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Irradiated Beryllium Disposal Workshop Idaho Falls, Idaho May 29 & 30, 2002

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Carlan H. Mullen
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July 2002

Idaho National Engineering and Environmental Laboratory
Bechtel BWXT Idaho, LLC

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Assistant Secretary for Environmental Management
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ABSTRACT

In 2001, while performing routine radioactive decay heat rate calculations for beryllium reflector blocks for the Advanced Test Reactor (ATR), it became evident that there may be sufficient concentrations of transuranic isotopes to require classification of this irradiated beryllium as transuranic waste. Measurements on samples from ATR reflector blocks and further calculations confirmed that for reflector blocks and outer shim control cylinders now in the ATR canal, transuranic activities are about five times the threshold for classification. That situation implies that there is no apparent disposal pathway for this material. The problem is not unique to the ATR. The High Flux Isotope Reactor at Oak Ridge National Laboratory, the Missouri University Research Reactor at Columbia, Missouri and other reactors abroad must also deal with this issue. A workshop was held in Idaho Falls Idaho on May 29-30, 2002 to acquaint stakeholders with these findings and consider a path forward in resolving the issues attendant to disposition of irradiated material. Among the findings from this workshop were (1) there is a real potential for the US to be dependent on foreign sources for metallic beryllium within about a decade; (2) there is a need for a national policy on beryllium utilization and disposition and for a beryllium coordinating committee to be assembled to provide guidance on that policy; (3) it appears it will be difficult to dispose of this material at the Waste Isolation Pilot Plant (WIPP) near Carlsbad, New Mexico due to issues of Defense classification, facility radioactivity inventory limits, and transportation to WIPP; (4) there is a need for a funded DOE program to seek resolution of these issues including research on processing techniques that may make this waste acceptable in an existing disposal pathway or allow for its recycle.

CONTENTS

EXECUTIVE SUMMARY

The Idaho National Engineering and Environmental Laboratory (INEEL) Workshop on Disposition of Irradiated Beryllium was held May 29-30, 2002 at the West Coast Hotel in Idaho Falls, Idaho. The objectives in convening the workshop were:

1. Disseminate and critically discuss the work that has been done to date to characterize irradiated beryllium waste and potential waste and issues associated with its disposal.

2. Solicit ideas and opinions on directions to proceed to establish a disposal pathway for this material.

3. Build a community consensus upon which to base a request for funding to resolve the issues identified.

Stakeholders were invited from many different sectors, especially those who must deal with irradiated beryllium.

The Problem

The discovery that much of the beryllium irradiated in fission reactors qualifies as transuranic (TRU) waste poses several problems with regard to its disposal or disposition:

- Operators of reactors using beryllium reflectors now appear to have no clearly defined disposal pathway for beryllium already irradiated but not disposed of.

- Changes should be made to the specifications for procurement of future beryllium for these reactors to prevent or substantially mitigate further creation of this waste form.

- Questions are raised regarding irradiated beryllium already disposed of at low-level radioactive waste facilities and whether it can remain there or require remedial action.

Extent

Beryllium is used in fission reactors as a neutron moderator and reflector. In the U.S., the active reactors of main concern include the Advanced Test Reactor (ATR) at the INEEL, the High Flux Isotope Reactor (HFIR) at Oak Ridge National Laboratory (ORNL), and the Missouri University Research Reactor (MURR) at Columbia, Missouri. Because of swelling caused by the production of helium and tritium from the beryllium itself, the beryllium must be replaced periodically. Used beryllium reflectors and other components must then be disposed of to make room for other activities and reduce on-site radiological inventories.

In addition to the currently operating reactors, several decommissioned reactors have beryllium reflectors that will eventually require disposal. Some of these are the Engineering Test Reactor (ETR) and the Materials Test Reactor (MTR) at the INEEL, the Plum Brook Reactor at Sandusky, Ohio, and the Omega West Reactor (OMR) at Los Alamos National Laboratory (LANL).

This issue is not confined to the U.S. The BR-2 reactor at Mol, Belgium faces the same issue as do more than 35 other reactors world wide.

Activation

Previously, it was thought that irradiated beryllium qualified as low-level radioactive waste. Until 1993, beryllium irradiated in the ATR was disposed of at the INEEL Radioactive Waste Management Complex (RWMC). Commencing in 1996, concerns arose regarding the level of C-14 in that beryllium and whether it should be classified as Greater-Than-Class-C waste as defined in 10 CFR 61. C-14 is produced by neutron activation of N-14, which exists as an impurity in the beryllium from the refining and manufacturing process. At that point, no further disposals were made of ATR beryllium.

Early in 2001, routine calculations to determine heat generation in irradiated beryllium discovered that there may be sufficient concentrations of TRU activation products from uranium impurity in the beryllium to require such beryllium to be classified as TRU waste.[a] Detailed composition data provided by Brush Wellman Company, vendor of the beryllium used in ATR Core 6, scheduled for installation in 2004, showed uranium concentrations from 25 to 110 μg/g in that beryllium with an average of about 71 μg/g. Initial calculations using MCNP-4B and ORIGEN2 codes indicated TRU activities more than 30 times the TRU classification threshold in ATR reflector blocks of that material. Subsequently, measurements were made on samples of beryllium from the 12 reflector blocks from prior cores currently in the ATR canal, furnished by Kawecki Beryllium Inc. (KBI). These showed a lower uranium impurity concentration, typically 30 μg/g. They also showed the presence of transuranic isotopes in good agreement with the predictions of the models. Improved calculations gave even better agreement with measurements but still indicated TRU concentrations in the reflector blocks about 5 times the TRU classification threshold. Outer shim control cylinders (OSCCs) also made of beryllium and in need of disposal, are estimated to be at even higher TRU concentrations.

Disposal

Disposition of irradiated beryllium has been similar at most reactor facilities

- Until 1993, ATR beryllium and that removed from other reactors was disposed of at the RWMC as low-level waste. Since then, beryllium removed from the ATR has been held in the canal adjacent to the reactor. Twenty ATR reflector blocks and nine OSCCs have been buried at the RWMC together with one reflector each from the ETR and the MTR and some other pieces from low-flux critical facilities. Twelve reflector blocks and 39 OSCCs are presently in the ATR canal.

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[a] Waste is considered TRU if the activity of alpha emitters with half-lives greater than 20 years exceeds 100 nCi/g unless it is (1) high-level radioactive waste; (2) waste that the DOE Secretary has determined, with the concurrence of the EPA Administrator, does not need the degree of isolation required by the disposal regulations; or (3) waste that the Nuclear Regulatory Commission has approved for disposal on a case-by-case basis in accordance with 10 CFR 61 [Pub. L. 102-579 (1992)].

- Until 1987, ORNL disposed of their beryllium waste at the ORNL burial ground. The first HFIR permanent reflector was so disposed of. The second was broken up and placed in an above-ground temporary storage vault in 1994, and the third, now in the HFIR pool, is planned for similar temporary storage. Semi-permanent reflectors 1-3 have been disposed of, the fourth is in the above-ground vault, and the fifth is in the pool awaiting disposal. Seven removable reflectors have been disposed of, one is in the above-ground vault, and two more are now in the pool awaiting transfer to an above-ground vault.

- MURR disposed of their first beryllium reflector at the Chem-Nuclear facility in Barnwell, South Carolina. The second one is now in their canal awaiting shipment to Barnwell. With the knowledge that the material is probably transuranic, it is unclear if that shipment will take place.

In considering disposal pathways, the only facility currently licensed in the U.S. for permanent disposal of TRU waste is the Waste Isolation Pilot Plant (WIPP) at Carlsbad, New Mexico. Three issues make it doubtful that this material can be disposed of there.

1. WIPP is only for Defense generated wastes. It is not clear whether ATR, HFIR, and MURR, which are not Defense facilities, could legally send wastes to WIPP.

2. The WIPP Land Withdrawal Agreement has a limit on total radioactive inventory for all isotopes of 5.1 MCi. The high concentrations of tritium (H-3) caused by neutron activity in the beryllium itself would consume an inordinate fraction of this available inventory.

3. It is not presently possible to ship the irradiated beryllium to WIPP because of high gamma radiation levels. Coming mainly from Co-60, again from impurity activation, the radiation fields are too high to be accommodated by available shipping casks without considerable decay or significant size reduction to small pieces that would require individual shipment. Estimates are that such decays would take longer than the scheduled WIPP closure date.

The Yucca Mountain Complex (YMC) in Nevada, which has not yet been licensed, may be a possible disposal site. Such waste has not yet been specifically excluded from that site. Shipping issues remain even if it could be accepted there.

A remaining option is to find a practical way to remove the transuranics and possibly other radioisotopes from the already irradiated material. Then, depending on the residual hazards, it could be disposed of as low-level waste or recycled. The latter is desirable because of the present hiatus from domestic production of beryllium metal by Brush Wellman. Methods suggested for purification include distillation, previously performed in the Soviet Union and currently under development in Ukraine, melting with a slagging agent, dissolution and precipitation or solvent extraction, and some form of zone refining.

Prevention

Estimates are that to avoid TRU classification of irradiated beryllium, initial uranium impurity levels will need to be less that 5 μg/g. Domestic ores and current refining processes are unlikely to make that goal. However, beryllium produced in Kazakhstan has traditionally been very low

in uranium impurity. Aside from political issues, it may be desirable to make use of that material for future procurements of beryllium reflectors. To date it has not been cost effective to purify domestic beryllium to the required levels, though that, too, may require rethinking.

An important issue with respect to availability of metallic beryllium for future fission reactor applications is the decision by Brush Wellman to no longer produce the metal from ore. They have contracted with the Defense Logistics Agency to purchase the US strategic stockpile material. By far, the majority of their beryllium production goes to BeCu alloys. Only about 10% of the beryllium is used for reactors. Present estimates are that the US strategic stockpile will be depleted in less than ten years at the forecast rate of consumption. Unless modern production facilities are built and domestic production resumes, the US will then be totally dependent on foreign supplies for beryllium.

Remediation

The quantity of TRU isotopes in irradiated beryllium previously disposed of is not large. The need for remediation at disposal sites will probably be determined by the impact of this material on the performance assessments of those sites. Most beryllium constituents, including hazardous metals and radionuclides of concern, are tightly bound up in the beryllium and are only released to the extent that the beryllium itself corrodes in the disposal facility. While irradiated beryllium is not hazardous by RCRA standards, measurements at the INEEL have demonstrated comparatively high corrosion rates for beryllium disposed of at the RWMC. This corrosion is responsible for release of tritium and C-14, which have been measured at the disposal sites and are confirmed to be coming from the beryllium. Transport of beryllium and its impurity activation products in the soil is not well understood. Further study of these issues is warranted.

Path Forward

Workshop participants arrived at the following actions as needed to deal with the issues of irradiated beryllium disposition.

Near Term

1. Establish a dialogue with DOE-HQ office regarding this beryllium issue (should include offices of NE, WM, EM, OS, etc.).

2. Write a summary report of this workshop.

3. Meet with DOE-HQ to discuss and present the results of this workshop.

4. Develop a funding request to charter a beryllium coordinating committee and begin development of National strategy (should be done in coordination with action item 3).

5. Publish a note to identify what has happened with the orphan waste program. Include as the results of that inquiry as part of the workshop summary report.

6. Contact medical (isotope) stakeholders regarding the issues identified at this workshop and include those contacts in the dialogue (action 1) and meeting (action 3) with DOE-HQ.

7. Contact other stakeholders (DOD, NASA, MURR, etc) that should be included in future development of a national strategy and solicit their support for a national strategy.

Most of these should be accomplished in June 2002 with some completed in mid-August.

Longer Term

1. Seek and develop a national/international program that can support education, research, negotiations, etc.

2. Develop a national strategy for beryllium supply and cycle.

3. Establish a beryllium coordinating committee to assist with developing the national strategy for supply, use, and disposition of beryllium.

4. Seek exemption for disposal of existing beryllium based on low risk and small quantities, while pursuing new beryllium that is free of undesirable impurities.

5. Develop/provide interim guidance to generators in the short term until a national strategy can be developed.

WORKSHOP PROCEEDINGS

Date(s) and Time(s)

May 29, 2002 from 08:30 to 17:30

May 30, 2002 from 08:30 to 11:00

Location

West Coast Hotel conference room, Idaho Falls, ID

Objectives

1. Disseminate and critically discuss the work that has been done to date to characterize irradiated beryllium waste and potential waste and issues associated with its disposal.

2. Solicit ideas and opinions on directions to proceed to establish a disposal pathway for this material.

3. Build a community consensus upon which to base a request for funding to resolve the issues identified.

Attendees

May 29, 2002

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Meeting Results

Action Items (near-term)

1. Establish a dialogue with DOE-HQ office regarding this beryllium issue (should include offices of NE, WM, EM, OS, etc.).

    - Assigned to: Linsey McDaniel (lead), Larry Miller, Steve Abeln, Julie Conner (responsible for field contacts), William Hill

    - Target Date: June 14, 2002, to start activities and conference calls.

2. Write a summary report of this workshop.

    - Assigned to: Glen Longhurst

    - Target Date: June 14, 2002, for draft for review by workshop members.

    - Target Date: June 28, 2002, to issue final report.

3. Meet with DOE-HQ to discuss and present the results of this workshop.

    - Assigned to: Linsey McDaniel (lead), Glen Longhurst, Steve Abeln

    - Target Date: August 9, 2002.

4. Develop a funding request to charter a beryllium coordinating committee and begin development of National strategy (should be done in coordination with action item 3).

    - Assigned to: Julie Conner (lead), other team members to be identified by Julie.

    - Target Date: August 9, 2002.

5. Publish a note to identify what has happened with the orphan waste program. Include as the results of that inquiry as part of the workshop summary report.

    - Assigned to: Carlan Mullen.

    - Target Date: June 16, 2002.

6. Contact medical stakeholders (isotope) regarding the issues identified at this workshop and include those contacts in the dialogue (action 1) and meeting (action 3) with DOE-HQ.

    - Assigned to: Glen Longhurst, Carlan Mullen will be a team member.

    - Target Date: August 9, 2002.

7. Contact other stakeholders (DOD, NASA, MURR, etc) that should be included in future development of a national strategy and solicit their support for a national strategy.

    - Assigned to: To-Be-Determined

    - Target Date: To-Be-Determined

Conclusions, Findings, and Assumptions

- New research has indicated there are impurities in the beryllium used as reflectors in nuclear reactors that results in waste that is not low-level and is Greater-Than-Class-C waste.

- There is no National strategy for the life cycle management (production, inventory and disposal) of the nation's beryllium supply.

    - The regulatory demands on production of beryllium make it uneconomical to manufacture in the US making the country dependent on foreign supplies.

    - Reevaluation of material already disposed of needs to be conducted in light of the new findings with regards to contaminants in the material.

    - There needs to be a clear disposal pathway for used (irradiated) material that will be generated as waste in the near future.

    - Interim storage capabilities are needed until a clear disposal pathway can be identified.

    - The continued operation of reactors using beryllium reflectors needs to be addressed in light of the newly identified hazards in irradiated beryllium waste.

- Solutions proposed to resolve the problem.

    - Seek and develop a national/international program that can support education, research, negotiations, etc.

    - Develop a National strategy for beryllium supply and cycle.

    - Establish a beryllium coordinating committee to assist with developing a national strategy for supply, use, and disposition of beryllium.

    - Seek exemption for disposal of existing beryllium based on low risk and small quantities, while pursuing new beryllium that is free of undesirable impurities.

    - Develop/provide interim guidance to generators in the short term until a national strategy can be developed.

Agenda

Wednesday, May 29th

8:30 a.m.	Welcome and introduction	Glen Longhurst (INEEL)
8:40 a.m.	Workshop Logistics	Buck West (INEEL)
8:45 a.m.	Beryllium Disposal: Background, Measurements, and Concerns	Glen Longhurst (INEEL)
10:00 a.m.	Break (refreshments courtesy of BBWI)	
10:30 a.m.	HFIR Beryllium Disposal Experience	Bill Hill (HFIR)
11:00 a.m.	Operational Test Reactors and Impurities Contained in Typical Alloys	Don Kaczynski (BW)
11:30 a.m.	Loss of U.S. Beryllium Metal Domestic Supply	Steve Abeln/Loren Jacobson (LANL)
12:00 noon	Lunch	
1:30 p.m.	Vacuum Distillation of Beryllium	Loren Jacobson (LANL)
2:00 p.m.	Beryllium Corrosion in Earthen Vaults	Kay Adler Flitton (INEEL)
2:30 p.m.	Radioactive Isotope Release from Buried Beryllium	Paul Ritter (INEEL)
3:00 p.m.	Break	
3:30 p.m.	The WIPP Remote Handled Transuranic Waste Program	Clayton Gist (DOE-Carlsbad)
4:00 p.m.	Plum Brook Reactor Beryllium	Brian Moyers (ANL)
4:20 p.m.	Open Discussion/Comment Resolution	Presenters/Participants
5:00 p.m.	Adjourn	

Thursday, May 30th

8:30 a.m. Town Meeting: Guided discussion to find answers to or suggest actions to answer the following questions:

Problem Definition

1. What are disposal concerns at facilities such as the High Flux Isotope Reactor (HFIR) and the Missouri University Research Reactor (MURR), which also use beryllium reflectors?

2. What inventories of irradiated beryllium, other than at operating reactors, will need to be disposed of?

3. What concerns exist for irradiated beryllium that has already been disposed of as low-level waste assuming it is TRU but not RCRA hazardous?

4. What is a reasonable upper bound on expenditures to identify a disposal solution? What is the total life-cycle cost attributable to beryllium using presently available or foreseeable material grades and disposal methods?

5. What is the problem?

Problem Consequences

6. What are the feasibility, cost, and programmatic impact if "Defense" classification is required for research reactor beryllium to be disposed of at WIPP?

7. What would be the consequences of failing to move now to resolve issues of disposal for irradiated beryllium?

8. If a disposal pathway cannot be found, can reactors continue to generate this waste stream?

9. What are the consequences of the problem(s)?

10:00 a.m. Break

10:15 a.m. Guided Discussion, (continued)

Can the problems be prevented, mitigated, or resolved?

What actions should we be taking?

10:50 a.m. Summary of discussion — Buck West

11:00 a.m. Closeout — Glen Longhurst

Meeting Process

The first day of the workshop was devoted to presentations about irradiated beryllium and issues concerning its use and disposition. During presentations, participants were permitted to enter comments or questions in the computers regarding the presentations. The presenters were later permitted to respond to the questions or comments. See pages following the presentations for the questions, comments, and answers for each.

A four-step structured process was conducted regarding problems with irradiated beryllium. The first step was to discuss and identify the problem. Participants were directed to enter into computers available for their use possible problems with irradiated beryllium. During this first step, participants were not allowed to see what others had entered. Participants were then allowed to see what others had entered and were directed to read the other responses and add additional comments, as they felt necessary. The potential problems were then discussed for a consensus of what the true problem is. Discussion first addressed the issues of declining supply of beryllium and impurities in existing supplies that cause problems with disposal of used material. The discussion shifted away from the supply issue and focused on a lack of recognition, by the United States, of the strategic importance of beryllium. The group identified an over-arching problem statement with five sub-elements. The sub-elements were considered to need immediate attention.

> Problem Statement: There is no national strategy for the life cycle management (production, inventory and disposal) of the nation's beryllium supply.

1. The regulatory demands on production of beryllium make it uneconomical to manufacture in the US; making the country dependent on foreign supplies.

2. Reevaluation of already disposed of material needs to be conducted in light of the new findings with regards to contaminates in the material.

3. There needs to be a clear disposal pathway for used (irradiated) beryllium and material that will be generated as waste in the near future.

4. Interim storage capabilities are needed until a clear disposal pathway can be identified.

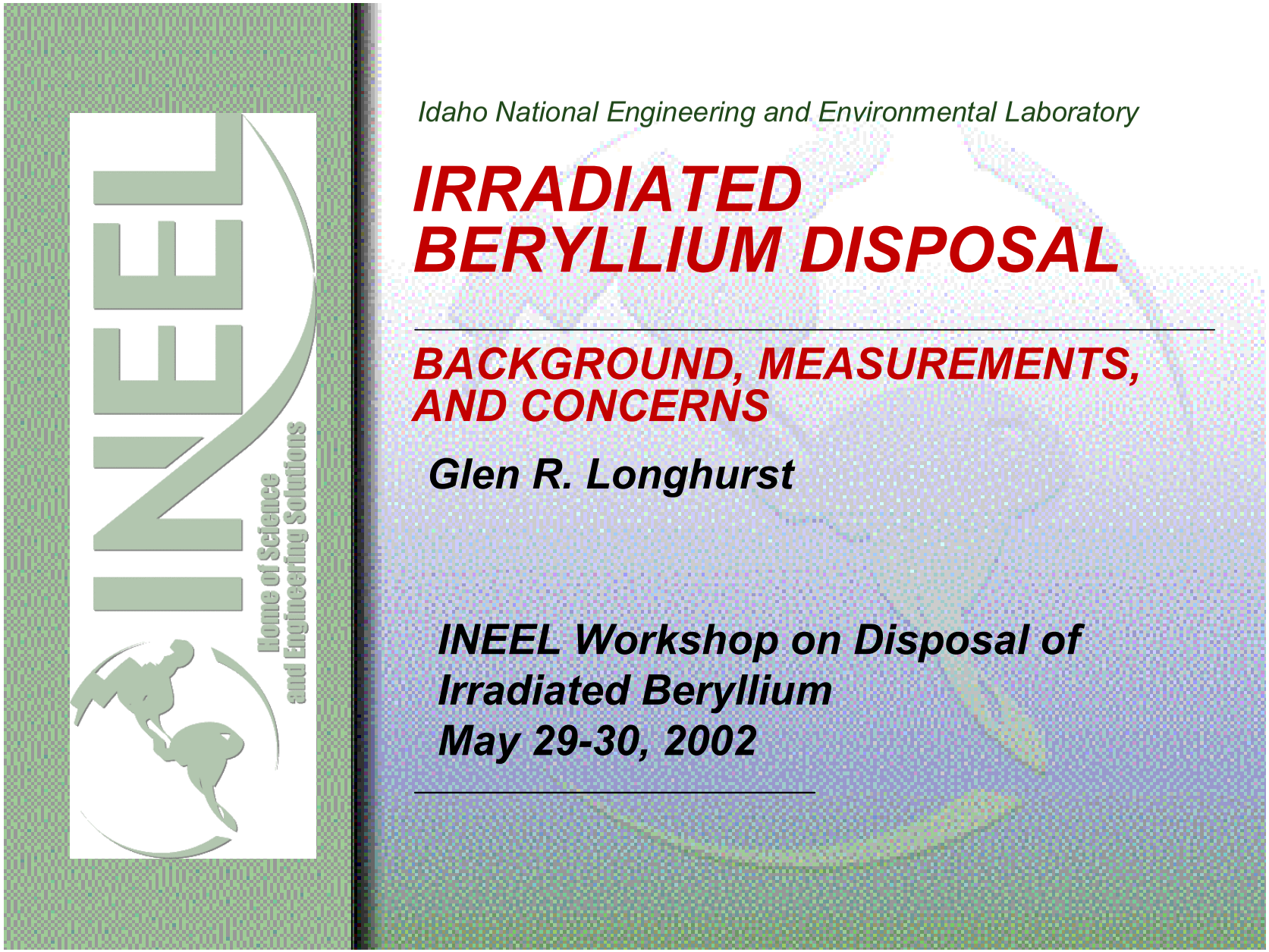
5. The continued operation of reactors using beryllium reflectors needs to be addressed in light of the newly identified impurities in irradiated waste.

After discussion of the problem, the group was then directed to use the computers to enter the consequences of not adequately addressing the problem statement. There was no discussion of the material entered. Responses are listed later in this record.

The group then turned their attention to the actions needed to correct the problem. The group was directed to enter one possible solution to the problem statement and/or sub-elements. The group then discussed the posted solutions and combined or revised the solutions as necessary. During the discussion, several possible solutions were merged with the development of a National strategy solution. This merging was done with the understanding that these merged solutions should be sorted into short- and long-term actions. The final and merged list of solutions is also provided later in this record.

After identification of possible solutions to the problem, the group developed actions items needed in the short-term to begin implementation of the possible solutions. See the Action Items in the Results section for the results of that discussion.

