Oper

Increase
Production Ra

Graphics 4437

Graphics 4437J: 2

PRETREATMENT

FERNALD

Task	Method	Advantages	Disadvantages	Relative Cost
Selective Lead Removal *Utilize Alter* *Reduce Complexity of Melter Operations and Metallurgy*	Extractive Metallurgy (Smelting)	• Technically Feasible	• Molten Slag (product glass) May not Pass TCLP • Foaming Problems in VITPP Melter May be Transferred to Smelter • Separate Processing needed for Lead • More Complex Plant Design	High
	Hydrometallurgy (Solvent Extraction)	• Technically Feasible	• Process Not Yet Commercialized • Requires Acidification & Dissolution of All or Most of Plant Feed • Separate Processing Needed for Lead • More Complex Plant Design	High
Selective Sulfate Removal *Reduce Complexity of Melter Operations* *Increase Production Rates*	No Technically Feasible Process Found			

Graphics 4437J: 2 2/97

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FERNALD

Task	Method	Advantages	Disadvantages	Relative Cost
Bentonite Separation *Utilize Alternative Disposal Method / Controlled Bentonite Addition to Feed*	Vacuum Removal with Aid of Houdini	• Good Separation Likely • Dry Process	• Feasibility Remains TBD • Must Dry & Crush Material Before Transfer • Significant Reliance on Houdini	Higher Than Baseline
	Hydraulic Retrieval and Transfer, Separation in Thickner	• Relatively Low Maintenance & High Reliability	• Required Design Data Not Yet Available • Bentonite Recovered as a Dilute Slurry • Lack Control of Bentonite Quantity in Feed	Baseline
	Clamshell Removal With Aid of Houdini	• Compatible With Subsequent Hydraulic Transfer & Thickener Separation • Clamshell is Simple, Robust & Reliable	• Significant Reliance on Houdini • Impact on Equipment Room TBD	Higher Than Baseline

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Graphics 4437G. 8 2

NIAGARA EXPERIENCE

Can we benefit from the experience at Niagara?

John Smets

000148

Graphics 4437G. 8 2/97

Graphics 4437H

NIAGARA FALLS STORAGE SITE

FERNALD

- Originally Lake Ontario Ordnance Works
- Storage of K-65 materials / Overflow sent to Fernald
  Material at NFSS = 3,000 m^3
  Material at FEMP = 6,130 m^3
- Transferred by Hydraulic Mining (1983-1985)

NIAGARA FALLS STORAGE SITE

FERNALD

- Contacted Staff at Niagara Falls:
  - Eric Newbury
  - Andy Phelps
- Reviewed Material and Requested Additional:
  - Video of Transfer Operations
  - Miscellaneous Reports
- Personnel will be involved in Reviews of FEMP Retrieval Concept Development

GOAL

SILO WASTE CHARACTERIZATION

DENNIS NIXON

Page 1

SILOS CHARACTERIZATION

GOAL

- The goal of the residue sampling effort was to obtain a complete cross section of the Silo's contents to confirm the physical, chemical, and radiological characteristic of the residue

- Provide residues to support the baseline risk assessment and perform treatability studies

Page 1a

SILO SAMPLING EFFORTS

- Silo 3 Residue Sampling completed in May 1989
- Silo 1 and 2 (K-65) Residue Sampling was completed on August 26, 1991 in accordance with the approved work plan.
- Sufficient material was collected throughout all silos cross sections to conduct all required analysis outlined in the Sampling and Analysis Plan in addition to providing the materials required to perform scheduled treatability studies.

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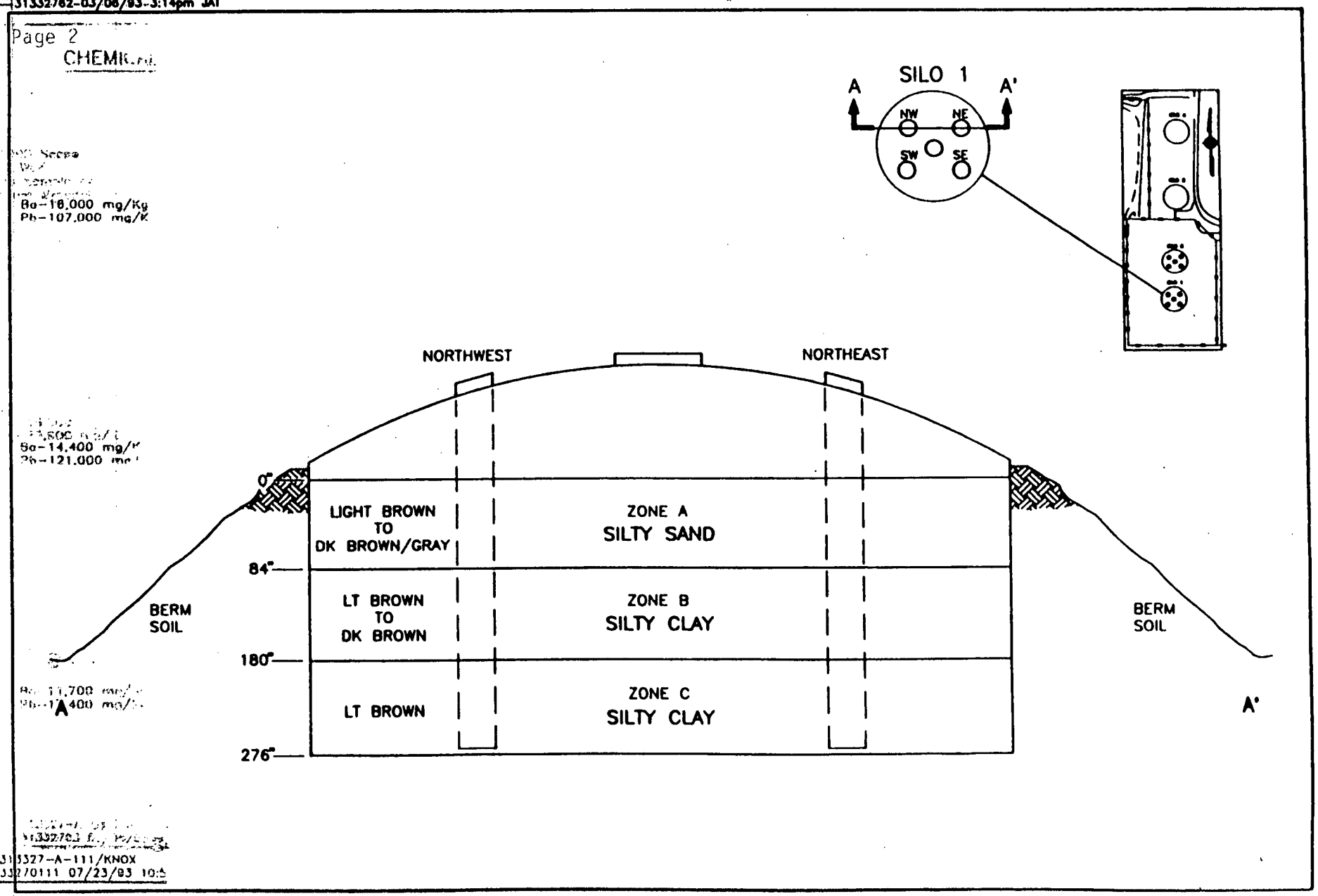

FIGURE 3-1. GENERALIZED VISUAL DESCRIPTION FOR SILO 1 CONTENTS

Ba-11,700 mg/Kg
Pb-17,400 mg/Kg

313327-A-111/KNOX
33270111 07/23/93 10:53am REP

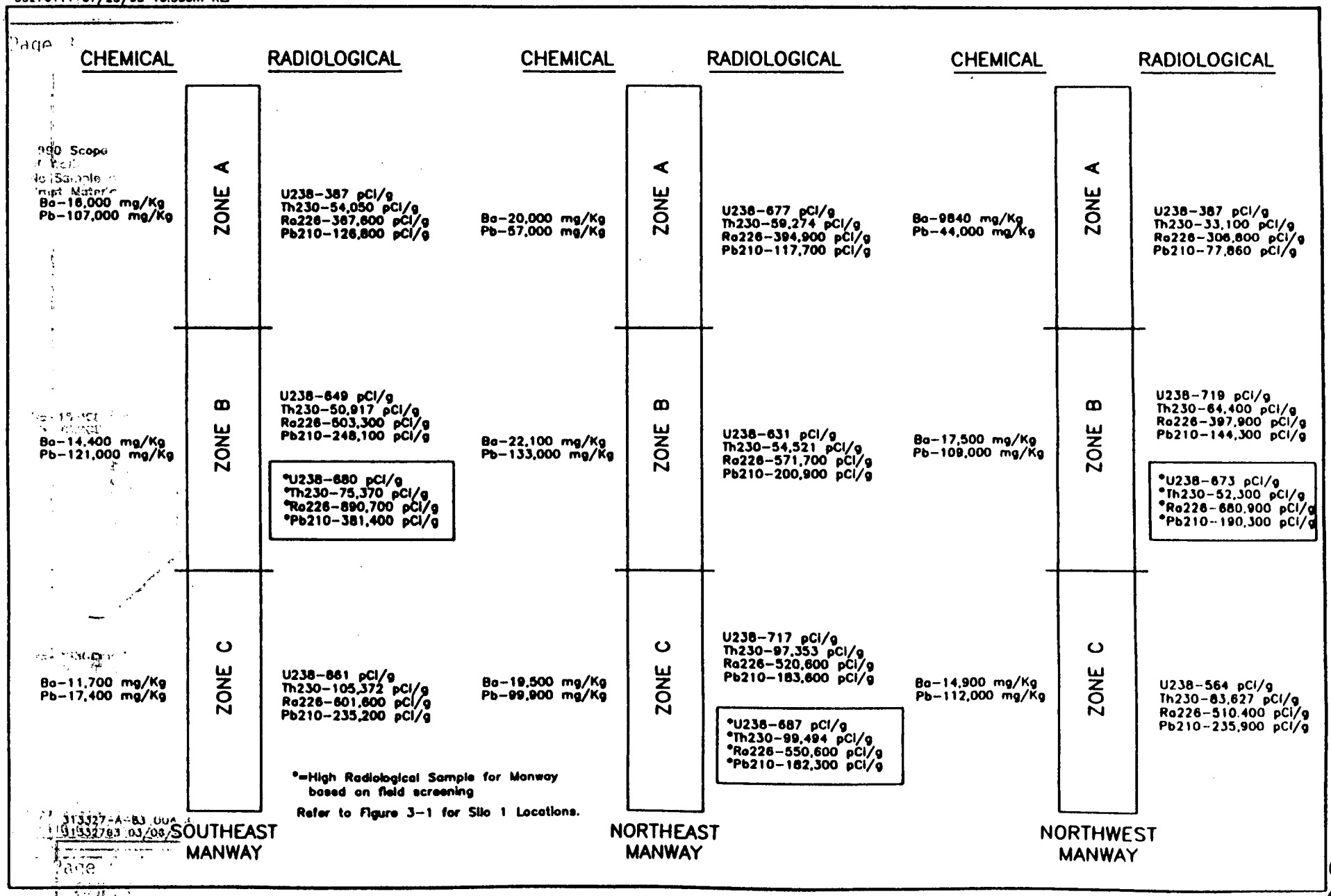

FIGURE 4-1. DISTRIBUTION OF PREDOMINANT CONSTITUENTS IN SILO 1-1990/91

1990 Scope of Work No Sample of Cover Material

Ba-15,900 mg/Kg
Pb-75,900 mg/Kg

Sb-763 mg/Kg
Pb-34,100 mg/Kg

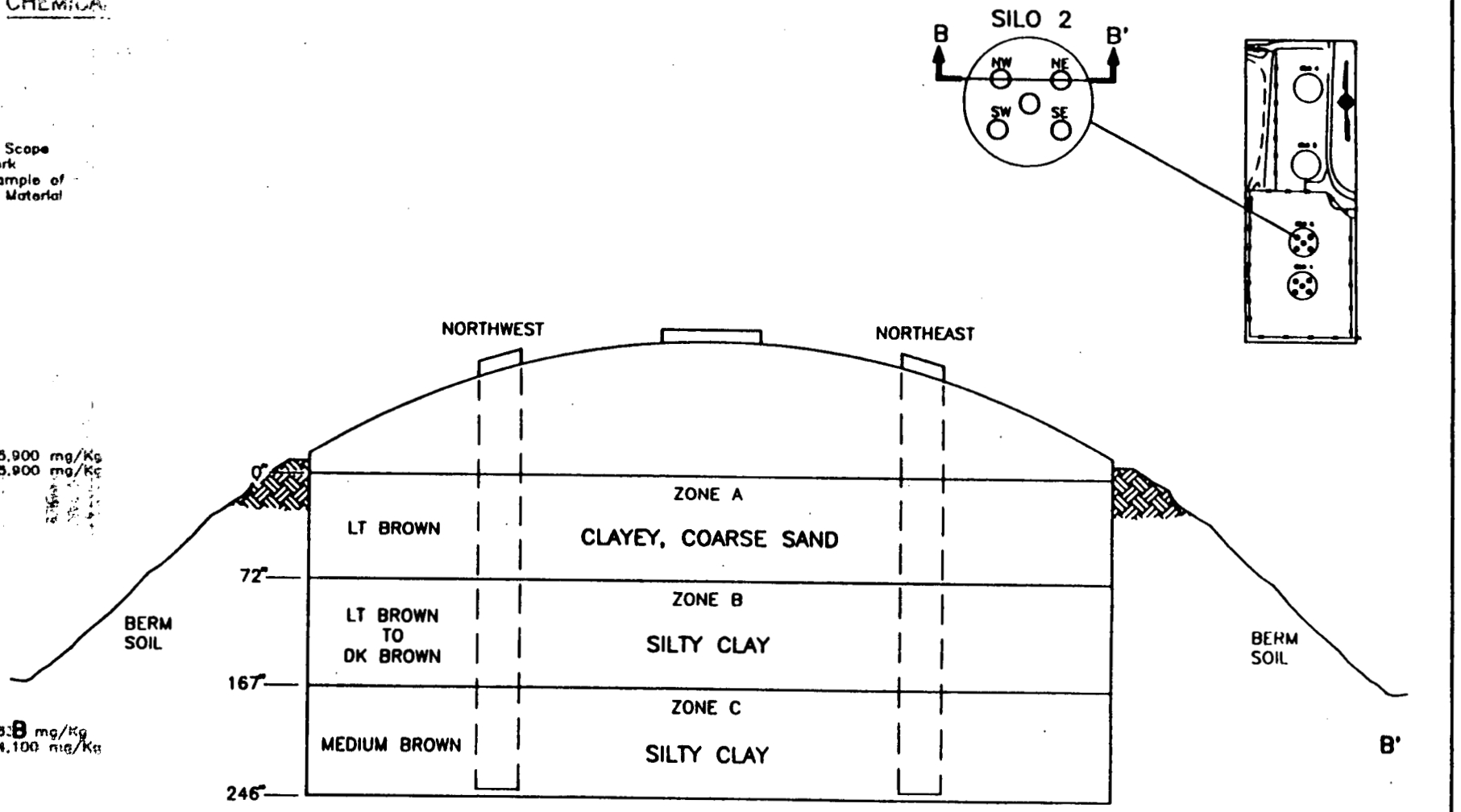

FIGURE 3-2. GENERALIZED VISUAL DESCRIPTION FOR SILO 2 CONTENTS

Ba-7630 mg/Kg
Pb-34,100 mg/Kg

313327-A-110/KNOX
33270110 07/28/93 3:44pm REP

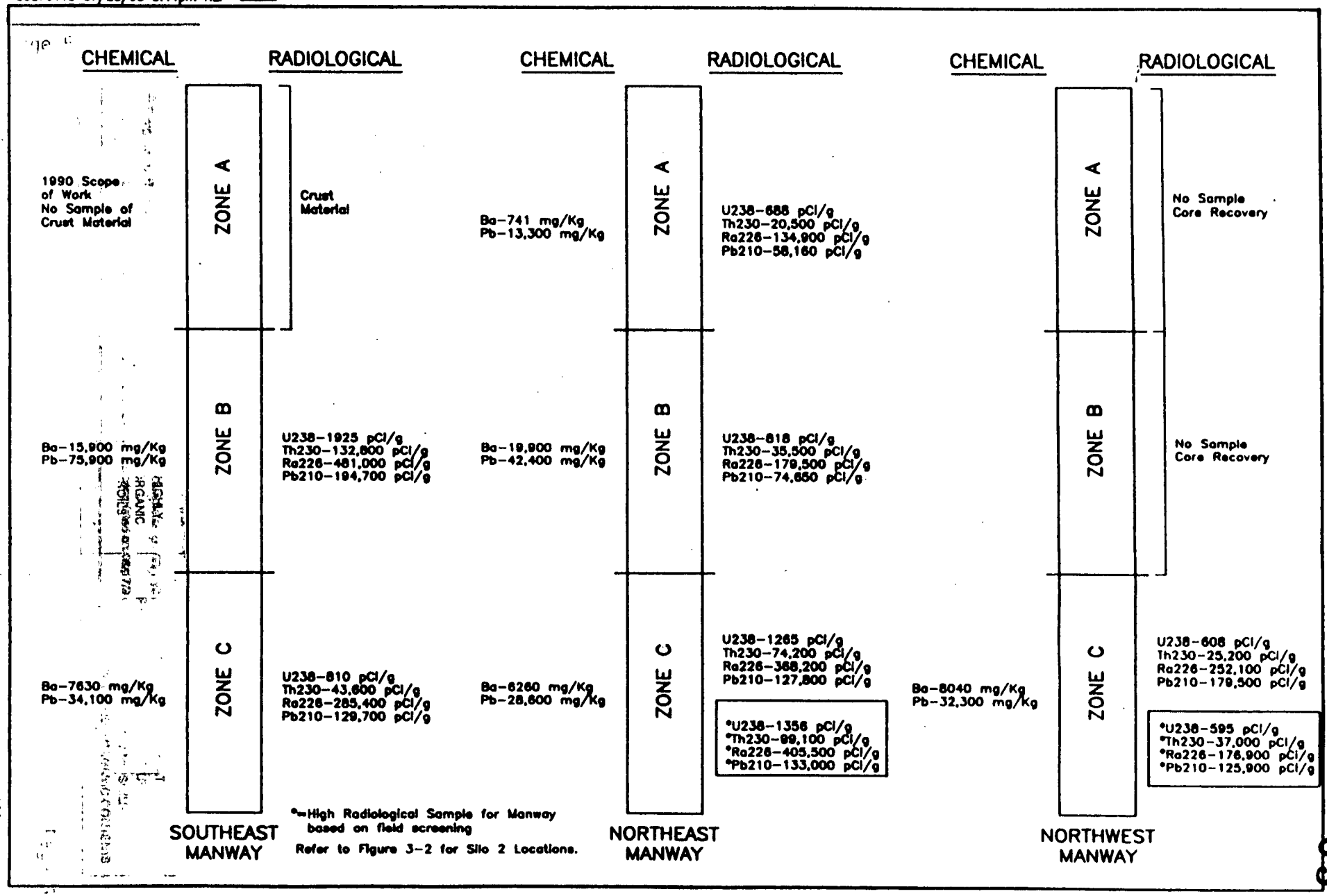

FIGURE 4-2. DISTRIBUTION OF PREDOMINANT CONSTITUENTS IN SILO 2-1990/91

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BORING/WELL LOGS LEGEND

CONSISTENCY OF COHESIVE SOILS

CONSISTENCY	UNCONFINED COMPRESSIVE STRENGTH (TONS PER SQUARE FT)
VERY SOFT	LESS THAN 0.25
SOFT	0.25 to 0.50
MEDIUM STIFF	0.50 to 1.0
STIFF	1.0 to 2.0
VERY STIFF	2.0 to 4.0
HARD	MORE THAN 4.0

DENSITY OF GRANULAR SOILS

DENSITY	STANDARD PENETRATION RESISTANCE
VERY LOOSE	0 – 4
LOOSE	5 – 10
MEDIUM DENSE	11 – 30
DENSE	31 – 50
VERY DENSE	OVER 50

STANDARD PENETRATION RESISTANCE IS THE NUMBER OF BLOWS REQUIRED TO DRIVE A 2-INCH O.D. SPLIT BARREL SAMPLER 12 INCHES USING A 140-POUND HAMMER FALLING FREELY THROUGH 30 INCHES. THE SAMPLER IS DRIVEN 18 INCHES AND THE NUMBER OF BLOWS RECORDED FOR EACH 6-INCH INTERVAL THE SUMMATION OF THE FINAL TWO INTERVALS IS THE STANDARD PENETRATION RESISTANCE.

COBBLES	GRAVEL		SANDS			SILT AND CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

USCS CLASSIFICATION FOR SOILS

COARSE – GRAINED SOILS

CLEAN GRAVELS (LITTLE OR – NO FINES)	GW	WELL-GRADED GRAVELS GRAVEL-SAND MIXTURES LITTLE OR NO FINES
	GP	POORLY-GRADED GRAVELS GRAVEL-SAND MIXTURES, LITTLE OR NO FINES
GRAVELS WITH FINES (APPRECIABLE AMOUNT OF FINES)	GM	SILTY GRAVELS, GRAVEL-SAND-SILT MIXTURES
	GC	CLAYEY GRAVELS GRAVEL-SAND-CLAY MIXTURES
CLEAN SANDS (LITTLE OR NO FINES)	SW	WELL-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
	SP	POORLY-GRADED SANDS GRAVELLY SANDS, LITTLE OR NO FINES
SANDS WITH FINES (APPRECIABLE AMOUNT OF FINES)	SM	SILTY SANDS, SAND-SILT MIXTURES
	SC	CLAYEY SANDS SAND-CLAY MIXTURES

FINE-GRADED/HIGHLY ORGANIC SOILS

SILTS AND CLAYS LIQUID LIMIT (LESS THAN 50)	ML	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY
	CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SILTY CLAYS, LEAN CLAYS
	OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
SILTS AND CLAYS LIQUID LIMIT (LESS THAN 50)	MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SANDY OR SILTY SOILS
	CH	INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS
	OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS
HIGHLY ORGANIC SOILS	PT	PEAT, HUMUS, SWAMP SOILS WITH HIGH ORGANIC CONTENTS

PEAT, HUMUS, SWAMP SOILS WITH HIGH ORGANIC CONTENTS

Vibra Core

Doug Moore Tr Corp

Drilling Equipment

Driller

FERNALD RI/FS

VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER: 303317	PROJECT NAME: FERNALD K-65 RESAMPLE PROJECT		
BORING NUMBER: 281-SE-A,B,C	COORDINATES: K-65 SILO 1, S.E. MANWAY	DATE: 08/22/91	
GROUND ELEVATIONS:	GWL: Depth	Date/Time:	DATE STARTED: 08/15/91
ENGINEER/GEOLOGIST: D. JARVIS	Depth:	Date/Time:	DATE COMPLETED: 08/20/91
DRILLING METHODS: VIBRA CORE - 3 IN. ID TUBE			PAGE 1 OF 1

DEPTH 0"	SAMPLE	DATE TIME	BLOWS ON SAMPLE	RECOVERY INCHES	DESCRIPTION	USGS	SYMBOL	TSF	REMARKS
	ZONE A		N/A	56.0	0 - 42" Uniform in type, light brown color and damp Clay/Grit texture 42 - 56" Normal crust material, single grain in appearance, medium brown Recovery Area * 0" at cutting shoe end	mm/sec		N/A	35 - 70 mR/hr 1.75-4.5 Kg/cm 2 Penetrometer Readings Tot. Wt.=10,027.3 gm
84"	ZONE B		N/A	61.0	0 - 36" Uniform Clay/Grit consistancy, light brown 36 - 46" Uniform Clay/Grit, Light brown color 46 - 57" Uniform Clay/Grit, medium brown color Recovery Area * 0" at cutting shoe end	mil		N/A	30-80 mR/hr range 0.75-2.0 Kg/cm 2 Penetrometer Readings Tot. Wt.=10,684.6 gm Section 3 - 24-36" sent for core. High Rad. analysis at 80 mR/hr
168"	ZONE C		N/A	58.0	0 - 55" of uniform Clay/Grit material that is medium brown in color 3" cave in crust type material Recovery Area	mil		N/A	30-50 mR/hr rad range 0.5-3.0 Kg/cm 2 Penetrometer Readings Tot. Wt.=9,855.7 gm 2 each 6" sections saved for triaxial tests.
252"									

NOTES:

Drilling Contractor: IT Corp

Drilling Equipment: Vibra Core

Driller: Doug Moore, IT Corp.

Borehole logged from surface of material to 13 feet from lip of manway to surface of material.

Zone A boring interval completed on 08/15/91.

Zone B boring interval completed on 08/17/91.

VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER: 303317	PROJECT NAME: FERNALD K-65 RESAMPLE PROJECT		
BORING NUMBER: 2S1-NE-A,B,C	COORDINATES: K-65 SILO 1, N.E. MANWAY	DATE: 09/11/91	
GROUND ELEVATIONS:	GWL: Depth	Date/Time:	DATE STARTED: 08/22/91
ENGINEER/GEOLOGIST: D. JARVIS	Depth:	Date/Time:	DATE COMPLETED: 08/26/91
DRILLING METHODS: VIBRA CORE - 3 IN. ID TUBE			PAGE 1 OF 1

DEPTH	SAMPLE	DATE TIME	BLOWS ON SAMPLE	RECOVERY INCHES	DESCRIPTION	USGS SYMBOL	TSF	REMARKS
0"	ZONE A		N/A	60.0	0 - 36" Light brown to dark brown/gray, Clay/Silt material - dry 36 - 60" Dry, light brown, Sandy/Grit Material Recovery Area * Cutting shoe at 0"	pc/ sm	N/A	15-35 mR/hr rad range 1.5-4.25 Kg/cm 2 Penetrometer Readings Tot. Wt.=10,656.8 gm
84"	ZONE B		N/A	69.0	Light brown to dark brown, Clay/Silt material, damp Recovery area indicated from material residue in Lexan tube	ml	N/A	Mechanical error with vibra core unit caused Lexan tube to empty into containment sleeve. No volatile samples recovered remain samples was recovered. 60 mR/hr Rad reading Tot. wt. 8,543.6 gm
180"	ZONE C		N/A	53.0	Light brown, Clay/Silt material, damp Recovery Area	ml	N/A	25-45 mR/hr rad range 0-1.25 Kg/cm 2 Penetrometer Readings Tot. Wt.=9,261.8 gm
276"								

NOTES:

Drilling Contractor: IT Corp

Drilling Equipment: Vibra Core

Driller: Doug Moore, IT Corp.

Zone A boring interval completed on 08/22/91.

Zone B boring interval completed on 08/24/91.

Zone C boring interval completed on 08/26/91.

Zone B boring interval completed on 08/10/

Drilling Contractor

Drilling Equipment

Driller

FERNALD RI/FS

VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER: 303317	PROJECT NAME: FERNALD K-65 RESAMPLE PROJECT		
BORING NUMBER: 231-NW-A,B,C	COORDINATES: K-65 SILO 1, N.W. MANWAY	DATE: 08-14/91	
GROUND ELEVATIONS:	GWL: Depth	Date/Time:	DATE STARTED: 08/08/91
ENGINEER/GEOLOGIST: D. JARVIS	Depth:	Date/Time:	DATE COMPLETED: 08/13/91
DRILLING METHODS: VIBRA CORE - 3 IN. ID TUBE			PAGE 1 OF 1

DEPTH	SAMPLE	DATE TIME	BLOWS ON	SAMPLE	RECOVERY	DESCRIPTION	USGS	SYMBOL	TSF	REMARKS
0'										
	ZONE A		N/A		21.8	No visual differences, material is a very lightly compacted grit that powders off when chiseled. Material is marbled colored between light brown to dark brown. Recovery Area 21.5 Inches	gc		N/A	23-35 mR/hr rad range 2.5 Kg/cm 2 Penetrometer Readings Tot. Wt.=3,938.7 gm *This is crust material. 08/09/91
78"	ZONE B		N/A		37.4	No visual strates, material is damp Clay type, with colors ranging from very light brown to medium brown Recovery Area 37.5 Inches	ml		N/A	35-60 mR/hr Range Tot. wt.=6,881.8 gm Penetrometer Reading = 1.0 - 1.25 Kg/cm 2 60 mR/hr. Area sent as high rad. Sample for sample core 08/11/91
174"	ZONE C		N/A		37.4	No visual strates, material is a damp, Clay type, light brown in color. Recovery Area 37 Inches			N/A	35-120 mR/hr range Tot. wt.=6,312.1 gm Penetrometer Readings 0.75-1.25 Kg/cm 2 120 mR/hr area sent for special high rad analysis 08/14/91
270"										

NOTES:

Drilling Contractor: IT Corp

Drilling Equipment: Vibra Core

Driller: Doug Moore, IT Corp.

Borehole depth from point of penetration in silo crust material.

Zone A boring interval completed on 08/18/91.

Zone B boring interval completed on 08/10/91.

BORING/WELL LOGS LEGEND

CONSISTENCY OF COHESIVE SOILS

CONSISTENCY	UNCONFINED COMPRESSIVE STRENGTH (TONS PER SQUARE FT)
VERY SOFT	LESS THAN 0.25
SOFT	0.25 to 0.50
MEDIUM STIFF	0.50 to 1.0
STIFF	1.0 to 2.0
VERY STIFF	2.0 to 4.0
HARD	MORE THAN 4.0

DENSITY OF GRANULAR SOILS

DENSITY	STANDARD PENETRATION RESISTANCE
VERY LOOSE	0 – 4
LOOSE	5 – 10
MEDIUM DENSE	11 – 30
DENSE	31 – 50
VERY DENSE	OVER 50

STANDARD PENETRATION RESISTANCE IS THE NUMBER OF BLOWS REQUIRED TO DRIVE A 2-INCH O.D. SPLIT BARREL SAMPLER 12 INCHES USING A 140-POUND HAMMER FALLING FREELY THROUGH 30 INCHES. THE SAMPLER IS DRIVEN 18 INCHES AND THE NUMBER OF BLOWS RECORDED FOR EACH 6-INCH INTERVAL THE SUMMATION OF THE FINAL TWO INTERVALS IS THE STANDARD PENETRATION RESISTANCE.

COBBLES	GRAVEL		SANDS			SILT AND CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

USCS CLASSIFICATION FOR SOILS

COARSE – GRAINED SOILS

CLEAN GRAVELS (LITTLE OR – NO FINES)	GW	WELL-GRADED GRAVELS GRAVEL-SAND MIXTURES LITTLE OR NO FINES
	GP	POORLY-GRADED GRAVELS GRAVEL-SAND MIXTURES, LITTLE OR NO FINES
GRAVELS WITH FINES (APPRECIABLE AMOUNT OF FINES)	GM	SILTY GRAVELS, GRAVEL-SAND-SILT MIXTURES
	GC	CLAYEY GRAVELS GRAVEL-SAND-CLAY MIXTURES
CLEAN SANDS (LITTLE OR NO FINES)	SW	WELL-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
	SP	POORLY-GRADED SANDS GRAVELLY SANDS, LITTLE OR NO FINES
SANDS WITH FINES (APPRECIABLE AMOUNT OF FINES)	SM	SILTY SANDS, SAND-SILT MIXTURES
	SC	CLAYEY SANDS SAND-CLAY MIXTURES

FINE-GRADED/HIGHLY ORGANIC SOILS

SILTS AND CLAYS LIQUID LIMIT (LESS THAN 50)	ML	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY
	CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SILTY CLAYS, LEAN CLAYS
	OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
SILTS AND CLAYS LIQUID LIMIT (LESS THAN 50)	MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SANDY OR SILTY SOILS
	CH	INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS
	OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS
HIGHLY ORGANIC SOILS	PT	PEAT, HUMUS, SWAMP SOILS WITH HIGH ORGANIC CONTENTS

PEAT, HUMUS, SWAMP SOILS WITH HIGH ORGANIC CONTENTS

Wink Vibra Core
Wink Core
Doug Moore IT Corp.
Doug Moore IT Corp.

Drilling Contractor
Drilling Equipment
Driller

FERNALD RI/FS

VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER:	303317	PROJECT NAME:	K-65 RESAMPLE PROJECT		
BORING NUMBER:	252-SE-A,B,C	COORDINATES:	K-65 SILO 2, S.E. Manway	DATE:	09/12/91
GROUND ELEVATIONS:		GWL: Depth	Date/Time:	DATE STARTED:	12/12/90
ENGINEER/GEOLOGIST:	D. JARVIS	Depth:	Date/Time:	DATE COMPLETED:	07/19/91
DRILLING METHODS:	WINK VIBRA CORE, 3 IN. ID TUBE			PAGE 1	OF 1

DEPTH 0'	SAMPLE	DATE	TIME	BLOWS ON	SAMPLE	RECOVERY	INCHES	DESCRIPTION	USGS	SYMBOL	TSF	REMARKS
	Zone A			N/A		43.9		Damp, gritty Sand, tightly compacted to a Silty Clay type material, light brown except 8-15" a dark brown to black color	sm		N/A	Tot. Core wt.= 7,738 gm Rad reading 12-30 mR/hr Penetrometer= 0.8-2.0 Kg/cm 2
	72"							Recovery area				
	Zone B			N/A		89.0		0-45" Damp, silty Clay 45-78" Wet, gritty Clay 78-89" Damp, silty Clay	ml ml ml		N/A	Tot. Core wt.= 14,685 gm Rad reading 12-44 mR/hr Penetrometer= 0.9-1.75 Kg/cm 2
	161"							Recovery area				
	Zone C			N/A		46.0		Damp, silty Clay, light brown tended to be gritty in a few spots.	ml		N/A	Tot. Core wt.= 7,838 gm Rad reading 12-20 mR/hr Penetrometer= 2.5 Kg/cm 2
	253"							Recovery area				

NOTES:

Drilling Contractor: IT Corp.

Drilling Equipment: Wink Vibra Core

Driller: Doug Moore, IT Corp.

Sampling started 12/12/90.

Shut down because of weather after 12/21/90.

resumed and completed 7/14/91.

PROJECT NUMBER: 303317	PROJECT NAME: K-65 RESAMPLE PROJECT		
BORING NUMBER: 252-NW-A,B,C	COORDINATES: K-65 SILO 2, N.W. Manway	DATE: 08/01/91	
GROUND ELEVATIONS:	GWL: Depth Date/Time:	DATE STARTED: 07/22/91	
ENGINEER/GEOLOGIST: D. JARVIS	Depth: Date/Time:	DATE COMPLETED: 07/29/91	
DRILLING METHODS: VIBRA CORE		PAGE 1 OF 1	

DEPTH 0'	SAMPLE	DATE TIME	BLOWS ON	SAMPLE	RECOVERY	DESCRIPTION	USGS	SYMBOL	TSF	REMARKS
65'	Zone A		N/A		0	Vibra Core apparently went down old WMCO hole. 0 - Recovery	N/A		N/A	See description.
150'	Zone B		N/A		0	0 - Recovery, Vibra Core still in old WMCO hole. Catcher in Lexan tube was destroyed by something. up to 12" of material had been in Lexan tube.	N/A		N/A	See description.
	Zone C		N/A		54.0	Damp Grit/Clay type material and compactable 54" Recovery area	sc		N/A	High Rad reading 25mR/hr. Subdivided into 3 sections.
234'										

NOTES:

Drilling Contractor: IT Corp.

Drilling Equipment: Vibra Core

Driller: Doug Moore, IT Corp.

Zone A boring interval completed on 7/23/91

Zone B boring interval completed on 7/24/91

Zone C boring interval completed on 7/29/91

FERNALD RI/FS

VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER: 303317	PROJECT NAME: FERNALD K-65 RESAMPLE PROJECT		
BORING NUMBER: 252-NE-A,B,C	COORDINATES: K-65 SILO 2, N.E. MANWAY	DATE: 08/07/91	
GROUND ELEVATIONS:	GWL: Depth / Date/Time:	DATE STARTED: 07/31/91	
ENGINEER/GEOLOGIST: D. JARVIS	Depth: / Date/Time:	DATE COMPLETED: 08/06/91	
DRILLING METHODS: WINK VIBRA CORE - 3 IN. ID TUBE		PAGE 1 OF 1	

DEPTH	SAMPLE	DATE	TIME	BLOWS ON	SAMPLE	RECOVERY	INCHES	DESCRIPTION	USGS	SYMBOL	TSF	REMARKS
0"												
	Zone A			N/A		12.0		Damp sandy grit-like material - typical of Silo 2 Crust material 12" Recovery	sm		N/A	Penetrometer = 1.6 Kg/cm 2 1992 gm 7 mR/hr
65"	Zone B			N/A		61.5		Very damp material ranging from medium brown to light brown in color. A Clay/Grit type texture. Rad range 25 mR/hr up to 34" from cutting shoe. Rest of 25" area at 35 mR/hr. Recovery Area	sc		N/A	5" Section 29" up from cutting shoe end, save for geotechnical Material to wet for Penetrometer tests.
162"	Zone C			N/A		64.0		Cutting shoe end is gray and black in color, material is damp, overall medium brown in color with Clay/Grit texture. Rad range 25 to 36 mR/hr Penetrometer reading range from 0 to 2.0 Kg/cm 2 Recovery Area	sc		N/A	36 mR/hr Section was used for high rad analysis for sample core
246"												

NOTES:

Drilling Contractor: IT Corp

Drilling Equipment: Wink Vibra Core

Driller: Doug Moore, IT Corp.

Depth from surface of crust material.

Zone A boring interval completed on 07/31/91

Zone B boring interval completed on 08/02/91

Zone C boring interval completed on 08/06/91

APPENDIX A RI/FS SAMPLE NUMBER LIST

SAMPLE NUMBER	SAMPLE LOCATION	LOCATION NUMBER	BORING LOCATION	COLLECTION DATE	ANALYTICAL PARAMETERS
99737	SILO 1	2S1-NE-A	ZONE A	06/23/91	HSL VOLATILE ORGANICS
99738	SILO 1	2S1-NE-A	ZONE A	06/23/91	HSL METALS
99739	SILO 1	2S1-NE-A	ZONE A	06/23/91	HSL MERCURY
99740	SILO 1	2S1-NE-A	ZONE A	06/23/91	CYANIDE
99741	SILO 1	2S1-NE-A	ZONE A	06/23/91	TCLP VOLATILE ORGANICS
99742	SILO 1	2S1-NE-A	ZONE A	06/23/91	TCLP METALS
99743	SILO 1	2S1-NE-A	ZONE A	06/23/91	RADIOLOGICAL
99745	SILO 1	2S1-NE-A	ZONE A	06/23/91	CHEMICAL
99746	SILO 1	2S1-NE-A	ZONE A	06/23/91	CHEMICAL
99747	SILO 1	2S1-NE-A	ZONE A	06/23/91	CHEMICAL
99748	SILO 1	2S1-NE-A	ZONE A	06/23/91	HSL SEMIVOLATILES & PEST./PCB
99749	SILO 1	2S1-NE-A	ZONE A	06/23/91	TCLP SEMIVOLATILES & PEST./PCB
99750	SILO 1	2S1-NE-A	ZONE A	06/23/91	CHEMICAL
99751	SILO 1	2S1-NE-A	ZONE A	06/23/91	TRIP BLANK
99989	SILO 1	2S1-NE-B	ZONE B	06/23/91	RINSATE
99990	SILO 1	2S1-NE-B	ZONE B	06/23/91	RINSATE
99991	SILO 1	2S1-NE-B	ZONE B	06/23/91	RINSATE
99992	SILO 1	2S1-NE-B	ZONE B	06/23/91	RINSATE
99993	SILO 1	2S1-NE-B	ZONE B	06/23/91	RINSATE
99994	SILO 1	2S1-NE-B	ZONE B	06/23/91	RINSATE
99995	SILO 1	2S1-NE-B	ZONE B	06/25/91	TRIP BLANK
99996	SILO 1	2S1-NE-B	ZONE B	06/25/91	TRIP BLANK
99997	SILO 1	2S1-NE-B	ZONE B	06/25/91	RINSATE
99999	SILO 1	2S1-NE-B	ZONE B	06/25/91	HSL METALS
100000	SILO 1	2S1-NE-B	ZONE B	06/25/91	HSL MERCURY
100001	SILO 1	2S1-NE-B	ZONE B	06/25/91	CYANIDE
100003	SILO 1	2S1-NE-B	ZONE B	06/25/91	TCLP METALS
100004	SILO 1	2S1-NE-B	ZONE B	06/25/91	RADIOLOGICAL
100009	SILO 1	2S1-NE-B	ZONE B	06/25/91	HSL SEMIVOLATILES & PEST./PCB
100010	SILO 1	2S1-NE-B	ZONE B	06/25/91	TCLP SEMIVOLATILES & PEST./PCB
100012	SILO 1	2S1-NE-B	ZONE B	06/26/91	TRIP BLANK
100019	SILO 1	2S1-NE-C	ZONE C	06/27/91	HSL VOLATILE ORGANICS
100020	SILO 1	2S1-NE-C	ZONE C	06/27/91	HSL METALS
100021	SILO 1	2S1-NE-C	ZONE C	06/27/91	HSL MERCURY
100022	SILO 1	2S1-NE-C	ZONE C	06/27/91	CYANIDE
100023	SILO 1	2S1-NE-C	ZONE C	06/27/91	TCLP VOLATILE ORGANICS
100024	SILO 1	2S1-NE-C	ZONE C	06/27/91	TCLP METALS
100025	SILO 1	2S1-NE-C	ZONE C	06/27/91	RADIOLOGICAL
100026	SILO 1	2S1-NE-C	ZONE C	06/27/91	CHEMICAL
100027	SILO 1	2S1-NE-C	ZONE C	06/27/91	CHEMICAL
100028	SILO 1	2S1-NE-C	ZONE C	06/27/91	CHEMICAL
100029	SILO 1	2S1-NE-C	ZONE C	06/27/91	CHEMICAL
100030	SILO 1	2S1-NE-C	ZONE C	06/27/91	HSL SEMIVOLATILES & PEST./PCB
100031	SILO 1	2S1-NE-C	ZONE C	06/27/91	TCLP SEMIVOLATILES & PEST./PCB
100032	SILO 1	2S1-NE-C	ZONE C	06/27/91	CHEMICAL
100033	SILO 1	2S1-NE-C	ZONE C	06/27/91	HSL VOLATILE ORGANICS
100034	SILO 1	2S1-NE-C	ZONE C	06/27/91	HSL METALS
100035	SILO 1	2S1-NE-C	ZONE C	06/27/91	HSL MERCURY
100036	SILO 1	2S1-NE-C	ZONE C	06/27/91	CYANIDE
100037	SILO 1	2S1-NE-C	ZONE C	06/27/91	TCLP VOLATILE ORGANICS
100038	SILO 1	2S1-NE-C	ZONE C	06/27/91	TCLP METALS
100039	SILO 1	2S1-NE-C	ZONE C	06/27/91	RADIOLOGICAL
100040	SILO 1	2S1-NE-C	ZONE C	06/27/91	HSL SEMIVOLATILES & PEST./PCB
100041	SILO 1	2S1-NE-C	ZONE C	06/27/91	TCLP SEMIVOLATILES & PEST./PCB
[illegible]	SILO 1	2S1-SE-C	ZONE C	[illegible]	[illegible]
99679	SILO 1	2S1-NW-A	ZONE A	06/09/91	HSL VOLATILE ORGANICS
99680	SILO 1	2S1-NW-A	ZONE A	06/09/91	HSL METALS
99681	SILO 1	2S1-NW-A	ZONE A	06/09/91	HSL MERCURY
99682	SILO 1	2S1-NW-A	ZONE A	06/09/91	CYANIDE
99683	SILO 1	2S1-NW-A	ZONE A	06/09/91	TCLP VOLATILE ORGANICS
99684	SILO 1	2S1-NW-A	ZONE A	06/09/91	TCLP METALS
100054	SILO 1	2S2-SNAC	ZONE COMPOSITE	07/12/91	GEOTECHNICAL

APPENDIX A RI/FS SAMPLE NUMBER LIST

SAMPLE NUMBER	SAMPLE LOCATION	LOCATION NUMBER	BORING LOCATION	COLLECTION DATE	ANALYTICAL PARAMETERS	
99666	SILO 1	2S1-SE-A	ZONE A	06/16/91	HSL MERCURY	
99667	SILO 1	2S1-SE-A	ZONE A	06/16/91	CYANIDE	
99668	SILO 1	2S1-SE-A	ZONE A	06/16/91	TCLP VOLATILE ORGANICS	
99669	SILO 1	2S1-SE-A	ZONE A	06/16/91	TCLP METALS	
99670	SILO 1	2S1-SE-A	ZONE A	06/16/91	RADIOLOGICAL	
99671	SILO 1	2S1-SE-A	ZONE A	06/16/91	CHEMICAL	
99672	SILO 1	2S1-SE-A	ZONE A	06/16/91	CHEMICAL	
99673	SILO 1	2S1-SE-A	ZONE A	06/16/91	CHEMICAL	
99674	SILO 1	2S1-SE-A	ZONE A	06/16/91	CHEMICAL	
99675	SILO 1	2S1-SE-A	ZONE A	06/16/91	HSL SEMIVOLATILES & PEST./PCB	
99676	SILO 1	2S1-SE-A	ZONE A	06/16/91	TCLP SEMIVOLATILES & PEST./PCB	
99677	SILO 1	2S1-SE-A	ZONE A	06/16/91	CHEMICAL	
99678	SILO 1	2S1-SE-A	ZONE A	06/17/91	TRIP BLANK	
99949	SILO 1	2S1-SE-B	ZONE B	06/16/91	RINSATE	
99950	SILO 1	2S1-SE-B	ZONE B	06/16/91	RINSATE	
99951	SILO 1	2S1-SE-B	ZONE B	06/16/91	RINSATE	
99952	SILO 1	2S1-SE-B	ZONE B	06/16/91	RINSATE	
99954	SILO 1	2S1-SE-B	ZONE B	06/16/91	RINSATE	
99955	SILO 1	2S1-SE-B	ZONE B	06/16/91	RINSATE	
99956	SILO 1	2S1-SE-B	ZONE B	06/16/91	RINSATE	
99957	SILO 1	2S1-SE-B	ZONE B	06/16/91	RINSATE	
99958	SILO 1	2S1-SE-B	ZONE B	06/18/91	HSL VOLATILE ORGANICS	
99959	SILO 1	2S1-SE-B	ZONE B	06/18/91	HSL SEMIVOLATILES & PEST./PCB	
99960	SILO 1	2S1-SE-B	ZONE B	06/18/91	TCLP VOLATILE ORGANICS	
99962	SILO 1	2S1-SE-B	ZONE B	06/18/91	TCLP SEMIVOLATILES	
99963	SILO 1	2S1-SE-B	ZONE B	06/18/91	CYANIDE	
99964	SILO 1	2S1-SE-B	ZONE B	06/18/91	HSL MERCURY	
99965	SILO 1	2S1-SE-B	ZONE B	06/18/91	HSL METALS	
99966	SILO 1	2S1-SE-B	ZONE B	06/18/91	RADIOLOGICAL	
99967	SILO 1	2S1-SE-B	ZONE B	06/18/91	TCLP METALS	
99975	SILO 1	2S1-SE-B	ZONE B	06/18/91	RADIOLOGICAL	
99976	SILO 1	2S1-SE-B	ZONE B	06/18/91	TCLP VOLATILE ORGANICS	
99977	SILO 1	2S1-SE-B	ZONE B	06/18/91	HSL VOLATILE ORGANICS	
99979	SILO 1	2S1-SE-B	ZONE B	06/18/91	HSL SEMIVOLATILES & PEST./PCB	
99980	SILO 1	2S1-SE-B	ZONE B	06/18/91	CHEMICAL	
99981	SILO 1	2S1-SE-B	ZONE B	06/18/91	CHEMICAL	
99982	SILO 1	2S1-SE-B	ZONE B	06/18/91	CHEMICAL	
99983	SILO 1	2S1-SE-B	ZONE B	06/18/91	CHEMICAL	
99984	SILO 1	2S1-SE-B	ZONE B	06/18/91	CYANIDE	
99985	SILO 1	2S1-SE-B	ZONE B	06/18/91	TCLP METALS	
99986	SILO 1	2S1-SE-B	ZONE B	06/18/91	HSL METALS	
99987	SILO 1	2S1-SE-B	ZONE B	06/18/91	CHEMICAL	
99988	SILO 1	2S1-SE-B	ZONE B	06/19/91	TRIP BLANK	
99722	SILO 1	2S1-SE-C	ZONE C	06/21/91	HSL VOLATILE ORGANICS	
99723	SILO 1	2S1-SE-C	ZONE C	06/21/91	HSL METALS	
99724	SILO 1	2S1-SE-C	ZONE C	06/21/91	HSL MERCURY	
99725	SILO 1	2S1-SE-C	ZONE C	06/21/91	CYANIDE	
99726	SILO 1	2S1-SE-C	ZONE C	06/21/91	TCLP VOLATILE ORGANICS	
99727	SILO 1	2S1-SE-C	ZONE C	06/21/91	TCLP METALS	
99728	SILO 1	2S1-SE-C	ZONE C	06/21/91	RADIOLOGICAL	
99729	SILO 1	2S1-SE-C	ZONE C	06/21/91	CHEMICAL	
99730	SILO 1	2S1-SE-C	ZONE C	06/21/91	CHEMICAL	
99731	SILO 1	2S1-SE-C	ZONE C	06/21/91	CHEMICAL	
99732	SILO 1	2S1-SE-C	ZONE C	06/21/91	CHEMICAL	99696
99733	SILO 1	2S1-SE-C	ZONE C	06/21/91	HSL SEMIVOLATILES & PEST./PCB	99697
99734	SILO 1	2S1-SE-C	ZONE C	06/21/91	TCLP SEMIVOLATILES & PEST./PCB	99698
99735	SILO 1	2S1-SE-C	ZONE C	06/21/91	CHEMICAL	99699
99736	SILO 1	2S1-SE-C	ZONE C	06/22/91	TRIP BLANK	99700
99701	SILO 2	2S2-SE-C	ZONE C	07/19/91	HSL VOLATILE ORGANICS	99701
100053	SILO 1	2S2-NA-C	ZONE COMPOSITE	07/09/91	GEOTECHNICAL	99702
100054	SILO 1	2S2-NA-C	ZONE COMPOSITE	07/09/91	GEOTECHNICAL	99703

APPENDIX A RI/FS SAMPLE NUMBER LIST

SAMPLE NUMBER	SAMPLE LOCATION	LOCATION NUMBER	BORING LOCATION	COLLECTION DATE	ANALYTICAL PARAMETERS
99653	SILO 2	2S2-NE-C	ZONE C	08/06/91	CHEMICAL
99654	SILO 2	2S2-NE-C	ZONE C	08/06/91	TRIP BLANK
99655	SILO 2	2S2-NE-C	ZONE C	08/06/91	HSL VOLATILE ORGANICS
99656	SILO 2	2S2-NE-C	ZONE C	08/06/91	HSL METALS
99657	SILO 2	2S2-NE-C	ZONE C	08/06/91	HSL MERCURY
99658	SILO 2	2S2-NE-C	ZONE C	08/06/91	CYANIDE
99659	SILO 2	2S2-NE-C	ZONE C	08/06/91	TCLP VOLATILE ORGANICS
99660	SILO 2	2S2-NE-C	ZONE C	08/06/91	TCLP METALS
99661	SILO 2	2S2-NE-C	ZONE C	08/06/91	RADIOLOGICAL
99662	SILO 2	2S2-NE-C	ZONE C	08/06/91	HSL SEMIVOLATILES & PEST./PCB
99663	SILO 2	2S2-NE-C	ZONE C	08/06/91	TCLP SEMIVOLATILES & PEST./PCB
99768	SILO 2	2S2-NW-C	ZONE C	07/30/91	HSL VOLATILE ORGANICS
99769	SILO 2	2S2-NW-C	ZONE C	07/30/91	HSL METALS
99770	SILO 2	2S2-NW-C	ZONE C	07/30/91	HSL MERCURY
99771	SILO 2	2S2-NW-C	ZONE C	07/30/91	CYANIDE
99772	SILO 2	2S2-NW-C	ZONE C	07/30/91	TCLP VOLATILE ORGANICS
99773	SILO 2	2S2-NW-C	ZONE C	07/30/91	TCLP METALS
99774	SILO 2	2S2-NW-C	ZONE C	07/30/91	RADIOLOGICAL
99775	SILO 2	2S2-NW-C	ZONE C	07/30/91	CHEMICAL
99776	SILO 2	2S2-NW-C	ZONE C	07/30/91	CHEMICAL
99777	SILO 2	2S2-NW-C	ZONE C	07/30/91	CHEMICAL
99778	SILO 2	2S2-NW-C	ZONE C	07/30/91	CHEMICAL
99779	SILO 2	2S2-NW-C	ZONE C	07/30/91	HSL SEMIVOLATILES & PEST./PCB
99780	SILO 2	2S2-NW-C	ZONE C	07/30/91	TCLP SEMIVOLATILES & PEST./PCB
99781	SILO 2	2S2-NW-C	ZONE C	07/30/91	CHEMICAL
99782	SILO 2	2S2-NW-C	ZONE C	07/30/91	HSL - QC DUPLICATE VOA
99783	SILO 2	2S2-NW-C	ZONE C	07/30/91	HSL - QC DUPLICATE METALS
99784	SILO 2	2S2-NW-C	ZONE C	07/30/91	HSL - QC DUPLICATE MERCURY
99785	SILO 2	2S2-NW-C	ZONE C	07/30/91	CYANIDE - QC DUPLICATE
99786	SILO 2	2S2-NW-C	ZONE C	07/30/91	TCLP - QC DUPLICATE VOA
99787	SILO 2	2S2-NW-C	ZONE C	07/30/91	TCLP - QC DUPLICATE METALS
99788	SILO 2	2S2-NW-C	ZONE C	07/30/91	RADIOLOGICAL - QC DUPLICATE
99790	SILO 2	2S2-NW-C	ZONE C	07/30/91	CHEMICAL - QC DUPLICATE
99791	SILO 2	2S2-NW-C	ZONE C	07/30/91	CHEMICAL - QC DUPLICATE
99793	SILO 2	2S2-NW-C	ZONE C	07/30/91	HSL - QC DUP. SEMIVOL. & PEST/PCB
99794	SILO 2	2S2-NW-C	ZONE C	07/30/91	TCLP - QC DUP. SEMIVOL. & PEST/PCB
99795	SILO 2	2S2-NW-C	ZONE C	07/30/91	CHEMICAL - QC DUPLICATE
99796	SILO 2	2S2-NW-C	ZONE C	07/30/91	HSL VOLATILE ORGANICS
99797	SILO 2	2S2-NW-C	ZONE C	07/30/91	HSL METALS
99798	SILO 2	2S2-NW-C	ZONE C	07/30/91	HSL MERCURY
99799	SILO 2	2S2-NW-C	ZONE C	07/30/91	CYANIDE
99800	SILO 2	2S2-NW-C	ZONE C	07/30/91	TCLP VOLATILE ORGANICS
99801	SILO 2	2S2-NW-C	ZONE C	07/30/91	TCLP METALS
99802	SILO 2	2S2-NW-C	ZONE C	07/30/91	RADIOLOGICAL
99803	SILO 2	2S2-NW-C	ZONE C	07/30/91	HSL SEMIVOLATILES & PEST./PCB
99804	SILO 2	2S2-NW-C	ZONE C	07/30/91	TCLP SEMIVOLATILES & PEST./PCB
99355	SILO 2	2S2-SE-B	ZONE B	12/21/90	TCLP METALS
99359	SILO 2	2S2-SE-B	ZONE B	12/21/90	VOA, SEMIVOL., PEST/PCB, RADIOLOGICAL
99692	SILO 2	2S2-SE-C	ZONE C	07/18/91	RINSATE
99693	SILO 2	2S2-SE-C	ZONE C	07/18/91	RINSATE
99694	SILO 2	2S2-SE-C	ZONE C	07/18/91	RINSATE
99695	SILO 2	2S2-SE-C	ZONE C	07/18/91	RINSATE
99696	SILO 2	2S2-SE-C	ZONE C	07/18/91	RINSATE
99697	SILO 2	2S2-SE-C	ZONE C	07/18/91	RINSATE
99698	SILO 2	2S2-SE-C	ZONE C	07/18/91	RINSATE
99699	SILO 2	2S2-SE-C	ZONE C	07/18/91	RINSATE
99700	SILO 2	2S2-SE-C	ZONE C	07/18/91	RINSATE
99701	SILO 2	2S2-SE-C	ZONE C	07/19/91	HSL VOLATILE ORGANICS
99702	SILO 2	2S2-SE-C	ZONE C	07/19/91	HSL SEMIVOLATILES & PEST./PCB
99703	SILO 2	2S2-SE-C	ZONE C	07/19/91	TRIP BLANK

APPENDIX A RI/FS SAMPLE NUMBER LIST

SAMPLE NUMBER	SAMPLE LOCATION	LOCATION NUMBER	BORING LOCATION	COLLECTION DATE	ANALYTICAL PARAMETERS
100097	SILO 3	S3SEA	ZONE A	05/25/89	FULL HSL/ RADIOLOGICAL
100098	SILO 3	S3NEABC	ZONE A,B,C	05/25/89	FULL HSL/ RADIOLOGICAL
100099	SILO 3	S3SEB	ZONE B	05/25/89	FULL HSL/ RADIOLOGICAL
100100	SILO 3	S3SEC	ZONE C	05/25/89	FULL HSL/ RADIOLOGICAL
100101	SILO 3	S3SEB	ZONE B	05/25/89	FULL HSL/ RADIOLOGICAL
100102	SILO 3	S3SEABC	ZONE A,B,C	05/25/89	FULL HSL/ RADIOLOGICAL
100103	SILO 3	S3NWA	ZONE A	05/25/89	FULL HSL/ RADIOLOGICAL
100104	SILO 3	S3NWB	ZONE B	05/25/89	FULL HSL/ RADIOLOGICAL
100105	SILO 3	S3NWC	ZONE C	05/25/89	FULL HSL/ RADIOLOGICAL
100106	SILO 3	S3NWC	ZONE C	05/25/89	FULL HSL/ RADIOLOGICAL
100107	SILO 3	S3NWABC	ZONE A,B,C	05/25/89	FULL HSL/ RADIOLOGICAL
MM3325	SILO 3	# 21	NA	05/25/89	EP TOXICITY
MM3326	SILO 3	# 22	NA	05/25/89	EP TOXICITY
MM3327	SILO 3	# 23	NA	05/25/89	EP TOXICITY
MM3328	SILO 3	# 24	NA	05/25/89	EP TOXICITY
MM3329	SILO 3	# 25	NA	05/25/89	EP TOXICITY
MM3330	SILO 3	# 26	NA	05/25/89	EP TOXICITY
MM3331	SILO 3	# 27	NA	05/25/89	EP TOXICITY
MM3332	SILO 3	# 28	NA	05/25/89	EP TOXICITY
MM3333	SILO 3	# 29	NA	05/25/89	EP TOXICITY
MM3334	SILO 3	# 30	NA	05/25/89	EP TOXICITY
MM3335	SILO 3	# 33	NA	05/25/89	EP TOXICITY
NW-1-A	SILO 3	NA	ZONE A	05/25/89	GEOTECHNICAL
NW-1-C	SILO 3	NA	ZONE C	05/25/89	GEOTECHNICAL
SE-1-A	SILO 3	NA	ZONE A	05/25/89	GEOTECHNICAL
SE-1-C	SILO 3	NA	ZONE C	05/25/89	GEOTECHNICAL
NE-1	SILO 3	NA	ZONE COMPOSITE	05/25/89	GEOTECHNICAL
100074	SILO 3	NA	ZONE COMPOSITE	11/12/92	TCLP RADIOLOGICAL
99410	DECANT TANK	NA	NA	04/09/91	RINSATE
99411	DECANT TANK	NA	NA	04/09/91	HSL METALS/ RADIOLOGICAL
99412	DECANT TANK	NA	NA	04/12/91	CHEMICAL/ FULL HSL/ RADIOLOGICAL
99414	DECANT TANK	NA	NA	04/16/91	TRIP BLANK
99415	DECANT TANK	NA	NA	04/16/91	CHEMICAL/ FULL HSL/ RADIOLOGICAL
99416	DECANT TANK	NA	NA	06/19/91	CHEMICAL/ FULL HSL/ RADIOLOGICAL
99417	DECANT TANK	NA	NA	06/21/91	RADIOLOGICAL
99420	DECANT TANK	NA	NA	07/18/91	RINSATE

FULL HSL = HSL VOLATILES, SEMIVOLATILES, PEST/PCB, METALS

TABLE 7-3

DATA LIMITATIONS AND RECOMMENDED ACTIONS

Data Limitation	Significance Alternatives Evaluation	Significance Baseline Risk Assessment	Recommended Action
Silos 1 and 2 and their contents			
Did not obtain samples of interstitial liquids when obtaining samples of Silos 1 and 2 residues, organic or inorganic	The uncertainty in the leachability of the silo contents will carry through the risk assessment for in situ remedial action alternatives which do not involve waste treatment.	Increased uncertainty in the levels of contaminants leaching into the perched groundwater.	No additional sampling is warranted. TCLP data and geochemical modeling provide an upper bound to the leachate source term. While additional sample data may improve the precision of the estimate of leachate concentration used in the fate and transport model, the associated risk estimate would not change appreciably.
No data regarding the level of contaminants or quantity of contaminated concrete in the silo structures	This will yield uncertainty in the cost estimate for ex situ remedial action alternatives. Also, there is some uncertainty with regard to level of worker exposures for ex situ remedial action alternatives.	None.	No additional sampling is warranted. For the purposes of the FS, all concrete will be assumed to be contaminated. Based on the total quantity of concrete in Silos 1 and 2, limited concrete data will have less than a 5 percent impact on the overall cost estimate for silo remediation. Further, health and safety planning will be based on conservative assumptions, assuring worker health and safety pending concrete sampling during remedial actions.
Screening level (ASL II) were used for semiquantitative data on Rn concentration in the silo headspaces to support fate and transport modeling	None.	Yields uncertainty in the source term for fate and transport calculations under the current source-term scenario. Fate and transport calculations were biased high by assuming a 20°F temperature gradient across the dome surface in establishing an Rn breathing rate from the silos.	No additional sampling is warranted. With the exception of the resident farmer, risk values due to Rn-222 for all hypothetical receptors, under the current source-term scenario, are on the order of 10^{-6}. Risks to the resident farmer are as high as 10^{-4}. These values are at least four orders of magnitude lower than risks associated with silo residues via other pathways. Thus, no level of improved precision in the Rn-222 source term would have an appreciable effect on the overall risk associated with Silo 3 residues.
Silo 3 and Its Contents			
There are no validated data regarding volatile organics or semivolatile organics, eluting before pentachlorophenol, in the Silo 3 residues.[a]	Creates uncertainty in identifying the constituents of potential concern for remedial action alternatives evaluation.	Uncertainty created in source-term definition for both current and future source-term scenarios.	No additional sampling is warranted. Process knowledge, as discussed in Section 4.1.4.2, eliminates the potential for the presence of these chemical constituents in Silo 3 in significant concentrations. Process knowledge, including the following factors (discussed in Section 4.1.4.2), eliminates the potential for the presence of these chemical constituents in Silo 3 in significant concentrations: (1) generating process introduced only tributyl phosphate and kerosene, (2) residues were dried through use of high temperature (950°F to 1500°F) furnacing, (3) dried residues were pneumatically blown into a hold tank and eventually into Silo 3, and (4) oxidizing environment is present within residues in Silo 3. Thus, any significant concentrations of these constituents would have been either combined and/or volatilized in the residue treatment, transport, or storage system. The risk contribution due to any remaining concentrations (less than ppm) of these constituents is inconsequential to the level of risk already calculated for the Silo contents.
Decant Sump Tank Coat			
No leak test was performed for the sump tank and associated piping[b]			

TABLE 7-3
(Continued)

Data Limitation	Significance Alternatives Evaluation	Significance Baseline Risk Assessment	Recommended Action
No data regarding the quantity of contaminated concrete in the silo for the foundation for the decant station, or the Drum Handling Building.	This will yield uncertainty in the cost estimate for ex situ remedial action alternatives. Also, there is some uncertainty with regard to level of worker exposures for ex situ remedial action alternatives.	None.	No additional sampling is warranted. Based on the total quantity of concrete in Silo 3, limited concrete data will have less than a 5 percent impact on the overall cost estimate for silo remediation. All concrete associated with Silo 3 will be assumed contaminated as part of the FS. Further, health and safety planning will be based on conservative assumptions, assuring worker health and safety pending concrete sampling during remedial actions.
No organic or inorganic TCLP data obtained for silo residues.	The uncertainty in the leachability of the silo contents will carry through the risk assessment for in situ remedial action alternatives which do not involve waste treatment.	Increased uncertainty in the levels of contaminants leaching into the perched groundwater.	No additional sampling is warranted. EP Toxicity data and geochemical modeling provide an upper bound to the leachate source term. As presented above, the results of HSL analyses for silo residues and process knowledge substantiates the absence of appreciable concentration of organic constituents. Further, the added precision to be gained through the use of TCLP versus EP Toxicity leachate analyses for inorganics is insignificant when compared to the total uncertainty inherent in risk calculations.
No laboratory validated data is available for perm surface soils.	None.	Yields uncertainty in the source term for fate and transport calculations under the current source-term scenario. Fate and transport calculations were biased high by assuming a 20°F temperature gradient across the dome surface in establishing an Rn breathing rate from the silos.	No additional sampling is warranted. With the exception of the resident farmer, risk values due to Rn-222 for all hypothetical receptors, under the current source-term scenario, are on the order of 10^{-4}. Risks to the resident farmer are as high as 10^{-4}. These values are at least four orders of magnitude lower than risks associated with silo residues via other pathways. Thus, no level of improved precision in the Rn-222 source term would have an appreciable effect on the overall risk associated with Silo 3 residues.
Screening level, semiquantative data (ASL-II) were used for Rn concentration in the silo headspaces to support fate and transport modeling.			
Surface and Subsurface Soils			
Silo 4 Structure			
No data regarding the level of contaminants or quantity of contaminated concrete in the silo structure.	This will yield uncertainty in the cost estimate for remedial action alternatives. Also, there is some uncertainty with regard to level of worker exposures for remedial action alternatives.	None.	No additional sampling is warranted. As Silo 4 has never been used for waste storage operations, the concrete in Silo 4 will be assumed to be clean or contain only minimal contamination during the FS. Based on the total quantity of concrete in Silo 3, limited concrete data will have less than a 5 percent impact on the overall cost estimate for remediation of Operable Unit 4. Further, health and safety planning will be based on conservative assumptions, assuring worker health and safety pending concrete sampling during remedial actions.
Decant Sump Tank Contents and Associated Piping			
No leak test was performed for the sump tank and associated piping.	This yields uncertainty regarding usability of the tank to collect leachate from the silo residues during remedial action alternatives, primarily those involving slurry mining removal techniques.	None. Fate and transport modeling assumed that the silo contents leached directly to the perched water, with no underdrain or lining system assumed present.	No integrity testing is warranted for RI/FS. Fate and transport modeling assumptions used for baseline risk assessment provide an upper bound estimate of exposure point concentrations in the soils/perched water underlying Silos 1 and 2. Water levels performed monthly on the decant sump provide no indication of significant tank leakage. The ability to use the decant sump tank to collect leachate from the silo residues during remediation of the silos is inconsequential to the alternatives evaluation process. Design phase integrity testing is recommended.

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TABLE 7-3
(Continued)

Data Limitation	Significance Alternatives Evaluation	Significance Baseline Risk Assessment	Recommended Action
Pipe Trench and Other Concrete Structures			
No data regarding the level of contaminants or quantity of contaminated concrete are available for the pipe trench, foundation for the decant lift station, or the Drum Handling Building pad.[b]	This will yield uncertainty in the cost estimate for remedial action alternatives. Also, there is some uncertainty with regard to level of worker exposures for remedial action alternatives.	None.	No additional sampling is warranted. Based on the total quantity of concrete in the referenced structures, limited concrete data will have less than a 2 percent impact on the total cost estimate for remediation of Operable Unit 4 under any remedial alternative. Further, health and safety planning will be based on conservative assumptions, assuring worker health and safety pending concrete sampling during remedial actions.
Earthen Berm Surrounding Silos 1 and 2			
No laboratory validated data is available for berm surface soils.[b]	The uncertainty in the level of contaminants present in the berm surface soil yields uncertainty in the short-term effectiveness for worker health and safety due to air transport of surface soil contaminants or direct radiation from surface soil contaminants during remedial actions. Further, similar levels of uncertainty would be present in establishing residual risk under in situ alternatives and volume and cost estimates for ex situ alternatives.	The uncertainties in the level of contaminants present in berm surface soil yield uncertainty in the input to the fate and transport model for air and surface water and the resulting exposure point concentrations.	No additional sampling is warranted. The use of berm subsurface soil sample data to represent berm surface soils provides a reasonable estimate of source strength because, as stated in Section 4.2.2, the berm was placed following completion of operations in the Operable Unit 4 area. Thus, it is reasonable to assume that contaminants in the berm soil (i.e.; prior to placement) would be uniformly distributed. Subsurface berm soil data were used since they provide a reasonable approximation of surface soil concentrations. Additional sampling data would reduce uncertainty but would not appreciably affect the content or conclusions of the overall baseline risk assessment. Particulate air monitoring in the general area and at site boundary during remedial actions involving surface soil will address worker health and safety related concerns.
Surface and Subsurface Soil			
There is no assurance that the RI data have detected all localized areas which contain elevated concentrations of the constituents of potential concern.[b]	The uncertainty in the level of contaminants present in the surface and subsurface soil yields uncertainty in the short term effectiveness for worker health and safety due to air transport of surface soil contaminants or direct radiation from surface soil contaminants during remedial actions. Further, similar levels of uncertainty would be present in establishing residual risk under in situ alternatives and volume and cost estimates for ex situ alternatives.	The uncertainty in the level of contaminants present in surface soil yield uncertainty in the input to the fate and transport model for air and surface water and the resulting exposure point concentrations.	No additional sampling is warranted. Localized areas of elevated contaminant concentrations are anticipated in preparation of the health and safety plans. Further, localized areas of elevated contaminant concentrations are assumed in the evaluation of remedial action alternatives. Finally, any remedial action alternative undertaken in Operable Unit 4 will significantly disturb surface soil, necessitating systematic monitoring and/or sampling of surface soil. The baseline risk assessment assumes uniform concentration of constituents of potential concern in the upper six inches of Operable Unit 4 surface soil. This assumption provides an upper bound estimate of the risk contribution from surface soils. Employing the conservative assumptions, the total contribution to risk attributable to soil pathways is two orders of magnitude less than comparable total operable unit-related risk estimates.

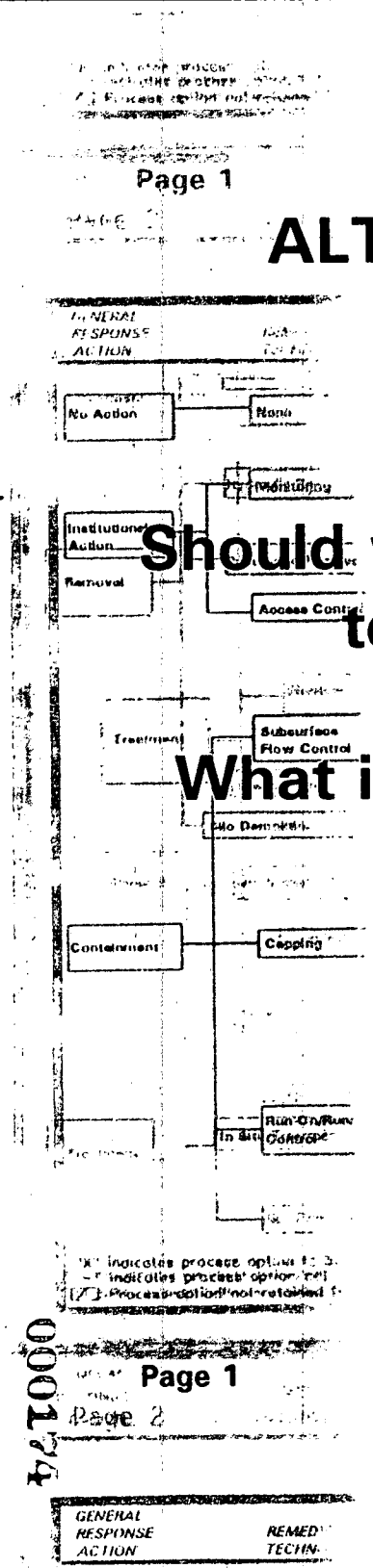
638

TABLE 7-3
(Continued)

Data Limitation	Significance Alternatives Evaluation	Significance Baseline Risk Assessment	Recommended Action
Perched Groundwater			
Uncertainty remains regarding the flow of perched groundwater and its interaction with Paddys Run.*	None. Remedial alternatives for perched groundwater will be evaluated under Operable Unit 5.	Uncertainty in the fate and transport calculations related to the flow of perched groundwater and its connection to the Great Miami Aquifer. Exposure point concentrations in perched water biased high through use of dilution model. Risk characterization provides upper bound estimate by assuming direct ingestion of perched water by hypothetical on-property farmer under future land-use scenario.	No additional sampling is warranted to support the RI. Three additional shallow wells are planned for installation to the west of Silos 1 and 2, between Operable Unit 4 and Paddys Run, to support the FS. Additional information relative to perched groundwater flow and its connection to the Great Miami Aquifer will be used in the evaluating potential remedial actions under Operable Unit 5. As presented in Section 5 and Appendix D, perched groundwater acts only as a pathway, not as a source, in fate and transport calculations. While additional perched groundwater data may refine these calculations, its impact on fate and transport calculations would be insignificant relative to the total risk and evaluation of the need for Operable Unit 4 remedial actions.

* Deviation from approved RI/FS Work Plan
** Not contemplated by approved RI/FS Work Plan

000173



ALTERNATIVE REMEDIATION TECHNOLOGIES

Should we give consideration to alternative remediation technologies? Perform a literature search.

What is the effectiveness of alternative technologies with respect to radon emissions?