PRESENTATIONS, COMMENTS, QUESTIONS, AND RESPONSES


INEEL
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IRRADIATED BERYLLIUM DISPOSAL
BACKGROUND, MEASUREMENTS, AND CONCERNS
Glen R. Longhurst
INEEL Workshop on Disposal of Irradiated Beryllium
May 29-30, 2002

OVERVIEW

- *Background - Use of beryllium in fission reactors*
- *Discovery - How we became aware of activation product problems*
- *Characterization - Measurements and calculations to quantify activation products*
- *Options - How should irradiated beryllium be disposed of*
- *Needs - What additional work is called for to resolve the present issues*

GRL 5/29/02 1

BACKGROUND

- *Research reactors use beryllium reflectors to enhance neutron flux density*
- *Because of neutron-induced swelling, the reflectors must be replaced at periodic intervals*
- *Irradiated beryllium was previously thought to be low-level waste*
- *Measurements of ATR reflector blocks have shown levels of ^{14}C and ^{94}Nb that may make many of them greater than 10 CFR 61 Class C for disposal*
- *Uranium impurity activation may make the irradiated beryllium transuranic waste*

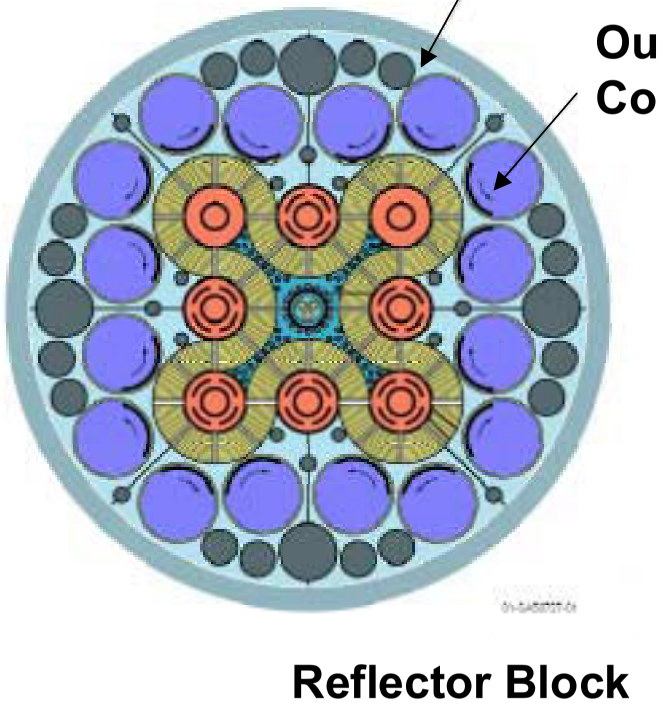
GRL 5/29/02 2

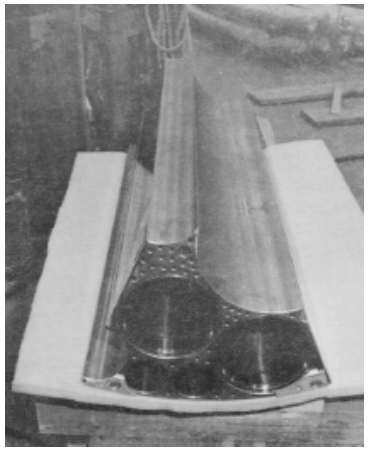
LARGE U.S. RESEARCH REACTORS USING BERYLLIUM REFLECTORS

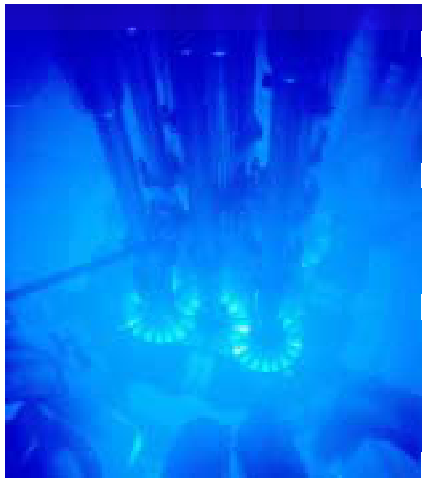
- *Advanced Test Reactor (INEEL)* — *250 MW*
- *High Flux Isotope Reactor (ORNL)* — *100 MW*
- *Missouri University Research Reactor* — *10 MW*

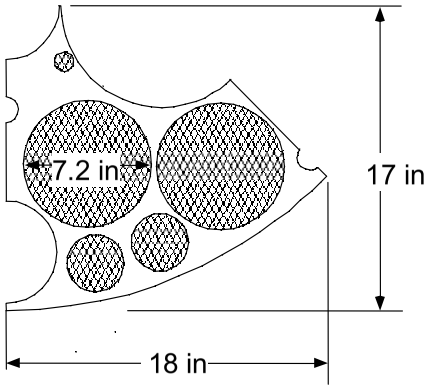
GRL 5/29/02 3

ATR BERYLLIUM



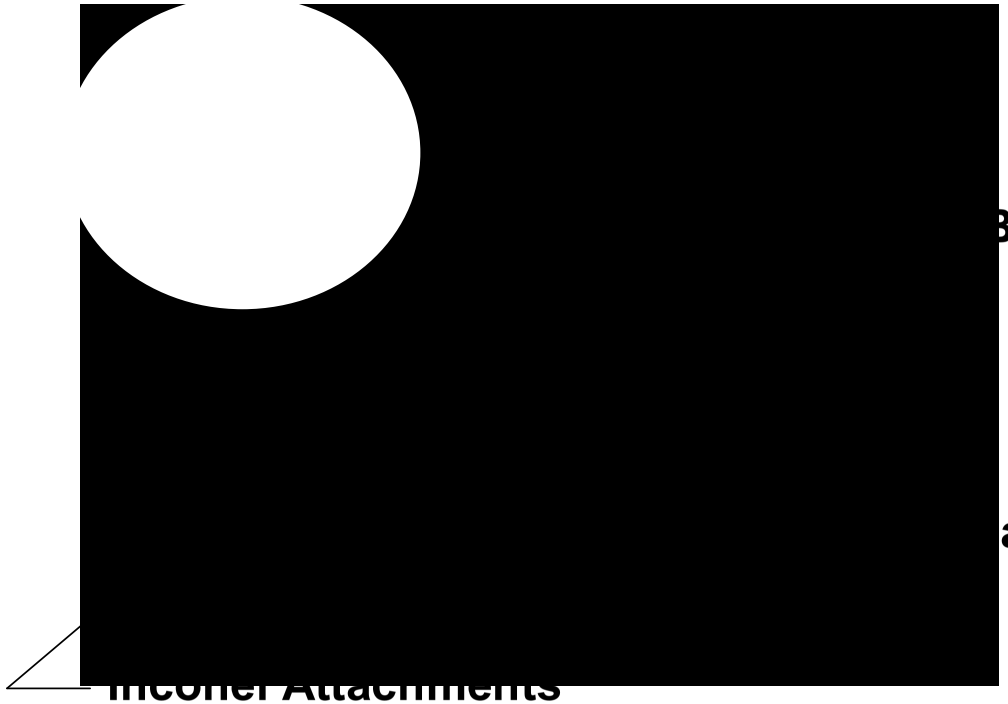






GRL 5/29/02 4

OUTER SHIM CONTROL CYLINDER



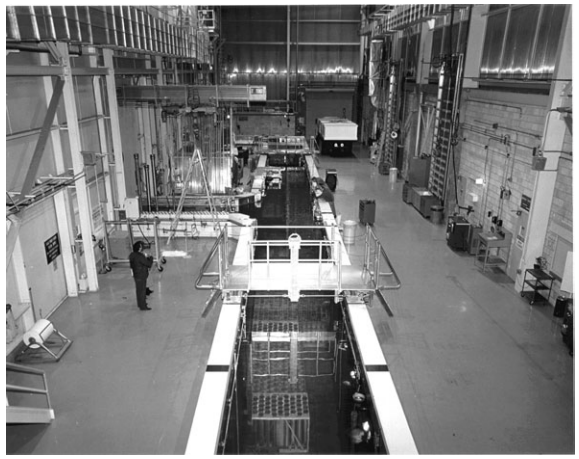
eryllium Segments

afnium Plates

Inconel Attachments

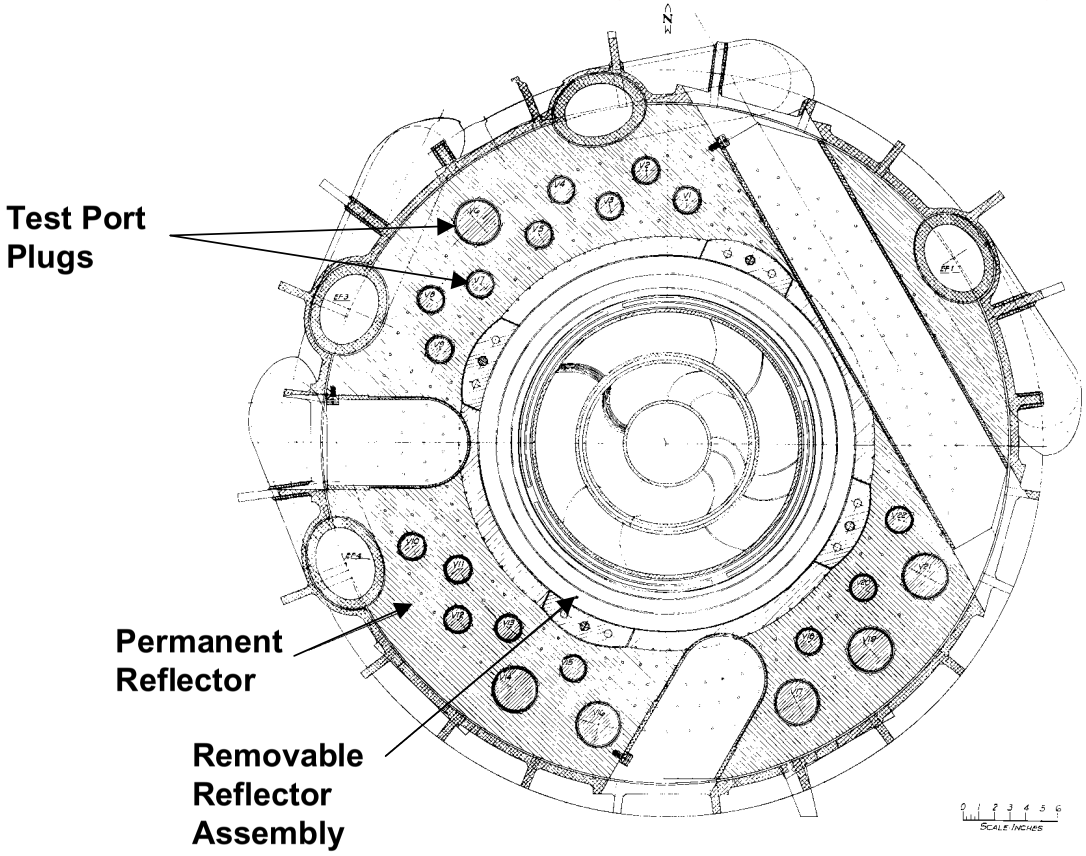
GRL 5/29/02 5

Twelve beryllium blocks and 39 OSCCs are now in the ATR canal.



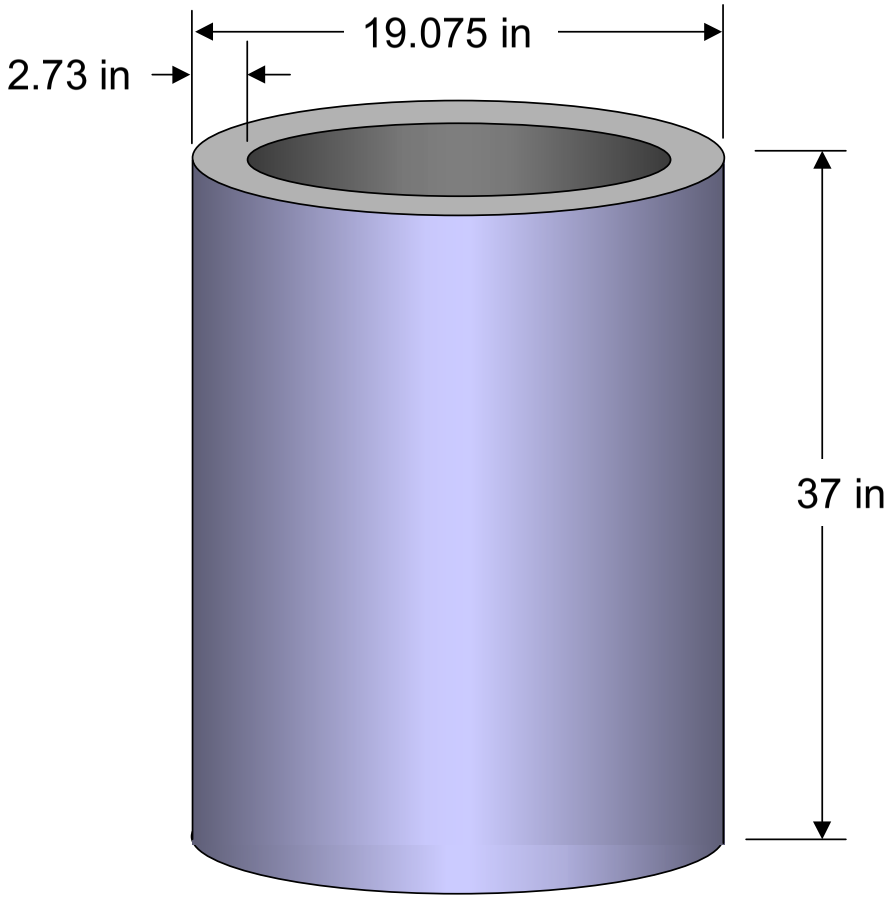
GRL 5/29/02 6

HFIR BERYLLIUM REFLECTOR



GRL 5/29/02 7

MURR BERYLLIUM REFLECTOR



164 kg Be

Replaced at nominally 8-year intervals

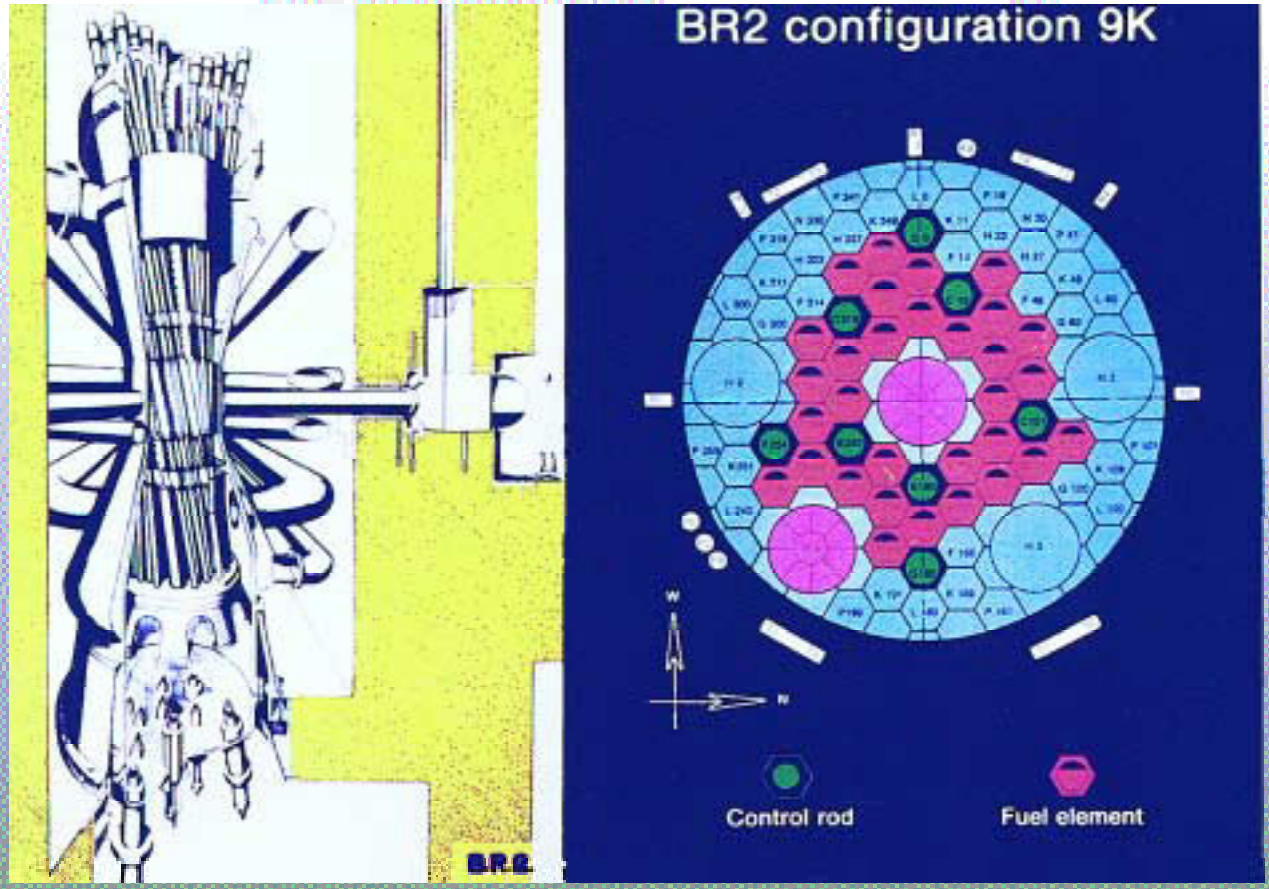
GRL 5/29/02 8

HIGH FLUENCE REACTORS WITH BERYLLIUM REFLECTORS OPERATING IN 2000

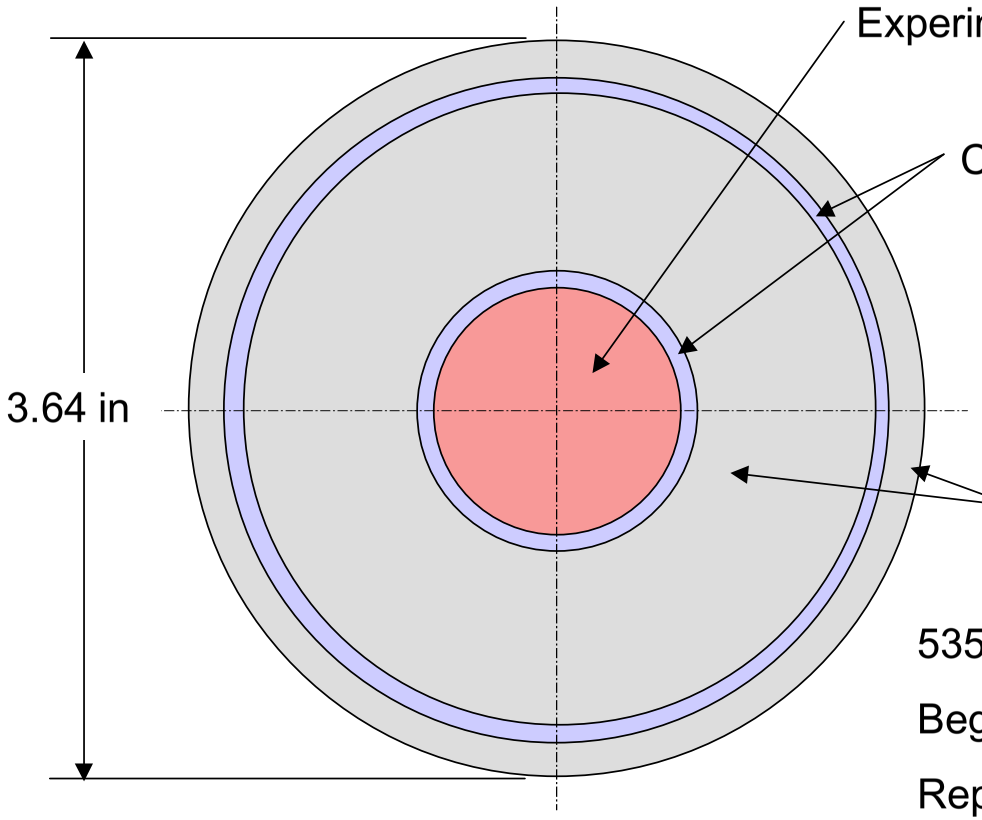
Reactor	Location	Rated Power (MW_{th})	Thermal Flux (n/cm^2s)	Fast Flux (n/cm^2s)	DateOn Line
ATR	INEEL, ID, USA	250	5.30E+14	1.50E+15	Jul-67
HFETR	Chenadu, Sichuan, China	125	6.20E+14	1.70E+15	Jan-79
BR-2	Mol, Belgium	100	1.20E+15	8.40E+14	Jun-61
HFIR	ORNL, TN, USA	100	1.50E+14	1.30E+15	Aug-65
MIR-M1	Dimitrovgrad, Russia	100		5.00E+14	Dec-66
SM-2	Dimitrovgrad, Russia	100	5.00E+15	2.00E+15	Oct-61
OSIRIS	Saclay, France	70	2.70E+14	1.60E+14	Sep-66
R-2	Nykoping, Sweden	50	4.00E+14	4.00E+14	May-60
RSG-GAS-30	Jarkata, Indonesia	30	5.00E+14	3.00E+14	Jul-87
SILOE	Grenoble, France	25	5.00E+14	5.00E+14	Mar-63
SAFARI-1	Pretoria, South Africa	20	2.50E+14	4.00E+14	Mar-65
Trigia-II	Pitesti, Romania	14	2.60E+14	2.60E+14	Nov-79
BER-2	Berlin, Germany	10	9.00E+13	4.50E+12	Apr-91
EWA	Otwock, Poland	10	1.00E+14	1.30E+14	Jun-58
MURR	Columbia, MO, USA	10	6.00E+14	1.00E+14	Oct-66
RBT-10/1	Riar, Russia	10	7.40E+13	6.90E+13	Dec-83
RBT-10/2	Riar, Russia	10	7.40E+13	6.90E+13	Dec-84

GRL 5/29/02 9

BELGIAN BR2 REACTOR



BR2 BERYLLIUM FILLING PLUG



535 kg Be in core

Began operation 1963

Replaced 1979-80

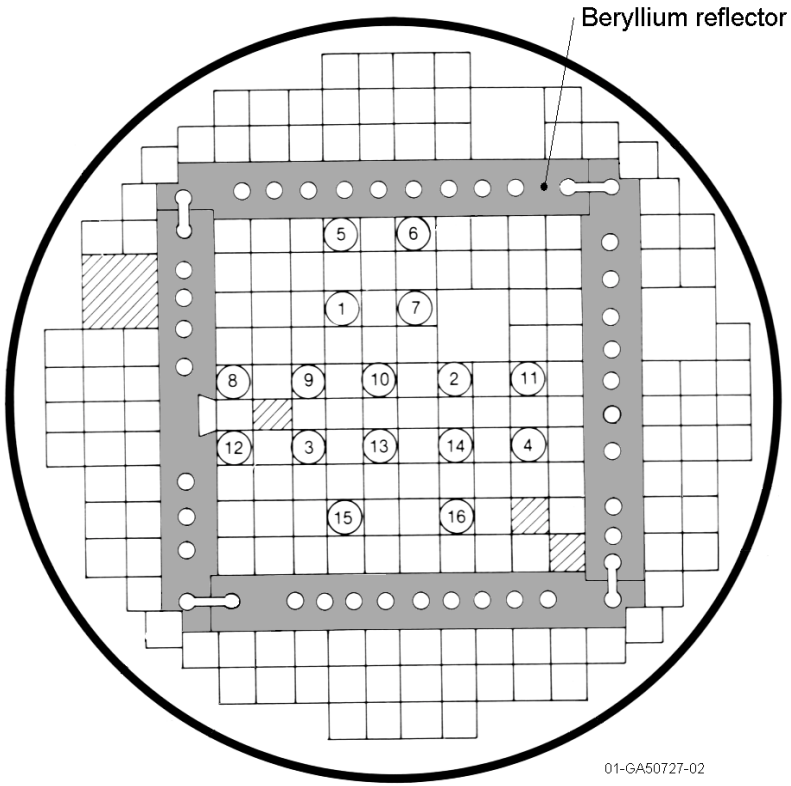
GRL 5/29/02 11

DECOMMISSIONED REACTORS WITH BERYLLIUM REFLECTORS THAT WILL REQUIRE DISPOSAL

- *Engineering Test Reactor (INEEL)*
- *Materials Test Reactor (INEEL)*
- *NASA Plum Brook Reactor (Sandusky, OH)*

GRL 5/29/02 12

ENGINEERING TEST REACTOR

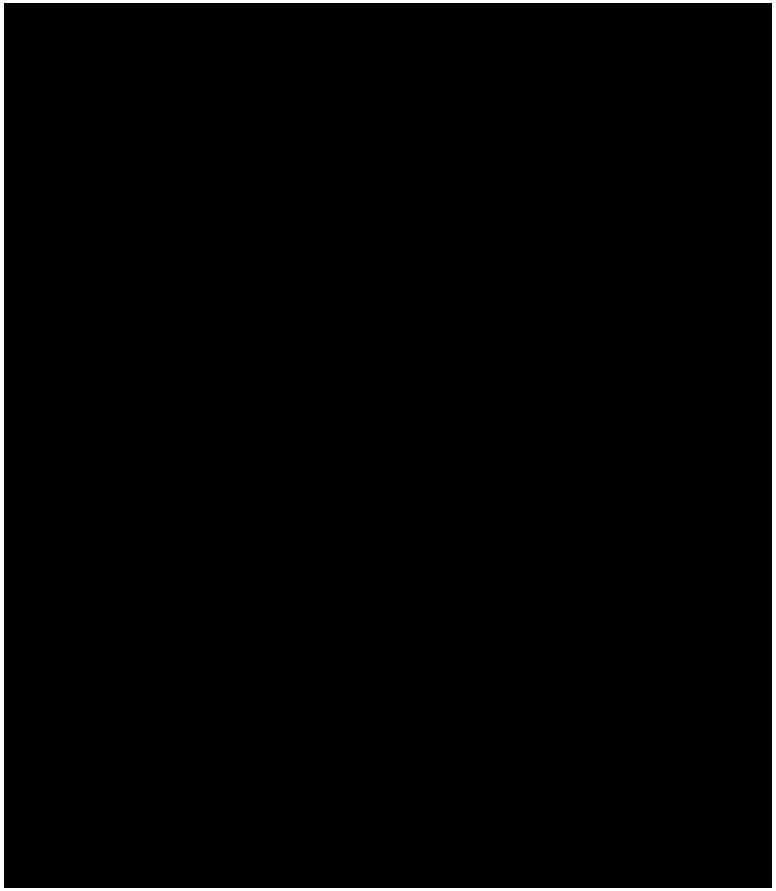


580.5 kg Be

1970 - 1981

GRL 5/29/02 13

MATERIALS TEST REACTOR

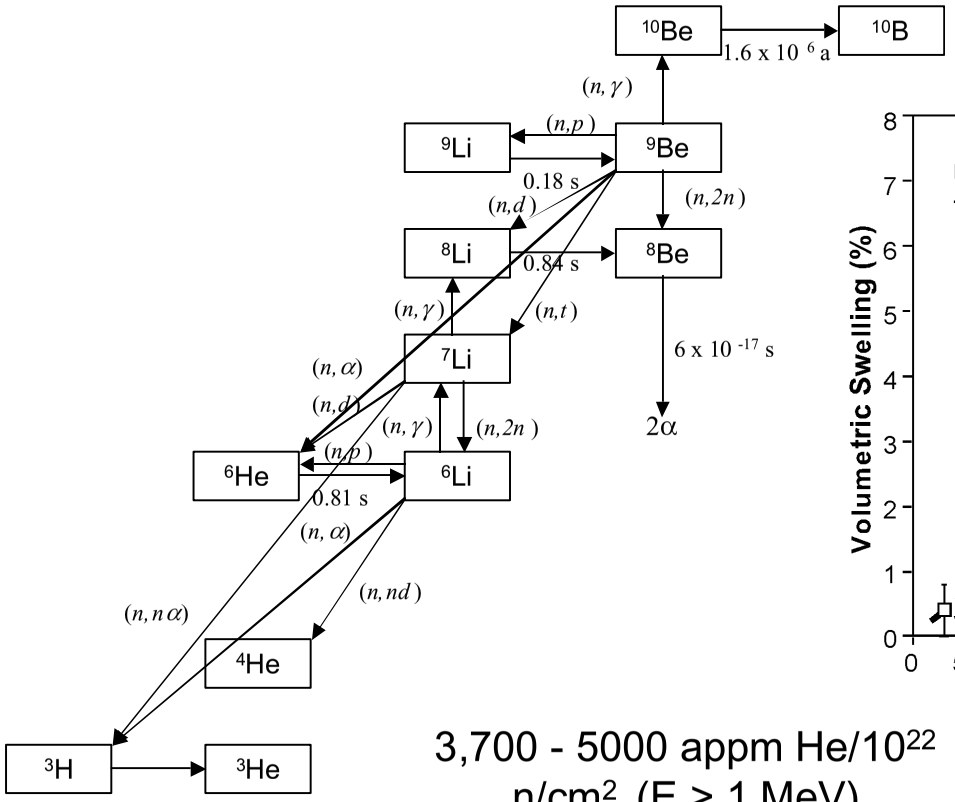


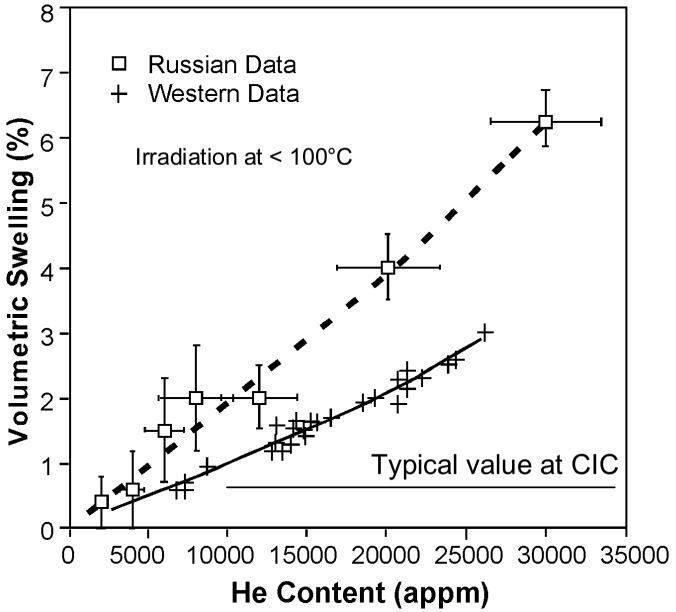
2,610 kg Be

1969 - 1970

GRL 5/29/02 14

Helium-induced swelling requires periodic replacement of beryllium



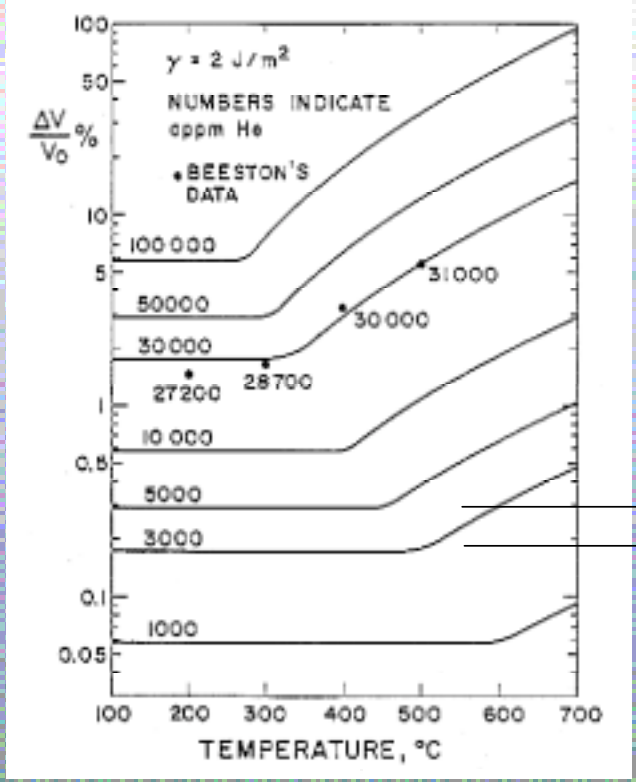


Sernyaev

3,700 - 5000 appm He/10^{22} n/cm^2 (E > 1 MeV)

Beryllium swelling depends on helium content and temperature

Typical ATR fast neutron fluence at CIC: 8 x 10^{21} n/cm^2



Range at ATR CIC

Wolfer, W. G., and McCarville, T. J., July 1985, "An Assessment of Radiation Effects in Beryllium," *Fusion Technology, 8*, pp. 1157-1164.