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GENERAL RESPONSE ACTION	REMEDIAL TECHNOLOGY	PROCESS OPTION	DESCRIPTION	SUBUNIT APPLICABILITY A	B	C	SCREENING COMMENTS
No Action	None	Not Applicable	No Action	X	X	X	Required for consideration by NCP
Institutional Action	Monitoring	Groundwater Monitoring	Installation of wells for monitoring groundwater	X	X	X	Potentially applicable
		Leachate Monitoring	Monitoring of leachate collection/detection system	X	X	X	Potentially applicable
		Radon Monitoring	Installation of radon monitoring devices	X	X	X	Potentially applicable
		Surface Water/Sediment Monitoring	Collection/analysis of surface water/sediment samples	X	X	X	Potentially applicable
Removal	Access Control	Physical Barriers	Fencing, security, limited road access, etc.	X	X	X	Potentially applicable
		Administrative Controls	Restricted access only, posted signs, etc.	X	X	X	Potentially applicable
Treatment	Subsurface Flow Control	Subsurface Drains	Gravity driven collection system	X	X	X	Potentially applicable
		Slurry Walls	A soil/bentonite grout wall emplacement	X	X	X	Potentially applicable
		Pumping Wells	Extraction/injection of water into ground	X	X	X	Potentially applicable
		Sheet Pilings	Steel/concrete forms joined and driven into ground	X	X	X	Potentially applicable
		Grout Curtains	Close-spaced grout injections isolate area	X	X	X	Potentially applicable
Containment	Capping	Concrete-Based Cap	Concrete slab poured over area of concern	X	X	X	Potentially applicable
		Asphalt-Based Cap	Asphalt poured over area of concern	X	X	X	Potentially applicable
		Soil/Clay-Based Cap	Compacted soil or clay cover over area of concern	X	X	X	Potentially applicable
		Chemical Sealant Cap	Chemical stabilizers mixed with surface soils	X	X	X	Potentially applicable
		Multimedia Cap	Cap formed with various layers	X	X	X	Potentially applicable
		Void Space Grout	Fill dome void space with grout	X	X	-	Not feasible for empty silos
	Run-On/Runoff Control	Sedimentation Basin/ Sediment Trap	Temporary storage of runoff to allow settling/Traps to intercept soil particles in runoff	X	X	X	Potentially applicable
		Diversion/Collection	Surface water routing controls	X	X	X	Potentially applicable
		Grading	Topography modification for route control	X	X	X	Potentially applicable
		Revegetation	Vegetative cover provides surface stability	X	X	X	Potentially applicable
	Silo Renovation	Silo Rehabilitation	Apply gunite, paint, concrete, etc. to silo	-	-	-	Silos will be removed if residues are removed

"X" indicates process option to be retained for evaluation
"–" indicates process option not applicable for that subunit
Process option not retained for any subunit.

FIGURE 2-2

INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS

GENERAL RESPONSE ACTION	REMEDIAL TECHNOLOGY	PROCESS OPTION	DESCRIPTION	SUBUNIT APPLICABILITY A	B	C	SCREENING COMMENTS
Removal	Mechanical Removal	Loader/Dozer	Tractor- or wheel-mounted excavation vehicles	-	-	X	Not applicable due to material consistency and silo strength limitations
		Crane w/Clamshell System	Tractor-, wheel-, or skid-mounted hoisting system	X	-	X	Not feasible due to material consistency
		Conveyor System	Belt-type conveyor system excavates material	-	-	X	Not feasible due to material consistency, accessibility, and silo strength limitations
		Backhoe	Tractor- or wheel-mounted excavation vehicles	-	-	X	Not feasible due to material accessibility, and silo strength limitations
		Dragline System	Excavating tool pulled across material	-	-	X	Not feasible due to material consistency
	Hydraulic Removal	Slurry Pump w/ Jetting Ring	Dislodges and hydraulically removes material	X	X	X	Potentially applicable
	Pneumatic Removal	Pneume/Dozer Dredging	In situ sludge pumping system	-	-	-	Not applicable because of material consistency
		Airlift Dredging	Expanding air pulls material behind it	-	-	-	Not applicable, requires depths > 20-30 ft
		Vacuum w/Cutterhead	Negative pressure displacement system	X	X	-	Not applicable due to material incompatability
Treatment	Physical Tr	Controlled Blasting	Use of explosive agents to demolish structure	-	-	X	Only applicable to silo structures
		Impact Hammer	Percussion tools to break apart silo	-	-	X	Only applicable to silo structures
		Flame Cutting	Ignition of iron and aluminum oxides to cut structure/rebar	-	-	X	Only applicable to silo structures
		Thermite Reaction Lance	High-temperature flame cutting device to cut silo	-	-	X	Only applicable to silo structures
		Gas Torch	Torch used to cut structure/rebar	-	-	X	Only applicable to silo structures
	Waste Transporta	Hydraulic Splitter	High pressure water used to cut structure	-	-	X	Only applicable to silo structures
	Silo Demolition	Non-explosive Demolition Compounds	Expanding agents fracture structure	-	-	X	Only applicable to silo structures
		Circular Diamond or Carbide Saws	Diamond tipped or carbide saws to cut structural rebar	-	-	X	Only applicable to silo structures
Disposal	On-Property Di	Diamond Rope Saw	Diamond-tipped rope saw to cut concrete/rebar	-	-	X	Only applicable to silo structures
		Diamond Chain Saw	Diamond-tipped chain saw to cut concrete/rebar	-	-	X	Only applicable to silo structures
	Chemical T	Abrasive Water Jet	Stream of abrasives to cut silo using a high-velocity water jet	-	-	X	Only applicable to silo structures
		Core Batch Drilling	Drilling closely spaced holes resulting in failure of structure when force is applied	-	-	X	Only applicable to silo structures
		Wrecking Ball	Crane-mounted weight used to collapse structure	-	-	X	Only applicable to silo structures
Treatment	In Situ Treatment	Shallow-soil mixing	Chemical-, and/or fly ash-based stabilization	-	-	X	Silo strength limitations
	Thermal T	Insitu Vitrification	High voltage crystallization/glassification of solids	X	X	X	Potentially applicable
		Surcharging	Compaction of material by addition of soil cover	-	-	-	Limited waste compaction expected
		Soil Aeration	Inject air and collect volatiles	-	-	-	Not applicable to inorganics
		Steam Stripping	Inject steam to drive off volatiles	-	-	-	Not applicable to inorganics

"X" indicates process option to be retained for evaluation
"-" indicates process option not applicable for that subunit
Process option not retained for any subunit.

Figure 2-2
(Continued)

"X" indicates process option to
"–" indicates process option
Process option not retained

GENERAL RESPONSE ACTION	REMEDIAL TECHNOLOGY	PROCESS OPTION	DESCRIPTION	Subunit Applicability A	B	C	SCREENING COMMENTS
Treatment	Biological Treatment						
	Waste Stabilization	Asphalt-Based Stabilization	Asphalt mixed with soil and solidified	X	X	X	Potentially applicable
		Cement-Based Stabilization	Cement mixed with soil and solidified	X	X	X	Potentially applicable
		Thermoplastic Encapsulation	Polymers mixed with soil and solidified	X	X	X	Potentially applicable
		Vitrification	High voltage crystallization/glassification of solids	X	X	X	Potentially applicable
	Decontamination & Decommissioning	Lime/Flyash Stabilization	Lime and fly ash mixed with soil	X	X	X	Potentially applicable
Treatment	Physical Treatment	Air Stripping	Volatile mass transfer process	-	-	-	Not applicable for inorganic materials
		Solid/Liquid Separation	Separation of solids and liquids	X	-	X	Not applicable due to dry powdery matrix
		Oil/Water Separation	Gravity differential separates free oil and water	-	-	-	Not applicable, no free oil phase
		Polymerization	Combines monomers to form polymers	-	-	-	Not applicable, few polymerizable materials
		FEMP AWWT	Treatment at FEMP Advanced Wastewater Treatment System	X	X	X	Potentially applicable
	Waste Transportation	Soil Aeration	Air injectors remove volatile organics	-	-	-	Not applicable for inorganic materials
		Steam Stripping	Steam injection removes volatile organics	-	-	-	Not applicable for inorganic materials
Disposal	On-Property Disposal						
	Chemical Treatment	Chemical Dechlorination	Reduces the amount of chlorinated compounds	-	-	-	Not applicable, few chlorinated compounds
		Oxidation/Ozonation/Photolysis	Organics destroyed by chemical oxidants	-	-	-	Not applicable for radionuclides
		Hydrolysis	Decomposition of compounds using water	-	-	-	Not applicable, material fully hydrolized
		Chemical Extraction	Impurities removed through solubility/affinity	X	X	X	Potentially applicable
	Off-Site Disposal	Reduction	Reduction of the ionic state of a compound	-	-	-	Not applicable, few reducible materials
	Thermal Treatment	Drying/Calcination	Removes water and decomposes carbonates	X	-	-	Silo 3 already calcined, does not treat radionuclides
		Incineration	Destroys hazardous organics and reduces volume	-	-	-	Not applicable for inorganic materials, radionuclides
		Thermal Desorption	Heating of a solid to drive off volatile organics	-	-	-	Not applicable for inorganic materials, radionuclides

"X" indicates process option to be retained for evaluation
"–" indicates process option not applicable for that subunit
Process option not retained for any subunit.

GENERAL RESPONSE ACTION | REMEDIAL TECHNOLOGY

Figure 2-2
(Continued)

"X" indicates process option
"-" indicates process option n
Process option not retained

GENERAL RESPONSE ACTION	REMEDIAL TECHNOLOGY	PROCESS OPTION	DESCRIPTION	SUBUNIT APPLICABILITY A	B	C	SCREENING COMMENTS
Treatment	Biological Treatment	Denitrification	Nitrates/nitrites reduced to molecular nitrogen	-	-	-	Not applicable due to lack of nitrates/nitrites
		Biological Detoxification	Microbial action degrades organics	-	-	-	Not applicable for radionuclides
		Land Farming	Microorganisms cultured in soil	-	-	-	Not applicable for radionuclides
	Decontamination and Decommissioning	Vacuum Scabbling	Pneumatically-driven piston, equipped with spikes used to chip away concrete and vacuumed up.	-	-	X	Only applicable to contaminated silo structures
		Pressure Washing	High pressure washer used to clean surface	-	-	X	Only applicable to contaminated silo structures
		Vacuum Grit-Blasting	Stream of abrasives propelled against surface to chip away concrete and vacuumed up	-	-	X	Only applicable to contaminated silo structures
		Acid Washing with Oxidizing Agents	Application of acid to dissolve concrete	-	-	X	Only applicable to contaminated silo structures
		Strippable Coatings	Application of material that cures to a thin solid coating and trapping contaminants in a polymer mix that may be stripped and disposed.	-	-	X	Only applicable to contaminated silo structures
Disposal	Waste Transportation	Rail Transport	Railroad transportation along available routes	X	X	X	Potentially applicable
		Truck Transport	Truck transportation along available routes	X	X	X	Potentially applicable
	On-Property Disposal	Engineered Disposal Facility	Engineered facility, capped when filled	X	X	X	Potentially applicable
		Above-Grade Vault	Above-ground disposal facility	X	X	X	Potentially applicable
		Lined/Unlined Pits/Trenches	Simple non-structural disposal units	-	-	-	Unacceptable for permanent disposal
	Off-Site Disposal	Nevada Test Site	Licensed government facility	X	X	X	Potentially applicable
		Permitted Commercial Disposal Site	Licensed commercial facility	-	-	X	Not applicable, cannot meet waste acceptance criteria
		New Facility Adjacent to FEMP	Engineered facility to be constructed	X	X	X	Potentially applicable
		New Facility w/in 300 Miles of FEMP	Engineered facility to be constructed	X	X	X	Potentially applicable
		Deep Geological Repository	Deep mined disposal facility	-	-	-	Not applicable, facility does not exist which accepts OU4 material

"X" indicates process option to be retained for evaluation
"-" indicates process option not applicable for that subunit
Process option not retained for any subunit.

Figure 2-2
(Continued)

UPDATE TO ALTERNATIVES ASSUMPTIONS & TECHNICAL BASIS

JOHN SMETS

FEBRUARY 11, 1997

g	SEG Concrete Boxes	Full Height White Metal Boxes	SEG Concrete Boxes	Full Height White Metal Boxes	Waste Packaging

Technical Basis & Assumptions

	Alternative 2 Vitrify 1 & 2, Cement 3		Alternative 3 Cement 1, 2 & 3	
	Vitrification	Cementation	Cementation	Cementation
Feed Basis	Silo 1 & 2 mixture	Silo 3	Silo 1 & 2 mixture	Silo 3
Volume of Residue	8,012 yd^3	5,088 yd^3	8,012 yd^3	5,088 yd^3
Volume of Bentogrout	878 yd^3	—	878 yd^3	---
Density of Residue/In-situ	132 lb/ft^3	57 lb/ft^3	132 lb/ft^3	57 lb/ft^3
Density of Residue/Dry	90 lb/ft^3	57 lb/ft^3	90 lb/ft^3	57 lb/ft^3
Density of Bentogrout/In-situ	100 lb/ft^3	—	100 lb/ft^3	---
Density of Bentogrout/Dry	74 lb/ft^3	---	74 lb/ft^3	---
Plant Capacity	12 MT/day	119 MT/day	85 MT/day	119 MT/day
Melter Capacity	6 MT/day	-	-	-
Melter Temperature	1150°C	-	-	-
No. of Trains	3	1	1	1
Operating Basis	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	4 months	3 years	4 months
Availability	90%	100%	80%	100%
Waste Loading	60% (dry weight)	45% (dry weight)	20% (dry weight)	45% (dry weight)
Waste Form	Gems	Monolith	Monolith	Monolith
Density of Treated Waste	173 lb/ft^3	100 lb/ft^3	114 lb/ft^3	100 lb/ft^3
Weight of Treated Waste	14,100 tons	8,100 tons	51,500 tons	8,100 tons
Waste Packaging	SEG Concrete Boxes	Full Height White Metal Boxes	SEG Concrete Boxes	Full Height White Metal Boxes

Technical Basis & Assumptions

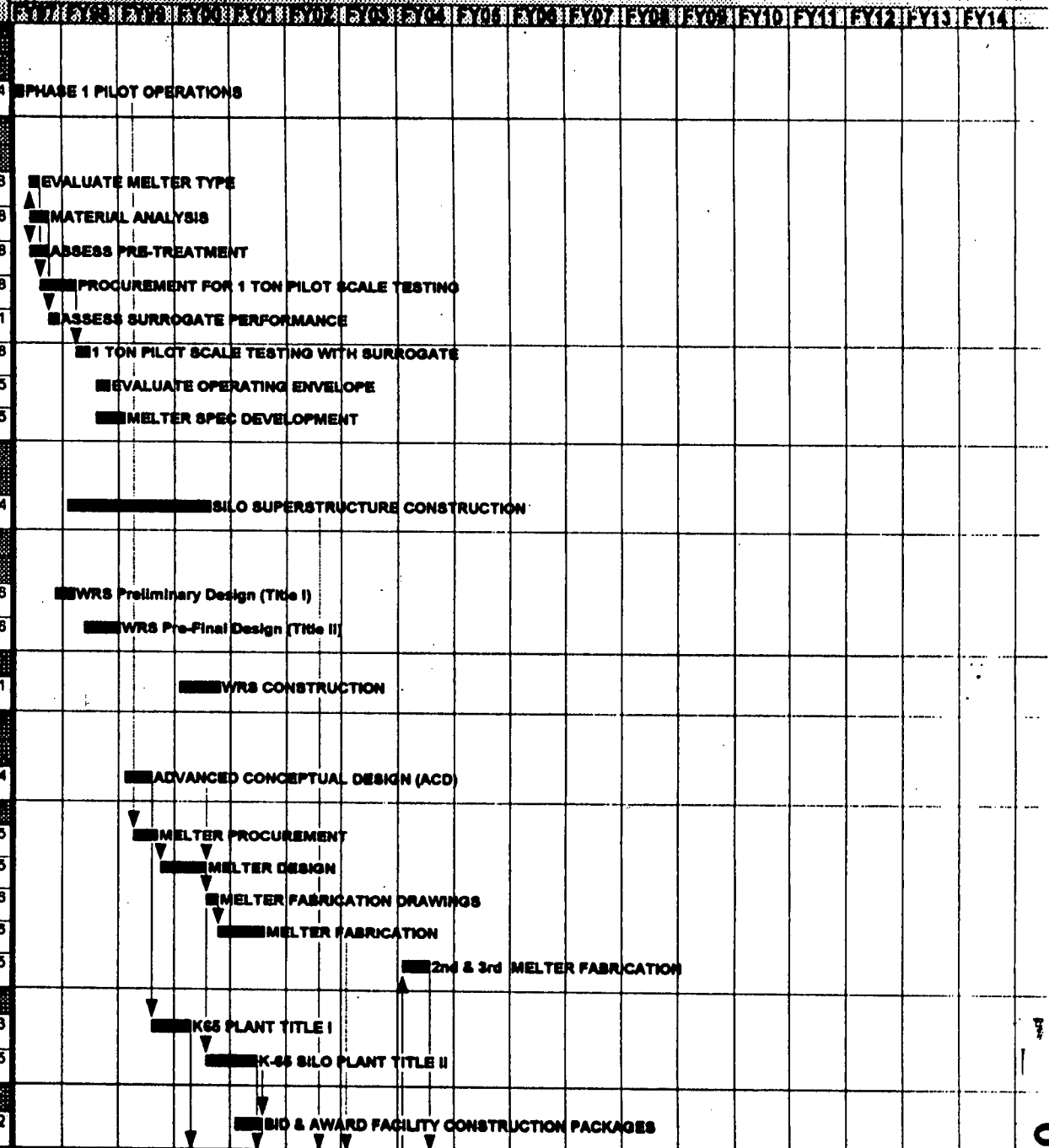
	Alternative 2 Vitrify 1 & 2, Cement 3		Alternative 3 Cement 1, 2 & 3	
	Vitrification	Cementation	Cementation	Cementation
Internal Volume of Container	2.3 yd^3	3.1 yd^3	1.7 yd^3	3.1 yd^3
Volume of Treated Waste	8,600 yd^3	6,088 yd^3	33,500 yd^3	6,088 yd^3
Packing Fraction	0.7	0.9	0.95	0.9
No. of Waste Containers	3,800	2,160	20,700	2,160
Estimated dose at exterior of container	70 mem./hr	2-3 mem./hr	15 mem./hr	2-3 mem./hr
External Volume of Container	4.9 yd^3	4.1 yd^3	4.9 yd^3	4.1 yd^3
Disposal Volume (with container)	18,500 yd^3	8,960 yd^3	101,400 yd^3	8,960 yd^3
Gross Weight of Container	21,000 lbs	8,600 lbs	17,000 lbs	8,600 lbs
Containers per shipment	2	4	2	4
No. of Waste Shipments	1,900	540	10,350	540
Transportation	Truck	Truck	Truck	Truck
Disposition of Silo Residues	NTS	NTS	NTS	NTS
Disposition of D&D Materials	Onsite Cell	Onsite Cell	Onsite Cell	Onsite Cell

Note 1 Excludes treatment of OU4 soils
2 Modified to include foam liner for radon attenuation

APPROACH TO TECHNOLOGY DEVELOPMENT ALTERNATIVE 2

ORIGINAL APPROACH	REVISED APPROACH
• Mini-melter testing of Actual Silo 1, 2 and 3 materials - Catholic University, Vitreous State Laboratory - 10 Kg/day scale melter - Evaluation of target glass formulations • Upgrade the Vitrification Pilot Plant consistent with the Upgrade Evaluation Report - Upgrades to enable processing of radioactive materials - Modifications to increase capacity from 1 MT/d to 4 - 6 MT/d - Utilization as facility for 2 MT/d remediation output - Demonstrated melter and support systems to be replicated in the final remediation facility	• Crucible testing of Actual Silo 1 & 2 material - Laboratory scale - Materials of construction - Evaluate target glass formulation • Mini-melter testing of Actual Silo 1 & 2 materials - 10 kg/day or greater - Evaluation of target low temperature formulations - Off-gas composition data, etc. • Pilot scale testing of surrogate material - 1 MT/d or larger (not at site) - Demonstrate scale up to determine specific melter rate at steady state operation • Full Scale Operations: - 1st module of full scale facility - Confirm full scale surrogate operations prior to introduction of contaminated materials - Use lessons learned from 1st module for fabrication of 2nd & 3rd melter train

Activity ID	Activity Description	Rem Dur	Early Start	Early Finish	Total Float
PILOT PLANT PHASE I					
OPERATIONS					
4AAC1399	PHASE 1 PILOT OPERATIONS	68*	19JUN96A	31JAN97	564
TREATABILITY STUDIES AHEAD FORWARD					
TREATABILITY STUDIES					
4AAC2120	EVALUATE MELTER TYPE	45	03MAR97	05MAY97	98
4AAC2100	MATERIAL ANALYSIS	85	03MAR97*	01JUL97	98
4AAC2110	ASSESS PRE-TREATMENT	85	03MAR97*	01JUL97	98
4AAC2151	PROCUREMENT FOR 1 TON PILOT	160	06MAY97	23DEC97	98
4AAC2105	ASSESS SURROGATE	45	02JUL97	04SEP97	361
4AAC2150	1 TON PILOT SCALE TESTING	65	26DEC97	30MAR98	98
4AAC2140	EVALUATE OPERATING	65	11MAY98	11AUG98	3,425
4AAC2160	MELTER SPEC DEVELOPMENT	129	11MAY98	10NOV98	245
SILO SUPERSTRUCTURE					
CONSTRUCTION					
4AEEH150	SILO SUPERSTRUCTURE	510*	04NOV97	25MAY00	284
WASTE RETRIEVAL SYSTEM					
DESIGN					
4ADF0523	WRS Preliminary Design (Title I)	80	22AUG97	17DEC97	356
4ADF0500	WRS Pre-Final Design (Title II)	160	25FEB98	12OCT98	356
CONSTRUCTION					
4ADFH525	WRS CONSTRUCTION	145	08NOV99	31JUL00	541
SILOS PROJECT					
PRELIMINARY					
4ACCH004	ADVANCED CONCEPTUAL DESIGN	120	12NOV98	07MAY99	274
MELTER SET UP					
4ACCH005	MELTER PROCUREMENT	103	14JAN99	10JUN99	265
4ACCH011	MELTER DESIGN	200	12JUL99	27APR00	245
4ACCH006	MELTER FABRICATION DRAWINGS	59	28APR00	21JUL00	496
4ACCH010	MELTER FABRICATION	200	24JUL00	10MAY01	496
4ACCH023	2nd & 3rd MELTER FABRICATION	125	27OCT03	28APR04	245
DESIGN					
4ACCH000	K65 PLANT TITLE I	175	10MAY99	20JAN00	313
4ACCH008	K-65 SILO PLANT TITLE II	230	28APR00	29MAR01	245
PROCUREMENT					
4ACCH600	BID & AWARD FACILITY	120	06NOV00	02MAY01	252



Early Bar
Progress Bar
Critical Activity

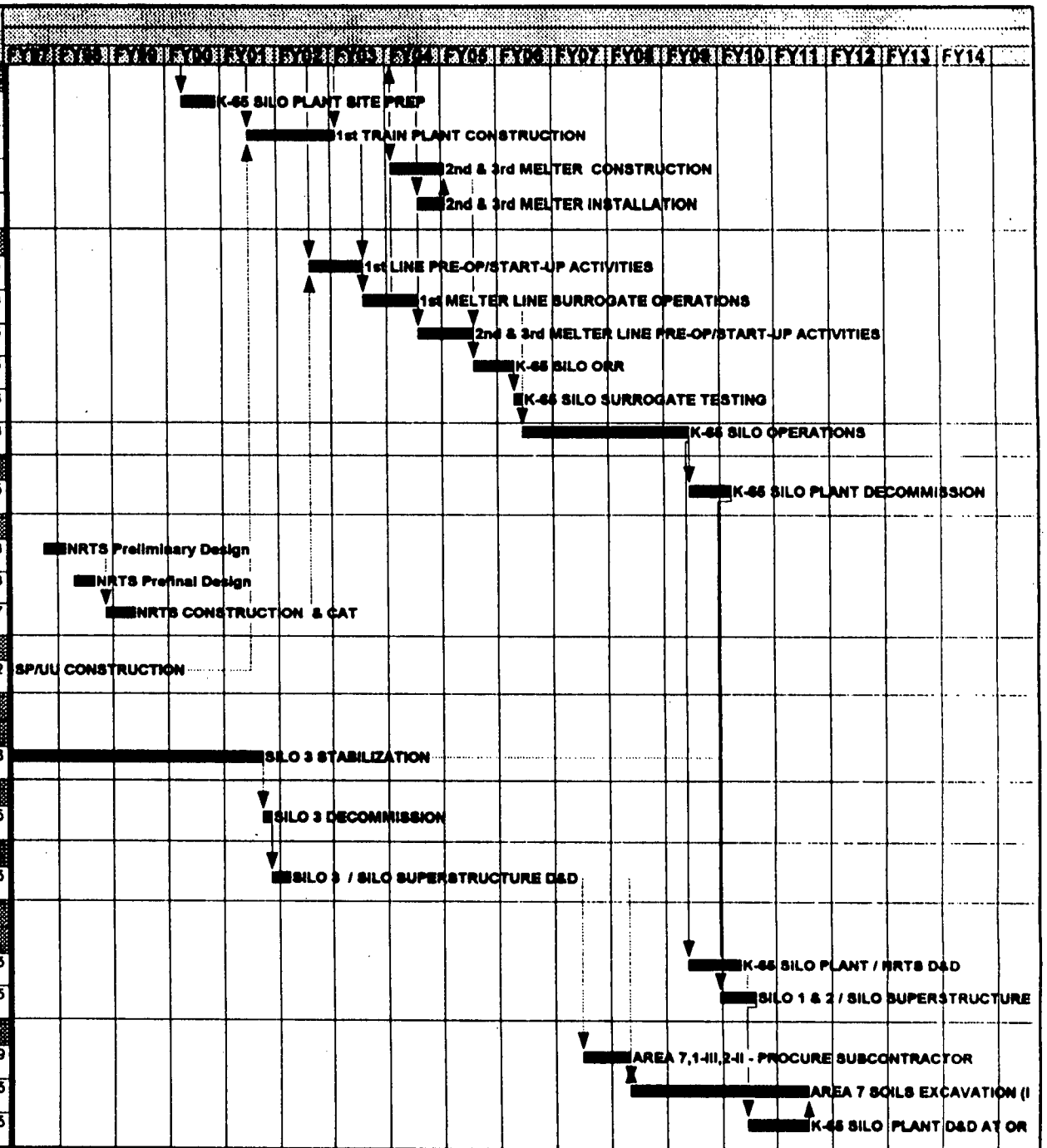
Page 5

ALTERNATIVE 2
w 3 MELTER LINES
SUMMARY LEVEL SCHEDULE

FERNALD
Environmental Management Project

63

Activity ID	Activity Description	Rem Dur	Early Start	Early Finish	Total Float
CONSTRUCTION					
4ACCH701	K-65 SILO PLANT SITE PREP	125	24JAN00	05SEP00	306
4ACCH700	1st TRAIN PLANT CONSTRUCTION	400	30MAR01	31OCT02	245
4ACCH702	2nd & 3rd MELTER	250	27OCT03	25OCT04	370
4ACCH504	2nd & 3rd MELTER INSTALLATION	125	29APR04	25OCT04	370
OPERATIONS					
4ACCH500	1st LINE PRE-OP/START-UP	250	30APR02	29APR03	245
4ACCH204	1st MELTER LINE SURROGATE	365	30APR03	28APR04	358
4ACCH503	2nd & 3rd MELTER LINE	250	29APR04	28APR05	245
4ACC8000	K-65 SILO ORR	180	29APR05	18JAN06	245
4ACC8100	K-65 SILO SURROGATE TESTING	60	19JAN06	19MAR06	358
4ACCH200	K-65 SILO OPERATIONS	1,095	20MAR06	18MAR09	358
DECOMMISSION					
4ACCH400	K-65 SILO PLANT DECOMMISSION	189	19MAR09	17DEC09	245
NEW RADON TREATMENT SYSTEM					
4ADCH000	NRTS Preliminary Design	100	07JUL97	25NOV97	673
4ADC0107	NRTS Prefinal Design	100	14JAN98	05JUN98	673
4ADCH005	NRTS CONSTRUCTION & CAT	100	20AUG98	22FEB99	537
SITE PREP/UU UTILITIES					
4ADJH000	SP/UU CONSTRUCTION	8	04MAR96A	06DEC96	172
SILO 3 STABILIZATION					
SILO 3 STABILIZATION					
4ACCH350	SILO 3 STABILIZATION	1,135*	16OCT96A	12JUN01	56
DECOMMISSION					
4ACJ2000	SILO 3 DECOMMISSION	40	13JUN01	08AUG01	1,775
D & D					
4ACC9650	SILO 3 / SILO SUPERSTRUCTURE	88	09AUG01	14DEC01	1,775
FINAL SITE REMEDIATION					
D & D					
4ACC9800	K-65 SILO PLANT / NRTS D&D	237	27FEB09	08FEB10	315
4ACC9600	SILO 1 & 2 / SILO	164	22SEP09	19MAY10	245
SOILS					
4ACJ1330	AREA 7,1-III,2-II - PROCURE	212	28MAR07	31JAN08	1,059
4ACJ1335	AREA 7 SOILS EXCAVATION (INCL	814	01FEB08	29APR11	245
4ACJ1340	K-65 SILO PLANT D&D AT OR	279	24MAR10	29APR11	245



4AAC2110 ASSESS PRETREATMEN

4AAC2105 ASSESS SUBCONTRACTOR

4AAC2120 EVALUATE MELTER

Project Start 01OCT96 — Early Bar
Project Finish 08APR12 — Progress Bar
Data Date 16FEB07 — Critical Activity
Plot Date 16FEB07

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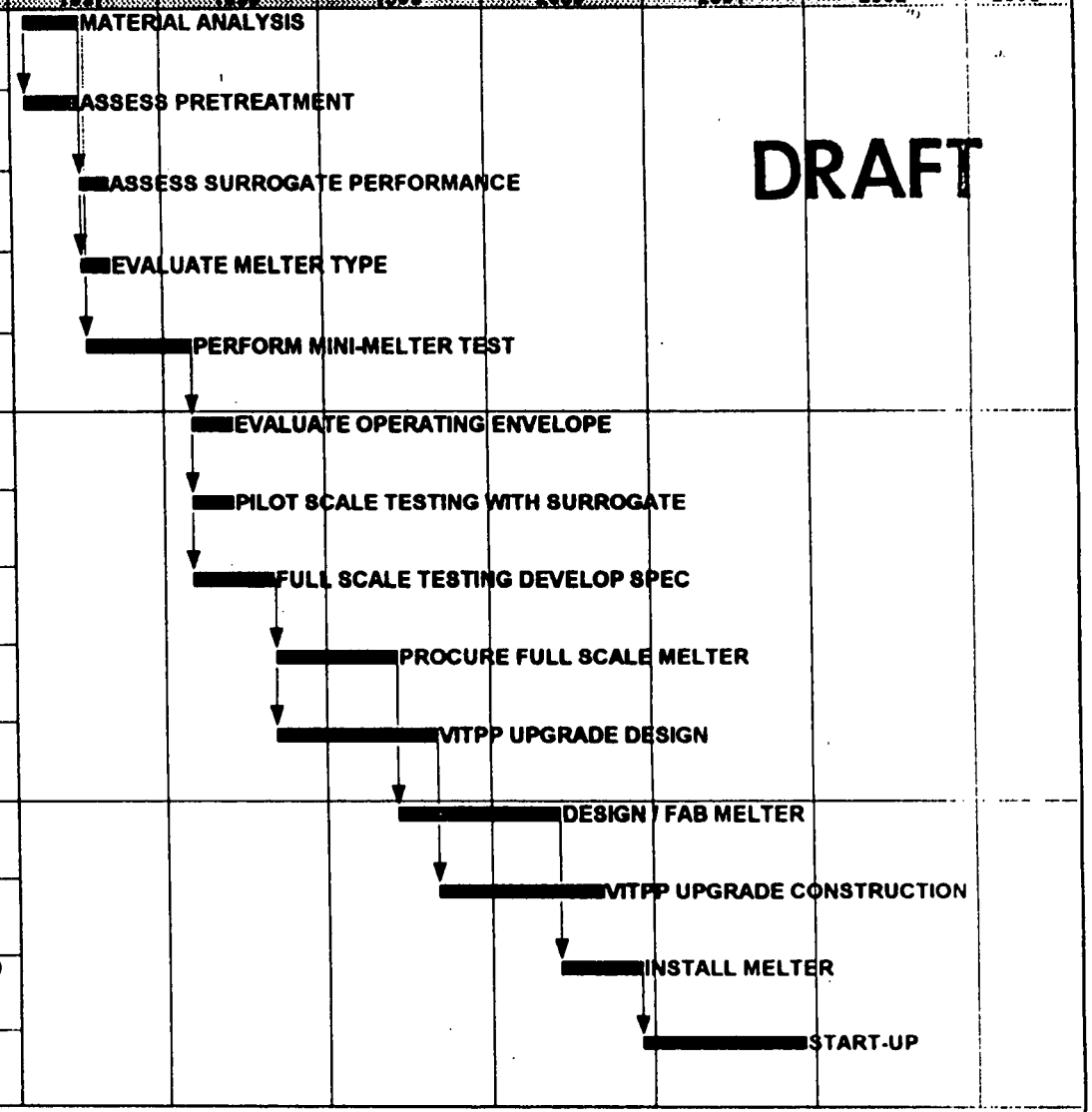
A204

Sheet 1 of 2

ALTERNATIVE 2
w 3 MELTER LINES
SUMMARY LEVEL SCHEDULE

FERNALD
Environmental Management Project

Activity ID	Activity description	Orig Dur	Early Start	Early Finish
AAC2100	MATERIAL ANALYSIS	85	03MAR97*	01JUL97
AAC2110	ASSESS PRETREATMENT	85	03MAR97*	01JUL97
AAC2105	ASSESS SURROGATE PERFORMANCE	45	02JUL97	04SEP97
AAC2120	EVALUATE MELTER TYPE	45	02JUL97	04SEP97
AAC2130	PERFORM MINI-MELTER TEST	160	14JUL97	04MAR98
AAC2140	EVALUATE OPERATING ENVELOPE	65	05MAR98	05JUN98
AAC2150	PILOT SCALE TESTING WITH SURROGATE	65	05MAR98	05JUN98
AAC2160	FULL SCALE TESTING DEVELOP SPEC	129	05MAR98	04SEP98
AAC2170	PROCURE FULL SCALE MELTER	186	08SEP98	07JUN99
AAC2210	VITPP UPGRADE DESIGN	250	08SEP98	07SEP99
AAC2180	DESIGN / FAB MELTER	250	08JUN99	06JUN00
AAC2220	VITPP UPGRADE CONSTRUCTION	250	08SEP99	06SEP00
AAC2190	INSTALL MELTER	125	07JUN00	05DEC00
AAC2200	START-UP	250	06DEC00	05DEC01



DRAFT

SILO 1 & 2 MELTER DEVELOPMENT

Project Start 01OCT96
Project Finish 05DEC01
Data Date 30JAN97
Plot Date 31JAN97

Early Bar
Progress Bar
Critical Activity

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ALT1

Sheet 1 of 1

SILO PROJECT
PATH FORWARD

FERNALD
Environmental Management Project

DRAFT RECOMMENDATION FOR ALTERNATIVE 1

HARRY ROBERTSON

FEBRUARY 11, 1997

This three chamber, molybdenum electrode design was used in the Vitrification Pilot Plant and has proved difficult to control.

INDEPENDENT REVIEW TEAM RECOMMENDATION FOR EXCLUDING VITRIFICATION OF SILOS 1,2 &3 TOGETHER

The Silos Project Independent Review Team recommends that Alternative 1 (Vitrification of Silos 1,2, &3 together) should be eliminated from further consideration. Further, the Vitrification of Silo 3 material by itself should also be eliminated from further consideration.

The basis of the recommendation is as follows:

Technical Complexity

The design of the melter of a combination of Silos 1, 2, &3 material must accommodate two specific glass chemistry requirements. These are:

The high sulfate concentration which requires a high temperature melter

and

The high lead content which requires an oxidizing environment to avoid the production of a metallic lead phase.

The combination of high temperature, oxidizing conditions and danger of metallic lead formation result in the need for a complicated and unique melter/electrode design configuration. This three chamber, molybdenum electrode design was used in the Vitrification Pilot Plant and has proved difficult to control.

as used in
control

A more practical approach is to focus on a less complex glass chemistry to allow usage of commercially available proven techniques and materials of construction for the melter design. This approach can be accomplished by eliminating the high sulfate Silo 3 waste from the vitrification program and insuring an oxidizing environment. In summary, the three-chamber design should be abandoned.

On the other hand the FEMP has demonstrated, as part of the mixed waste stabilization program, that the implementation of the stabilization/solidification technology (i.e. cementation) would be an effective treatment of the Silo 3 residues through the successful treatment of similar, thorium bearing residues.

The technical simplicity of the stabilization/solidification process would allow the treatment of the Silo 3 residues by a more predictable process and therefore, with a more predictable schedule and cost.

Health and Safety

The stabilized waste form (cementation) for Silo 3 material meets all applicable, relevant and appropriate requirements and is protective of human health and the environment.

RECOMMENDATION FOR EXCLUDING ALTERNATIVE 1 ALTERNATIVE 1/SILO 3

- Sulfate foaming can cause problems with electrodes
- Sulfate layering can cause current fluctuations
- High temperature requirements result in
  - High corrosion
  - Materials of construction limitations
- Need to maintain Redox conditions results in unique three chamber melter design
- Combining all three silos results in
  - Mixing low radiological hazard material with higher hazard material
  - Increase in the quantity of high hazard material
  - Precludes using contact handling on some portion of material

Cost & Schedule Committee
"Base Case"

Michael Connors

February 11, 1997

0001190

Cost & Schedule Committee

Presentation Objectives:

* Address Independent Review Team Questions & Comments
* Changes to the "Base Case"
  - Schedule
  - Cost
* Funding Constraint Impacts

000191

638

Cost & Schedule Committee

CRITICAL INDEPENDENT REVIEW TEAM COMMENTS & RESOLUTIONS

Comment #1:

The cost presented in the base case estimates for D&D and the treatment of contaminated soils for Alternative #2 and Alternative #3 do not appear to be the same basis.

Answer #1:

The D&D cost is based on the estimated volume of plant debris. The vitrification alternative has more equipment requirement therefore the estimated volume of debris is greater. The volume of debris is multiple by a cost /cu ft. for the D&D estimate. The treatment of the soils underneath the silos was assumed to be remediated by the same method as the silos waste was treated. In Alternative #2 the soils under the silos were to be vitrified and disposed of at NTS and in Alternative #3 the soils were to be stabilizated and disposed at NTS. In the case of Alternative #2 this treatment of waste would require a replacement melter. Upon further review the cost presented for Alternative #2 was in error. Upon further review by the technology team the soil remediation assumption was changed to shipping the contaminated soil in white metal boxes for disposal at NTS.

000192

Cost & Schedule Committee

Comment #3:

Consider eliminating future use of the existing vitrification pilot plant (Given the extent of modifications necessary to upgrade the VITPP for both radioactive service and 6 MT/day operation.

Answer #3:

The optimized Alternative #2 schedule has implemented a 1 Ton/day surrogate testing, radioactive mini-melter testing and the use of the first full scale melter for extended surrogate testing prior to the construction of the 2nd and 3rd melter trains in place of the future vitrification pilot plant activities for vitrification technology development.

(See Melter Technology Development Schedule)

000193

638

Cost & Schedule Committee

Comment #5:

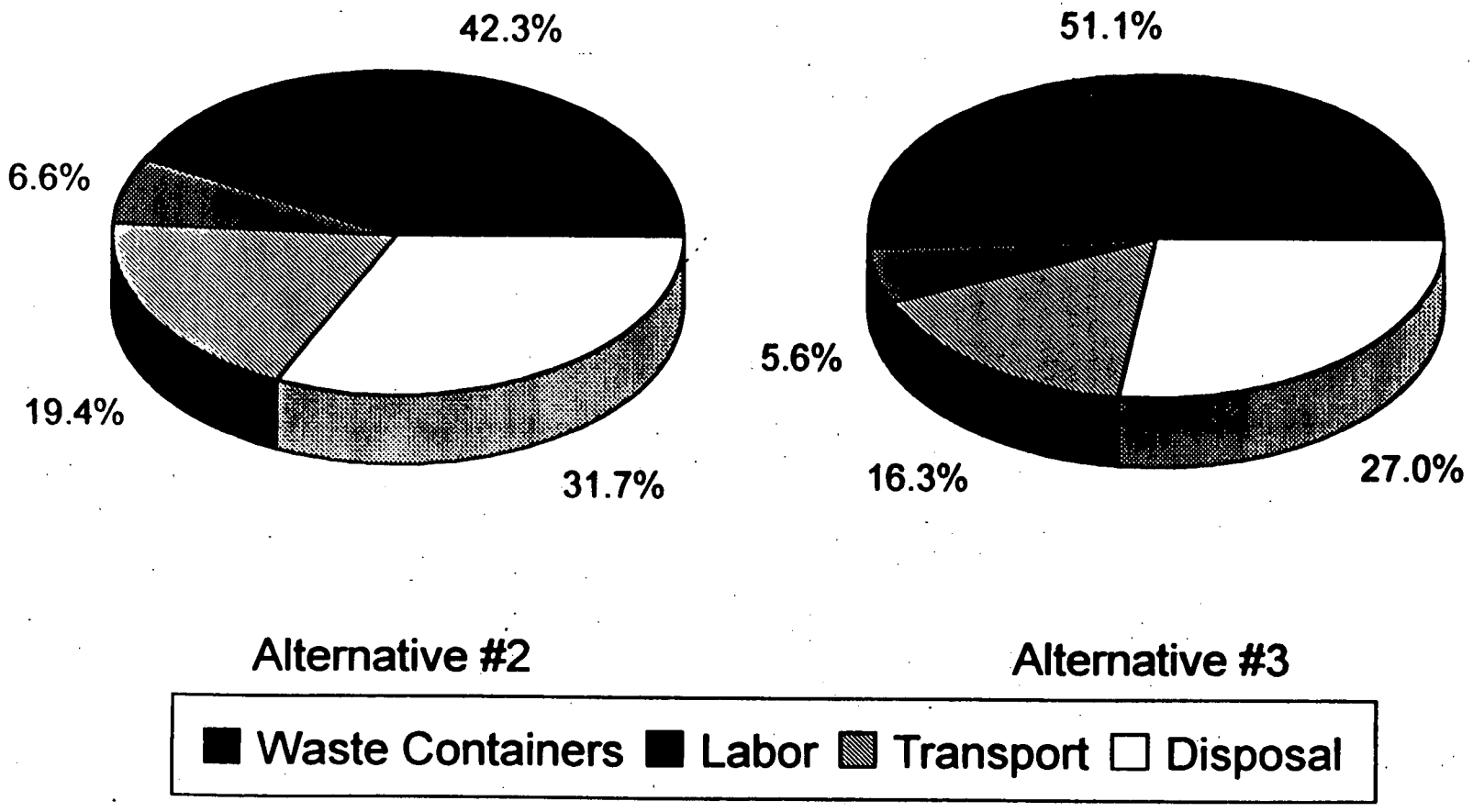
From the base case cost estimate presented, it did not appear that the shipping containers for both the Silo 1&2 alternatives for vitrification and cementation were on the same basis (As described in the basis and assumption for each of the Alternative)

Answer #5:

The cost basis for Alternative #2 and Alternative #3 were utilizing the SEG containers. The impact of waste loading influence the range and expected value of the waste shipping/waste packaging and disposal

000194

Waste Packaging /Transportation and Disposal Comparison



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638

Cost & Schedule Committee

ALTERNATIVE #2 & #3 BASE CASE ASSUMPTION AND LOGIC CHANGES BASE ON INDEPENDENT REVIEW TEAM COMMENTS

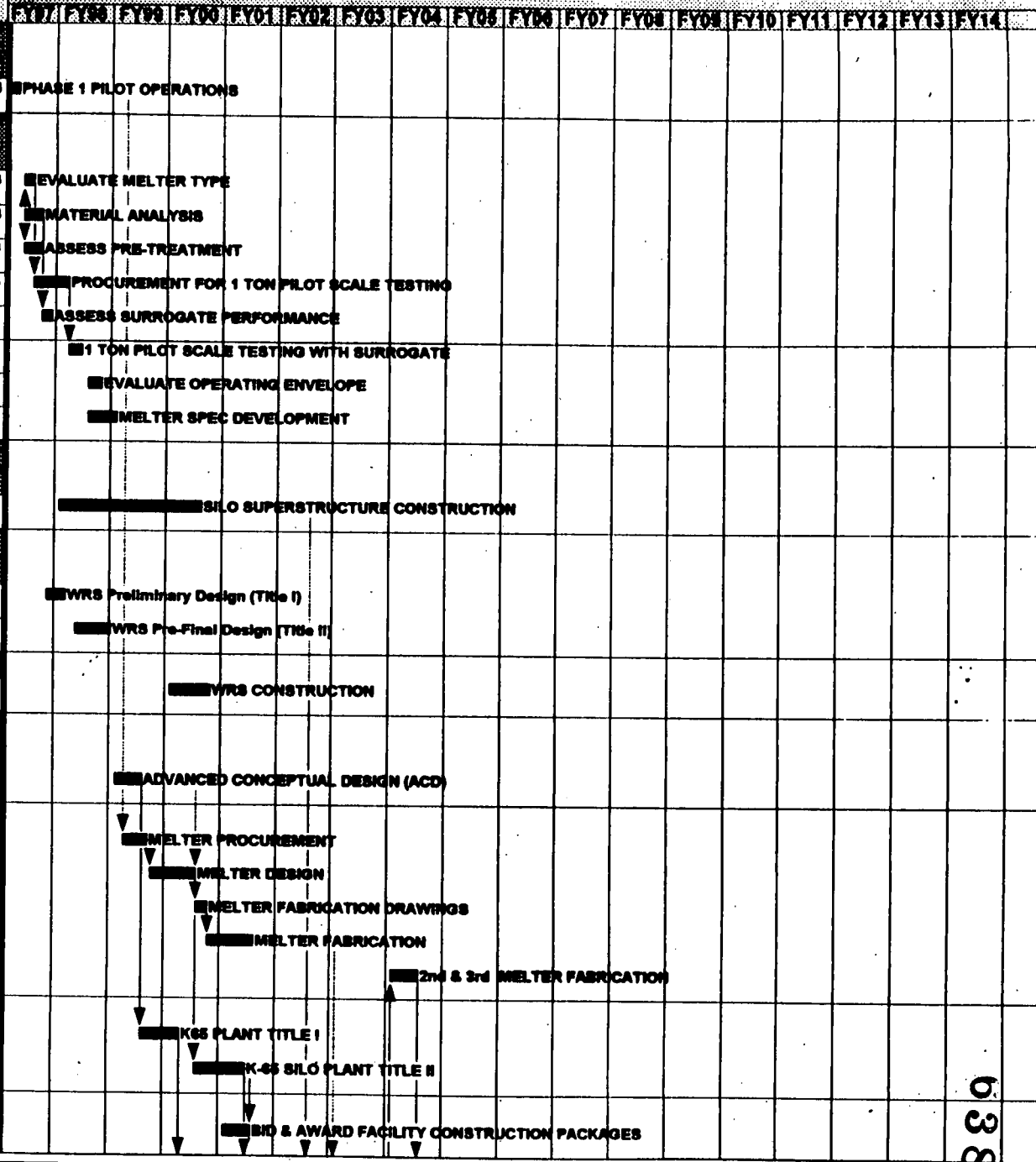
- Soil Remediation under the silos has been changed to consist of disposing the contaminated soil in white metal boxes, shipping and burial at NTS for both alternatives.

- Replace Phase II of the Vitrification Pilot plant with a melter technology development program utilizing laboratory, off-site testing and the 1st melter train for the final remediation plant as a full scale test prior to installing the 2nd and 3rd melter trains. (See Melter Technology Development Schedule).