GRL 5/29/02 16

PRINCIPAL CONCERNS

- *Reflector blocks and OSCCs occupy canal space needed for other activities*
- *Plans for continued ATR operation mean irradiated beryllium must be disposed of or removed to other temporary storage*
- *Previous disposal at RWMC has been discontinued because of discoveries regarding ^{14}C and waste classification issues*
- *To date, no permanent disposal pathway has been identified for highly irradiated beryllium*

GRL 5/29/02 17

Discovery of activation product issues was almost accidental

- *Initial concerns focused on ^{14}C that may limit disposal*
- *Routine activation calculations revealed transuranic activation products in excess of TRU classification threshold*
- *Measurements were made to verify concentrations of uranium and selected transuranics*
- *More refined calculations were performed to estimate concentrations in ATR reflector blocks and OSCCs*
- *Additional measurements confirmed calculations*

GRL 5/29/02 18

Analysis used combination of MCNP-4 and ORIGEN2 codes

- *A detailed structural model of ATR was available*
- *MCNP-4 was used to generate macroscopic reaction cross sections for selected regions (localized volumes and block averages)*
- *ORIGEN2 was used with actual flux histories to calculate activation product concentrations in the selected regions*
- *Calculated inventories may vary by factors of 2 depending on assumed location of shim plates and fuel burn up profiles*

GRL 5/29/02 19

Idaho National Engineering and Environmental Laboratory

CALCULATED CONCENTRATIONS OF β^- EMITTERS

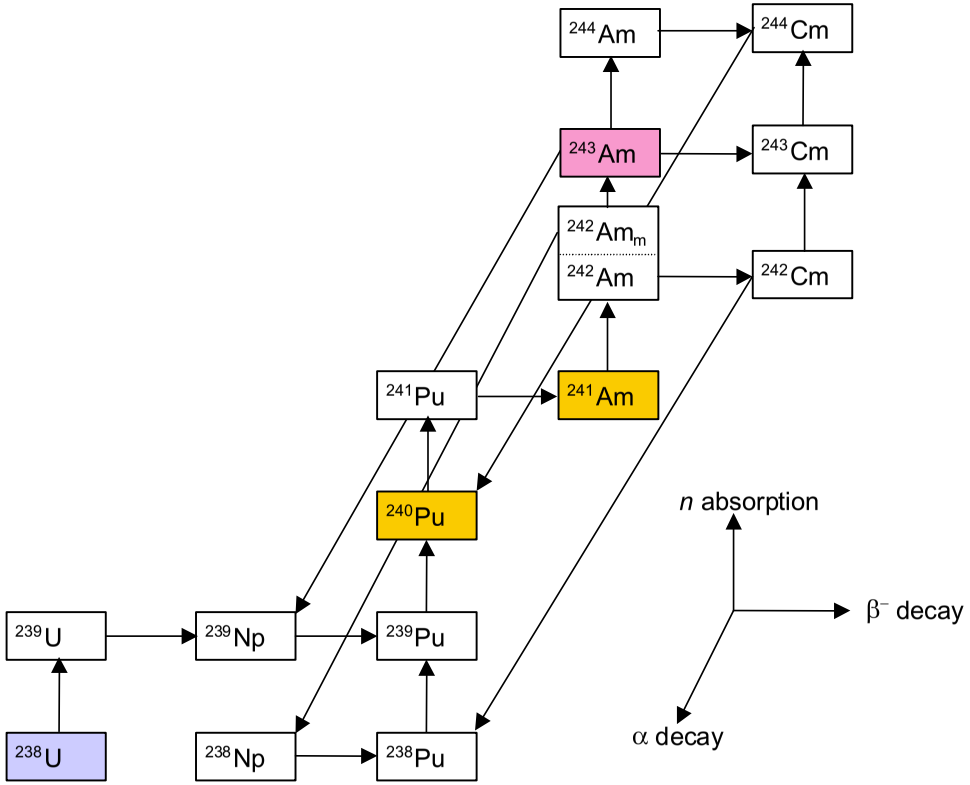
Beryllium Block	ATR Core/Lobe	Block Average Specific Activity (Ci/m^3)							Sum-of-Fractions from 10 CFR 61	
ID No.		^{14}C[a]	^{59}Ni	^{63}Ni	^{60}Co	^{94}Nb[b]	^{99}Tc	^{90}Sr	Table 1	Table 2
010R	3/NE	35.37	0.6062	113.98	687.9	1.475E-03	9.015E-03	17.53	0.46	0.02
11R	2/NW	24.78	0.5310	86.85	226.5	1.185E-03	6.962E-03	11.30	0.32	0.01
15L	2/NW	24.00	0.5283	86.38	225.2	1.178E-03	6.926E-03	11.24	0.31	0.01
015R	4/NW	26.03	0.5554	105.07	1823.2	1.299E-03	7.910E-03	18.59	0.34	0.02
016L	3/SE	54.73	0.7020	156.31	935.7	2.080E-03	1.260E-03	26.12	0.70	0.03
016R	4/NE	28.05	0.5742	110.31	1883.5	1.332E-03	8.011E-03	18.85	0.36	0.02
017L	4/NE	21.98	0.5520	104.02	1800.0	1.277E-03	7.764E-03	18.23	0.29	0.02
017R	4/SE	53.43	0.6798	154.86	2641.4	1.873E-03	1.198E-02	29.79	0.68	0.03
018R	4/SW	31.70	0.6377	134.33	2301.2	1.665E-03	1.039E-02	25.03	0.41	0.02
020L	4/SE	62.54	0.6890	159.07	2695.1	1.978E-03	1.204E-02	30.06	0.80	0.03
021L	4/SW	57.24	0.6398	135.27	2316.8	1.674E-03	1.051E-02	25.36	0.73	0.02
022L	4/NW	38.05	0.5666	1080.1	1861.3	1.323E-03	7.924E-03	18.64	0.49	0.02
OSCC	3/SE	148.1	0.4389	130.80	849.1	2.948E-03	0.01245	28.45	1.87	0.02
10 CFR 61 Class C Limits (Ci/m^3)		80	220	7000	no limit	0.20	3	7000		
Governing Table from 10 CFR-61		Table 1	Table 1	Table 2	Table 2	Table 1	Table 1	Table 2		

a. Nitrogen concentration of 300 μg/g assumed

b. The ^{94}Nb result shown here was based on an assumed ^{93}Nb impurity concentration of 0.2 μg/g. The ^{93}Nb concentration was estimated from information provided to us by metallurgists. However, actual measured data from ANL-W shows ^{93}Nb concentrations that are much higher (e.g., from 1 to 23 μg/g).

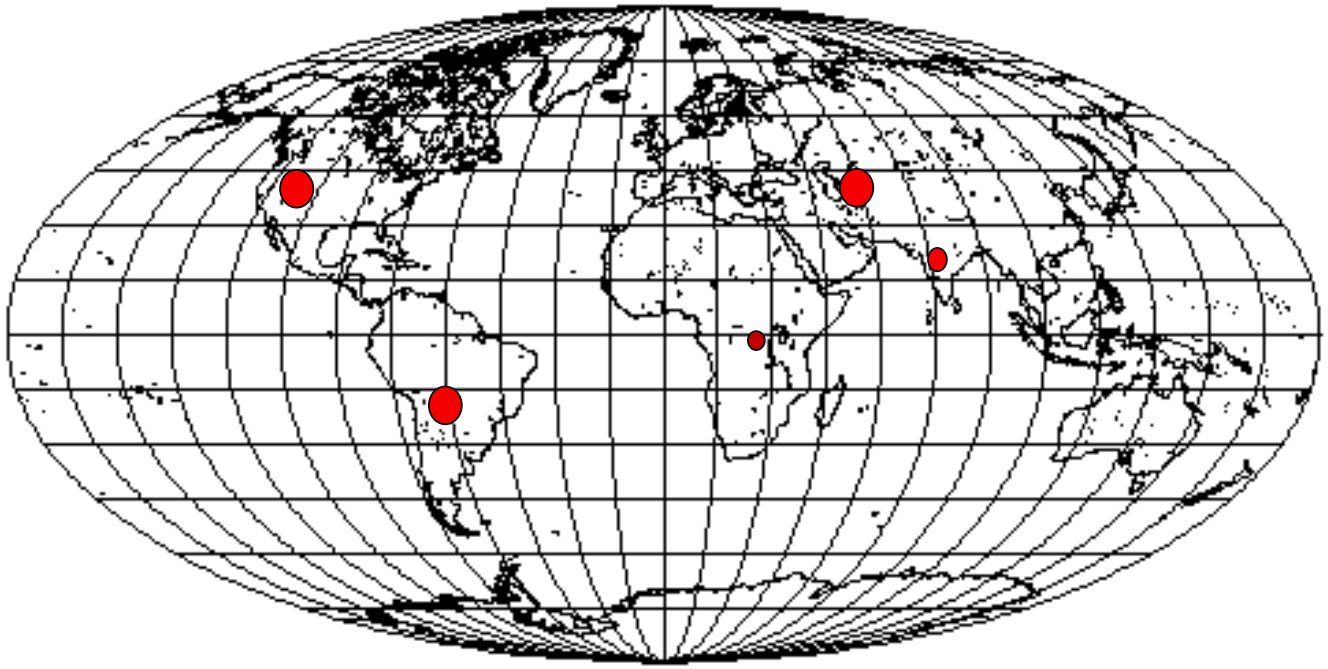
GRL 5/29/02 20

TRANSURANIC ACTIVATION PATHWAYS



GRL 5/29/02 21

PRINCIPAL SOURCES OF BERYLLIUM



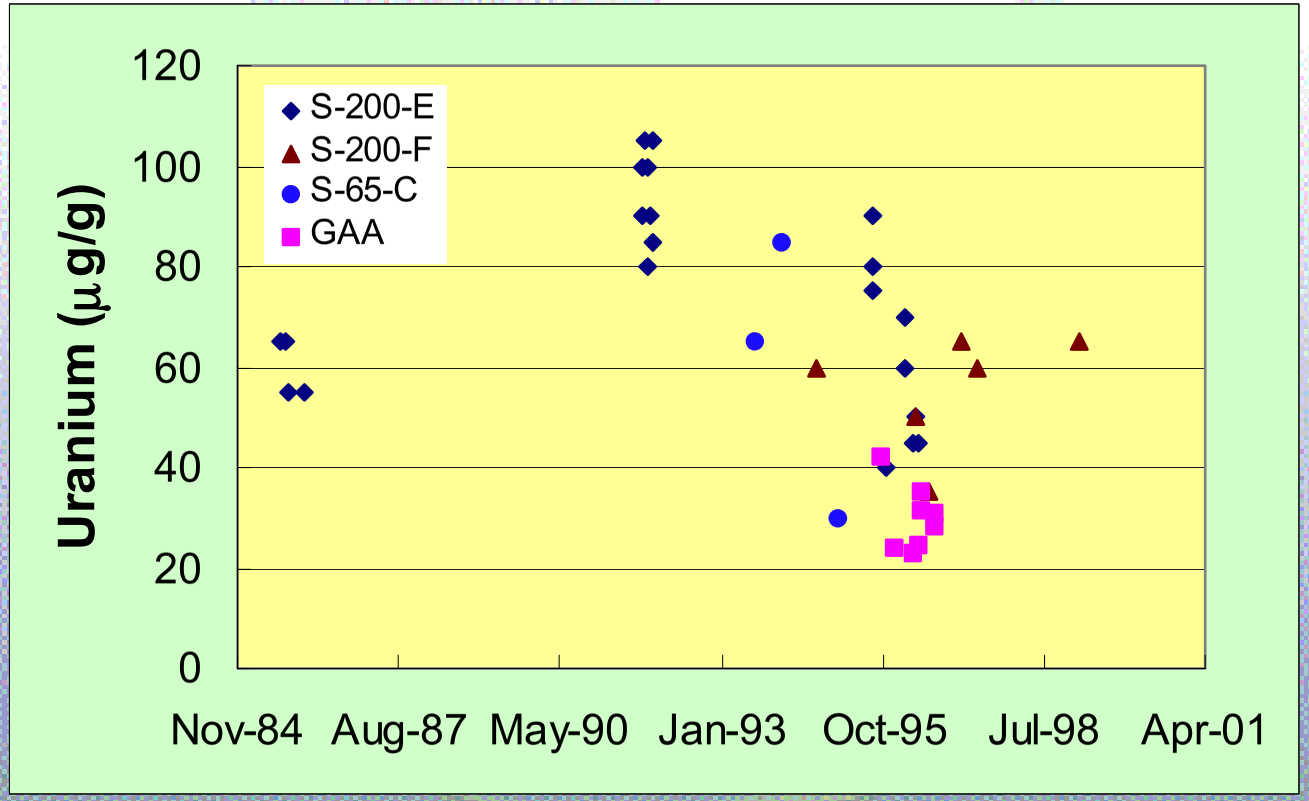
GRL 5/29/02 22

IMPURITIES LEADING TO ACTIVATION PRODUCTS IN BERYLLIUM (μg/g)

Activation Product	Impurity Precursor	TShG (Russian)	S-200E (BW)	ATR Est. (KBI)
^{14}C	N	280	50	230
^{60}Co, ^{60}Fe	Fe	500 - 1,500	600	1,500
^{59}Ni, ^{63}Ni	Ni	10 - 100	100	226
^{60}Co	Co	< 10	7	12
^{94}Nb	Nb	10	50	1-21
^{108}Ag	Ag	0.3	5	2.2
^{238}Pu, ^{239}Pu, ^{242}Pu, ^{241}Am, ^{242}Am, ^{243}Am, ^{243}Cm, ^{245}Cm, ^{246}Cm	U	-	20-110	24-41
^{137}Cs, (fission product)				

GRL 5/29/02 23

Brush Wellman data indicates significant uranium impurity



GRL 5/29/02 24

ACTIVATION CALCULATION POINT ESTIMATE

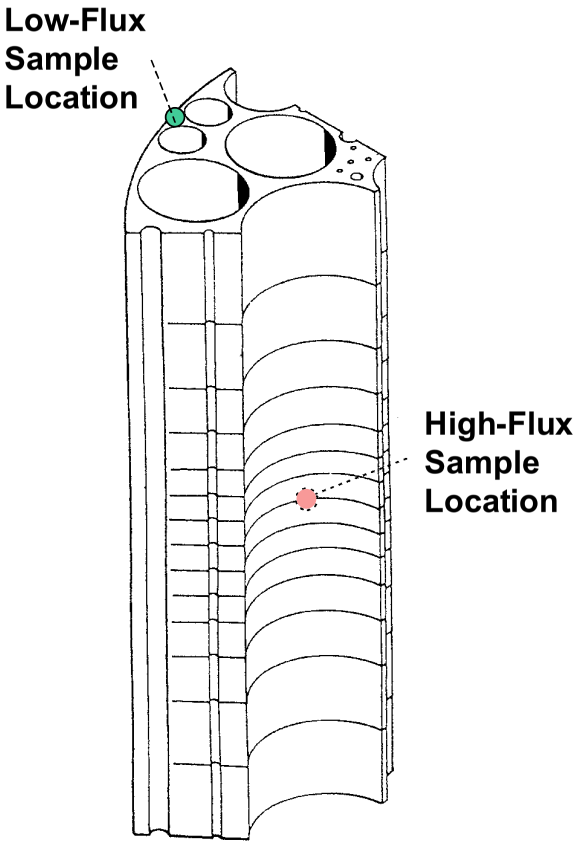
Block 020L, Core IV

BOL ^{238}U Concentration Assumed (wppm)	72
Start Date	5/18/86
Irradiation End Date	2/27/94
Irradiation Megawatt-Days	68710
Decayed to Date	06/15/01

Transuranic Nuclides	Concentration (nCi/g)	
^{238}Pu	1,750	
^{239}Pu	159	
^{240}Pu	146	
^{241}Am	1,370	
TOTAL (Block Average)	3,425	34.2 x Threshold

GRL 5/29/02 25

REFLECTOR BLOCK SAMPLING



- **Low-flux samples taken from all 12 blocks in ATR canal in 2000**
- **Sample taken 9/13/01 from high-flux location on Block 010R**
- **ANL-W performed measurements using both wet-chemical and physical analysis (ICP-MS)**
- **Confirmed computer modeling results with fair agreement**

GRL 5/29/02 26

BERYLLIUM BLOCK URANIUM CONCENTRATION MEASUREMENTS*

Block S. No.	020L	017R	017L	015R	021L	018R	022L	016R	016L	010R	11R	15L
Date Removed	1994	1994	1994	1994	1994	1994	1994	1994	1986	1986	1977	1977
Core Loading	IV	IV	IV	IV	IV	IV	IV	IV	III	III	II	II
MWd (historical)	68710	68710	41883	41565	57389	57389	41565	41883	72984	47259	36569	36569
Measured EOL ^{238}U (ICP-MS) ($\mu g/g$)	25	24	NA	32	27	25	NA	24	NA	30	NA	41
Measured EOL ^{238}U (Fluorimetry) ($\mu g/g$)	32	NA	NA	27	26	28	NA	31	NA	37	NA	NA
Measured ^{137}Cs ($\mu Ci/g$)	0.2	0.1	0.1	0.1	0.3	0.2	0.1	0.1	0.2	0.2	0.1	0.1
Minimum BOL ^{238}U to produce the measured ^{137}Cs	10	5	5	5	15	10	5	5	10	10	5	5

*Low flux sample location

GRL 5/29/02 27

CONCLUSIONS FROM THE MEASUREMENTS

OBSERVATION	IMPLICATION
• ANL-W measurements of KBI ATR blocks using two different techniques agree well with each other (16%)	ANL-W measurement process is accurate
• ANL-W measurements of U (57 μg/g) in Brush Wellman standard sample agree closely with vendor data (65 μg/g)	Brush Wellman estimates of U impurity (72 μg/g ave) in their Be are probably correct
• KBI U impurity apparently lower than Brush Wellman	Ore source is important to expected level of U impurity

GRL 5/29/02 28

Refined calculations gave predicted concentrations in good agreement with measurements

- *Code inputs were refined to reflect measured concentrations of naturally occurring impurities*
- *Better cross section libraries were used*
- *Calculations were performed for locations where samples were taken*

GRL 5/29/02 29

COMPARISON OF CALCULATION POINT ESTIMATE WITH MEASUREMENTS AT BLOCK 010R HIGH FLUX POSITION

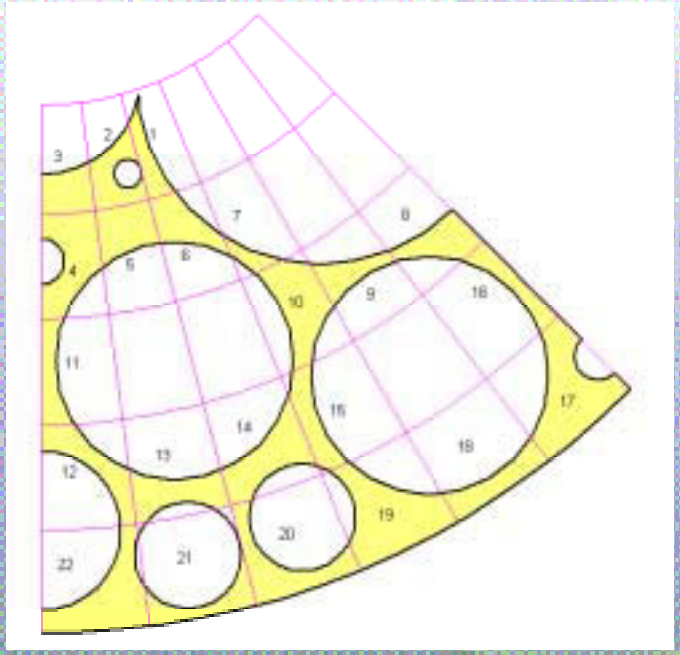
Block 010R, Core III, 47,259 MWd, Decayed to 7/15/2001

BOL ^{238}U Concentration Assumed (wppm) 30

Transuranic Nuclides	Concentration (nCi/g)		
	Calculated	Measured	Ratio
^{238}Pu	481	51.5	9.3
^{239}Pu	39.7	14.9	2.7
^{240}Pu	79.2	52.3	1.5
^{242}Pu	1.28	0.59	2.2
^{241}Am	504	206	2.5
^{243}Am	44.2	41.0	1.1
^{245}Cm	7.36	5.16	1.4
^{246}Cm	14.3	45.9	0.3
^{247}Cm	1.86E-04	6.51E-04	0.3
Total at Point	1,171	418	2.8
Block Average	1,710	610 (Implied)	

GRL 5/29/02 30

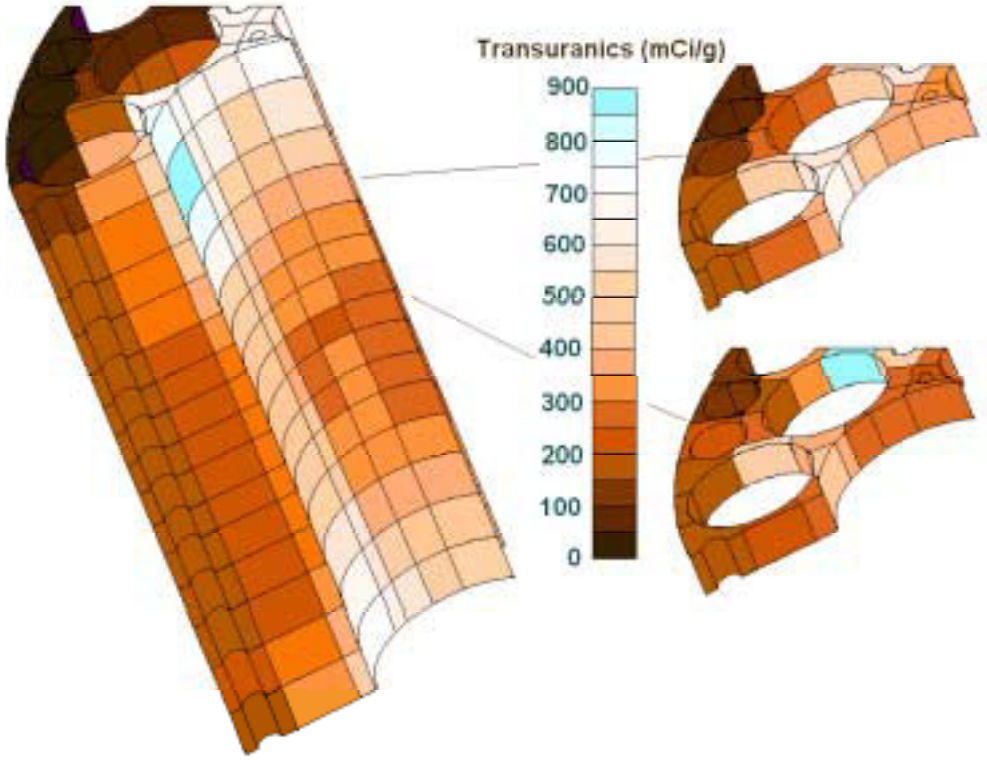
More refined calculations were performed on a more finely segmented model



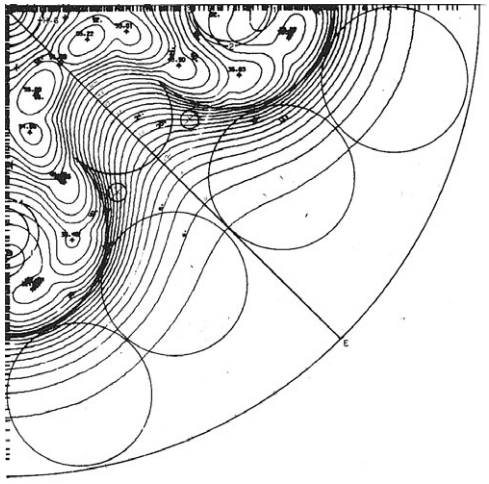
ATR reflector block 010R was subdivided into 22 x 15 = 330 zones

GRL 5/29/02 31

Calculations showed that the greatest TRU concentrations are not at the highest flux locations