- Alternative #3 waste package/disposal assumptions were revised by the technology group to utilize the SEG containers as the expected waste packaging plan. (See Technology group presentation for details)

0001196

Activity ID	Activity Description	Rem Dur	Early Start	Early Finish	Total Float
PILOT PLANT PHASE I					
OPERATIONS					
4AAC1399	PHASE 1 PILOT OPERATIONS	68*	19JUN96A	31JAN97	564
TREATABILITY STUDIES/PATH FORWARD					
TREATABILITY STUDIES					
4AAC2120	EVALUATE MELTER TYPE	45	03MAR97	05MAY97	98
4AAC2100	MATERIAL ANALYSIS	85	03MAR97*	01JUL97	98
4AAC2110	ASSESS PRE-TREATMENT	85	03MAR97*	01JUL97	98
4AAC2151	PROCUREMENT FOR 1 TON PILOT	160	06MAY97	23DEC97	98
4AAC2105	ASSESS SURROGATE	45	02JUL97	04SEP97	361
4AAC2150	1 TON PILOT SCALE TESTING	65	26DEC97	30MAR98	98
4AAC2140	EVALUATE OPERATING	65	11MAY98	11AUG98	3,425
4AAC2160	MELTER SPEC DEVELOPMENT	129	11MAY98	10NOV98	245
SILO SUPERSTRUCTURE					
CONSTRUCTION					
4AEEH150	SILO SUPERSTRUCTURE	510*	04NOV97	25MAY00	284
WASTE RETRIEVAL SYSTEM					
DESIGN					
4ADF0523	WRS Preliminary Design (Title I)	80	22AUG97	17DEC97	356
4ADF0500	WRS Pre-Final Design (Title II)	160	25FEB98	12OCT98	356
CONSTRUCTION					
4ADFH525	WRS CONSTRUCTION	145	08NOV99	31JUL00	541
SILOS PROJECT					
PRELIMINARY STUDIES/ACTIVITIES					
4ACCH004	ADVANCED CONCEPTUAL DESIGN	120	12NOV98	07MAY99	274
MELTER SET-UP					
4ACCH005	MELTER PROCUREMENT	103	14JAN99	10JUN99	265
4ACCH011	MELTER DESIGN	200	12JUL99	27APR00	245
4ACCH006	MELTER FABRICATION DRAWINGS	59	28APR00	21JUL00	496
4ACCH010	MELTER FABRICATION	200	24JUL00	10MAY01	496
4ACCH023	2nd & 3rd MELTER FABRICATION	125	27OCT03	28APR04	245
DESIGN					
4ACCH000	K65 PLANT TITLE I	175	10MAY99	20JAN00	313
4ACCH008	K-65 SILO PLANT TITLE II	230	28APR00	29MAR01	245
PROCUREMENT					
4ACCH600	BID & AWARD FACILITY	120	06NOV00	02MAY01	252



Project Start 01OCT96
Project Finish 08APR12
Data Date 20NOV96
Plot Date 19FEB97

Early Bar
Progress Bar
Critical Activity

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A2R4

Sheet 1 of 2

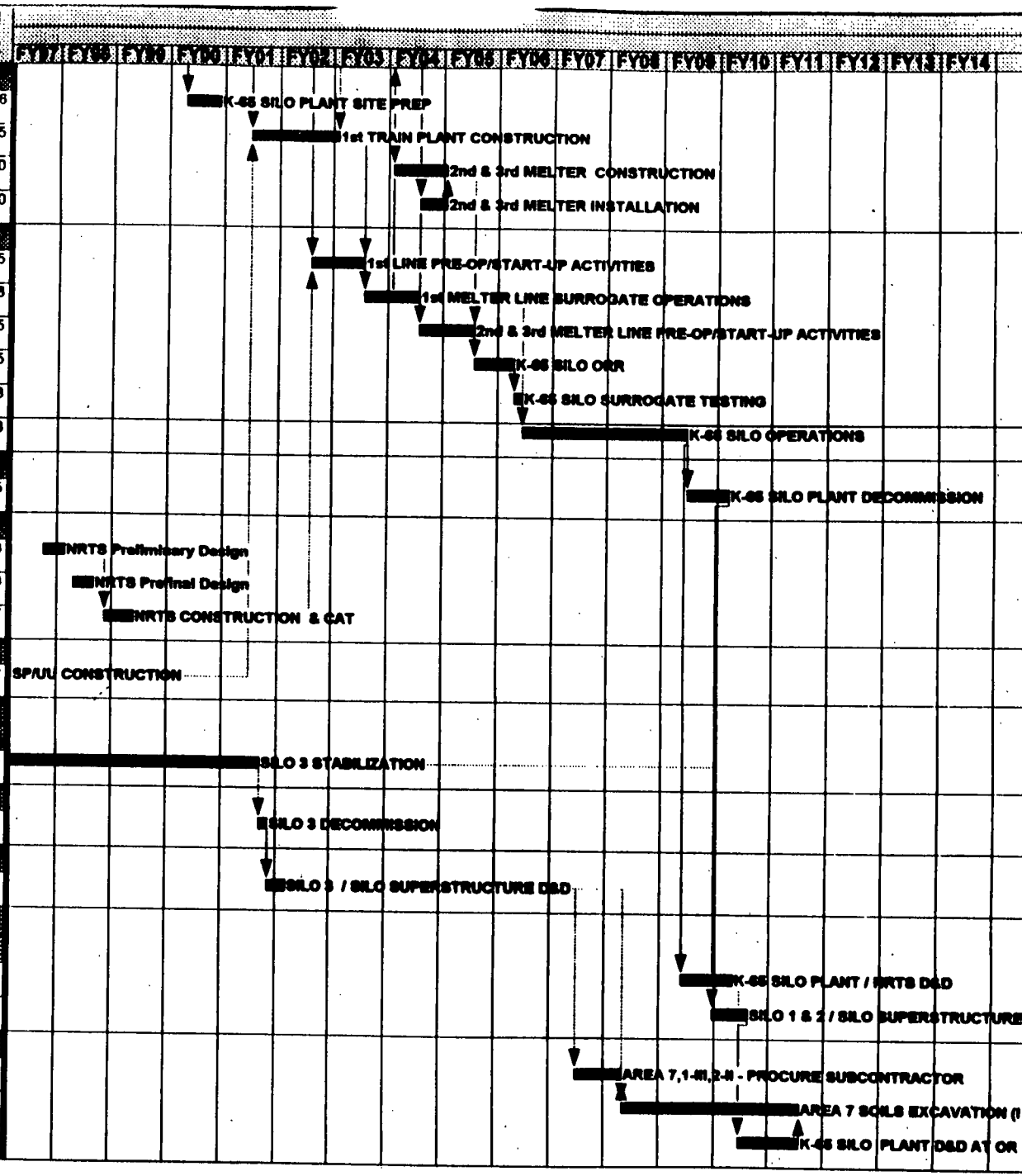
ALTERNATIVE 2
w 3 MELTER LINES
SUMMARY LEVEL SCHEDULE

FERNALD
Environmental Management Project

638

000157

Activity ID	Activity Description	Rem Dur	Early Start	Early Finish	Total Float
CONSTRUCTION					
4ACCH701	K-65 SILO PLANT SITE PREP	125	24JAN00	05SEP00	306
4ACCH700	1st TRAIN PLANT CONSTRUCTION	400	30MAR01	31OCT02	245
4ACCH702	2nd & 3rd MELTER	250	27OCT03	25OCT04	370
4ACCH504	2nd & 3rd MELTER INSTALLATION	125	29APR04	25OCT04	370
OPERATIONS					
4ACCH500	1st LINE PRE-OP/START-UP	250	30APR02	29APR03	245
4ACCH204	1st MELTER LINE SURROGATE	365	30APR03	28APR04	358
4ACCH503	2nd & 3rd MELTER LINE	250	29APR04	28APR05	245
4ACC8000	K-65 SILO ORR	180	29APR05	18JAN06	245
4ACC8100	K-65 SILO SURROGATE TESTING	60	19JAN06	19MAR06	358
4ACCH200	K-65 SILO OPERATIONS	1,095	20MAR06	18MAR09	358
DECOMMISSION					
4ACCH400	K-65 SILO PLANT DECOMMISSION	189	19MAR09	17DEC09	245
NEW RADON TREATMENT SYSTEM					
4ADCH000	NRTS Preliminary Design	100	07JUL97	25NOV97	673
4ADC0107	NRTS Prefinal Design	100	14JAN98	05JUN98	673
4ADCH005	NRTS CONSTRUCTION & CAT	100	20AUG98	22FEB99	537
SITE PREP UC UTILITIES					
4ADJH000	SP/UU CONSTRUCTION	8	04MAR96A	06DEC96	172
SILO 3 STABILIZATION					
SILO 3 STABILIZATION					
4ACCH350	SILO 3 STABILIZATION	1,135*	16OCT96A	12JUN01	56
DECOMMISSION					
4ACJ2000	SILO 3 DECOMMISSION	40	13JUN01	08AUG01	1,775
D & D					
4ACC9650	SILO 3 / SILO SUPERSTRUCTURE	88	09AUG01	14DEC01	1,775
FINAL SITE RESTORATION					
D & D					
4ACC9800	K-65 SILO PLANT / NRTS D&D	237	27FEB09	08FEB10	315
4ACC9600	SILO 1 & 2 / SILO	164	22SEP09	19MAY10	245
SOILS					
4ACJ1330	AREA 7,1-III,2-II - PROCURE	212	28MAR07	31JAN08	1,059
4ACJ1335	AREA 7 SOILS EXCAVATION (INCL	814	01FEB08	29APR11	245
4ACJ1340	K-65 SILO PLANT D&D AT OR	279	24MAR10	29APR11	245



Data Date 01OCT99
Project Start 01OCT99
Project Finish 09APR12
Data Date 29NOV99
Plot Date 16FEB07

Early Bar
Progress Bar
Critical Activity

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A2M

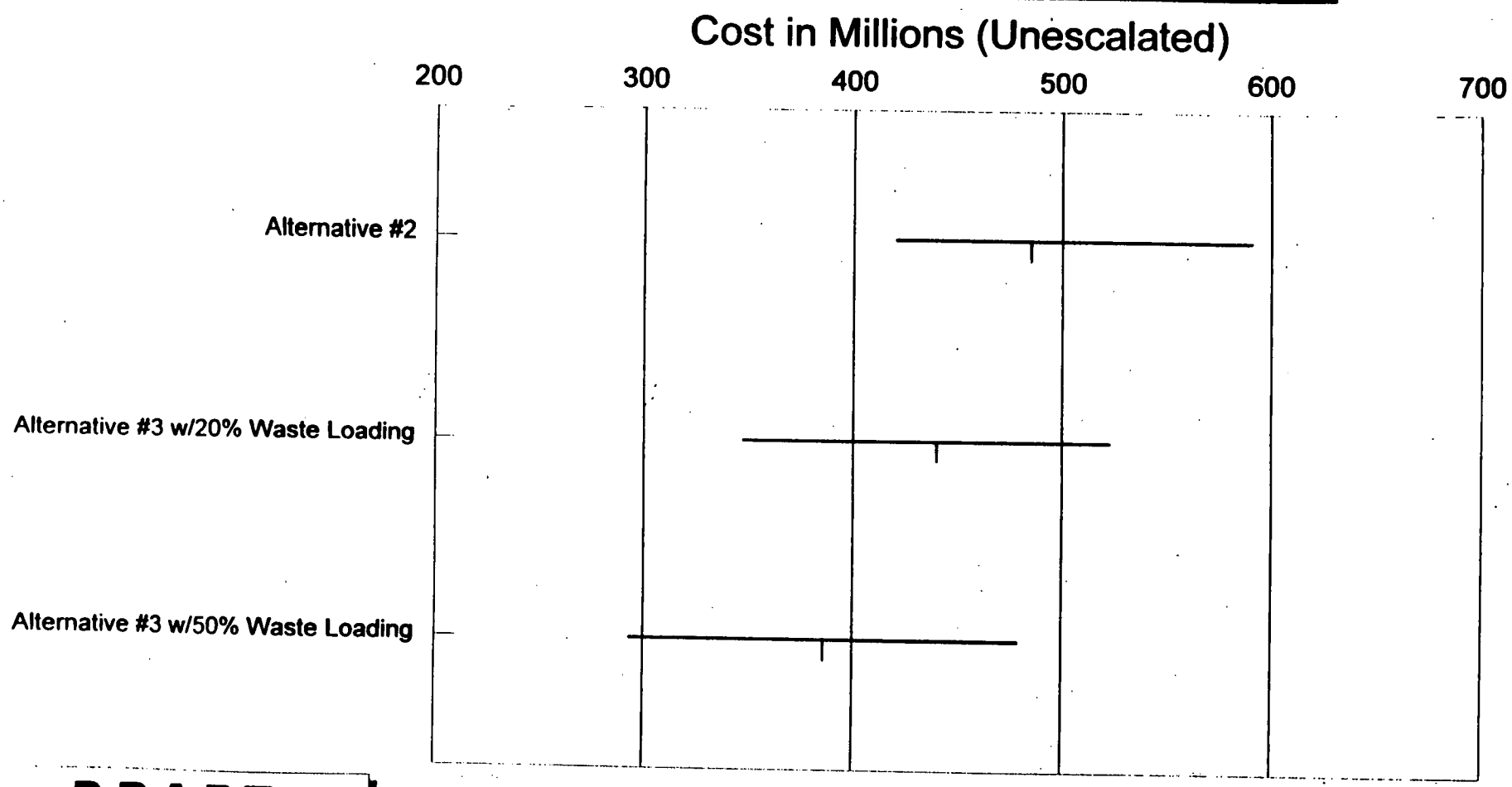
Sheet 1 of 1

Page 9

ALTERNATIVE 2
w 3 MELTER LINES
SUMMARY LEVEL SCHEDULE

FERNALD
Environmental Management Project

Alternative Life Cycle Cost
FY97 Through Completion



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000199

638

Cost & Schedule Committee

Changes in Base Cases in accordance with Independent Review Team Recommendation for Alternative #2

	Alternative #2 Base Case Presented in 1/97	Alternative #2	Change	Explanation
Schedule Completion Date	May 2010	[illegible]	[illegible]	[illegible]
Vitrification Pilot Plant Cost	77	12	65	Alternative #2 Delete Phase II of the VITPP replace with expanded minimelter testing, 1 ton/day surrogate testing and material analysis
Silo #3 Stabilization Cost	25	25	0	
Final Remediation Engineering Cost	47	51	(4)	Alternative #2 changed to have 12 engineers committed to the melter development process
Final Remediation Construction Cost	115	135	(20)	Alternative #2 changed 20 million to allow for construction modification after 1 year surrogate test with 1st melter
Final Remediation Operation Cost	60	75	(15)	Alternative #2 changes 15 million to allow for the 1 year surrogate testing with the 1st melter
Waste Pkg/Shipping/Disposal Cost	80	80	O	Alternative #3 changes due to the expected value of waste shipment was revised to reflex using the SEG boxes and 20% waste loading
D&D/Soils Remediation Cost	63	40	23	Alternative #2 soil was incorrectly estimated in the original base case. Soils will not be vitrified or stabilized just packaged and shipped to NTS
Project Management Cost	48	54	6	Alternative #2 changed by 6 million due to schedule extension for the melter development
Waste Retrieval Cost	16	16	0	
Total Direct Cost	531	[illegible]	[illegible]	[illegible]

000200

Cost & Schedule Committee

Changes in Base Cases in accordance with Independent Review Team Recommendation for Alternative #3

	Alternative #3 Base Case Presented in 1/97	Alternative #3	Change	Explanation
Schedule Completion Date	[illegible]	[illegible]	[illegible]	[illegible]
Vitrification Pilot Plant Cost	9	9	0	Alternative #2 Delete Phase II of the VITPP replace with expanded minimelter testing, 1 ton/day surrogate testing and material analysis
Silo #3 Stabilization Cost	25	25	0	
Final Remediation Engineering Cost	20	20	0	Alternative #2 changed to have 12 engineers committed to the melter development process
Final Remediation Construction Cost	68	68	0	Alternative #2 changed 20 million to allow for construction modification after 1 year surrogate test with 1st melter
Final Remediation Operation Cost	29	29	0	Alternative #2 changes 15 million to allow for the 1 year surrogate testing with the 1st melter
Waste Pkg/Shipping/Disposal Cost	135	198	(63)	Alternative #3 changes due to the expected value of waste shipment was revised to reflex using the SEG boxes and 20% waste loading
D&D/Soils Remediation Cost	36	36	0	Alternative #2 soil was incorrectly estimated in the original base case. Soils will not be vitrified or stabilized just packaged and shipped to NTS
Project Management Cost	45	45	0	Alternative #2 changed by 6 million due to schedule extension for the melter development
Waste Retrieval Cost	12	12	0	
Total Direct Cost	[illegible]	[illegible]	[illegible]	[illegible]

0002201

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Cost & Schedule Committee

PRELIMINARY FUNDING IMPACTS

SCENARIO	EST. COMPLETION
Alternative 2 Base Case	April 2011
With Funding Constraints	Approximately a 1-year delay*
With Severe Funding Constraints	Approximately a 4-year delay*
Alternative 3 Base Case	February 2008
With Funding Constraints	December 2009
With Severe Funding Constraints	July 2013

* Completion dates are based on judgements and will vary upon development of a detailed schedule.

000202

Responses to January Independent Review Team Comments

Comment #1: The cost presented in the base case estimates for D&D and the treatment of contaminated soils for Alternative #2 and Alternative #3 do not appear to be the same basis.

Answer #1: The D&D cost is based on the estimated volume of plant debris. The vitrification alternative has more equipment requirement therefore the estimated volume of debris is greater. The volume of debris is multiple by a cost /cu ft. for the D&D estimate. The treatment of the soils underneath the silos was assumed to be remediated by the same method as the silos waste was treated. In Alternative #2 the soils under the silos were to be vitrified and disposed of at NTS and in Alternative #3 the soils were to be stabilizated and disposed at NTS. In the case of Alternative #2 this treatment of waste would require a replacement melter. Upon further review the cost presented for Alternative #2 was in error. Upon further review by the technology team the soil remediation assumption was changed to shipping the contaminated soil in white metal boxes for disposal at NTS.

Comment #3: Consider eliminating future use of the existing vitrification pilot plant (Given the extent of modifications necessary to upgrade the VITPP for both radioactive service and 6 MT/day operation.

Answer #3: The optimized Alternative #2 schedule has implemented a 1 Ton/day surrogate testing, radioactive mini-melter testing and the use of the first full scale melter for extended surrogate testing prior to the construction of the 2nd and 3rd melter trains in place of the future vitrification pilot plant activities for vitrification technology development.
(See Melter Technology Development Schedule)

Comment #5: From the base case cost estimate presented, it did not appear that the shipping containers for both the Silo 1&2 alternatives for vitrification and cementation were on the same basis (As described in the basis and assumption for each of the Alternative)

Answer #5: The cost basis for Alternative #2 and Alternative #3 were utilizing the SEG containers. The impact of waste loading influence the range and expected value of the waste shipping/waste packaging and disposal

Comment # 9: The activities associated with the checkout of the Waste Retrieval System is not reflected on the schedule.

Answer #9: The activities are on the detailed 4 schedule supplied with the January meeting minutes.

Comment #10: Eliminate all fast track elements of the base case schedule:

Answer #10: FDF believes that System Operability Testing overlapping with construction for 50% allows the operator to be trained and instrumental in the system operability testing. Also the plan was to conduct construction turnover by systems while construction is still activity to allow construction corrective action will minimal impact.

The duration of bid and award of construction packages is based on the site standard bid and award cycle. Currently evaluating this duration with construction procurement.

The construction activities were detailed in the level 4 schedule. The construction activities for Alternative #2 were modified in the optimization of melter technology development.

The design periods in Alternative #2 were modified in the optimization of melter technology development.

Comment #8 & 11: Perform a detailed cost and schedule contingency analysis

Answer #8 & 11: Not performed at this time due to resource limitation. Plan to perform a detailed cost and schedule contingency analysis prior to rebaselining the Silos Project.

Comment #12: Allow adequate time for interaction with regulators (EPA, DNFSB, NRC and State of Nevada)

Answer #12: FDF believes this is addressed in the detailed level 4 schedule which was issued with the January meeting minutes.

Comment #13: Development of operating and maintenance procedures do not appear on the schedule

Answer #13: FDF believes this is addressed in the detailed level 4 schedule which was issued with the January meeting minutes.

Comment #14: Development of PSAR appears on the schedule, development of the FSAR does not appear on the schedule.

Answer #14: The FSAR is included in the level 4 schedule, there is a schedule programming error which omits the FSAR from the level 2 schedule.

Comment #15: Operator training for the final remediation facility does not appear on the schedule.

Answer #15: The detailed level 4 activities for the final remediation has not been developed for out year activities. The resources for the operator training is included in the Final remediation startup hammock activity.

Comment #16: Cold testing of the final remediation facility does not appear on the schedule.

Answer #16: The cold testing of the final remediation facility is the 90 day activity "Surrogate Testing". The detailed activity not noted is the detailed System operability testing for all the system which includes cold testing of the systems prior to readiness. The resources to perform the system operability is include in the startup hammock activity.

Comment #17 &18: The duration of the Silo #3 stabilization is to optimistic and the cost estimate is not adequate.

Answer #17 & 18: The estimate and durations for Silo #3 stabilization were obtained from the Silo #3 Alternative Report. The cost and duration are consistent between Alternative #2 and Alternative #3 and should not impact the decision analysis process. The duration and cost will be adjusted via Change Proposal once a vendor for treating Silo #3 waste is selected.

Comment #21 &22: The procurement of waste containers and site storage of waste containers prior to use are not indicated in the schedule.

Answer #21 & 22: The out year detailed activities are not defined at this time, but the cost for waste containers are included in the Waste Management Hammock Activity.

Detailed Base Case Assumptions For Alternative #2

Assume melter life is 3 years.

Assume that the final remediation melter specification is logically based on the radioactive minimelter test, 1ton/day surrogate testing and material of construction testing.

Assume final remediation Title II design is not initiated until Melter design and Title I design EPA comments are completely addressed.

Assume approximately 20% cost growth due to design changes as a result of the 1st melter train surrogate train testing.

Assume that the final remediation construction will be turned over by system for startup.

Assume 100 FTE required to operate the final remediation facility, this operating staff will be utilized during the startup and readiness prep phase for training, procedure development, conduct of operation, and system operability testing support.

Assume that the New Radon Treatment System (NRTS), Waste Retrieval System (WRS) and the Silo superstructure will be handle as a separate project and will have there own safety basis, readiness, and testing program.

Assume that the cost and schedule for Silo #3 remediation in the Silo #3 Alternative study were adequate.

Assume that the project management and project oversight requirements are twice of the FY96 project management due to overall increase in activity. FY96 Actual $1,955K

Assume that the debris from the silo superstructure/silos/ process facility will be disposed of in the On-site-disposal-cell. Due to the uncertainty of the facility contamination the range was 100% and the expected value was 50% of the range were the estimate is the lower bound of the range.

April 1996 Basis of Estimate

D&D Silos based on 17 manhours per cubic yard of concrete @ $27.84/hr
D&D Silos superstructure based on 22.9 manhours per ton of steel @ $31.56/hr
D&D of NRTS/VITPP/Final Remediation Facility @ $83/square foot
D&D of Trailer and storage areas @ $45/square foot

Assume waste and contaminated soils will be disposed of at NTS. Due to the uncertainty of the soil contamination the cost estimate for soils was the lower bound of the range and the expected value was twice the estimated value.

April 1996 Basis of Estimate

Berm Soil	10540 cubic yards
Surface soil 6" depth across OU4 Area	4440 cubic yards
Subsoil 5' depth below Silos #1&2	14650 cubic yards

The basis for Construction management was the actual VITPP construction management which were concurrently managing 3 major construction subcontractors. (Approximately 100K/month).

The basis for Startup and Readiness Preparation was the VITPP actuals. The average startup and readiness preparation cost for the Vitrification Pilot Plant was approximately 1million per month for 5 months (January 1996 - May 1996).

The spare parts requirements during Final remediation operation were assumed to be 10% of the equipment cost.

Detailed Base Case Assumptions For Alternative #3

Assume that the Silos Project ROD Amendment and additional treatability testing to support the stabilization of Silo #1&2 material is accomplished in two years.

Assume that the initiation of Final remediation Title I is logically driven by the ROD amendment and the additional treatability test data.

Assume final remediation Title II design is not initiated Title I design EPA comments are completely addressed.

Assume that the final remediation construction will be turned over by system for startup.

Assume 35 FTE required to operate the final remediation facility, this operating staff will be utilized during the startup and readiness prep phase for training, procedure development, conduct of operation, and system operability testing support.

Assume that the New Radon Treatment System (NRTS), Waste Retrieval System (WRS) and the Silo superstructure will be handle as a separate project and will have there own safety basis, readiness, and testing program.

Assume that the cost and schedule for Silo #3 remediation in the Silo #3 Alternative study were adequate.

Assume that the project management and project oversight requirements are twice of the FY96 project management due to overall increase in activity.. FY96 Actual $1,955K

Assume that the debris from the silo superstructure/silos/ process facility will be disposed of in the On-site-disposal-cell. Due to the uncertainty of the facility contamination the range was 100% and the expected value was 50% of the range were the estimate is the lower bound of the range.

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D&D Silos superstructure based on 22.9 manhours per ton of steel @ $31.56/hr
D&D of NRTS/VITPP/Final Remediation Facility @ $83/square foot
D&D of Trailer and storage areas @ $45/square foot

Cost & Schedule Committee

Assume waste and contaminated soils will be disposed of at NTS. Due to the uncertainty of the soil contamination the cost estimate for soils was the lower bound of the range and the expected value was twice the estimated value.

April 1996 Basis of Estimate

Berm Soil	10540 cubic yards
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The spare parts requirements during final remediation operation were assumed to be 10% of the equipment cost.

TECHNICAL COMMITTEE

HARRY ROBERTSON

FEBRUARY 12, 1997

000210

LIST B

Technical Uncertainties Meeting Screening Criteria	Impact Ranking	Weighted Average Probability Alt 2	Weighted Average Probability Alt 3	Sensitivity Range
1. Melter design requires development (best possible expertise, optimum glass composition)	1	0.58	n/a	0.1-1
2. Melter life differs from design basis	7	0.47	n/a	0-1
3. Waste chemistry different than expected	5	0.34	0.34	0-1
4. Waste loading varies significant from basis	3 (tie)	0.24	0.34	0-1
5. Plant capacity doesn't meet design basis	8	0.23	0.11	Alt. 2:0-1 Alt. 3:0-0.1
6. Generation of significant amounts off-spec material	6	0.15	0.22	Alt. 2:0-0.1 Alt. 3:0-1
7. Gem making capacity not achieved	9 (tie)	n/a	n/a	n/a
8. Lack of vendor response to RFP for stabilization or melter	9 (tie)	n/a	n/a	n/a
9. Radon standards cannot be met by stabilization	2	0.11	0.27	Alt. 2:0-0.1 Alt. 3:0-1
10. NTS won't take waste form other than glass	3 (tie)	n/z	0.22	0-1

THE DECISION TREE

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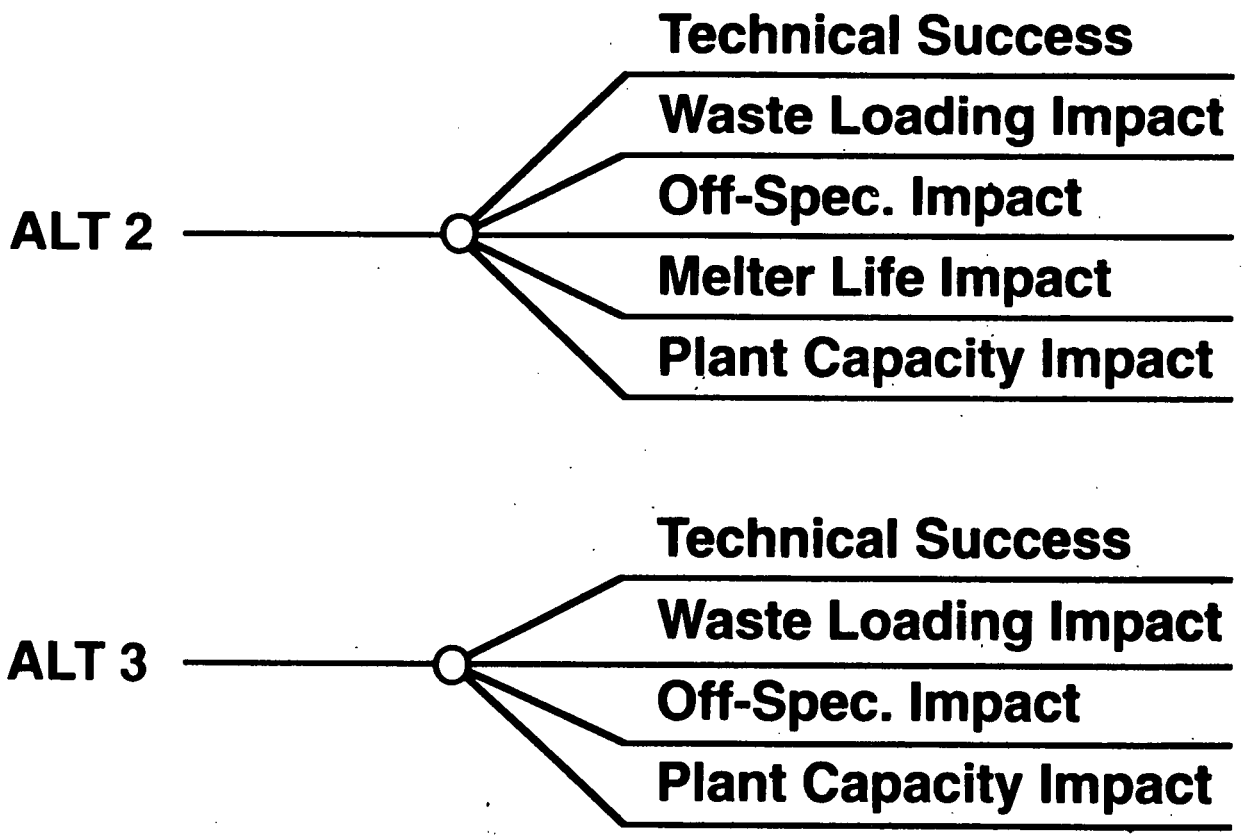

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Technical Committee

WASTE LOADING VARIES SIGNIFICANTLY FROM DESIGN BASIS

	ALTERNATIVE 2	ALTERNATIVE 3
Basis	Design Basis is 60wt%	Design Basis is 20wt%
Impact	Significant impact is assumed to be only 40% can be achieved for steady operations	Significant impact is assumed to be only 10% can be achieved for steady operations
Result	Extends operating period from 3 to 4-1/2 years (with 3 melters). Since melter life is 3 years (design basis), then must add two new melters and operate them for 2-1/4 years more. Waste shipments increase by one-half.	Extends operations an additional 3 years and doubles the waste shipments. (Cannot run plant for second shift as quantity of waste shipments controls production rate).
Probability	p = 0.15	p = 0.05

GENERATION OF SIGNIFICANT AMOUNTS OF OFF-SPEC MATERIAL

	ALTERNATIVE 2	ALTERNATIVE 3
Basis	Minimal off-spec material (<2%)	Minimal off-spec material (<2%)
Impact	Significant off-spec material is assumed to be 10%	Significant off-spec material is assumed to be 15%
Result	Extends operating period beyond the 3 year melter life and results in the need for a new melter and operation for another year.	Increases the amount of material that must be treated. Since the plant is operated only one shift, 5 days a week, there is a need for a second shift for approximately 6 months.
Probability	p = 0.05	p = 0.05

Technical Committee

PLANT CAPACITY DOES NOT MEET DESIGN BASIS

	ALTERNATIVE 2	ALTERNATIVE 3
Basis	Design Basis is 12 MT/day	Design Basis is 85 MT/day
Impact	Significant under capacity is assumed to be 6 MT/day	Significant under capacity is assumed to be 42 MT/day
Result	Extends operating period from 3 to 6 years (with 3 melters). Since melter life is 3 years (design basis), then must add three new melters and operate them for 3 years more.	Extends operating time by 24,000 hours (equivalent to 3 years). Since the plant is operated only one shift 5 days a week, there is a need for a second shift throughout the 3 years of operation.
Probability	p = 0.10	p = 0.05

MELTER LIFE DOES NOT MEET DESIGN BASIS

	ALTERNATIVE 2	ALTERNATIVE 3
Basis	Design Basis is 3 years.	N/A
Impact	Significant reduced melter life is assumed to be 2 years.	N/A
Result	Results in the need for two additional melters which operate for 1-1/2 years beyond the first 2 years.	N/A
Probability	p = 0.25	N/A

COST & SCHEDULE COMMITTEE REPORT
DEVIATIONS FROM "BASE CASE"

MICHAEL CONNORS

FEBRUARY 12, 1997

0002417

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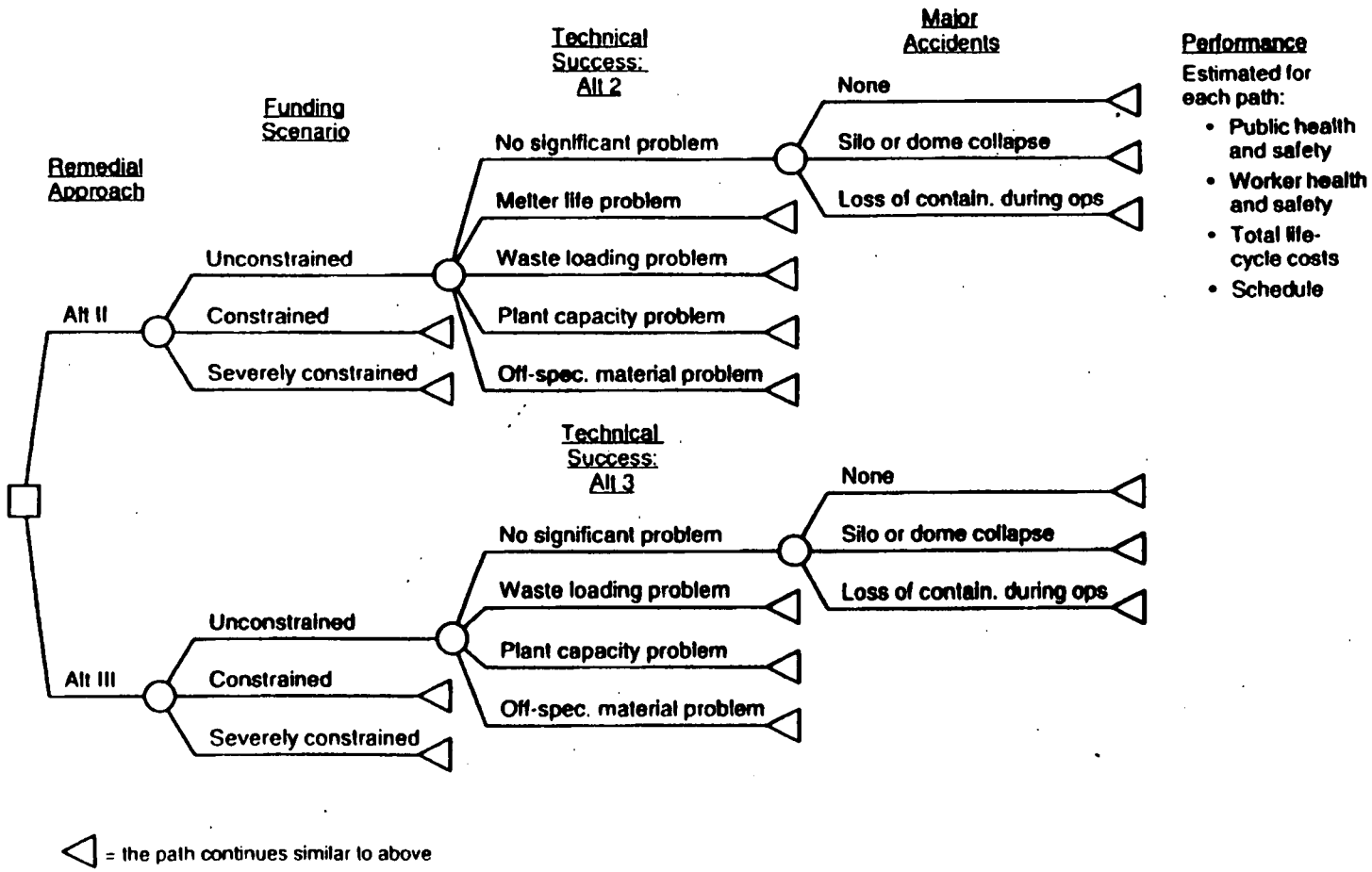
The decision tree



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Cost & Schedule Committee

COST AND SCHEDULE EVALUATION OF TECHNOLOGY AND SAFETY IMPACTS

- Finalize Alternative #2 and Alternative #3 base cases .
- Evaluate the technical and safety impacts with the technical and safety committees.
- Assess the schedule and cost impacts in rough order of magnitudes.
- Provide total direct cost and escalation cost and schedule information for input to the decision analysis model
- Provide schedule input to the safety team for safety risk evaluation for the decision analysis model
- Evaluate the impacts of the technical and safety impacts given funding constraints
- Provide schedule and cost information for the technical and safety impact for the funding constrained cases for input into the model.

000219

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IRT PRELIMINARY RECOMMENDATIONS

HARRY ROBERTSON

FEBRUARY 13, 1997

000250

IRT Preliminary Recommendations

DRAFT

OUTLINE OF INDEPENDENT REVIEW TEAM REPORT

EXECUTIVE SUMMARY

DESCRIPTION OF THE ACTIVITIES OF THE TEAM

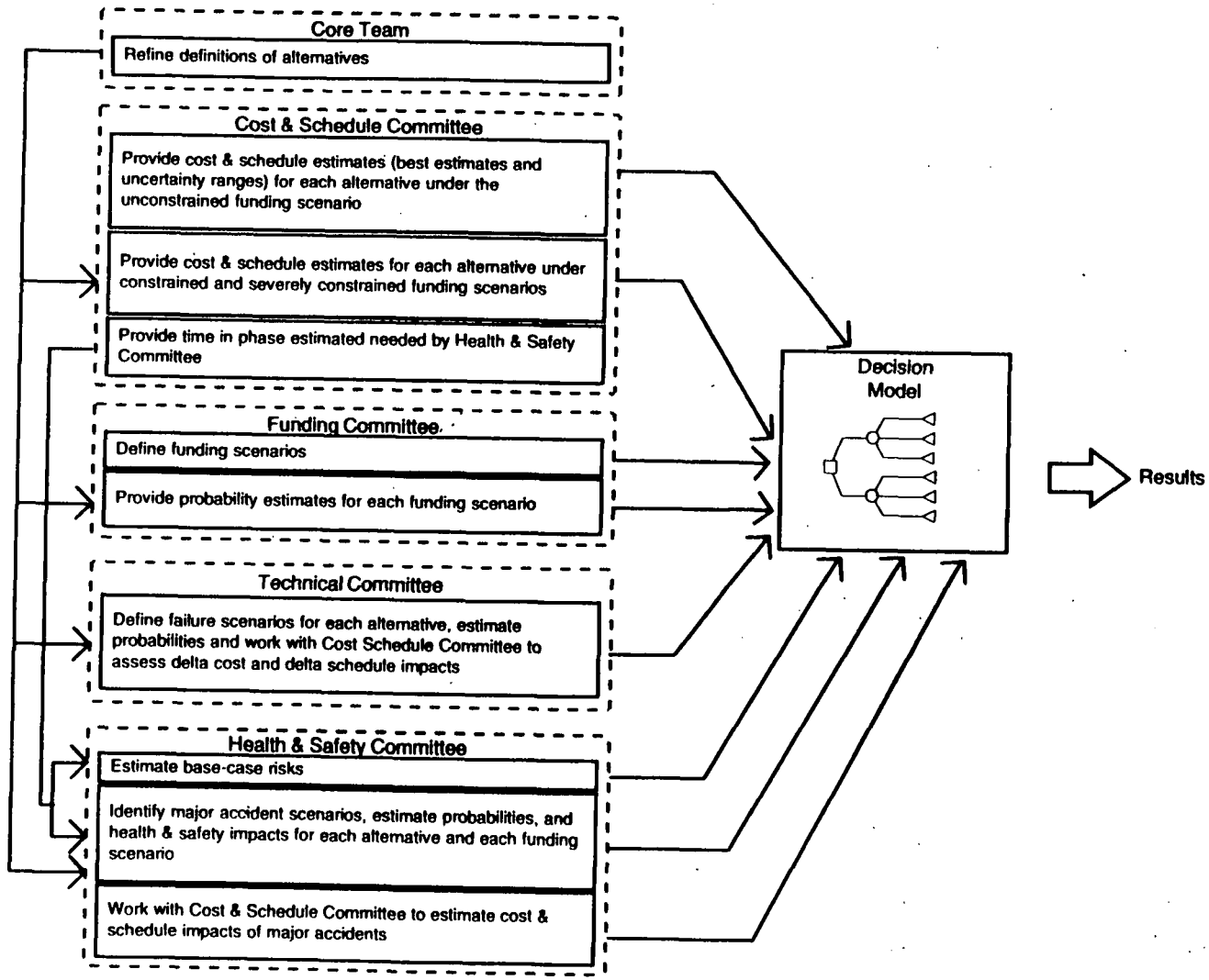
RECOMMENDATIONS OF THE TEAM

- PATH FORWARD
- OTHERS

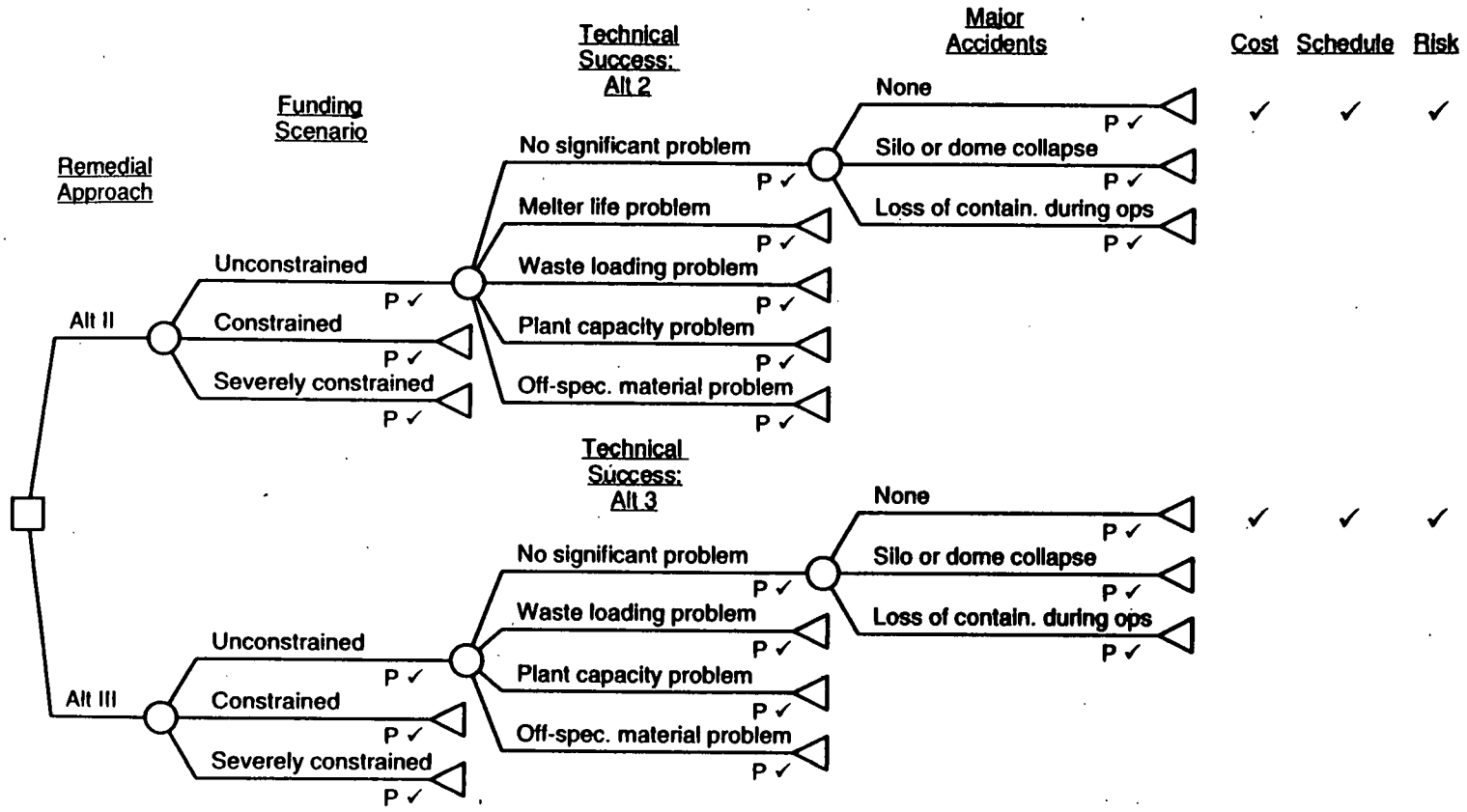
DECISION ANALYSIS MODEL ..... BY ADA

REFERENCES

Committee Tasks



The decision tree



◁ = the path continues similar to above

✓ = input received

note cost, schedule, and risk estimates have been generated for the 4 other "No significant technical problem", "No major accident" paths

00023

Schedule of Tasks

December 12&13 Meeting	January 21–23 Meeting	February 11–13 Meeting	February 27–28 Meeting
• develop logic for estimating probabilities and performance • generate base case performance estimates • begin "optimizing" design for each alternative	• revise base case to reflect IRT comments at Jan. 21 meeting • estimate performance for other paths through tree • estimate probabilities for key uncertainties	• perform model runs • perform sensitivity analysis	generate conclusions and recommendations

ADA
Applied Decision Analysis, Inc.
(2167\PRESENT\DAPROCE2.PPT4)
00022A

WASTE CONTAINER REQUIREMENTS & BASIS

Address the ability of a waste container to contain radon.

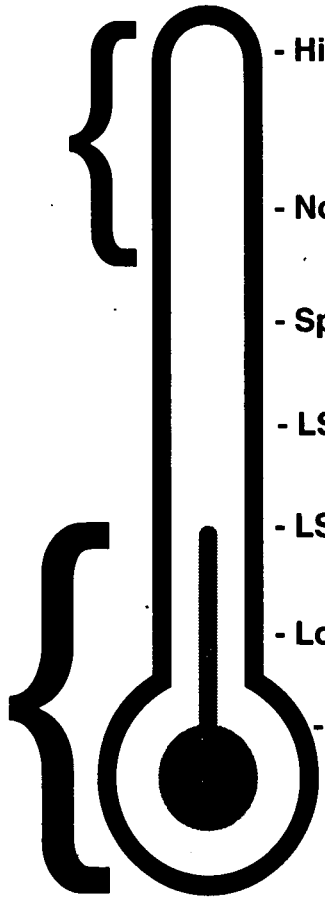
Mike Smith

Graphics 4437G.3 2/97

SHIPMENT OF SILO RESIDUES IN COMPARISON TO OTHER SHIPMENTS OF RADIOACTIVE MATERIAL

FERNALD

Radioactive Material DOT Hazard Classifications



- Highway Route Controlled Quantity
- Normal Form
- Special Form
- LSA - III
- LSA - II
- Low Specific Activity (LSA) - I
- Limited Quantity

Majority of Radioactive Material Shipments

Silo Residues

Majority of Fernald Shipments

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000226

SILO RESIDUES QUALIFICATION FOR SHIPMENT AS LSA-II MATERIAL

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LSA-II Limit Calculation
(10^{-4} A_2/g)

	A_2 Limit (Ci)	LSA-II Limit (Ci/g)	Fraction of LSA-II Limit
K-65 Residues	0.110	1.10×10^{-5}	0.0976
Silo 3 Residues	0.00851	8.51×10^{-7}	0.0929

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EXCLUSIVE USE, CLOSED TRANSPORT 49CFR173

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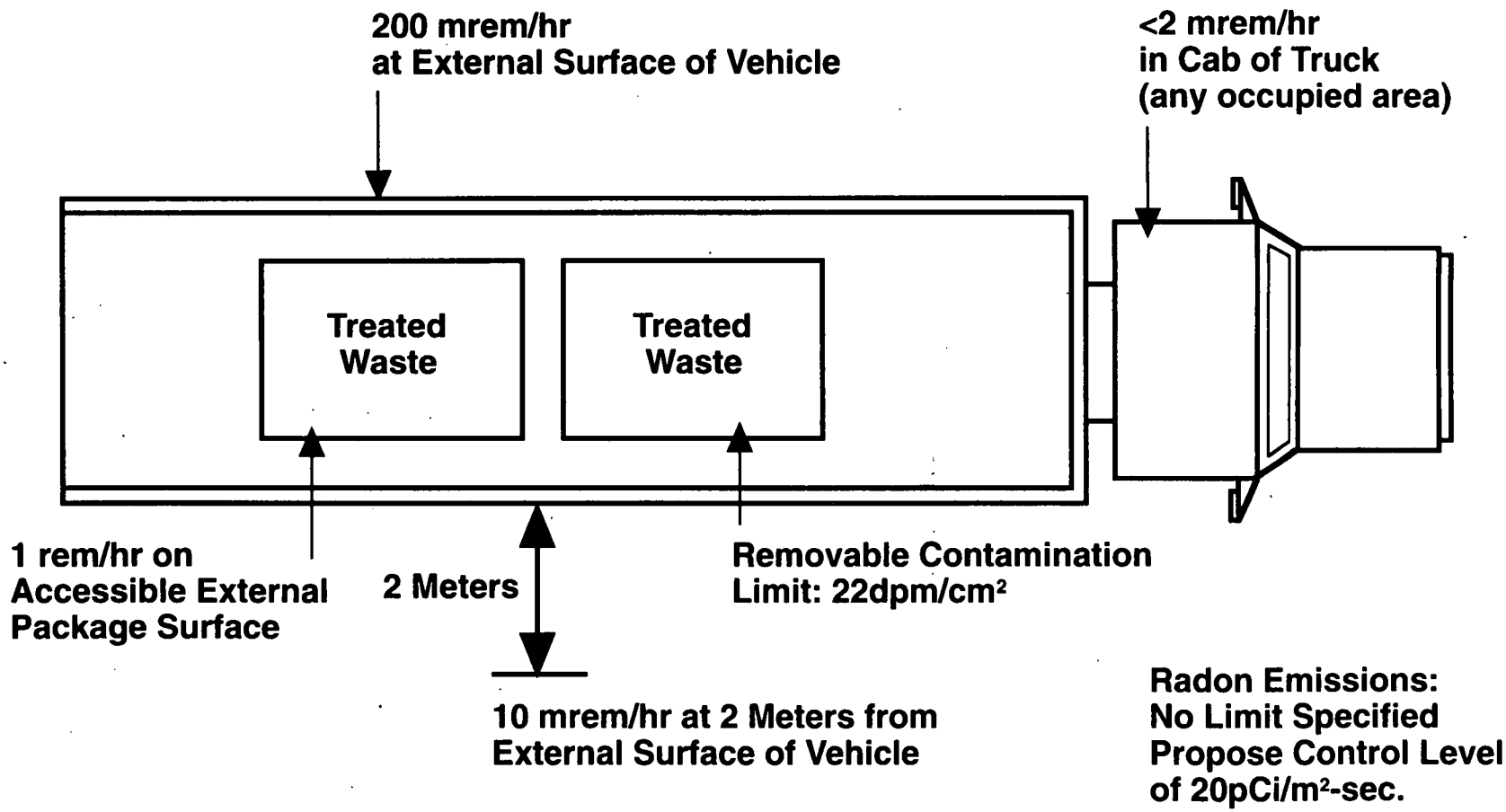

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RADIATION LEVELS FROM VITRIFIED K-65 RESIDUES IN A SEG ENDUROPAK CERTIFIED FOR THE TRANSPORT OF LSA-II MATERIAL

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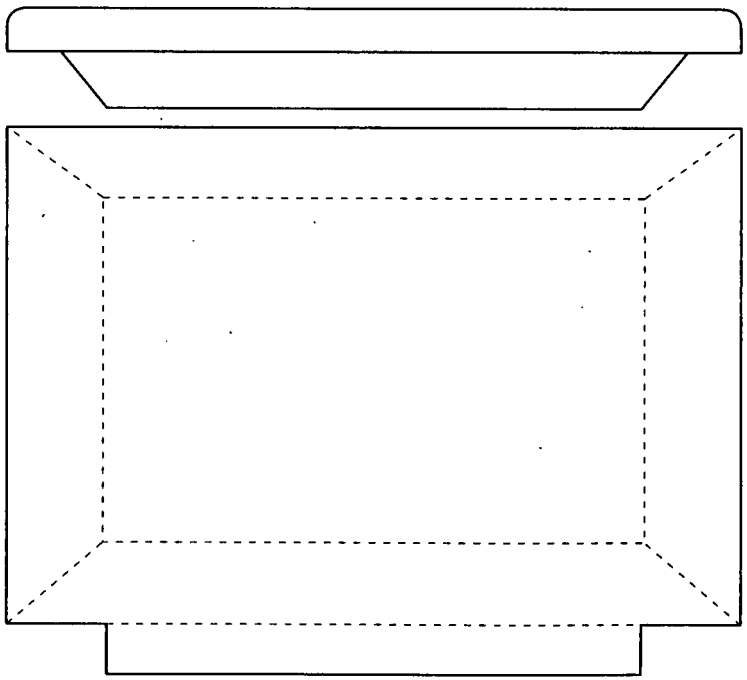


Vitrified K-65 Residues

60% dry weight waste loading

Radiation Level on Contact = 75 mrem/hr

Radiation Level at 1 meter = 19 mrem/hr

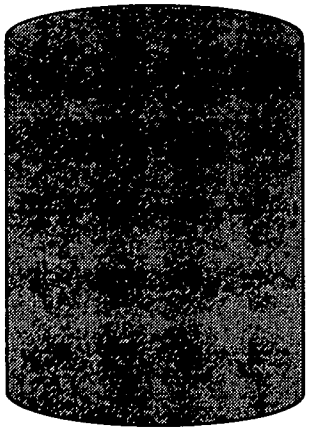
Radiation Level at 2 meters = 8 mrem/hr

Graphics 4437F. 5 2/97

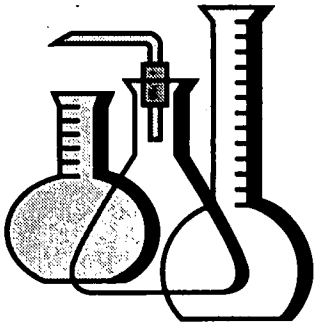
OPTIONS FOR RADON SHIPMENT CONTAINERS

FERNALD

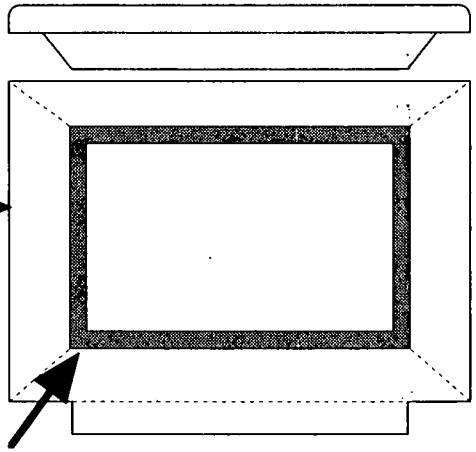
Small Container with Tight Seal



Radon Retaining Additives



Large Container with Retardant



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000230

DESIGN FOR RADON CONTAINMENT

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- Current SEG container design can be modified to contain radon from cement.
- Response to radon emanation from Silos in 1987 identified several polyurethane foams which had radon retardation properties. Examples include:
  - Elastomer Foam
  - Rigid Foam
  - Flexible Foam
- A foam liner could be added to the interior of the current SEG container to retard radon emanation thru concrete.
- Test data from the 1987 study was used to estimate the thickness of polyurethane .
- Confirmation of approach is needed through a cement waste container testing.