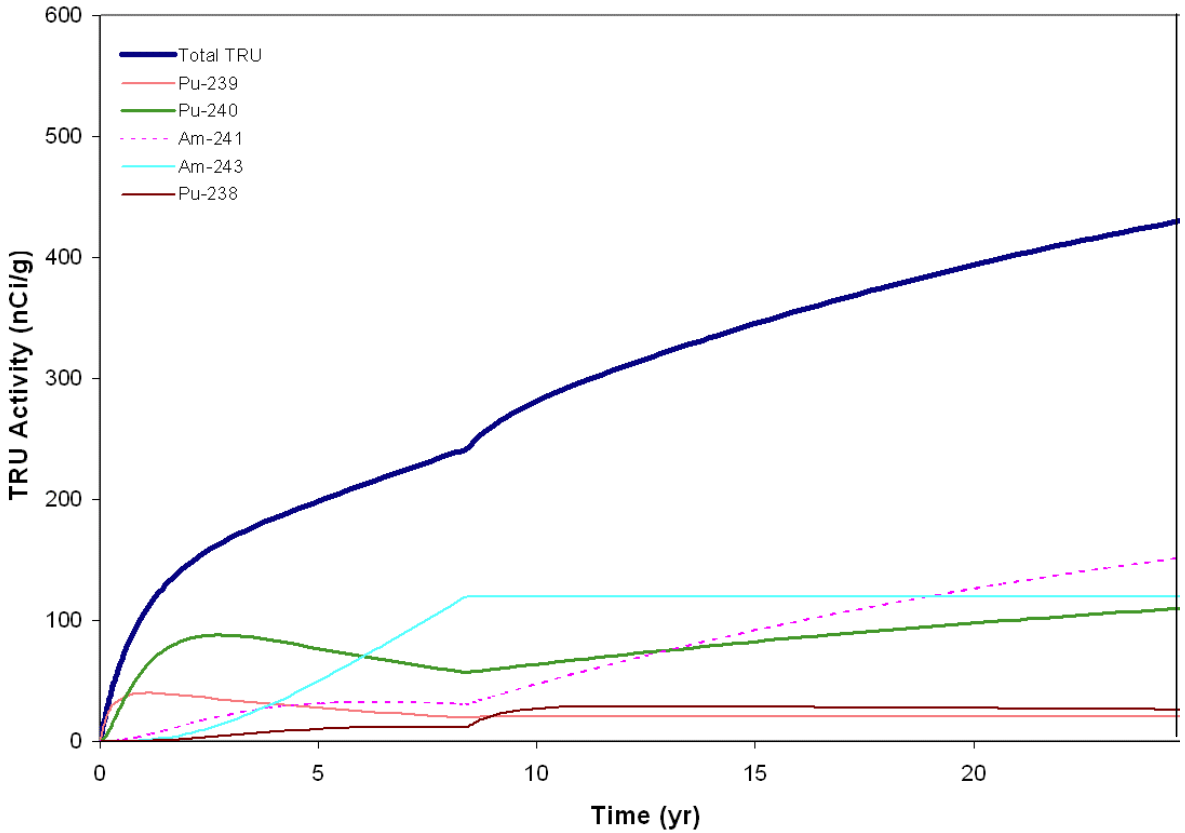


ATR East Quadrant Flux Intensity Profile



GRL 5/29/02 32

Transuranic concentrations vary in a complex way with time and flux history



Block average for 010R

GRL 5/29/02 33

Detailed model results were similar to point estimates and measurements

	Low-flux Site Segmented Model	Low-flux Site Specific Calculation	Low-flux Site Measured Value
^{239}Pu (nCi/g)	6.353	5.119	4.4
Total TRU (nCi/g)	13.719	8.56	N/M
	High-flux Site Segmented Model	**High-flux Site Specific Calculation**	**High-flux Site Measured Value**
^{239}Pu (nCi/g)	11.98	11.71	14.9 & 13.0
Total TRU (nCi/g)	286.46	279.5	434.8 & 506.5
	Block Average Segmented Model	**Block Average Specific Calculation**	**Block Average Measured**
Total TRU (nCi/g)	277.08	492.81	N/M

Models appear to mostly underestimate

GRL 5/29/02 34

CONCLUSIONS FOR TRANSURANIC ACTIVATION PRODUCTS

- *Activation modeling may over-predict or under-predict depending on level of detail included*
- *Burnout of intermediate products means highest TRU concentration is not at highest flux location*
- *Radioactive decay means TRU concentrations increase with time after irradiation is complete*
- *Most beryllium reflector blocks and outer shim control cylinders from the ATR exceed by several times the threshold for TRU classification:*

  Alpha emitters with half-lives greater than 20 years at aggregate concentrations greater than 100 nCi/g

GRL 5/29/02 35

Further study raised questions about RCRA hazards in irradiated beryllium

- *Previous TCLP testing on unirradiated beryllium showed no significant RCRA toxic metals in leachate*
- *Gold impurity is transmuted to mercury in irradiated beryllium*
- *There is enough gold impurity in some beryllium to raise concern if it were leachable in a TCLP*
- *Swelling from irradiation does not appear to accelerate leaching*
- *Indications from a TCLP on irradiated beryllium are that mercury leaching is not a problem*

GRL 5/29/02 36

RCRA HAZARDOUS IMPURITIES IN BERYLLIUM (μg/g)

Impurity	TShG (Russian)	S-65 (B W)	ATR Meas. (KBI)
Cr (from V)	200 - 400	25	174 (3.4 Est.)
As	-	<0.1	<8.4
Se	-	<1	<6.3
Ag	0.3	5	7.8
Cd	-	5	3.1
Ba	-	<30	<50
Ni	10 - 100	100	191
Hg (from Au)	<1	<0.2 (6-33*)	<4.3 (<33.3)

* Measured Au in S-200F ATR Core VI samples

GRL 5/29/02 37

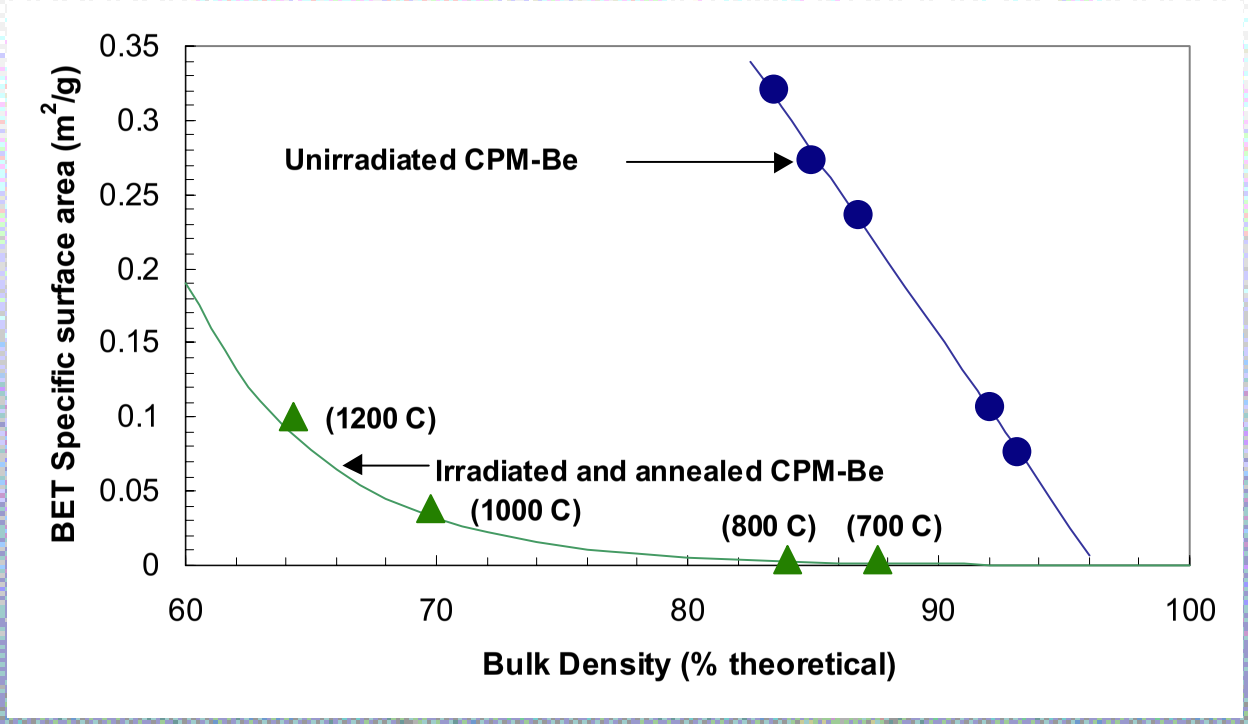
Total Hg and Au measured at ANL-W in beryllium samples taken from low-flux sites on ATR reflector blocks

Sample (Block Serial No.)	Au (μg/g)	Hg (μg/g)	^{196}Hg	^{198}Hg	^{199}Hg	^{200}Hg	^{201}Hg	^{202}Hg
79789 (15L)	< 0.5	2.12	0.169	0.229	0.532	0.506	0.300	0.386
79785 (202L)	33.3*	4.34	0.1479	3.910	0.114	0.156	0.008	0.070
79784 (018R)	0.532	0.490	0.062	0.239	0.043	0.090	0.013	0.044
79788 (11R)	<0.5	<0.5						
79786 (021L)	17.8	3.36	0.099	2.948	0.107	0.102	0.023	0.078
79783 (017R)	<0.5	<0.5						
79779 (015R)	0.692	0.443	0.071	0.160	0.048	0.081	0.007	0.076
79781 (016R)	0.826	0.399	0.058	0.196	0.036	0.065	0.003	0.048
79778 (010R)	<0.5	<0.5						

*A large measurement uncertainty exists with this sample. Some data indicated the gold concentration may be higher on this sample. However, those data are suspect as being inaccurate.

GRL 5/29/02 38

BET specific surface area measurements on compacted powder metallurgy (CPM) beryllium after irradiation in EBR-II.



GRL 5/29/02 39

Metals in the Block 010R sample before the TCLP and concentrations found in the extraction fluid following the TCLP.

Analyte	Total in Sample (μg/g)	2-σ Error (%)	Concentration in the leachate (mg/L)	2-σ Error (%)	40 CFR 261 Limit (mg/L)
Ag	7.8	±15	<0.4	NA	5
As	<8.4	NA	<2.4	NA	5
Ba	<50	NA	<2.8	NA	100
Be	99.4 wt%	±10	8.0	±10	None
Cd	3.1	±15	<0.2	NA	1
Cr	174	±10	0.81	±10	5
Hg	<0.7	NA	<0.007	NA	0.2
Ni	191	±10	0.24	±10	None
Pb	10.9	±15	<0.25	NA	5
Sb	110	±10	<0.22	NA	None
Se	<6.3	NA	<0.09	NA	1
Tl	<2.1	NA	<0.20	NA	None

GRL 5/29/02 40

FRACTIONAL RELEASES OF SELECTED METALS IN THE TCLP TEST ON THE HIGH-FLUX SITE SAMPLE FROM BLOCK 010R

Metal	Solubility in Be	Fraction Released (%)
Be	N/A	0.016
Cr	Low	9.31
Ni	Low	2.51
^{137}Cs	None	0.011
^{60}Co	None	0.018

GRL 5/29/02 41

Mercury should show the same behavior as ^{60}Co and ^{137}Cs

- *Each is insoluble in beryllium*
- *None has any significant mobility in beryllium at temperatures below 600 C*
- *Each will be released in only proportion to the beryllium dissolution*
- *At 0.02% release in TCLP, required mercury (gold) concentration in irradiated beryllium to fail TCLP would be 20,000 μg/g*
- *We conclude irradiated beryllium is non-hazardous with respect to RCRA Toxicity*

GRL 5/29/02 42

THE DISPOSAL PROBLEM

The only US facility presently licensed for permanent disposal of transuranic* waste is the Waste Isolation Pilot Plant (WIPP) in New Mexico.

- ***Only for Defense-generated waste***
- ***Limit of 5.1 MCi total capacity (LWA does not differentiate isotopes, and blocks have ^{3}H)***
- ***Material must be transported to WIPP (gamma radiation from ^{60}Co is a problem)***
- ***WIPP is presently unable to accept remote handled TRU waste***

** > 100 nCi\g, RWMC can accept <10 nCilg (^{241}Pu, ^{242}Cm higher)*

GRL 5/29/02 43

ADDITIONAL ISSUES

- *How should irradiated Be from ATR or other reactors be stored until a disposal pathway is found?*
- *Can irradiated Be be processed to fit an existing disposal pathway?*
- *Can we mitigate further production of Be with transuranic contamination by changing to foreign supplier or preprocessing beryllium for ATR and other reactors?*
- *Is there a need to remove and process Be already disposed of at RWMC and elsewhere?*

GRL 5/29/02 44

RECOMMENDED ACTIVITIES

COMPUTATION

Perform code sensitivity analysis to find ways to improve accuracy of calculated findings

TEMPORARY STORAGE

Evaluate costs and consequences of above ground temporary storage

PRE-DISPOSAL PROCESSING

Investigate feasibility and costs for

- Distillation
- Dissolution/precipitation
- Coatings
- Melting/slagging
- Chemical reaction
- Entombment

GRL 5/29/02 45

RECOMMENDED ACTIVITIES, Cont'd

POLUTION PREVENTION

Explore feasibility and costs for changing to foreign Be or using specially processed (e.g., distilled) domestic Be

REMEDIATION

Conduct further studies to evaluate extent of corrosion and radionuclide release and transport

DISPOSAL PATHWAYS

Conduct formal discussions with repository operators to establish acceptability or lack thereof for irradiated Be

GRL 5/29/02 46

CALL TO ACTION

- *Resolve to address this problem now*
  - *ATR operational issue*
  - *Problem may exist at other U.S. reactors*
  - *May be international waste disposal problem*
  - *Research and development are needed to resolve technical issues*
  - *Should explore legalities and ramifications for disposal at existing facilities*
- *Enlist broad support to establish and fund program to coordinate activities and resolve issues*

GRL 5/29/02 47

Comments on Irradiated Beryllium Disposal Issues, Background, Measurements, and Concerns

- It was mentioned in presentation no one uses GTCC designation. Greater than class C waste designation is codified in 10CFR61 and is the law. Nb-94 and C-14 are part of GTCC determination. {#25, Raj Bhatt[b]}

- Russian *Be* concerns[c]: Do they use *Be* ore with the same impurities that contribute to TRU issues? {#26, Kay Adler Flitton}

    - Response to #26--Russian *Be* ore typically does not have the same impurity content as US ore. {#29, Loren Jacobson}

- Mullen noted as a side comment the existence of activated graphite waste materials from MTR etc. that could have similar activated impurity issues {#27, Gary Anderson}

- Did you find U in the KBI *Be*? {#30, Don Kaczynski}

    - Response to #30: Uranium averaged 25-30 wppm in KBI beryllium samples taken from the blocks that were in the ATR. {#92, Glen Longhurst}

- Impurity in *Be* after processing also dependent upon how refined/processed. {#31, Gary Anderson}

- Since we are addressing one isotope being outside the class C limits, C-14, why can't we just adjust the limit upward as a regulatory change based on an updated risk analysis? Risk can't be much given that we live in a world full of C-14. {#32, Lawrence E. Miller}

- Did the ATR activation analysis consider data provided by material sampling, or was it based on metallurgical profiles "presumed" for the alloy? {#33, Bryan M. Moyers}

    - Response to #33: Early calculations were performed using best available information, mostly from literature, but later calculations used measured data, wherever they were available. The last two rounds used measured data. {#94, Glen Longhurst}

- How can the average be higher than the high flux value? {#34, Jeff Brower}

    - Response to #34: At very high fluence, some of the TRU burns away. Thus, the highest TRU concentrations are at locations where the fluence is moderate. The peak

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[b] Information in brackets {} are a reference number for the comment and the comment author's name. The reference number is used to link comments and responses.

[c] *Be* = beryllium.

seems to be reached after about 1.5 - 2 years of irradiation in ATR. {#95, Glen Longhurst}

- Capture comment that minimum uranium-238 must be less than 5 wppm based upon models to not exceed 100 nCi/g transuranics (primarily Am-241 and Pu-240 in growth, Am-243 builds during irradiation then holds constant after removal. {#35, Gary Anderson}

- Although the argument on TCLP release of Hg appears sound as a basis for a non-RCRA hazardous determination it hinges on Hg being not soluble as stated. A confirming TCLP on a *Be* material with Hg in it would be good to have as a validation point to convince doubters. {#36, Gary Anderson}

    - Response to #36 on TCLP - one should be cautioned when applying TCLP to raw materials to determine what would leach from a specific item disposed. Such that the test is used to determine the leachability on items disposed (i.e. disposal of *Be* plates). In most cases, the shape (or more precisely the surface area) of the item in contact with the leaching solution has more to do with its potential as a RCRA waste than the raw materials. {#46, Sheryl Leeper}

    - Comment on #46: A complicating factor for beryllium TLCPs is the oxide film that forms on the surface of beryllium after crushing to the size required for TLCP. Experimental data on chromium shows significant variation in release fraction with powder form. {#97, Glen Longhurst}

- Beryllium disposed as LLW likely has more problems than being disposed as TRU. {#37, Carlan Mullen}

- Eventually a quantitative statement of statistical confidence and tolerance factor will be needed on the code/model predictions for radionuclide concentrations (a distribution is needed accounting for variations in the source *Be*, the flux history (fluence), cross-sections etc). A combination of model based sensitivity studies and selected additional irradiated sample data will be needed to provide this bases. {#38, Gary Anderson}

- Shim cylinders are less well known than the reflector blocks, estimate of TRU concentrations? {#39, Gary Anderson}

- Is the flux high enough in the small research reactors, i.e. TRIGAs to result in TRU concentrations that exceed 100nCi/gm? {#40, Julie Conner}

- Clarify the source of the *Be* and the impurity (uranium concentration) concentrations for the model data comparisons and point out that the newer BW material actually has higher impurities than the KBI materials used earlier. {#42, Gary Anderson}

- ORIGEN S is, an update version of the ORIGEN code, is now available. {#43, Buck West}

    - Comment 43: Will use of ORIGEN S code make difference in calculation compared to ORIGEN {#55, Raj Bhatt}

- How far out in time will the net in-growth of Am and Pu stop and concentrations turnover? {#44, Gary Anderson}

    - Response to #44: Bill Hill indicated turnover or leveling out after about 30 years. {#96, Glen Longhurst}

- Shim cylinders had about eight years of flux. These were operated at 250 MW reactor power, current operation is now around 125 MW. {#45, Buck West}

- TCLP corrosion test is a RCRA determination test, but other corrosion mechanisms may act in actual disposal environments. These need to be considered for both existing disposed materials and the future disposal pathways. {#47, Gary Anderson}

- Russian beryllium has been available only since the early 90's. Estimate Russia will make between 40-60 tons this year. {#48, Buck West}

- Although the Hg may meet the TCLP criteria, it does not mean one is out of the woods with RCRA. It only means that the LDR requirements have been met. {#49, Clayton Gist}

- We keep on saying high flux does not necessarily mean higher concentration because of burn-up of products; at the same time claim that shim cylinders will have higher concentration due to higher flux experienced by them. {#50, Raj Bhatt}

    - Comment on #50: As was pointed out, it appears that the location in the reflector where TRU concentrations are highest is in the OSCCs. {#98, Glen Longhurst}

- What environmental regulatory requirements apply to the already disposed *Be* blocks and cylinders? Who is responsible for its management? I presume this would be handled under the CERCLA process, by EM. {#51, Brian Anderson}

- Distilling *Be* to remove impurities before use would add an up-front cost, but that cost should be more than recovered by not having to deal with activated impurities and TRU after use. Also, distilling after use and then reuse of salvaged *Be* should also yield savings over the long run by removing the costs to mine, transport and refine *Be* ore and it would also take the irradiated *Be* disposal problem off the table. {#52, Lawrence E. Miller}

- Blocks and shim cylinders have other material attached to it, also NRC allows disposal of similar material (generated in reactor) in same package. A determination needs to be made about waste as a package rather than just calculating concentration for beryllium weight only. {#53, Raj Bhatt}

    - Comment 53: Do you mean that volumetric averaging for the entire OSS assembly including the Hf plates would result in levels below the TRU level? It would still be GTCC, but not TRU?? {#56, Julie Conner}

    - Response to #53: I believe the OSCCs would be more hazardous (greater TRU concentrations) than the blocks because of their locations. Most of the OSCCs are

Brush Wellman material that is typically higher in uranium than the KBI blocks. {#100, Glen Longhurst}

- Problem needs to be divided into three distinct but related parts. Disposition of 1) The materials already disposed (ER issue), 2) management and ultimate disposition of the materials currently in the pool or other storage or that will be produced in the near future (from continued reactor ops and from D&D of ETR/MTR etc,) and 3) prevention/minimization of longer term future *Be* waste from continued reactor operations. {#54, Gary Anderson}

    - Re: Comment #54. A key piece of part 2 is what regulatory requirements apply and how do we get "permission" to continue current plans to place similar *Be* components into the ATR during the next CIC, scheduled for early CY 2004, knowing that there is no defined path for disposal? This is an element that I would like to see defined and answered during this workshop. {#58, Brian Anderson}

- Glen asked if there were any fundamental flaws in the arguments given in his presentation? No response. {#57, Buck West}

- The ATR reflector blocks and shim cylinders have other metal parts attached that must be considered when planning a disposal path. The recent INEEL work has focused on the beryllium metal only. Separation of the non-beryllium hardware parts has been considered to remove the GTCC items. {#59, Carlan Mullen}

- Not all of the irradiated beryllium that is stored or will be generated in the future from reactor operations will be remote handled TRU, some of it will be remote handled LLW. Therefore a disposal path is needed for both and each will have major difficulties to over come to move the beryllium to disposal. {#103, Carlan Mullen}

In general discussion at the end of the first day regarding comments made on earlier presentations, the following points were made by the presenter, Glen Longhurst, and other participants regarding some of the comments made on this presentation.

- {#32, Lawrence Miller} Current limits for C-14 placement in the RWMC are based on analyses of impacts on the performance assessment (PA) for the facility. Presumably, if it can be shown that higher limits on C-14 would not have an adverse impact on the PA, for example because of tight binding in irradiated beryllium, it may be possible to increase the limits.

- {#36, Gary Anderson} The TCLP test made on the high-flux sample from Block 010R has been challenged because it had no detectable gold or mercury. The decision regarding further sampling and TCLP testing on irradiated beryllium that is known to have gold and mercury in it is a trade between cost and need. It was demonstrated in the work done at ANL-W that

materials known to be insoluble in beryllium are released in a TCLP only in proportion to the dissolution of the beryllium matrix. Determination that mercury is insoluble in beryllium has previously been made by others. It is a practical impossibility to collect a "representative" sample according to the strict legal definition of a sample required to make a hazardous waste determination in this case. Therefore, the question is: is there adequate information available to draw the conclusion that irradiated beryllium is non-hazardous with respect to mercury? Further testing would in all probability not change the conclusion, but it may remove some doubt. The cost of taking another sample from a different block and making the required measurements would be on the order of $30K.

- {#37, Carlan Mullen} Carlan explained that there are many issues associated with disposal of low-level waste. Because of the numerous qualification criteria, it may require greater administrative effort to accomplish the disposal as LLW than would be required for disposal as TRU where many of these other issues are inconsequential.

- {#40, Julie Conner} The degree to which uranium impurity in small reactors would be transmuted to TRU isotopes depends on a number of factors. The low-power reactors almost invariably operate at lower neutron fluxes than the larger ones such as ATR and HFIR. However, activation in the ATR, for example, exceeds the TRU threshold after only a few months of operation though the beryllium lifetime in ATR is typically 8 years. Therefore, it is quite likely that beryllium irradiated in a small reactor could become transuranic.

- {#51, Brian Anderson} Responsibility for material buried at various waste disposal sites appears to belong to the facility operator. When the waste is accepted, the operator assumes ownership. However, this issue warrants further clarification.

- {#53, Raj Bhatt} Activation calculations and results conducted at the INEEL on beryllium reflector blocks and OSCCs have not included any consideration of the non-beryllium pieces attached to them. We suppose there is no reason to remove those pieces if it is determined that the beryllium components can be disposed of as TRU waste. In effect, with regard to TRU isotope concentrations, they would serve as *de facto* diluents.

HFIR Beryllium Disposal Experience

W E Hill
Research Reactors Division
Oak Ridge National Laboratory

ORNL Historical Use of Beryllium

- LITR
- BSR
- ORR

)