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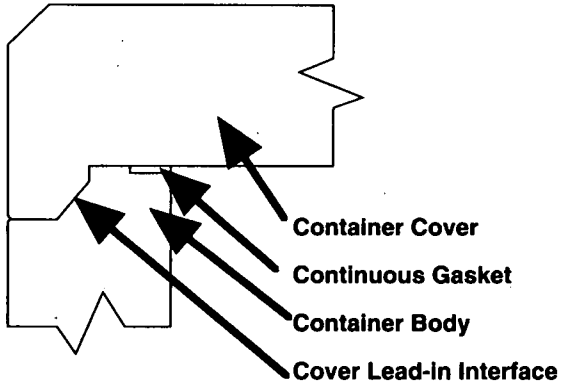
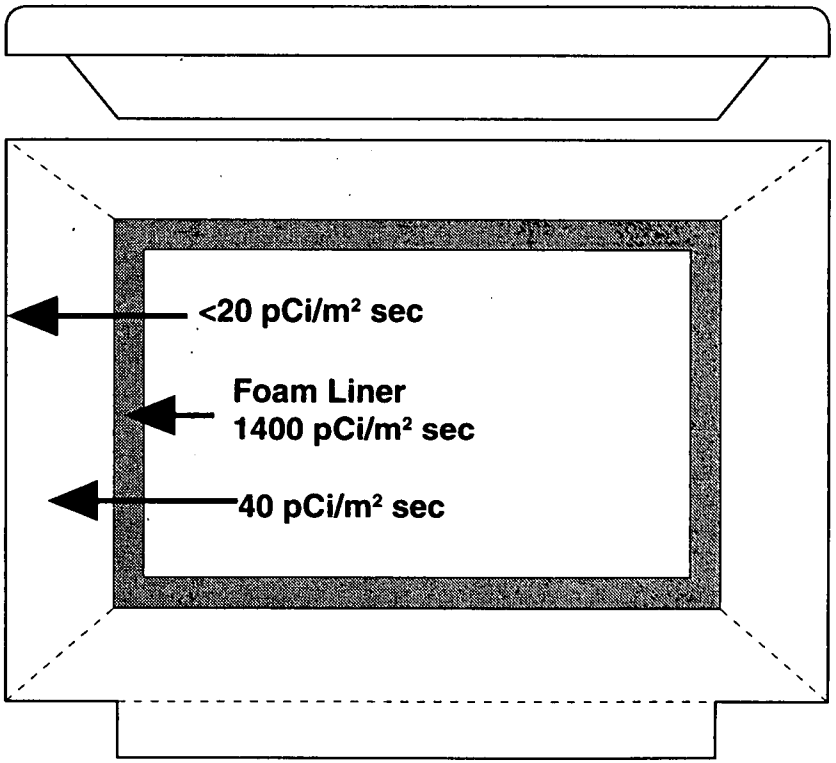
RADIATION LEVELS FROM VITRIFIED K-65 RESIDUES IN A SEG ENDUROPAK CERTIFIED FOR THE TRANSPORT OF LSA-II MATERIAL

FERNALD



Section thru Container
Upper Perimeter



Stabilized K-65 Residues

20% dry weight waste loading
2" foam board liner inside for radon attentuation

Radiation Level on Contact = 15 mrem/hr

Radiation Level at 1 meter = 5 mrem/hr

Radiation Level at 2 meters = 2 mrem/hr

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CONCLUSIONS

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- Current SEG container design can be modified to contain radon emanation.
- Modified container concept is conservative. (not optimized)
- Container is suitable for both waste forms and should not represent a discriminator with respect to treatment technology decision.

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TRANSPORTATION COMPARISON - TRUCK VS. RAIL

Provide a comparison of waste transportation by rail and truck.

Mike Smith

000234

TRANSPORTATION SAFETY AND COST COMPARISON

FERNALD

- Direct Truck
- Intermodal (Combination Rail and Truck)

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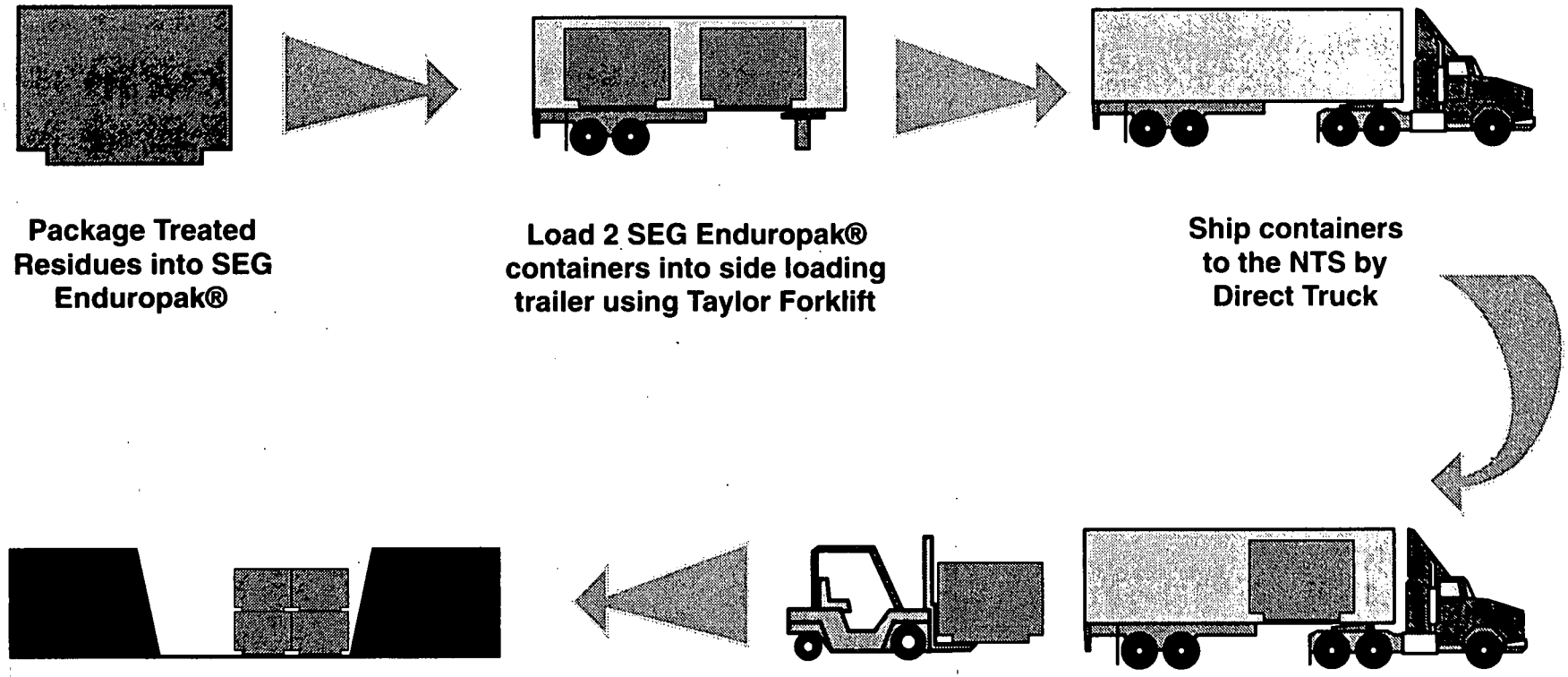
FLOW DIAGRAM FOR DIRECT TRUCK WASTE SHIPMENTS TO THE NTS

FERNALD



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FLOW DIAGRAM FOR INTERMODAL WASTE SHIPMENTS TO THE NTS

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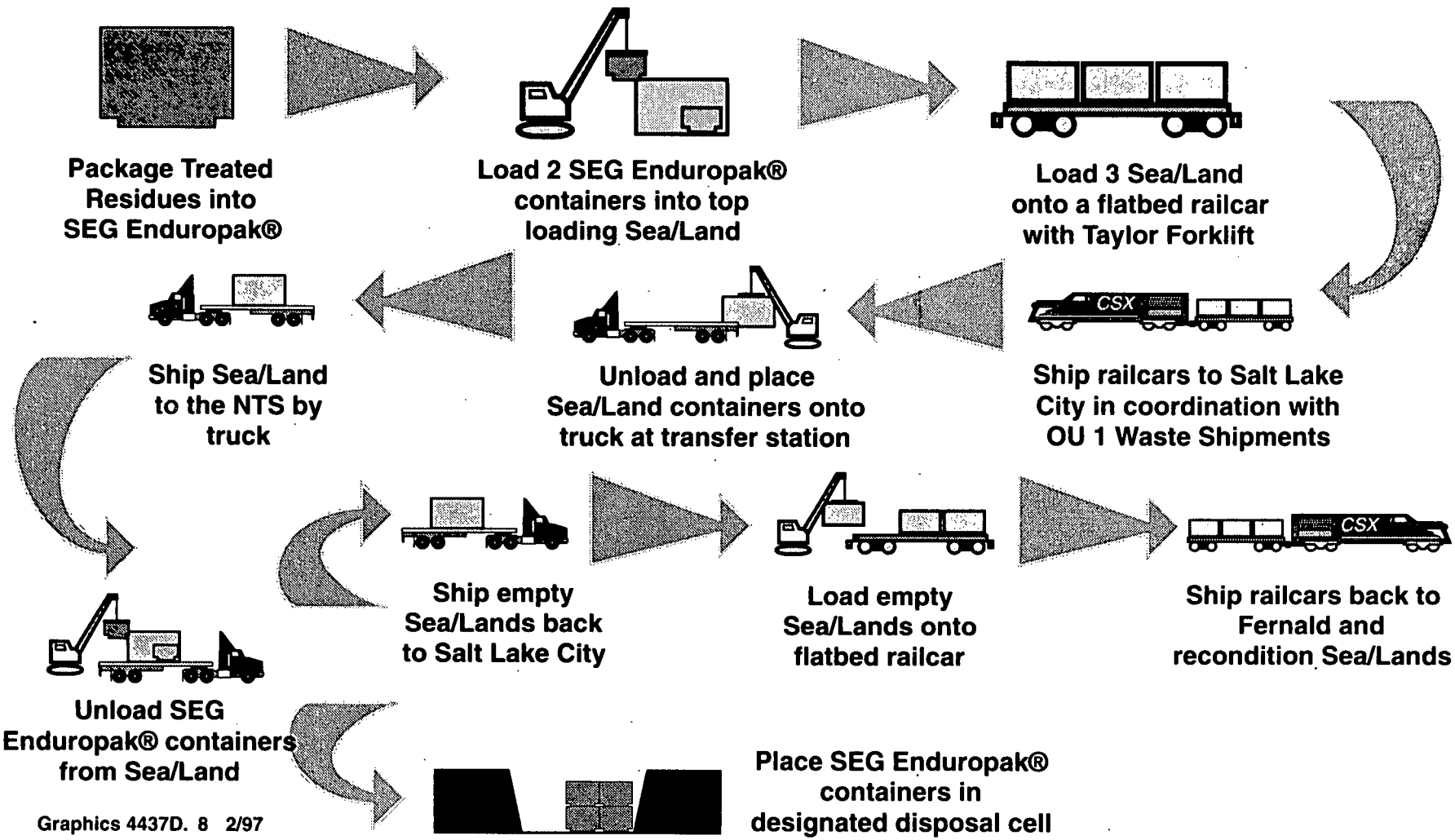

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ASSUMPTIONS FOR ESTIMATING RISKS AND COSTS

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	Vitrified Silos 1 and 2 Residues		Stabilized Silos 1 and 2 Residues		Stabilized Silo 3 Residues	
	Direct Truck	Intermodal	Direct Truck	Intermodal	Direct Truck	Intermodal
# of Containers	3,800	3,800	20,700	20,700	2,160	2,160
# of Railcars per Shipment	NA	20	NA	20	NA	20
# of Containers per Railcar	NA	3	NA	3	NA	3
# of Containers per Sea/Land	NA	2	NA	2	NA	4
# of Rail Shipments	NA	32	NA	173	NA	9
# of Containers per Truck	2	2	2	2	4	4
# of Truck Shipments	1,900	1,900	10,350	10,350	540	540

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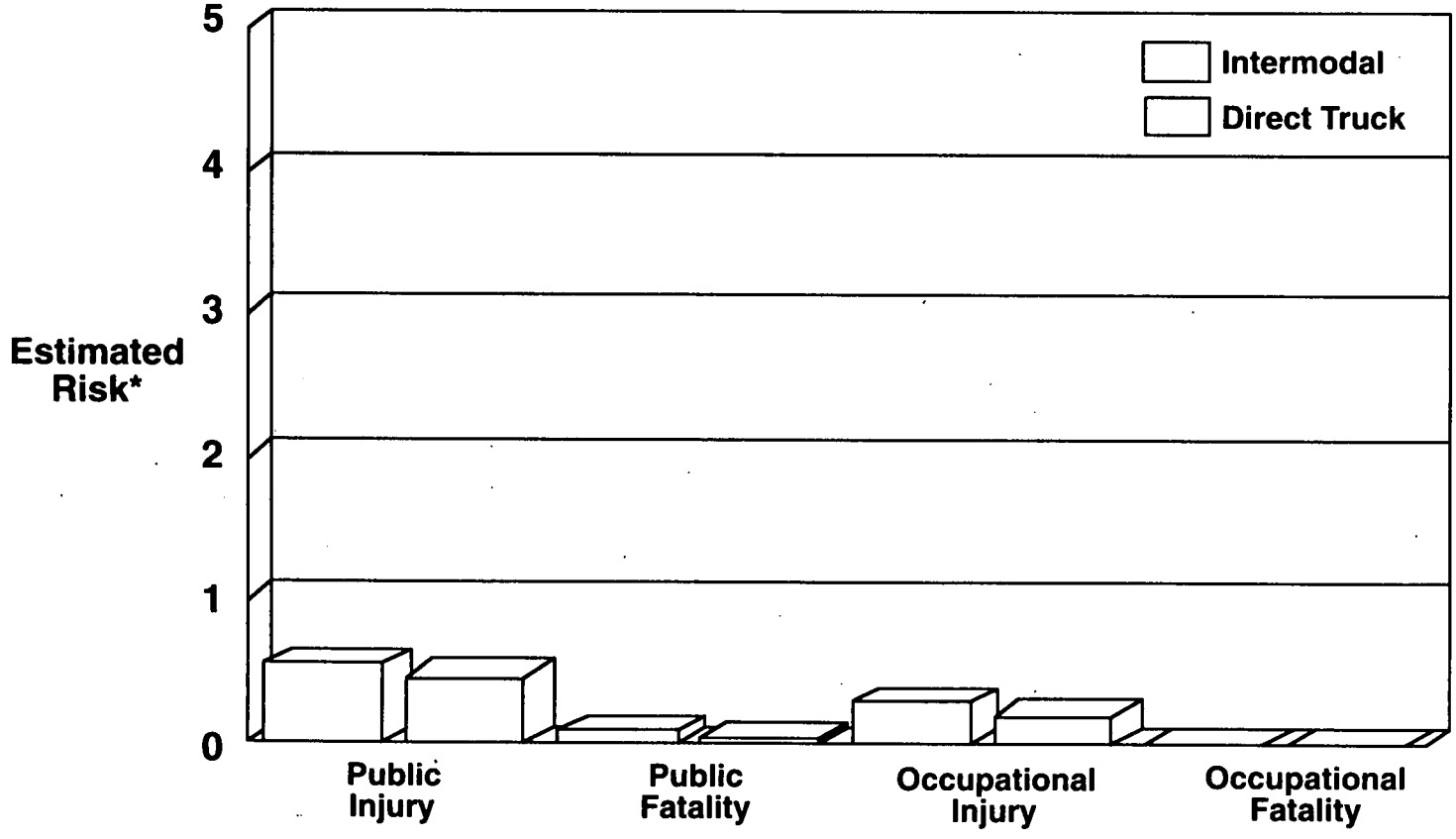
ESTIMATED TRANSPORTATION RISKS TO WORKERS AND THE PUBLIC RESULTING FROM SHIPMENT OF VITRIFIED SILO 1 AND 2 RESIDUES

FERNALD



* Risk estimate does not address increase in material handling associated with intermodal shipments.

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COMPARISON OF RADIOLOGICAL RISKS TO THE PUBLIC RESULTING FROM TRANSPORT OF VITRIFIED SILO RESIDUES

FERNALD

	Transportation Mode	
	Intermodal	Direct Truck
	Maximally Exposed Individual [1]	Maximally Exposed Individual [1]
K-65 Vitrified Gems Packaged within SEG Enduropak ®Containers	7.37×10^{-8}	14.2×10^{-8}
Silo 3 Vitrified Gems Packaged within SEG Enduropak ®Containers	2.85×10^{-9}	3.45×10^{-9}
Number of Shipments (Fernald to NTS)	640 railcars/1,600 Truck	1,600 Truck

[1] Risk numbers represent the increased probability of an individual developing a cancer due to exposure to the transported material.

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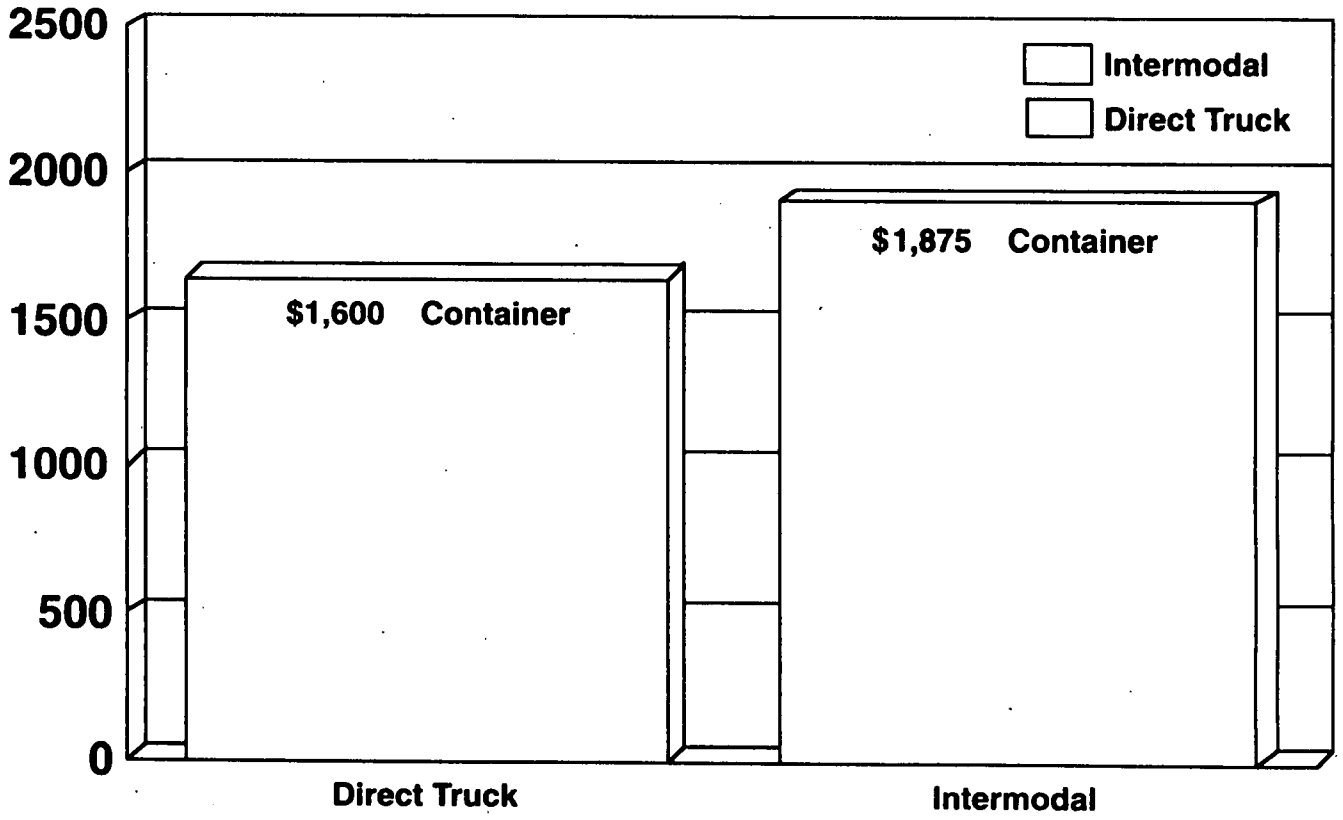
UNIT COSTS FOR SHIPPING VITRIFIED RESIDUES TO THE NTS

FERNALD



Cost does not include additional storage required for intermodal transport.

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CONCLUSIONS

FERNALD

- No significant difference in safety for shipping wastes by direct truck versus intermodal to the NTS.
- Current information indicates direct truck is the more cost-effective transport option for shipping to the NTS.
- Mode of transportation has no impact on determining best treatment option for the residues.
- Will continue to evaluate transportation options as new information becomes available to determine the safest and most cost-effective mode.

000242

WASTE LOADING SENSITIVITY ANALYSIS

Perform a sensitivity analysis with respect to the waste loading assumptions.

Karen Wintz

000243

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PERFORM A SENSITIVITY ANALYSIS WITH RESPECT TO WASTE LOADING ASSUMPTIONS

FERNALD

CONSTANTS IN ANALYSIS

Quantity of Untreated Waste	10,290 tons or 8,890 cu yd
Waste Packaging	SEG Concrete Box with a 2 inch foam liner for radon attenuation
Internal Volume of Container	1.7 cu yd (internal dimensions with foam board 56" x 38" x 38")
External Volume of Container	4.9 cu yd
Density of Treated Waste	114 lb/cu ft (based upon treatability study data)
Packing Fraction	95% - waste will be in a monolith form

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BASIS FOR WASTE LOADINGS

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OU4 Treatability Study demonstrated a 30% waste loading (dry weight)

Reduced waste loading to 20% dry weight based upon slurry feed of waste (Base Case)

Estimate waste loading of 50% dry weight may be able to meet NTS requirements

SENSITIVITY ANALYSIS

FERNALD

	Base Case	Treatability Study Loading	Estimate for Evaluation
	20% Waste Loading	30% Waste Loading	50% Waste Loading
Weight of Treated Waste	51,500 tons	34,300 tons	20,600 tons
Volume of Treated Waste	33,500 cu yd	22,300 cu yd	13,400 cu yd
Number of waste containers	20,700	13,800	8,300
Gross Weight of Container	17,000 lbs	17,000 lbs	17,000 lbs
Waste containers per shipment	2	2	2
Number of waste shipments	10,350	6,900	4,150
Estimated Dose at Exterior of Container (1 cm)	15 mrem/hr	23 mrem/hr	38 mrem/hr
Estimated Dose at 2 meters	2 mrem/hr	3 mrem/hr	4 mrem/hr
Disposal Volume (with container)	101,400 cu yd	67,600 cu yd	40,700 cu yd

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CONCLUSIONS

FERNALD

- Waste loading has significant impact on waste treatment operations, transportation, and disposal cost.

- Our assumptions for the base case are conservative.

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FEASIBILITY OF PIT 5 / WASTE MIX OPTION

Is it feasible to dispose of Silo waste by mixing with FEMP pit materials?

Jeff Stone

000248

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