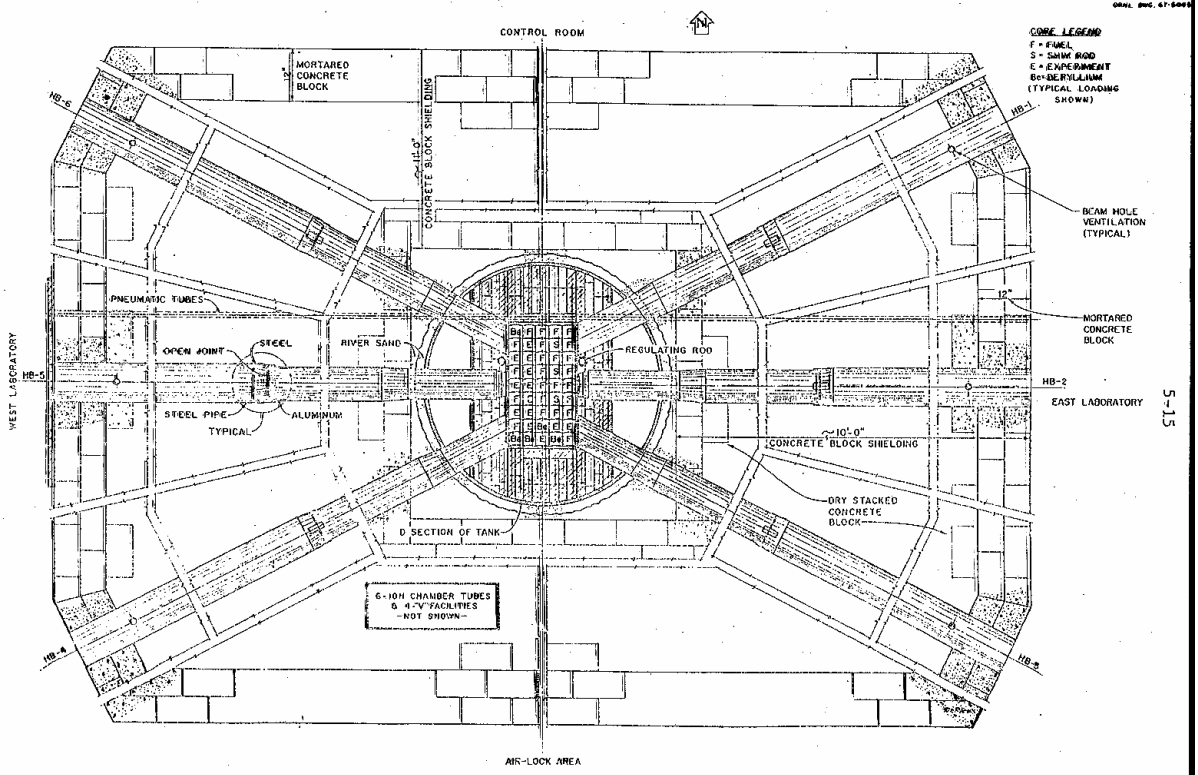


Fig. 5.2.6. Horizontal Cross Section of the LITR

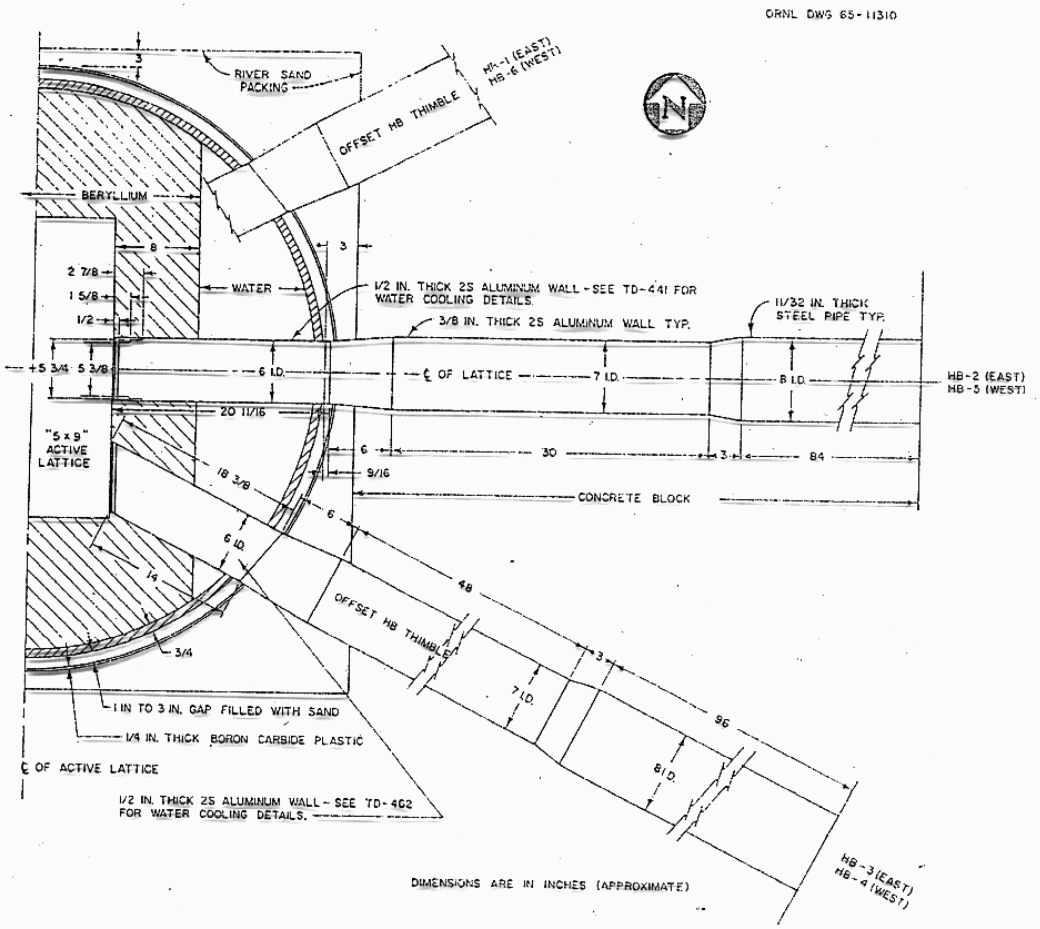


Fig. 5.4.1. LITR Beam Hole Dimensions

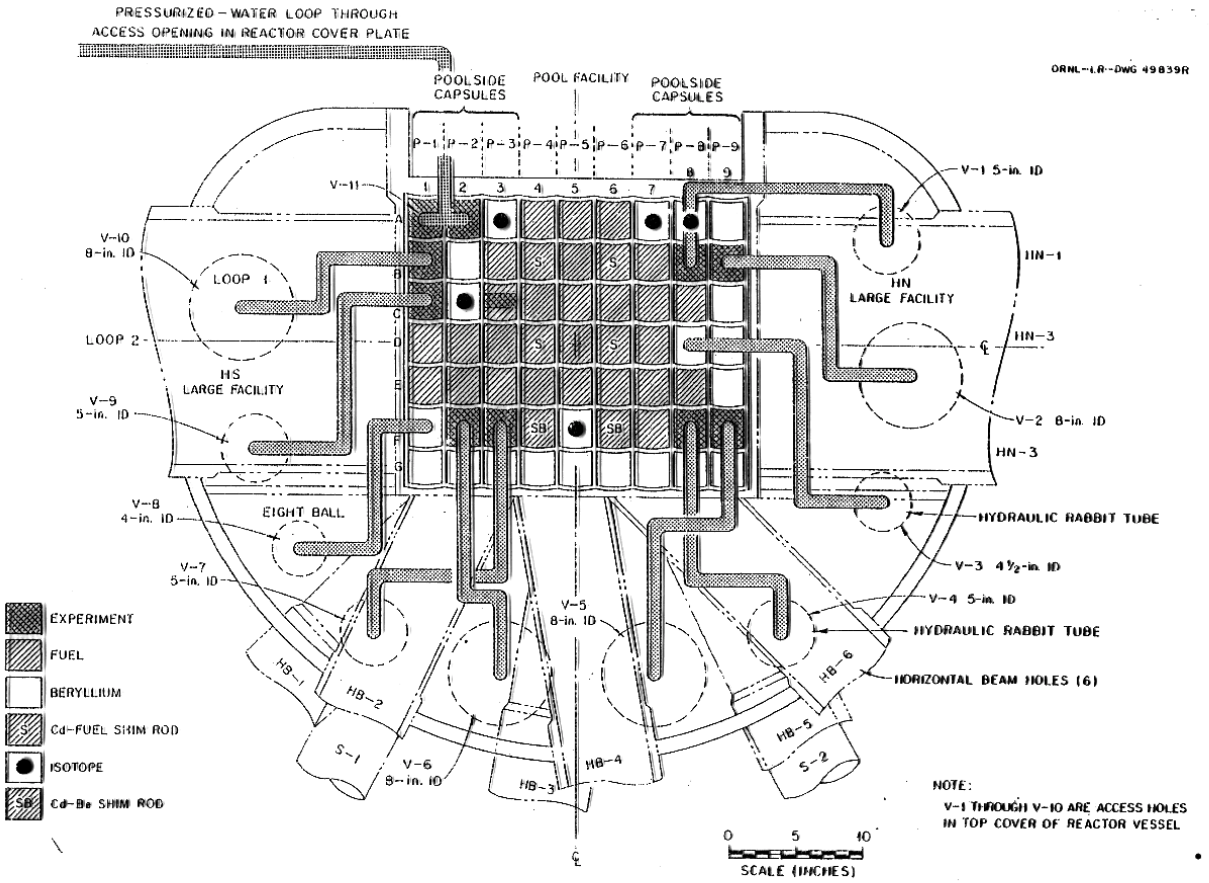
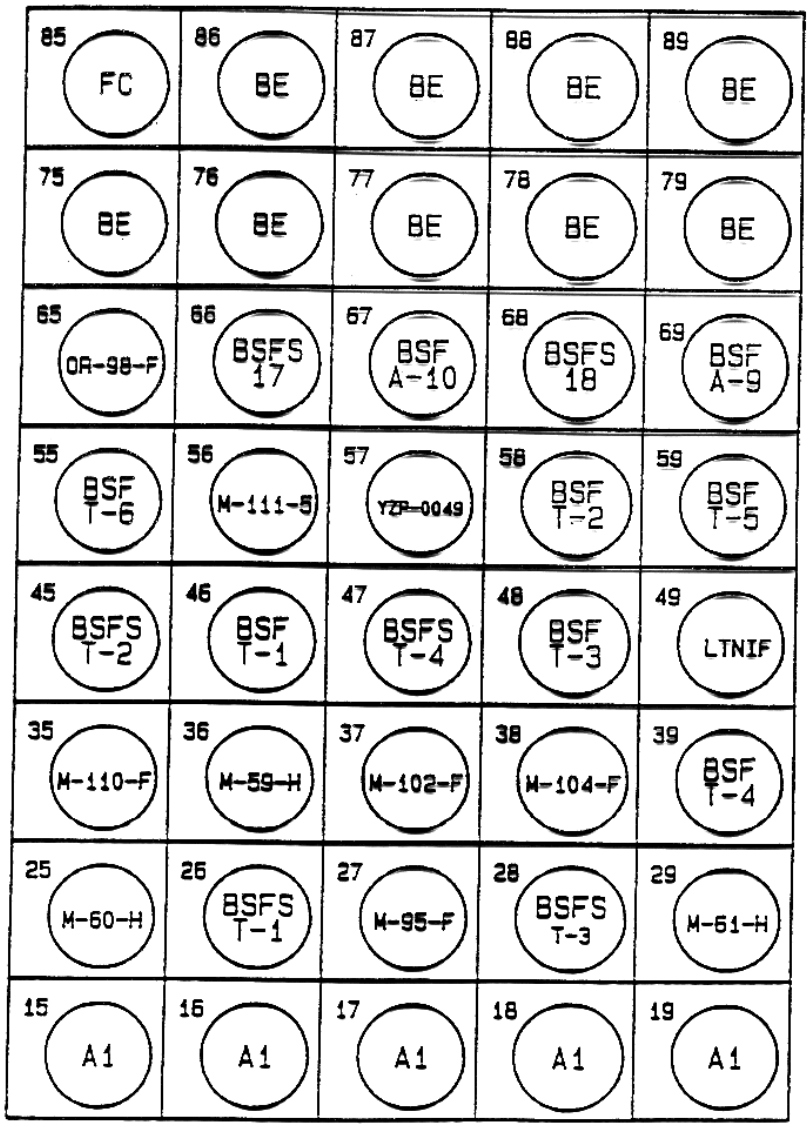


Fig. 5.9. Lattice Pattern and Experiment Locations.



Note: Core grid positions in rows 1 through 8 and columns 1 through 4 were occupied by the east D_2O tank.

Fig. 2.1.2-1 BSR core configuration board for core 102

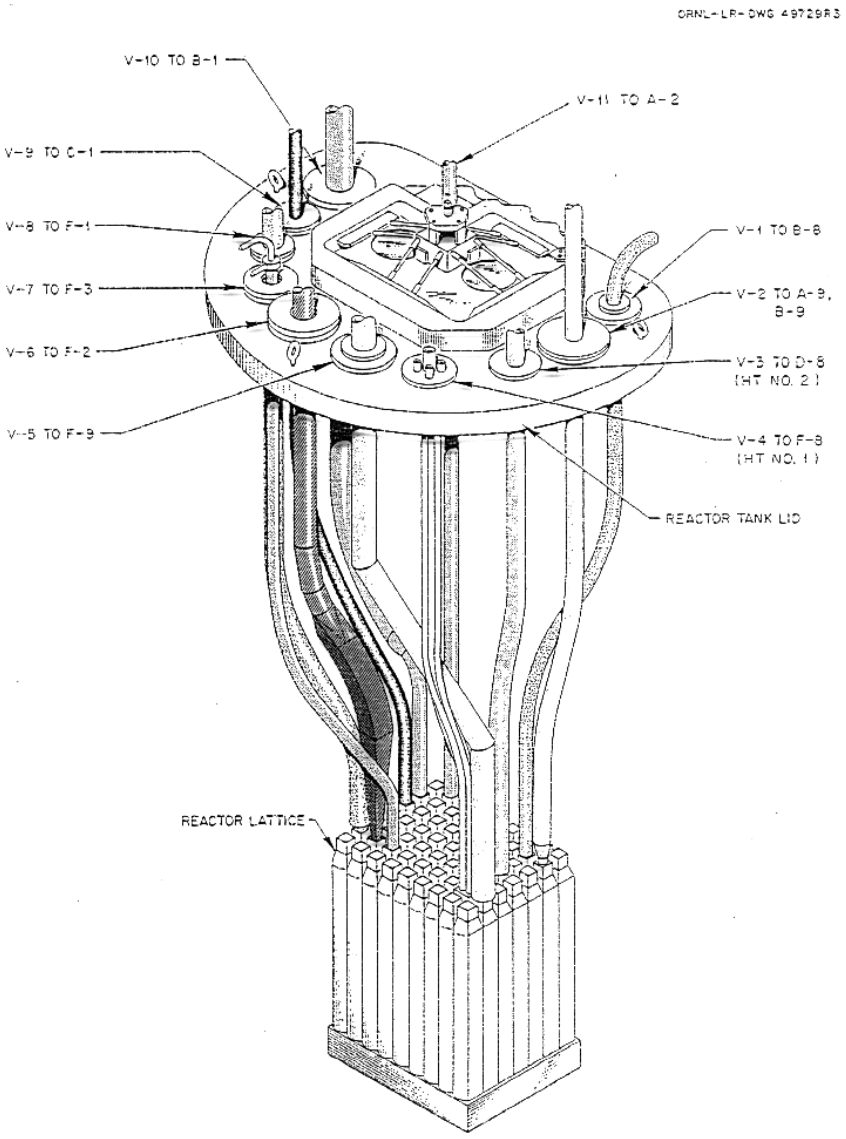


Fig. 5.8. In-Reactor Experimental Facilities.

6. Undesirable -- water is supplied from the reactor cooling system and is discharged into the pool cooling system through the degasifier.

System No. 2. -- The No. 2 hydraulic tube system for the ORR, Fig. 5.11, is a facility designed to allow irradiation of as many as 25 capsules simultaneously: 20 capsules ½ in. OD by 2½ in. long and 5 capsules ⅝ in. OD by 2½ in. long. The facility consists of five separate tubes that are essentially independent of each other. Tubes 21, 22, 23, and 24 accommodate five ½-in.-OD capsules each, and tube 25 accommodates five ⅝-in.-OD capsules.

The loading station, located on the north wall of the center pool, consists of five loading chambers, each of which is provided with a hinged top and lockdown mechanism to facilitate insertion and removal of capsules. Each loading chamber is designed with a water control valve built as an integral part of the loading chamber. This valve

HFIR Beryllium

- HFIR
  - Permanent
  - Semi-permanent
  - Removable
  - Plugs

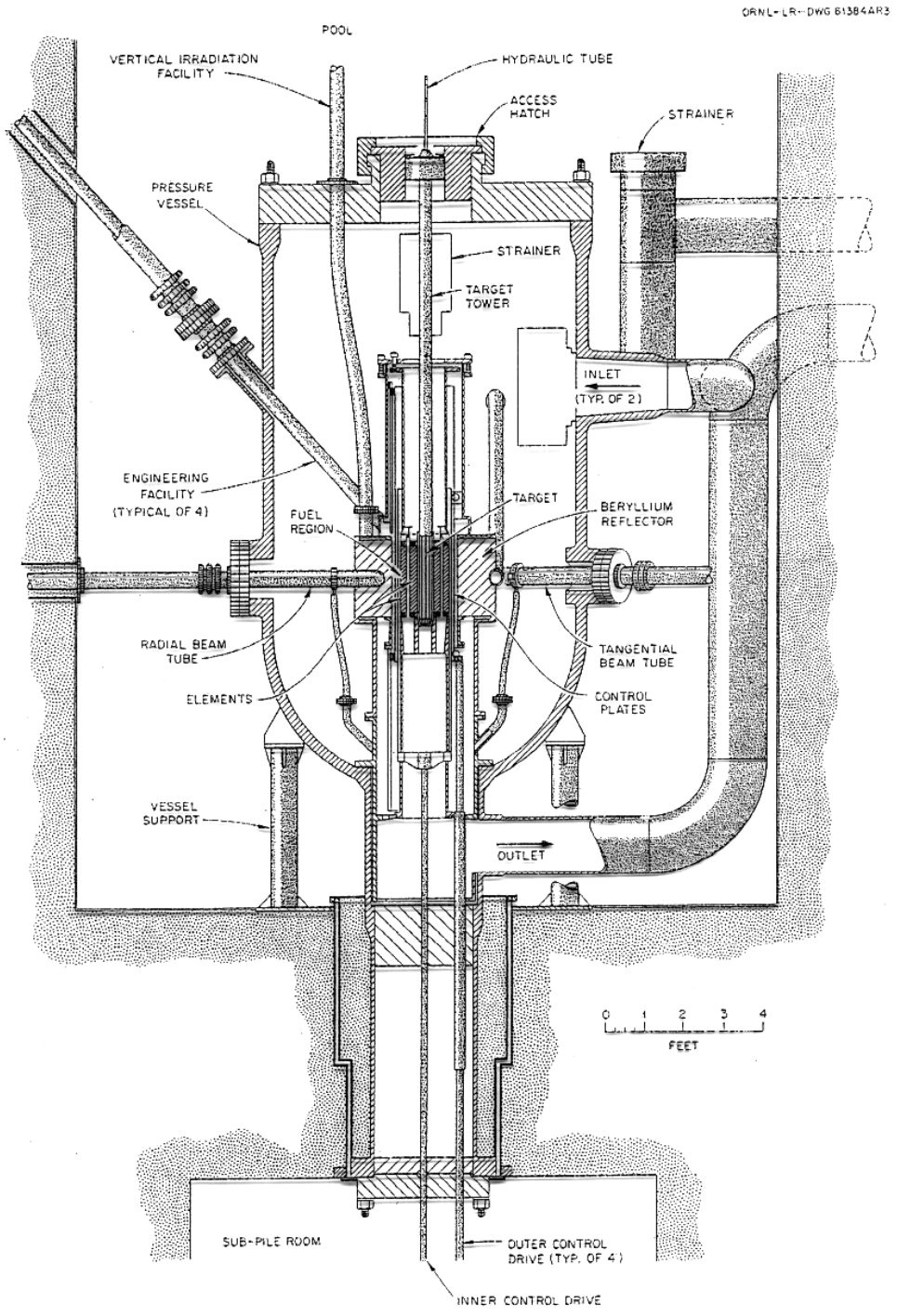


Fig. 5.1.2. Vertical Section of Reactor Vessel and Core.

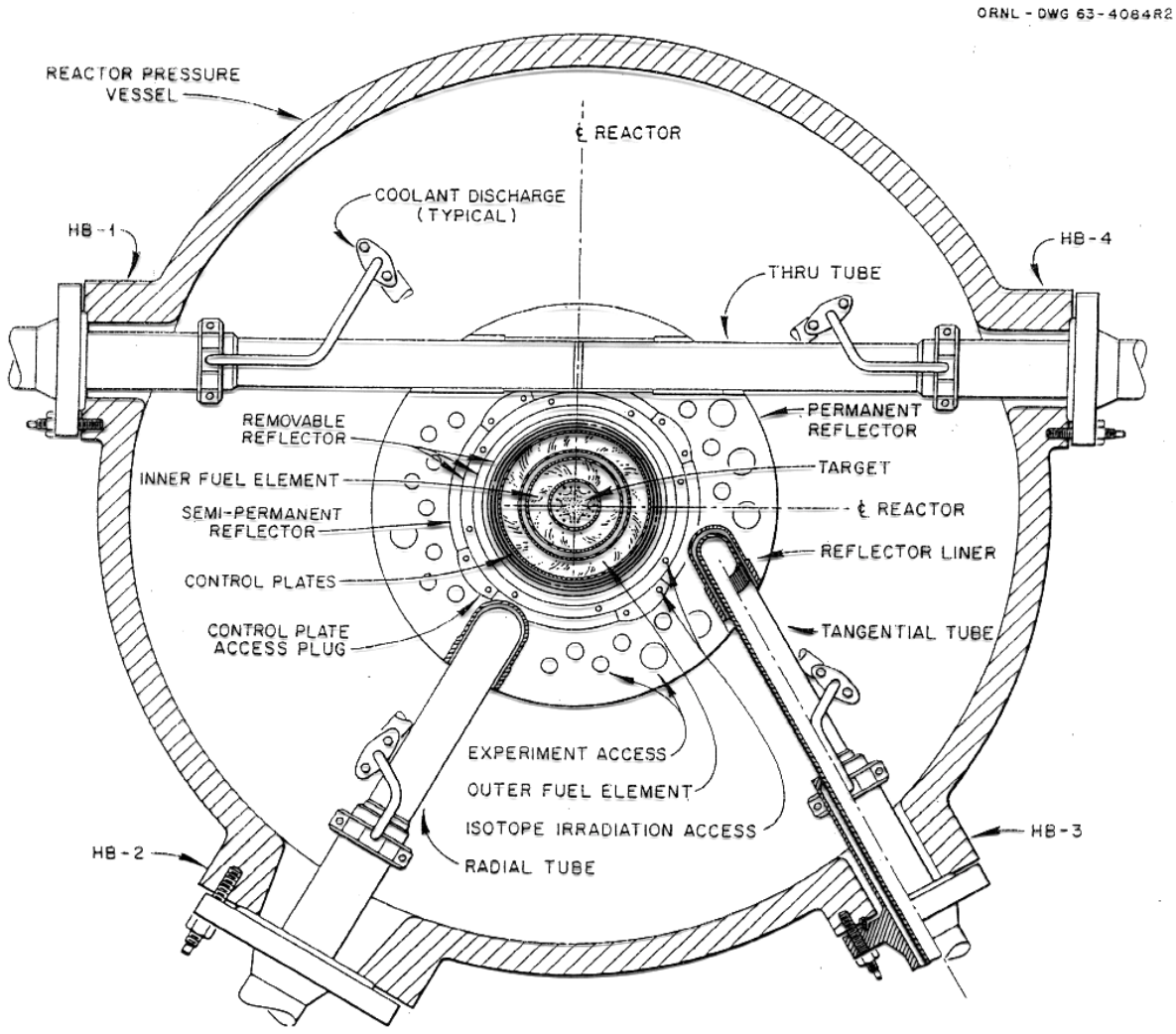


Fig. 5.1.3. Plan View of Reactor Core.

Permanent Beryllium

HFIR Beryllium Permanent

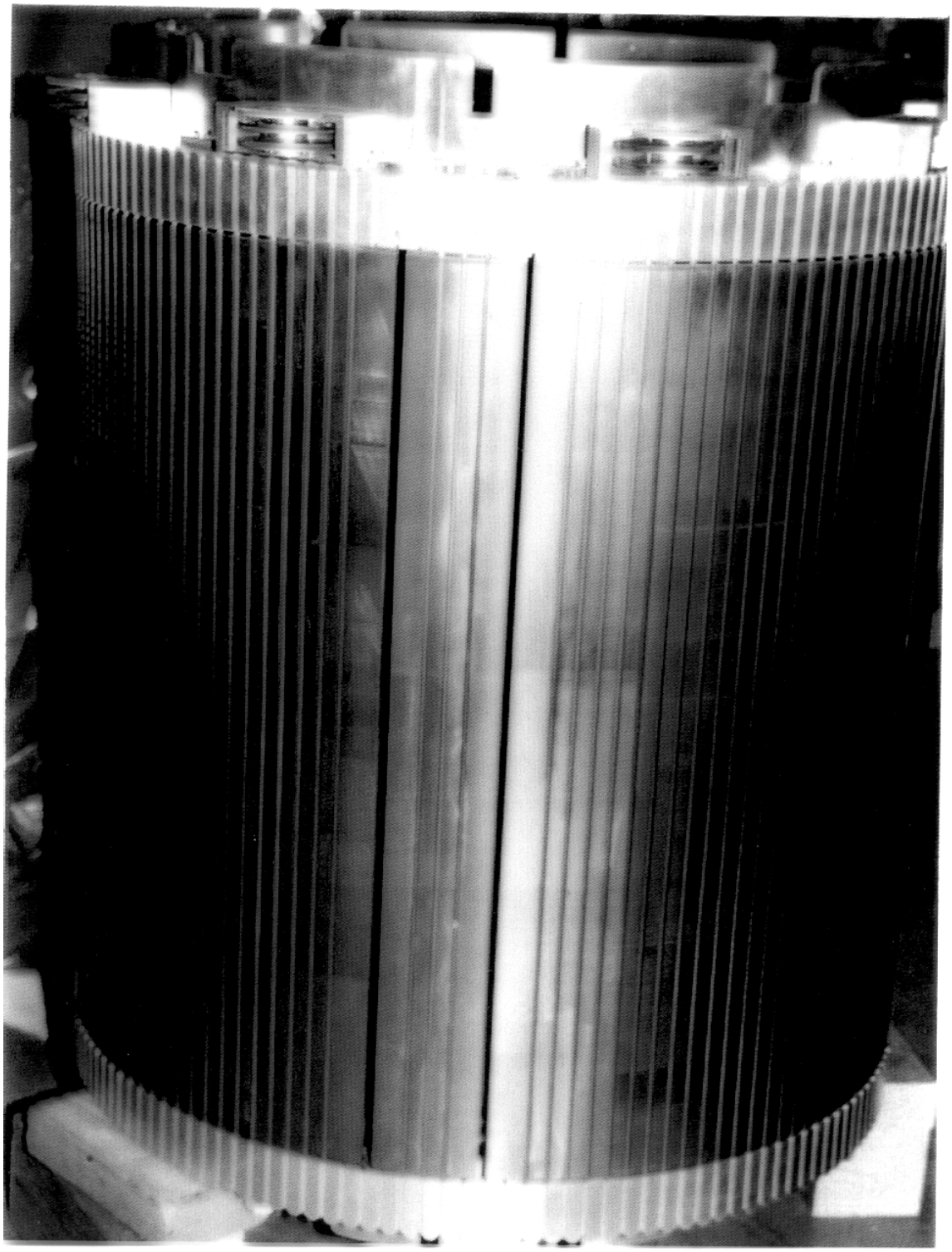
- Permanent reflectors have a lifetime of 279,000 MWd
  - # 4 permanent reflector in reactor.
  - #1 broken up and disposed of.
  - #2 is in an above-ground vault.
  - #3 is in pool waiting disposal – plan to place in above-ground vault.
  - Typical dose ~ 1700 R/hr @ contact after 90 days decay.

Semi-Perm. Beryllium

HFIR Beryllium Semi-Permanent

- Semi-permanent reflectors have a lifetime of 167,400 MWd
  - # 6 is in reactor.
  - #1-3 have been disposed of
  - #4 is in an above-ground vault.
  - #5 is in pool waiting disposal– plan to place in above-ground vault.
  - Typical dose ~ 8,000 R/hr @ contact.

Removable Beryllium



HFIR Beryllium Removable

- Removable reflectors have a lifetime of 83,700 MWd
  - #12 is in reactor.
  - #1-7 have been disposed of
  - #8 is in an above-ground vault.
  - #9 & 10 are in pool waiting disposal – one of these will go in an above-ground vault.
  - Typical dose ~ 14,000 R/hr @ contact

Activity Levels of HFIR Permanent Beryllium

- Majority of dose comes from Co-60 ~ 3,500 Ci.
- Majority of activity is tritium ~ 200,000 Ci.
- Other bad actors include C-14 @ ~ 118 Ci & Ni-63 @ ~ 54 Ci.

Characterization of Permanent Reflectors

- Permanent reflectors characterized using ORIGEN S.
- Dose calculations are obtained from Microshield.
- Characterization of # 2 & # 3 show they are or will exceed 100 nCi/gm of TRU constituents.
- Isotopes – Pu-238 (peaks after 3 yrs), Pu-240 (continually builds; factor of 3.5 - 30 yr level/discharge level), Am-243, Cm-246.
- Other TRU isotopes present at lower levels.

Uranium Impurities in Permanent Beryllium

- # 1 - <.001 %
- # 2 – 0.0090 %
- # 3 – 0.0044 %
- # 4 - not analyzed, 50 gm sample of powder and 50 gram sample of solid included w/ shipment

HFIR Beryllium Removal Process

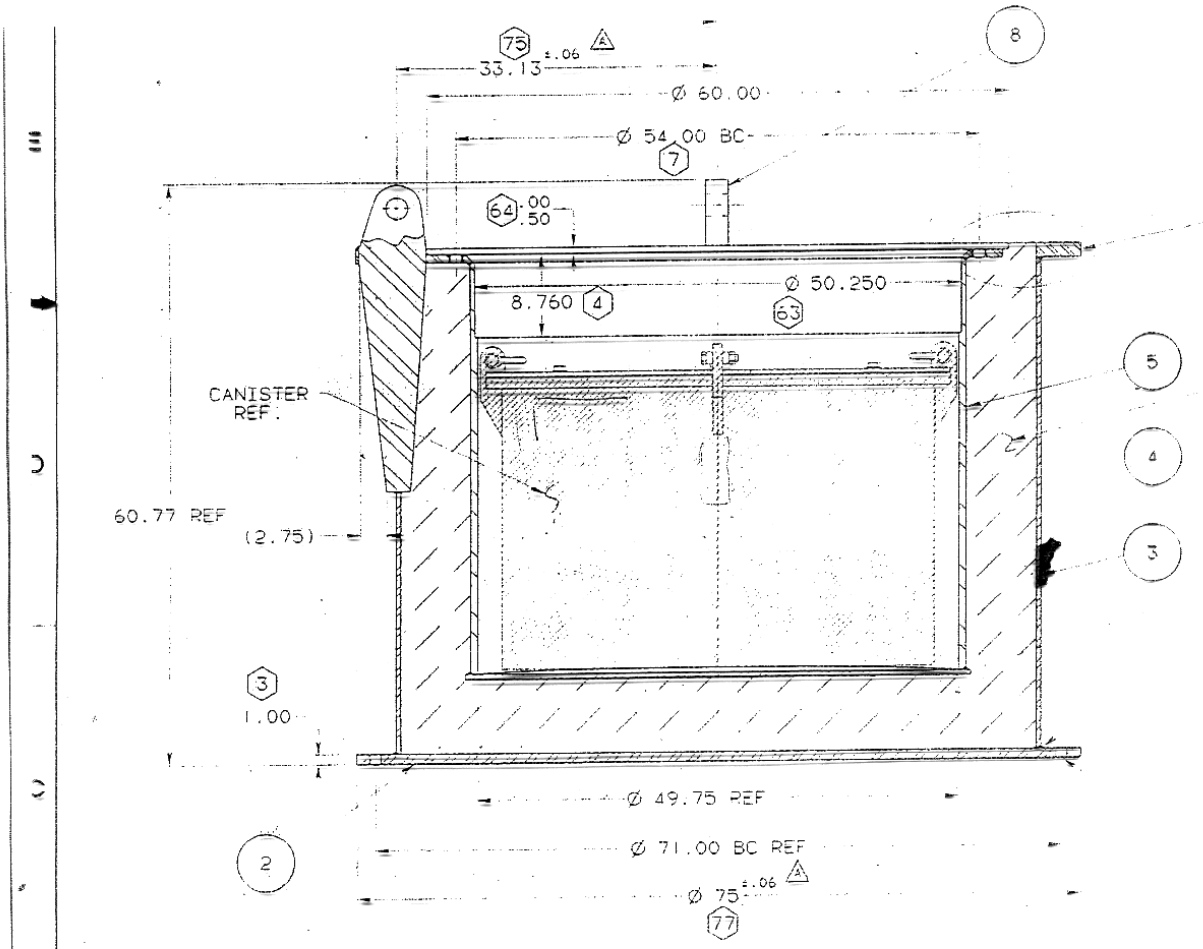
- Up to 1987, HFIR disposed of in-pool waste by sending it to ORNL's burial ground.
- In or about 1987, ORNL stopped burying waste.
- To obtain more footprint space, RRD designed and built an above-ground storage vault.

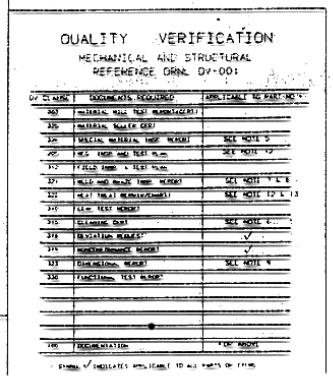
HFIR Beryllium Removal Process con't

- Vault was designed by ORNL Engineering & RRD
- Funded by RRD.
- Built by Ranor using competitive bid process.

HFIR Waste Disposal Vault

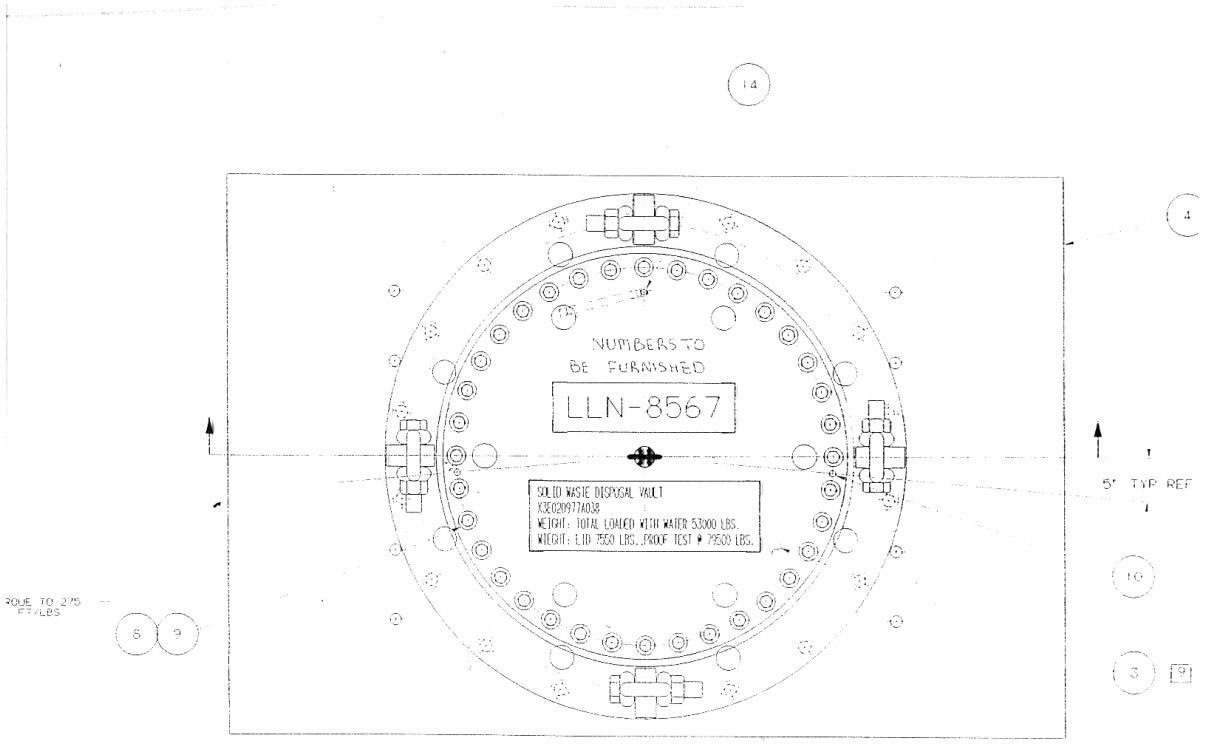
- Vault is constructed of SS with 7.25” thick lead-filled walls.
- Vault weighs ~ 52,000 lbs.
- A canister inside the vault holds the waste package and has a 30’ long lanyard to allow remote transfer.
- Vault and canister are vented and have drain features.





1 VAULT BODY - WELDMENT

SCALE: 1/8" = 1"
MACHINE AFTER BOTH
WELD ASSY & LEAD POUR


14
4
NUMBERS TO
BE FURNISHED
LLN-8567
SOLID WASTE DISPOSAL VAULT
X3E020977A038
WEIGHT: TOTAL LOADED WITH WATER 53000 LBS.
WEIGHT: LID 7550 LBS. PROOF TEST @ 79500 LBS.
5" TYP REF
10
3
9
6
9

HFIR Beryllium Transfer

- Transferal of custody to above-ground storage location required an MOA.
- Vault was loaded with in-pool beryllium components and relocated in summer of 1994.
- Second vault was procured in 1995 and is ready to be filled.
- Cost for complete vault package in 1995 $ was ~ $200,000.

Current Status

- First vault is still in EM-contractor custody.
- No problems to date.
- HFIR is planning to fill the second vault this FY to clear footprint space in the pool.

Fiscal Responsibilities of the Reactor Operations Division

ROD is fiscally responsible for the following actions:

(1) Packaging and relocation of the activated components from HFIR to Facility 7856.

(2) Upgrade of Solid Waste Storage Area 6 (SWSA 6) Liquid Waste Solidification Pad-2 (LWSP-2) authorization basis, to allow storage of the activated components in SWSA 6. The authorization basis documentation shall be similar to that provided for Facility 7856 for which the DOE has provided contingent approval.

(3) Relocation of the activated components from Facility 7856 to the SWSP-2 Pad at SWSA 6.

(4) AT THE OPTION OF WMTDD, transport, size reduction and re-packaging of the reflector for off-site shipment prior to termination of HFIR operations unless responsibility for the reflector is reassigned by DOE directive prior to notification of permanent HFIR shutdown.

Fiscal Responsibilities of the Waste Management and Technology Development Division

WMTDD is fiscally responsible for the following actions:

(1) Storage of the activated components in accordance with its approved authorization basis.

(2) Construction and maintenance of storage pads at 7856 and SWSA 6, if required.

(3) Authorization basis revisions, with the exception of the initial LWSP-2 upgrade, if required.

11/19/93

L.L. Radcliffe, Director
Waste Management and Technology
Development Division

B.S. Willis, Director
Reactor Operations Division

MEMORANDUM OF AGREEMENT BETWEEN WASTE MANAGEMENT AND TECHNOLOGY DEVELOPMENT DIVISION AND REACTOR OPERATIONS DIVISION CONCERNING FISCAL RESPONSIBILITIES FOR ACTIVATED REACTOR COMPONENTS REMOVED FROM THE HIGH FLUX ISOTOPE REACTOR POOL

Background

Since its startup in 1966, the High Flux Isotope Reactor (HFIR) has routinely generated activated components which have reached the end of their useful life. Until 1987, these components were transferred to Oak Ridge National Laboratory (ORNL) burial grounds for disposal. One of the activated components which was previously buried is a 24-inch tall x 43-inch diameter doughnut-shaped permanent beryllium reflector. In addition to other activated components, the HFIR pool currently contains another of these beryllium reflectors which is occupying a large area of pool floor space. There are also separate beryllium pieces, called semi-permanent and renewable beryllium, which are nestled inside the large permanent assembly. The floor space occupied by the beryllium is required to expand HFIR's fuel storage capabilities. Failure to clear the floor space will ultimately result in shutdown of the HFIR.

The practice of disposing of the activated reactor components by burial has been suspended pending finalization of the Performance Assessments for proposed disposal sites and resolution of several DOE and State of Tennessee policy regulatory issues. To remove the incidental activated components and beryllium, the ORNL Research Reactors Division has designed and is currently procuring a lead-shielded transport/storage container. This container will be utilized to remove the activated components from the HFIR pool and provide containment during transport to an ORNL Waste Management and Remedial Action Division (WMRAD) storage location, Facility 7856. WMRAD has upgraded the authorization basis for Facility 7856 to receive and store these components. At Facility 7856, the lead-shielded container will be placed inside an existing concrete storage vault on a gravel pad and stored until a final disposition plan is developed.

The Waste Management and Technology Development Division (WMTDD) cannot accept unconditional fiscal responsibility for the activated reactor components at this time. As a result, the Waste Management and Technology Development Division cannot accept the activated components for storage without a commitment from the Reactor Operations Division to request funding for actions as outlined in the final disposition plan. This Memorandum of Agreement delineates WMTDD's and ROD's responsibilities for the activated components currently stored in HFIR pool. It shall remain in effect, and ROD shall retain ownership of the activated components, until DOE policy directives reassign responsibility for this item, or HFIR is permanently shut down. Should permanent HFIR shutdown be scheduled for completion prior to DOE reassignment of responsibility, WMTDD shall have the option to return the beryllium reflector to HFIR for planned actions (which may include size reduction) and packaging for off-site shipment before HFIR operations are terminated.

DOE F 1325.8
(4-93)

United States Government

memorandum

epartment of Energy

Oak Ridge Operations

Waste Management Operations
Dist: T.F. Scanlan
Date: 12/1

H.L. Adair X R.C. Orrin
D.D. Drake D.J. Peterson
K.G. Edgemon F.J. Schultz
D.F. Hall X C.B. Scott
F.R. Hodges M.W. Tull
K.W. Lingerfelt C. Whitmire, Jr.
B.C. McClelland X File
Route/Date Copy X
Person Responsible:
Commitment No. Due Date:

DATE: November 24, 1993

REPLY TO ATTN OF: EW-922:Roddye

SUBJECT: MEMORANDUM OF AGREEMENT FOR HIGH FLUX ISOTOPE REACTOR POOL COMPONENTS

TO: W. F. Manning, Deputy Assistant Manager, Energy Research and Development, Advanced Neutron Source, ER-10

Attached is a signed copy of the subject Memorandum of Agreement. An advance copy of this was sent by facsimile to Dave Rosine on November 22, 1993.

If you have any questions, please contact Mac Roddye at 576-1801.

Larry L. Radcliffe, Director
Waste Management and Technology
Development Division

Attachment

cc w/attachment:
R. Hultgren, ER-10
D. Rosine, ER-12
C. Frye, K-1037, MS 7375
T. Scanlan, 3047, MS 6023
C. Manrod, 3047, MS 6023

Comments on HFIR Beryllium Disposal Experience

- The ORNL experience is the beryllium would curve and if you didn't pull it out and turn it it would then get stuck in the core. {#60, Buck West}

- Have there been previous beryllium cores disposed of from the inactive reactors? Have the beryllium cores that remain in the reactor been there since the reactor went critical? {#61, Carlan Mullen}

    - In response to question #61, yes, several beryllium elements have been disposed of on-site. Don't know the history of the beryllium elements in these reactors. I suspect that very few are original. {#132, WE Hill}

- Where was the first HFIR reflector shipped to? {#62, Glen Longhurst}

    - In response to #62 - the first blocks were disposed on site. {#64, Buck West}

    - In response to question #62, the first permanent reflector was shipped to ORNL's burial ground. {#133, WE Hill}

- What was the disposal problem associated with core 2 as LLW? {#63, Carlan Mullen}

    - In response to #63 - the second permanent reflector was not in a geometry suitable for on-site disposal. Size reduction was not an option and no cask was available for transport off-site. Therefore, we chose on-site storage in above-ground Vaults. {#181, WE Hill}.

- Any H-3 release from *Be* stored above ground? Concrete can cause H-3 release because of pH. *Be* starts corroding as soon as pH drops below 7.0. {#65, Raj Bhatt}

    - Comment #65 - There probably is some H-3 release from the vault. I'm not aware of any measurements, however. The beryllium is not in contact with concrete. The vaults are drained. Your comment on pH is noted, thanks. {#182, WE Hill}

- Has the non-beryllium hardware attached to the beryllium reflector been removed for the cores that have been disposed? {#66, Carlan Mullen}

    - Comment # 66- Non-beryllium hardware was removed when it was feasible. Several reflectors still have SS and aluminum with them. {#183, WE Hill}

- The first core was not characterized and was disposed on site. {#70, Buck West}

- HFIR has observed tritium in the pool coming from the reflector. {#71, Buck West}

- Confirm cost of $600k for Ranor to design and build first dry storage vault for HFIR permanent reflector, then added a second unit for $200k. Did this include the transfer cask from pool to dry storage as well? Rough order-of-magnitude other costs to HFIR/ORNL WM

to perform the procurement and setup the total facility/operation for the dry storage? {#72, Gary Anderson}

  - Comment # 72 - Development costs for the vault were around $550K. These costs were for designers, draftsmen, analysts, and miscellaneous support. The cost to build the vault was about $200K for the vendor + travel, QA, etc to oversee the fabrication. The vault was the transfer cask. The storage facility was developed for other ORNL waste so we piggybacked on that to an extent. There was about a man-month of effort in 1995 to develop a safety basis for storage of the vault. Many of the supporting analyses were done during development and design of the vault (part of the $550K development costs). These included a drop test analysis, heat load analysis, shielding analysis, & seismic analysis. The storage pad is not elaborate. It consists of a gravel pad with a fence around it. {#185, WE Hill}

- Is the concentration of TRU above the TRU thresholds for the removable and semi-permanent reflectors? {#73, Julie Conner}

  - Question #73 - The semi-permanent and removable reflectors have not been characterized. {#180, WE Hill}

- Did ORNL develop a waste with no path to disposal plan prior to your last *Be* being removed from the Rx? {#74, Julie Conner}

  - Comment # 74 - RRD did complete No Path to Disposal forms for several reactor components including the beryllium reflectors. The forms were approved by the required parties prior to the HFIR entering the last *Be* outage. {#184, WE Hill}

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Ineel Workshop
Disposal of Irradiated Beryllium

Dr. Donald Kaczynski
Mr. Larry Ryczek

May 29, 2002

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Information Reported on the Operational Test Reactors

14710 W. Portage River S. Road • Elmore, OH 43416 • (419) 862-4127 or (419) 862-4173

- Research is based on data available from Brush Wellman records and the International Atomic Energy Agency
  - High correlation between IAEA Data and BWI
- Only Test Reactors that are operational or in construction are listed
- Some future reactors, especially cold neutron sources, are considering AlBeMet, a composite consisting of 62% by weight beryllium and the balance in 1100 series aluminum
- Cost is 50-60 percent less than pure beryllium

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Operational Test Reactors Using Beryllium Reflectors

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- Research is based on data available from Brush Wellman records and the International Atomic Energy Agency
- Only Test Reactors that are operational or in construction are listed
  - Possible that some reactors are not reported due to supply being made from Kazahkstan or others
- Some future reactors, especially cold neutron sources, are considering AlBeMet, a composite consisting of 62% by weight beryllium and the balance in 1100 series aluminum
- Cost is 50-60 percent less than pure beryllium

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Table of Contents and Description of Terms

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- **Tables of Research Reactors**
  - **United States**
  - **Russian Federation**
  - **Japan**
  - **Canada**
  - **Europe**
  - **Rest of World**
- **Table includes Country, Operator Name, Reactor Type, and Power (Steady in KW)**

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Operational Test Reactors In the United States

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Country	Reactor and Operator Name	Reactor Type	Power (KW)
US	ATR – BWXT Idaho	TANK	250,000
US	HFIR – Oak Ridge National Laboratory	TANK	85,000
US	MURR – University Of Missouri	TANK IN POOL	10,000
US	PULSTAR – N.C. State University	POOL	1,000
US	RINSC Rhode Island NSC	POOL	2,000
US	Cold Neutron Source – Los Alamos National Laboratory (Under Construction)	Cold Neutron	?
US	Spallation Neutron Source – Oak Ridge (Under Construction)	Cold Neutron	?

Operational Test Reactors In the Russian Federation

14710 W. Portage River S. Road • Elmore, OH 43416 • (419) 862-4127 or (419) 862-4173

Country	Reactor and Operator Name	Reactor Type	Power (KW)
Russian Federation	IR-8 Kurchatov Institute	POOL	8,000
Russian Federation	IRT – State Committee of High Education of Russia	POOL	2,500
Russian Federation	IRT-T – Institute of Nuclear Physics, TOMSK Univ.	POOL	6,000
Russian Federation	MIR.M1 – Research Institiute of Atomic Reactors	POOL	100,000
Russian Federation	RBT-10/2 – Scientific & Research Institute of Atomic Reactors	POOL	7,000
Russian Federation	SM-3 - Scientific & Research Institute of Atomic Reactors	TANK	100,000
Russian Federation	RU-0008 – Russian Academy of Sciences	TANK	18,000

Operational Test Reactors In Japan

14710 W. Portage River S. Road • Elmore, OH 43416 • (419) 862-4127 or (419) 862-4173

Country	Reactor and Operator Name	Reactor Type	Power (KW)
Japan	JRR-3M – Japan Atomic Energy Research Institute	POOL	20,000
Japan	JMTR - Japan Atomic Energy Research Institute	POOL	250,000
Japan	ITER - Japan Atomic Energy Research Institute (NEW ?)	Fusion	?

Operational Test Reactors In Canada

14710 W. Portage River S. Road • Elmore, OH 43416 • (419) 862-4127 or (419) 862-4173

Country	Reactor and Operator Name	Reactor Type	Power (KW)
Canada	Slowpoke – University of Alberta	SLOWPOKE-2	20
Canada	Slowpoke – Saskatchewan Research Council	SLOWPOKE-2	20
Canada	Slowpoke – Dalhousie Unversity	SLOWPOKE-2	20
Canada	Slowpoke – University of Montreal	SLOWPOKE-2	20
Canada	Slowpoke – RMC, Department of Chemistry & Chemical Engineering	SLOWPOKE-2	20

Operational Test Reactors In Europe

14710 W. Portage River S. Road • Elmore, OH 43416 • (419) 862-4127 or (419) 862-4173

Country	Reactor and Operator Name	Reactor Type	Power (KW)
France	OSIRIS – CEA/CEN – SACLAY	POOL	70,000
Germany	FRG-1 – GKSS, FORSCHUNGSZENTRUM	POOL	5,000
Germany	BER-II – Hanh-Meitner Institute Berlin GMBH	POOL	10,000
Sweden	SE-0001 – Studsvik Nuclear AB	TANK	50,000
Netherlands	HFR – European Commision, Joint Research Center	TANK IN POOL	45,000
Netherlands	HOR – Delft University of Technology	POOL	2,000
United Kingdom	JET – European Community	Fusion	?
United Kingdom	Rutherford Appleton Laboratory Experimental Reactor (New)	?	?

Operational Test Reactors In the Rest of the World

14710 W. Portage River S. Road • Elmore, OH 43416 • (419) 862-4127 or (419) 862-4173

Country	Reactor and Operator Name	Reactor Type	Power (KW)
Ukraine	UA-0001 – National Academy of Sciences of Ukraina	TANK	10,000
Poland	MARIA – Institute of Atomic Energy	POOL	30,000
Romania	TRIGA II PITESTI – Institute for Nuclear Power Research	TRIGA Duel Core	14,000
South Africa	SAFARI-1 – South African Nuclear Energy Corporation	TANK IN POOL	20,000
Kazahkstan	KZ-0003 – RK Ministry of Sciences	TANK	60,000
Korea	KAERI – Unknown (New)	?	?

Brush Wellman Grades for Beryllium for Nuclear Reflector Applications

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Element	S-200-F Spec.	S-65 Spec	S-65 Select	AlBeMet
Be (min)	98.5	99		60-64
BeO	1.5	1		1% O
C	0.15	0.1		0.1
Fe	0.13	0.08		
Al	0.1	0.06		36-40
Mg	0.08	0.06		
Si	0.06	0.06		
N		0.0400	0.0250	
Mn		0.0120		
Cr		0.0100		
Ni		0.0200		
Ag		0.0010		
Ca		0.0100		
Co		0.0010		
Cu		0.0100		
Cd		0.0020		
Mo		0.0020		
Pb		0.0020		
Li		0.0003		
B		0.0003		
W		0.0400		
U	0.0010	0.0400	0.005	
Zr		0.0400		
Ti		0.0400		
Sc		0.0400	0.0100	

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Comments on Operational Test Reactors and Impurities Contained in Typical Alloys

- BW and KBI were active in buying back scrap and some of the measurements of some of the KBI reflectors may represent their use of BW scrap with a higher uranium content. {#75, Buck West}

- Is the beryllium going to the ceramics business essentially the same composition as that going to the metals business? {#76, Glen Longhurst}

- DOE is about 5-10% of the BW sales. This impacts their ability to respond to additional processing of the reflectors and may increase costs. {#77, Buck West}

- BW provides blanks to be machined by some other company. {#78, Buck West}

- Blank weight for an ATR block (179 lb.) is about 1500 lb. {#79, Glen Longhurst}

- What radiological limits would apply if previously irradiated beryllium could be recycled in beryllium fabrication? {#80, Glen Longhurst}

- Lack of profit in the beryllium market makes development of a new processing facility unlikely for a private company without some government help and funding. {#81, Buck West}

- If a process were to be available for irradiated beryllium recycling, how would the irradiated waste by-products be handled/treated/disposed? {#82, Kay Adler Flitton}

- S-65 *Be* could be made to meet the < 5 ppm U goal (current levels are 2.5 ppm to 3.5 ppm, could work to a spec of <5 ppm.) Don said, just a guess, S-65 *Be* could sell for perhaps a 20% surcharge, and require a lead-time of probably a month for additional processing. {#83, Brian Anderson}

- Where can NASA find information on "Lockalloy", presumably a brand name of a beryllium alloy? {#89, Bryan M. Moyers}

    - re#89--NASA sponsored a lot of work on "Lockalloy" in the 1970's I think, related to its potential for use as a ventral fin on the SR-71 aircraft. The composition is the 62%*Be* 38%Al referred to now as Albemet 162. Brush Wellman has a lot of information on this alloy (or, more properly, composite). The National Aerospace Plane project sponsored work on *Be*Al materials, and some of it is in open literature. Also, I gave a talk 4 years ago on *Be*-Al to the annual Space Propulsion conference at JPL. Please send me your e-mail, and I will try to get some additional information to you. Mine is: jake@lanl.gov {#93, Loren Jacobson}

    - RE: #93 Bryan.Moyers@grc.nasa.gov. {#156, Bryan M. Moyers}

- INEEL prepared a P^2 proposal two years ago to substitute S65C for the existing S200F grade for future procurements of ATR beryllium reflectors. Further study needs to address the mechanical properties to make sure there are no impacts to reactor operation from such a material substitution. {#99, Carlan Mullen}

- One DOE-EM facility has several hundred pounds of *Be* reading about 0.5 mR/hr. Is there a "free release" limit for this material? Could this material be recycled, and would there be any interest in recycling this material? {#122, Nate Chipman}

- Information can be obtained on all grades of beryllium and the aluminum beryllium product line, Brush Wellman trade named Al*Be*Met, on the Brush Wellman web page. brushwellman.com. There are a number of papers which describe the "Lockalloy" composition which is the same as Al*Be*Met 162. {#149, Don Kaczynski}

- The S-65 product sells for about 35% more than the S-200 F product in large blocks. {#150, Don Kaczynski}

- I have no idea how hot 0.5mR/hr. is. If it presents no particular handling issues we could possible recycle it in our Ohio operations. If it is "hot" then I do not see where we can help you. {#153, Don Kaczynski}

    - Re: #153. INEEL administrative radiological exposure limit is 500 mr/year. DOE maximum limit is 5,000 mr/year. If a worker was in contact with (holding) the material for 1,000 hours (6 months) he would receive his 500 mr/year administrative limit. If the material is in a process vessel, or shielded in some way, the exposure would be much less. {#176, Brian Anderson}

Loss of U.S. Beryllium Metal Domestic Supply

An Evaluation of Supply & Demand for Defense

Steve Abeln
Los Alamos National Laboratory

MST-6 Beryllium Technology

Overview

- ✓ Beryllium: What is It?
- ✓ Why Do We Need It?
- ✓ Who Supplies It?
- ✓ How Much Do We Have of It?
- ✓ What is the Long-Term DOE Posture?
- ✓ What Threatens the Supply?
- ✓ What Happens if We Lose It?
- ✓ What Should We Do?

About Beryllium

Unique Property Set

- ✓ **Light weight:** 66% lighter than aluminum
- ✓ **Rigidity:** 4x > aluminum, 2.5x > Titanium, and 1.5x > steel
- ✓ **Heat Capacity:** highest of all metals
- ✓ **Thermal Conductivity:** 4x > steel, half that of copper, equivalent to aluminum
- ✓ **Damping Capacity:** Superior to aluminum and steel by a factor of two
- ✓ **Reflectivity:** 98% in the infrared range
- ✓ **Transparent** to X-rays

Why Do We Need Beryllium?

To maintain our military/surveillance strategic and tactical advantages.

- Strategic Satellite Applications
- Missile Applications
- Target Acquisition (FLIR) Applications
- Nuclear Application

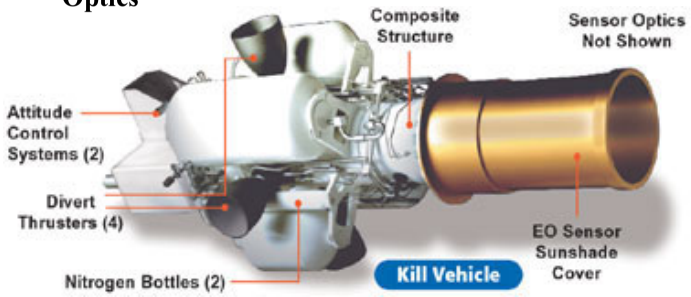
DoD Usage - Missile Applications

- Strategic Missile Maintenance
  - Minuteman, Peacekeeper, Others
- Strategic Missile Defense
  - GBI/EKV
  - LEAP
  - Arrow, Others
- Applications
  - Guidance Components
  - Optics
  - Electronic Substrates

Beryllium IMU

Trident

Beryllium Sunshade and Optics



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MST-6 Beryllium Technology

DoD Usage - Aircraft Electronic Applications

- Fighter Aircraft
  - F-22, F-16, JSF, others
- Helicopter
  - V-22, Comanche, others
- Applications
  - Countermeasures
    - ATIRCM, SIRFC, Classified
  - Computers, Power Modules
  - Radar Subsystems
  - Microwave Substrates

F-22 Raptor

BeAl, Be/BeO Electronic Hardware

DoD Usage - Airborne FLIR Applications

- Fighter Aircraft
  - –F-22, F-16, JSF, others
- Helicopter
  - –V-22, Comanche, others
- Applications
  - –Countermeasures
    - •ATIRCM, SIRFC, Classified
  - –Computers, Power Modules
  - –Radar Subsystems
  - –Microwave Substrates

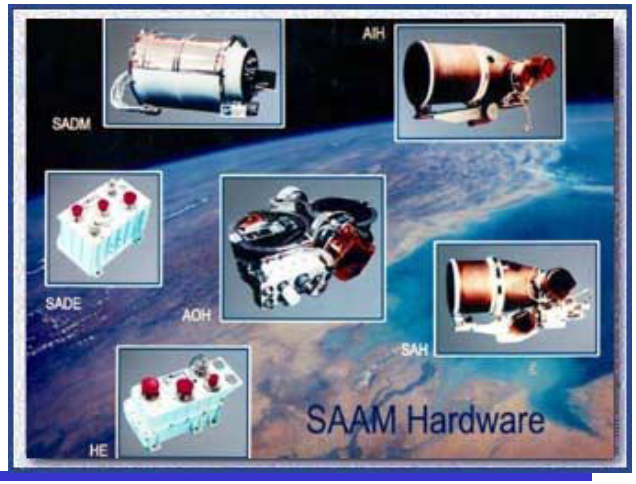
F-22 Raptor

BeAl, Be/BeO Electronic Hardware

DoD Usage - Strategic Satellite Applications

- Strategic Missile Defense
  - SIBRS High and Low, Classified Satellites
- Surveillance
  - Classified
- Communications
  - Classified
- Applications
  - Launch Detect, Tracking
  - Optic Visual
  - Satellite Gimbals, Structure
  - Nuclear Survivability

DMSP



MST-6 Beryllium Technology

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Who Supplies Beryllium?

Beryllium Sources & Users

✓ Sources

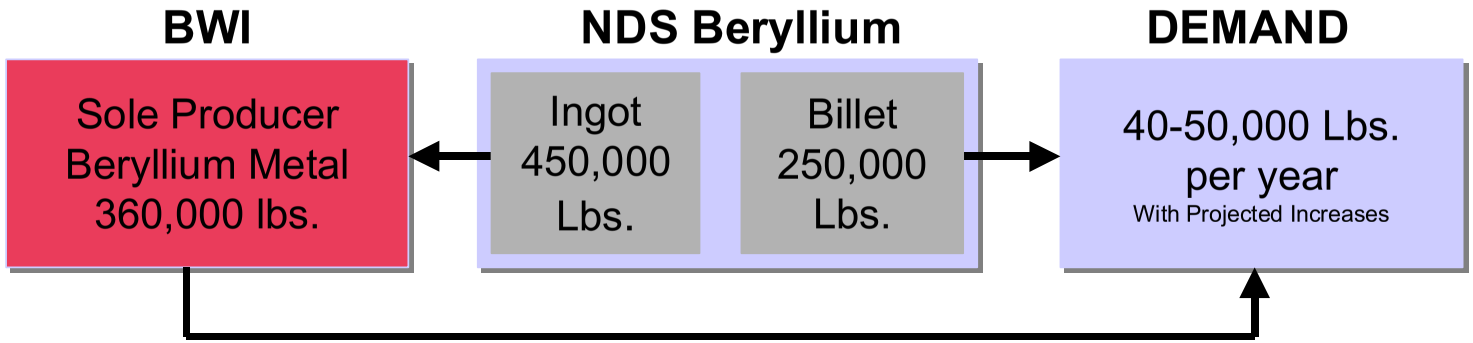
- Western World Supplier – Brush Wellman
- Russia – Kazakhstan
- China
- India

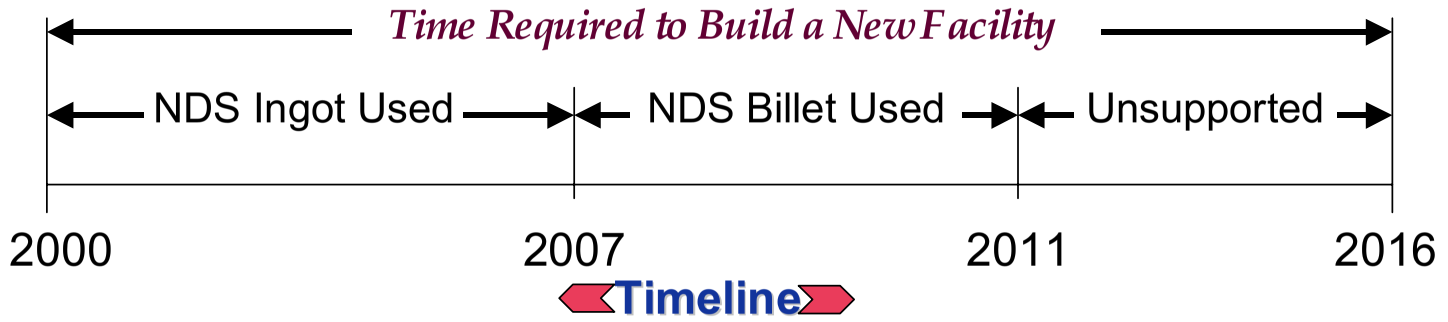
✓ Users

- Currently
  - → 30% Defense
  - → Remainder in foreign (our allies) & commercial
- Projected
  - → ***Be*** requirements for defense will increase to 50-60% of BW shipments in the next two years
    - Missile defense, Strategic satellites, Aircraft

How Much Beryllium Do We Have?

Beryllium Supply & Demand





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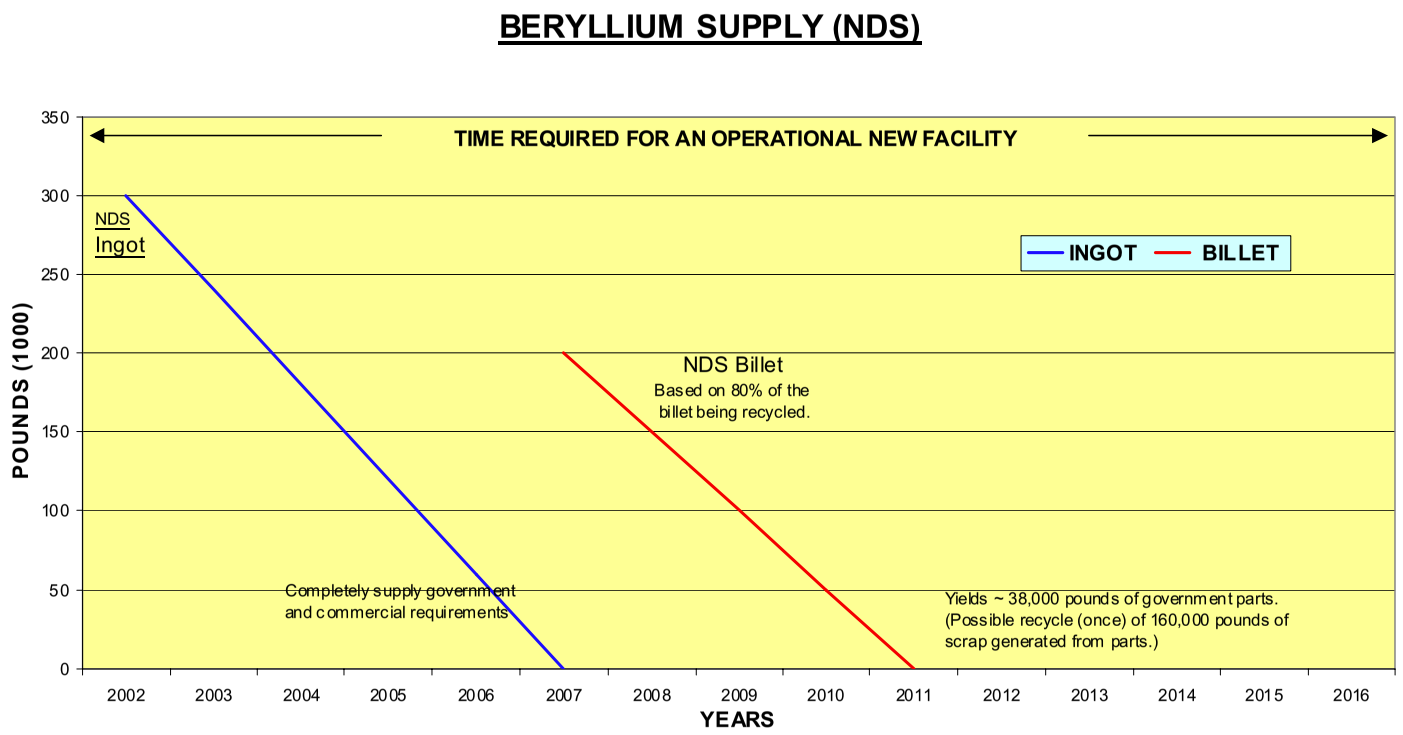
MST-6 Beryllium Technology

What is the Time Line for Be Supply?



How Much Beryllium Do We Have?

National Defense Stockpile

- ✓ **Congressional and Defense Department push to liquidate NDS assets.**
  - Already sold *BeCu* alloy and beryllium ingot (450,000 lbs)
- ✓ **There remains between 200,000 and 250,000 lbs of usable beryllium billet in the NDS.**
  - Equates to approximately 20,000 to 25,000 lbs of parts (assuming a 10% utilization after machining)
- ✓ **Protection of beryllium billet assets in the NDS is essential based on the unpredictable position of Brush Wellman.**
  - ALL of the NDS holdings of *Be* Billet would be required to meet DOE START II rebuild scenarios.

What is the DOE/NNSA Long-Term Posture?

- ✓ **In House Supplies:**
  - By 2011, our in-house supply inventory will be reduced from 811 to 319
- ✓ **4 out of 6 weapons in the Enduring Stockpile require Beryllium**
- ✓ **DOE HQ is working to secure all the NDS Billet for DOE use**
  - → Not Likely when DoD understands current their requirements
- ✓ **Doing nothing will force the DOE to become dependent upon a foreign source for its Beryllium**

What Threatens the Supply?

- ✓ **Sole source supplier - Brush Wellman (BW)**
  - → Insufficient Beryllium metal market to justify corporate capital investment
- ✓ **Prevalence of CBD & Liability for the Commercial Supplier**
- ✓ **Agency for Toxic Substances and Disease Registry (ASTDR)** investigations – *Environmental Releases*
- ✓ **DOE rule-making/OSHA rule-making**
  - → DOE Rule issued (1999)
  - → OSHA rule-making now in the pre-rule stage—issued a request for information by *September 2002*

What Threatens the Supply?

Brush Wellman Plant Status

- ✓ **Obsolete commercial facility & operations**
  - → Plant built in the late 1950's
    - Engineering Controls - HVAC, Access Control, Environmental controls
    - Manufacturing Technologies – refining, powder production, consolidation, machining
- ✓ **Beryllium operations—part of plant on respirators**
  - → Approximately 100 workers
- ✓ **Aerosol containment problems resulted in Brush Wellman closing its metal refining operations (2000)**
  - → Currently buy *Be* ingots from National Defense Stockpile (360,000 lbs)
- ✓ **Plant layoffs nearly halved BW worker population (2001) from 800 to 550**
- ✓ **BW cannot justify the capital investment required to upgrade its facilities to meet <u>required</u> lower exposure standards**

What Happens if We Lose the Domestic Supply?

- ✓ **Beryllium—no replacement and no substitute in several critical Defense technologies**
  - → Provides the U.S. with both strategic and tactical advantages
  - → Its loss will force the U.S. and its allies to become dependent on foreign sources
- ✓ **Take no action and U.S. will lose critical expertise**
- ✓ **If U.S. loses Beryllium production control, U.S. also loses export control**

What Should We Do?
Options

- **No Government Action**
  - **U.S. loses domestic supply and control of a critical and strategic material**

- **Government Owned Facility**
  - → Use Beryllium ingot sales in NDS stockpile ($21 million) to fund initial development studies
  - → Pursue congressional authorization for modern beryllium plant
  - → Fund entire development and construction with defense monies

Comments on Loss of U.S. Beryllium Metal Domestic Supply

- Did LANL just built a brand new *Be* finishing facility? Or was it Sandia? {#84, Raj Bhatt}

    - Response to #84--LANL has a new, state of the art beryllium facility which is now in operation for machining of parts. We also hope to have our atomization up and running soon, along with a beryllium foundry. Later on we plan to include joining (brazing), mechanical testing, and injection molding. Also we will soon be plasma spraying beryllium. {#91, Loren Jacobson}

- General Note: If we intend to keep buying beryllium for reactors, its price is likely to climb. Are these factors being included in reactor budget projections? {#85, Glen Longhurst}

    - Re: Comment #85. No, NR budgets for ATR do not include a significant increase for *Be* Reflector components. The NR budget is level funded, with a nonimal 1.7% escalation. {#90, Brian Anderson}

- Why not a cost plus contract with Brush Wellman to allow them to build a new facility to meet emerging safety requirements and national needs while still making a profit? Government has done this before. {#86, Lawrence E. Miller}

- Given the lead time for procurement and the decrease in availability of beryllium over the next 8-10 years will there be any beryllium to replace the reflector at ATR? It is hoped that this workshop will help to answer that question and raise the issue to DOE for consideration. {#87, Buck West}

- The ingots in the national stockpile have already been purchased by Brush Wellman. {#88, Buck West}

- It sounds like there is no strategic plan for managing this strategic material. {#105, Brian Anderson}

    - re 105--The current plan is to not have a national defense stockpile by 2007. The only thing that DLA is doing is gradually selling everything off. DOE has now requested DOD to transfer control of the remaining billet material to DOE. This should at least control the current structural grade, which we expect to start using in 2007. {#129, Loren Jacobson}

- With respect to the apparent impending shortage of *Be* supply here in the US, DOE and DOD should commission new plant for producing, refining, and diffusing pure *Be* to produce *Be* metal to the specs that are needed. This could be a COCO with Private Sector investment, or should be a GOCO if the economics do not support private investment. {#107, Brian Anderson}

VACUUM DISTILLATION OF BERYLLIUM

- **Loren A. Jacobson**
- **Los Alamos National Laboratory**

- **28 May 2002**

OUTLINE

- **History of Application of Distillation to Be**
- **Current and Proposed Work**
- **Laboratory Scale Apparatus Description**
- **Possible Application to Beryllium Recovery/Recycle**
- **Concerns**
- **Recommendations**

History of Vacuum Distillation Application

- First developed on a Lab Scale in Ukraine, employed on an Industrial Scale in Kazakhstan
- Past Practice—99.7% in two steps
- Future Possibility—99.999% in two steps
- We are teamed with Kharkiv on CRDF program, proposing process improvement
- Induction skull melting could be used for less melt contamination

Current and Proposed Work

Kharkiv Institute of Physics and Technology continues to work on improvements to vacuum distillation.

Some preliminary work to explore design issues performed last FY at LANL.

KIPT now has been awarded the CRDF funded project to investigate further efficiency improvements to vacuum distillation of beryllium.

LANL is co-investigator on that project.

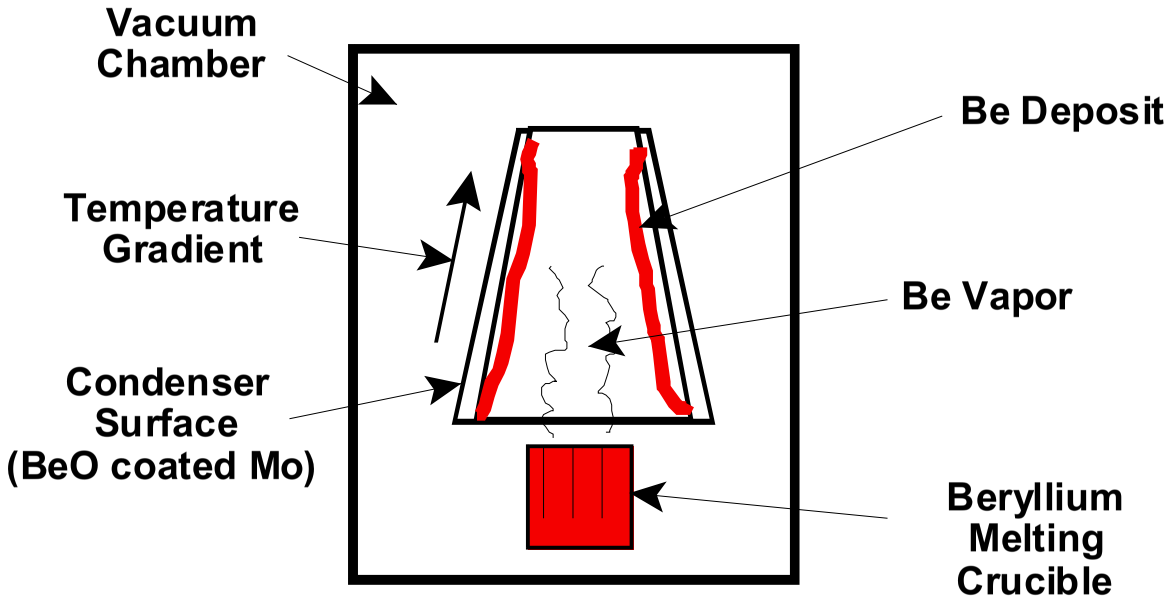
We are proposing an IPP program with KIPT and Brush Wellman to have units fabricated at KIPT, evaluated in US.

Vacuum Distillation

Apparatus in use at Kharkiv Institute of Physics and Technology.

Note that the lower part of the apparatus has holes for gloves so that charge can be manipulated without undue exposure of the operator.

Vacuum Distillation—Schematic



Application of Distilled Be to Recycle

- Assume that scrap Be is contaminated from machining to a level of 97.0%Be (2% BeO and Fe main impurities)
- Vacuum melting can slag off the BeO, leaving 99.0%Be and 0.2%Fe, plus other impurities.
- Per kilogram of Be there would be 2 grams of iron.
- Add 500 grams of 99.9%Be to each kg of impure Be. Now the Fe content is ~0.135% or 1350 parts per million.
- This is within the specification for allowed iron impurity in structural beryllium.

Concerns

Vapor pressures of various impurity elements.

Possible chemical reactions with intentional additions.

Studies will be difficult—must allow for unwanted elements to collect in condensate.

Disposal of Crucibles.

Further process of condensate.

Recommendations

Collect information on the properties of impurity elements.

Perform some sub-scale laboratory experiments to investigate process variables.

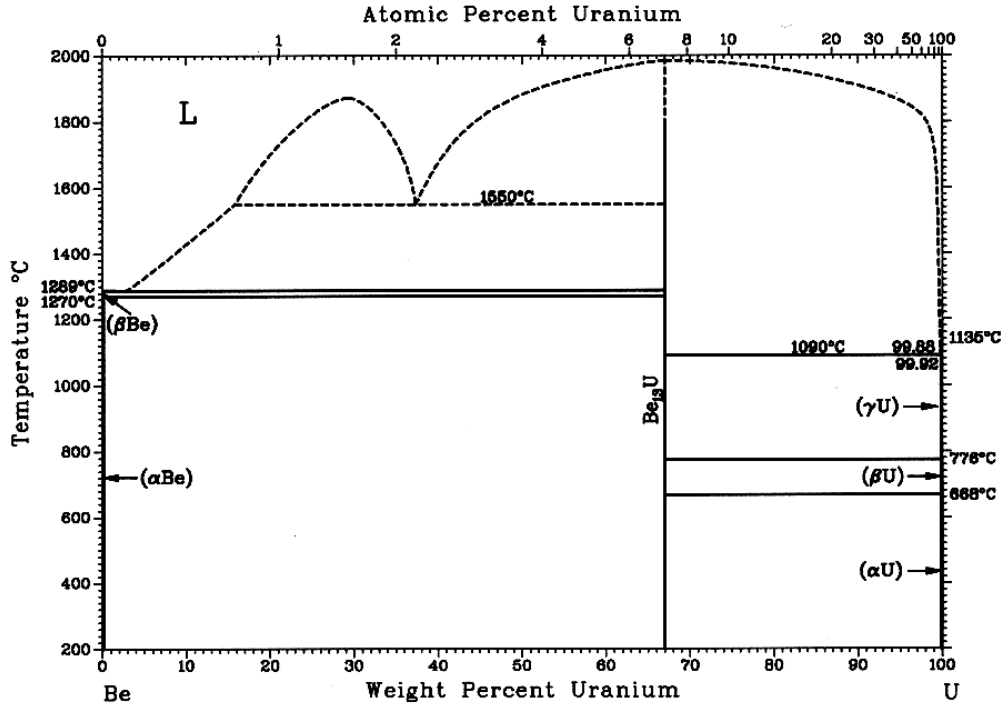
Assemble equipment (maybe with help of Kharkiv or Ulba).

Distill contaminated material.

Dispose of remainder.

Alternative Recommendation

Look at the U-Be Phase Diagram:



Los Alamos NATIONAL LABORATORY

MST-6, Metallurgy

Alternative Recommendation (Cont.)

The compound UBe_{13} can accommodate other similar elements (Actinides)

Holding just above the eutectic temperature could precipitate the compound, with other elements

Biggest question: What is the actual eutectic composition for Be-U? (This could be the minimum concentration achievable.)

Comments on Vacuum Distillation of Beryllium

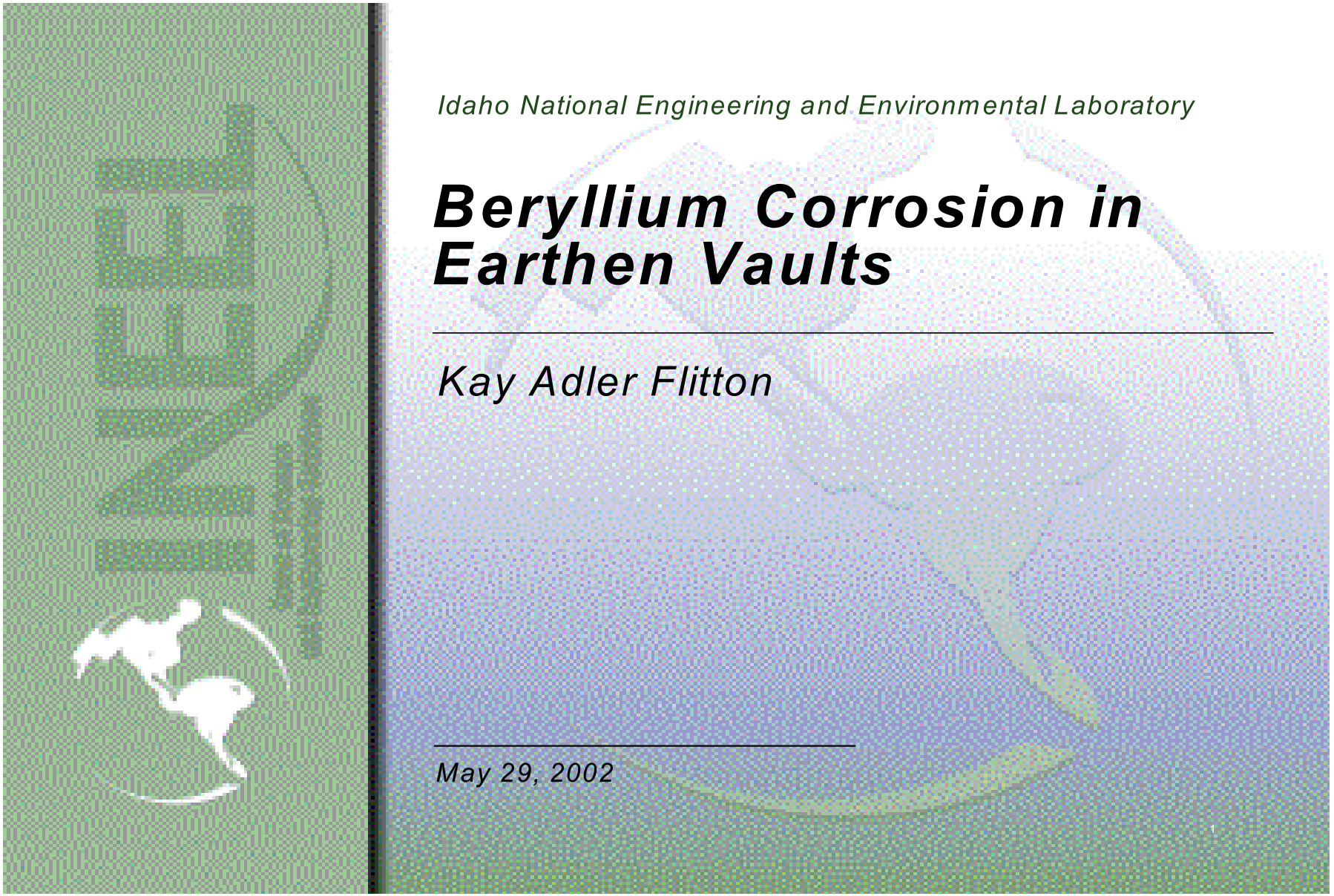
- What additional complications to distillation would come about if the material required remote handling because of gamma radiation? {#101, Glen Longhurst}

- Consider performing demonstration tests of distillation using non-radioactive isotopes of TRU elements of concern or chemical/physical analog substitutes in beryllium samples. {#102, Glen Longhurst}

- The Ukrane process could be done remotely on irradiated beryllium. The quantity of material to be processed may not be feasible under this process. {#104, Buck West}

- It appears that a dissolution process followed by solvent extraction may be able to remove impurities. Processes akin to uranium/plutonium recovery from spent nuclear fuel and recovery of other materials from irradiated targets. These processes are usually remotely operated. {#106, Nate Chipman}

    - re #106--at present, the process for winning beryllium metal from the ore, with the intermediate of beryllium hydroxide, then ammonium beryllium fluoride, then beryllium fluoride reacted with Mg to give *Be* metal, is so complicated that once you have metal, it is thought to be desirable to keep it in that form as much as possible. Maybe one of the processes being considered for the future, such as electrolysis of molten salt, would allow for a process involving dissolution as you suggest. {#136, Loren Jacobson}


Idaho National Engineering and Environmental Laboratory
Beryllium Corrosion in Earthen Vaults
Kay Adler Flitton
May 29, 2002
1

Disposed Activated Metals

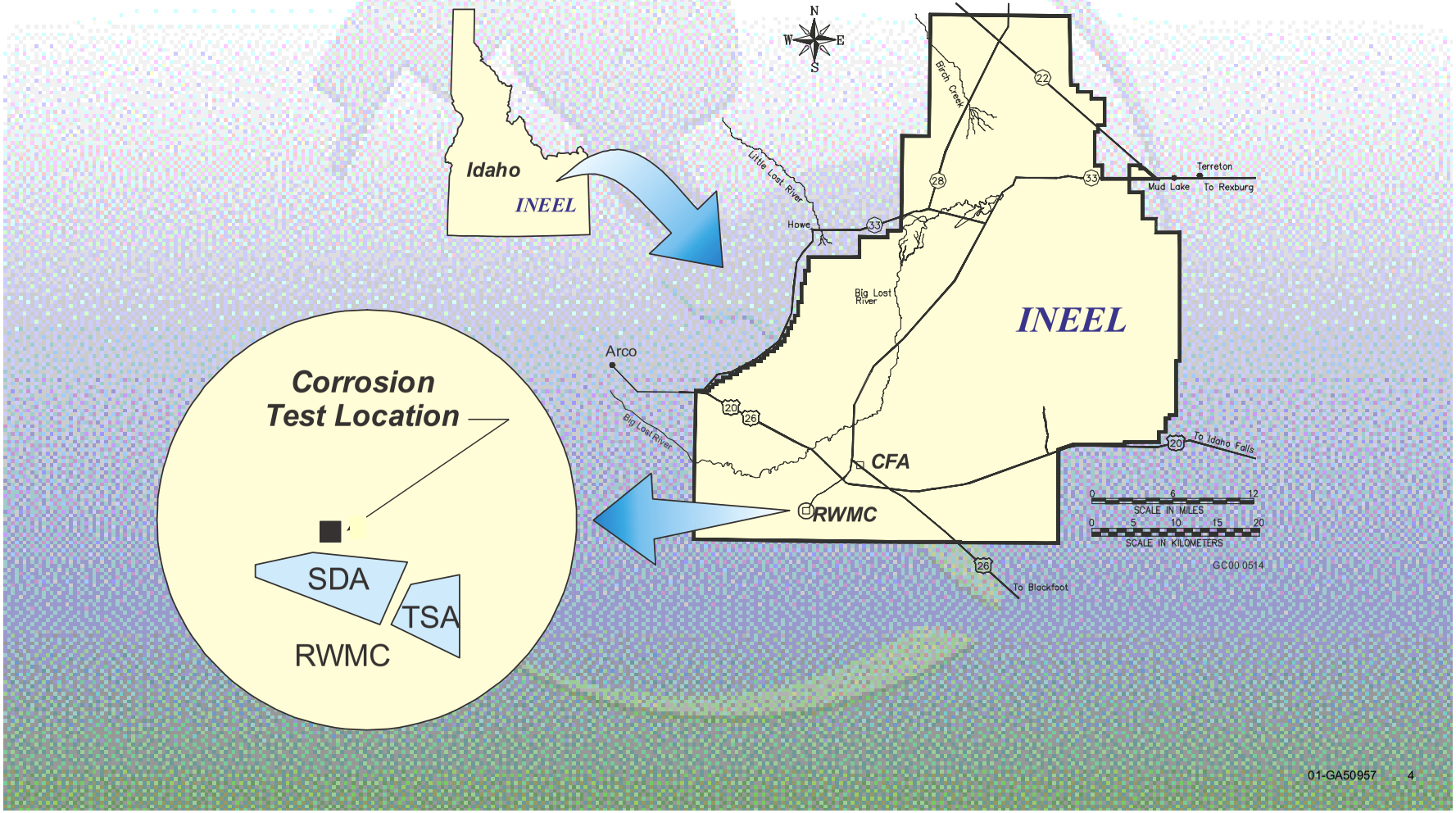
- ***Activation products significant to long-term disposal: carbon-14, nickel-59, nickel-63, niobium-94 and technetium-99.***
- ***These radionuclides are bound into the beryllium matrix, thus, corrosion of the buried activated metals releases these contaminants into the soil.***
- ***Understanding site-specific corrosion rates will help to understand the subsequent transport of the radionuclides into the vadose zone environment.***

Beryllium Corrosion in Earthen Vaults

- Test location
- Environmental factors
- Disposals
- Test installation and sample retrieval
- Corrosion measurement
- Corrosion rate determination
- 1 and 3 year samples
- 1 and 3 year results
- Recommendations

Idaho National Engineering and Environmental Laboratory

Test Location



Site Specific Environmental Factors

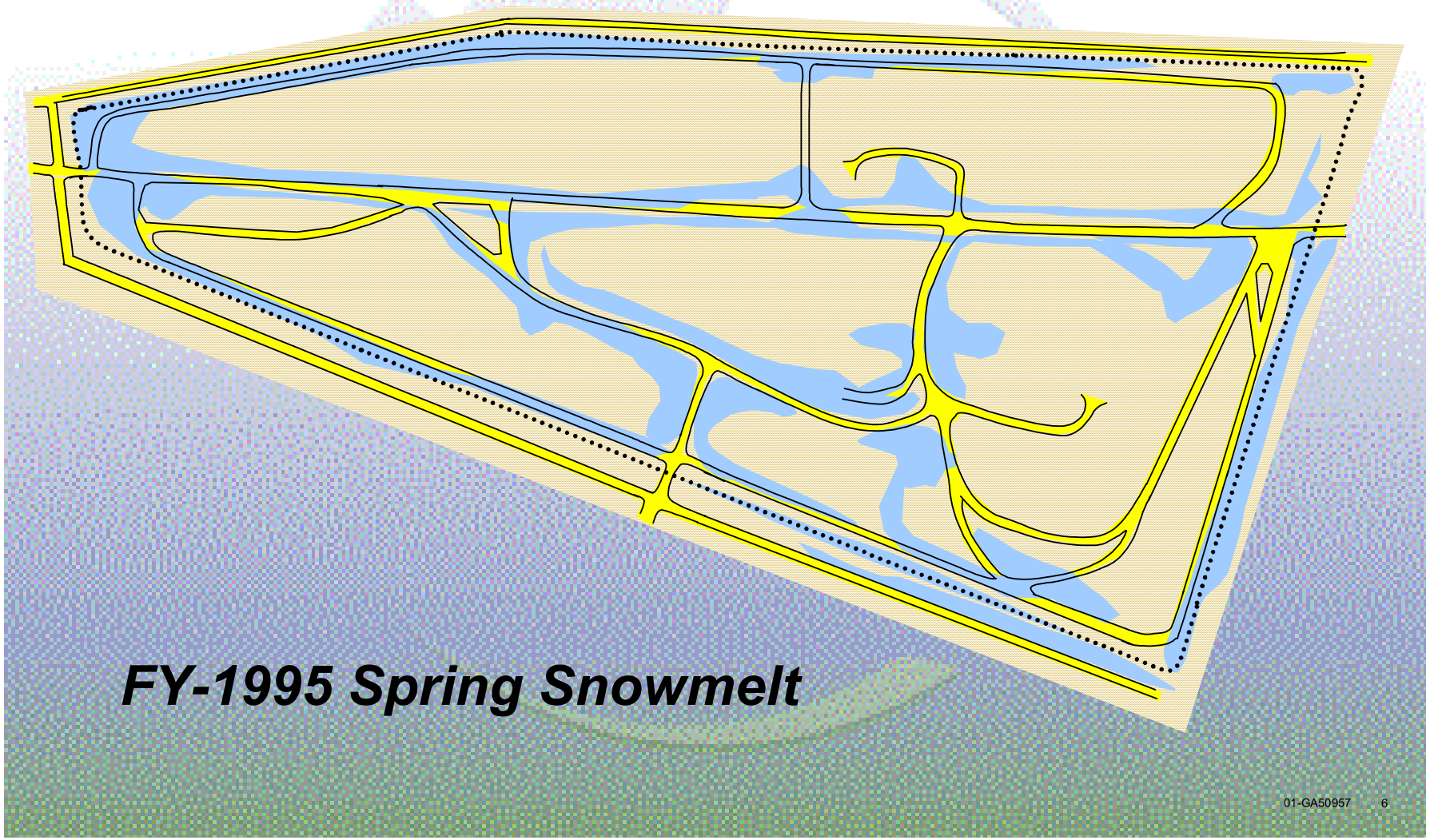
Corrosion Factors

- Soil Resistivity
- Mildly Alkaline
- Soil Moisture
- Soil Temperature

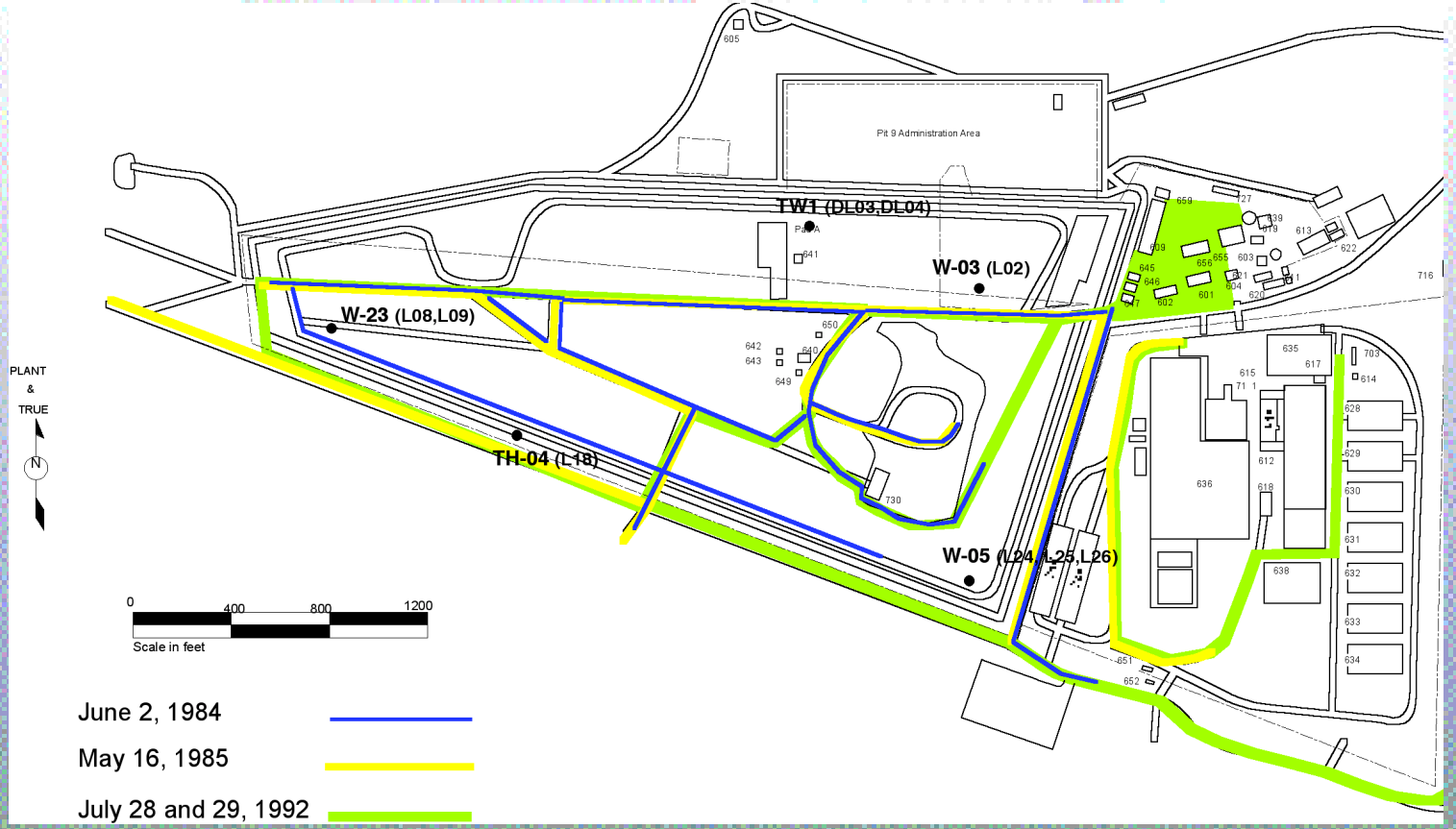
Site Specific Environmental Factors

- Water Infiltration
- Dust Suppressant Applications

Water Infiltration



Dust Suppressant Applications



Disposal

Corrosion Test Assumptions

- ***Activated beryllium corrodes at the same rate as unirradiated beryllium metal when exposed to an underground environment.***

- ***Conditions at the test location are representative of the actual disposal locations.***


Test Installation

Corrosion Measurement

- Mass Loss
- Surface Area
- Pit Depths

125 RMS - Be Block Finish

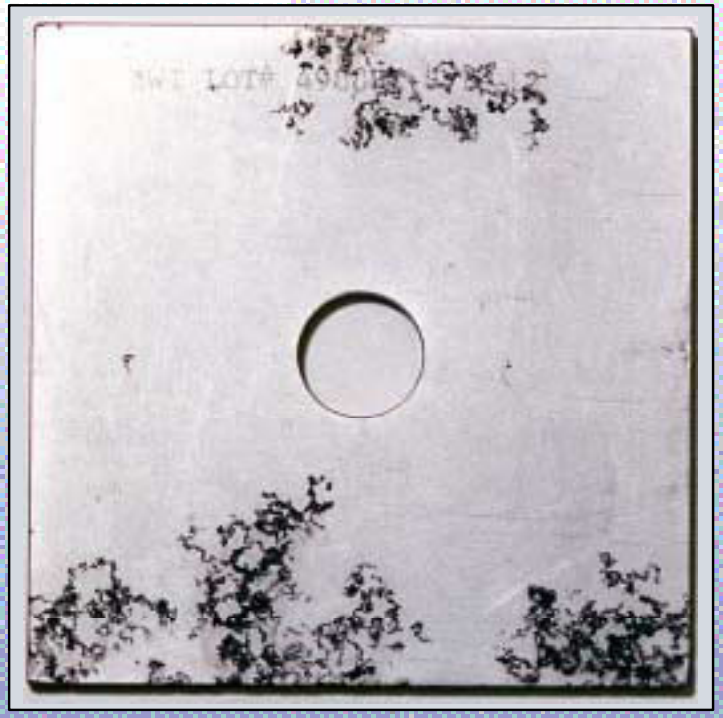
$$\text{Corrosion Rate (years/mm)} = \frac{\text{Density } (g/mm^3) \times \text{Area } (mm^2) \times \text{Time (years)}}{\text{Weight Loss } (g)}$$

Excavated Coupons
(as recovered - before cleaning)

1 year CA02-5-7 S/N-12

3 years CA04-3-3 S/N-16

Excavated Coupons
(after chemical cleaning)

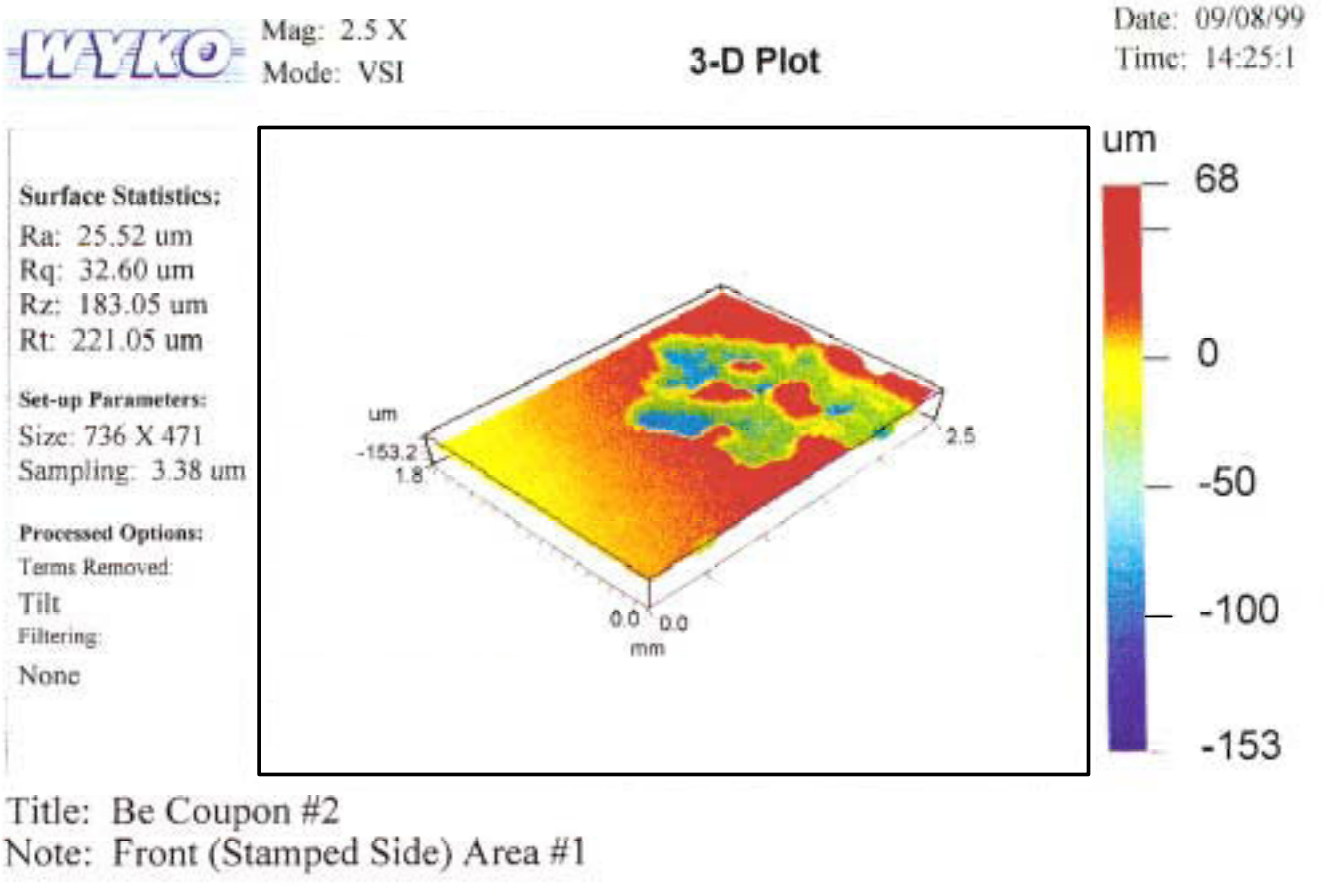


1 year CA02-5-7 S/N-12

3 years CA04-3-3 S/N-16

01-GA50957 13

1 Year of Underground Exposure Scanning Vertical Interferometry



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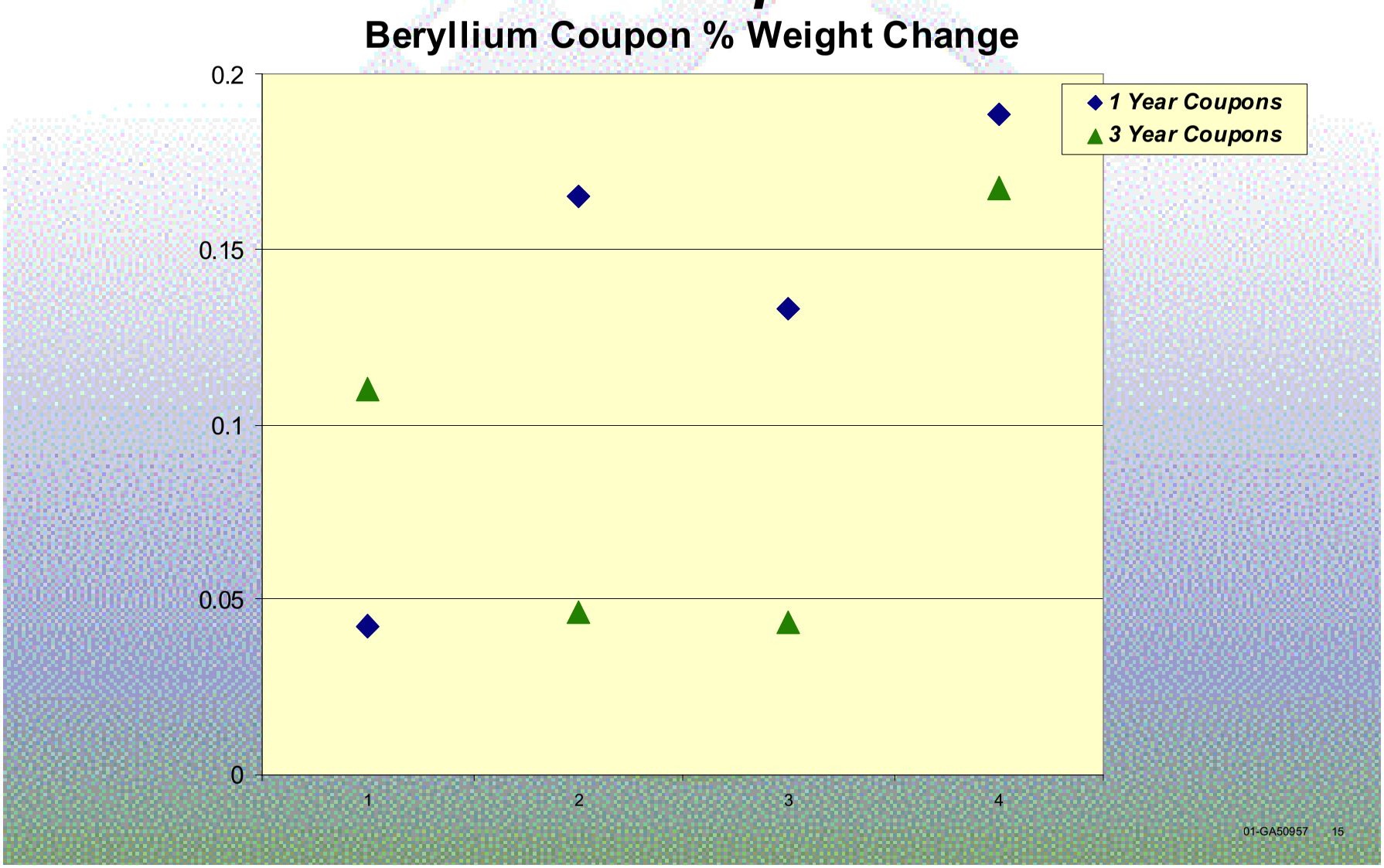
1 Year and 3 Year Comparison at 4 Feet



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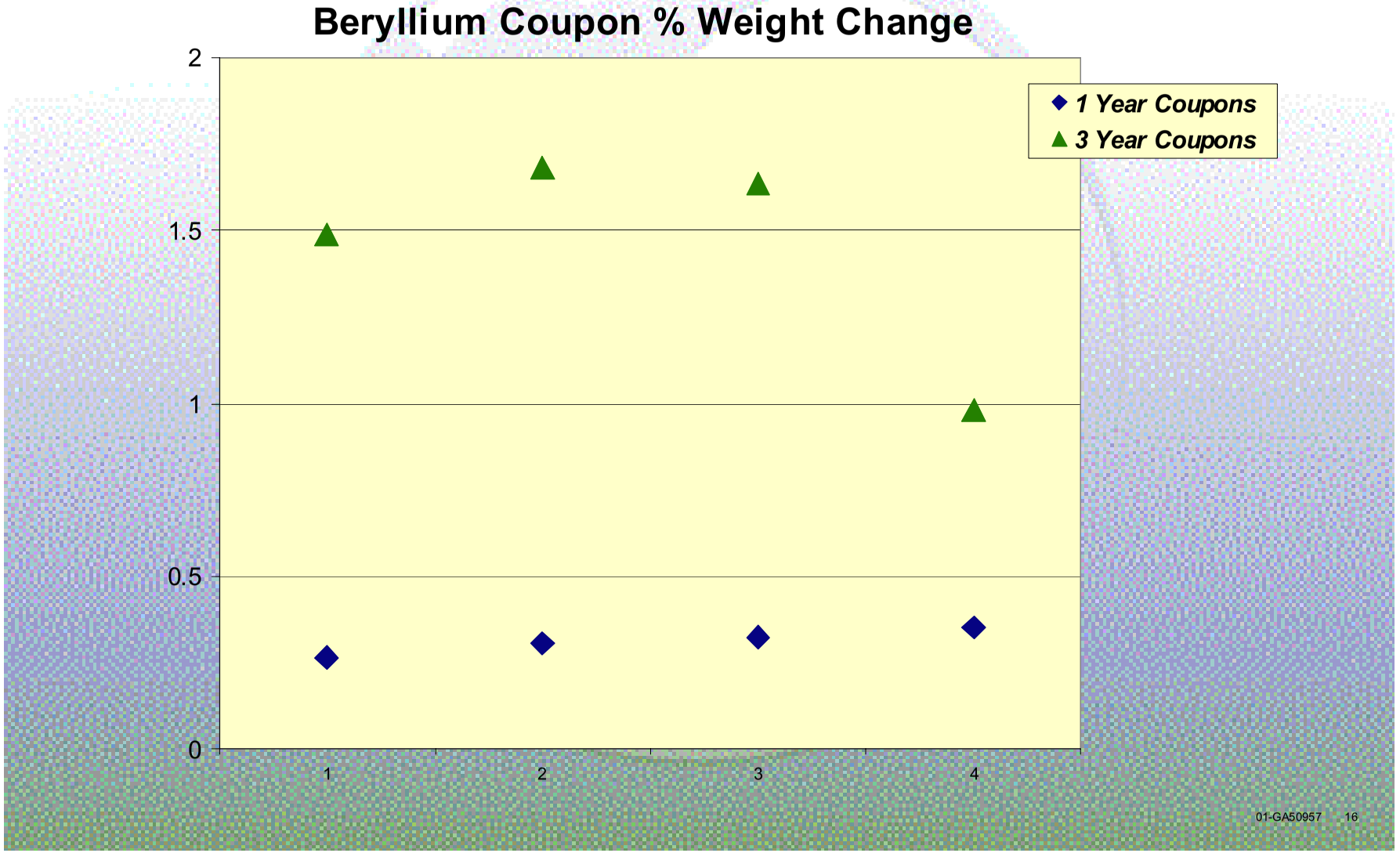
1 Year and 3 Year Comparison at 10 Feet



Microbiologically Induced Corrosion

- *Sulfide reducing bacteria identified in surrounding soil*
- *Presence of heterotrophic on coupon surface (organic acid producer)*
- *No denitrifying or mineral acid producing bacteria identified on coupon surfaces*
- *Sulfide reducing bacteria on some beryllium coupons after 3 years*

Results

- *Beryllium had a measurable rate of underground corrosion at both depths tested.*
- *The underground corrosion rate decreased slightly at the 4-foot level over time.*

  1 year: 350-1600 year/mm
  3 year: 1100-4600 year/mm

- *The underground corrosion rate increased slightly with time at the 10-foot depth.*

  1 year: 195-260 year/mm
  3 year: 120-195 year/mm

Recommendations

- Continue Long Term Test with retrievals at five year intervals
- Add Electrical Resistance Corrosion Probes for real-time corrosion comparison
- Continue to monitor for Microbiologically Induced Corrosion

Recommendations (Continued)

- Continue to monitor soil environment at the test location and at the disposal location for correlation
- Conduct a controlled field-scale Magnesium Chloride corrosion test
- Attempt to back-calculate irradiated beryllium corrosion rate with environmental data and nuclear modeling

Selected Sources

- *"Long Term Corrosion/Degradation Test First Year Results" by R. E. Mizia, et al., INEEL/EXT-99-00678, September 2000.*
- *"Long Term Corrosion/Degradation Test Third Year Results" by M. K. Adler Flitton, et al., INEEL/EXT-01-00036, September 2001.*
- *"Underground Corrosion of Activated Metals in an Arid Vadose Zone Environment" by M. K. Adler Flitton, et al., NACE 2002 publication, April 2002.*

Comments on Beryllium Corrosion in Earthen Vaults

- There are chloride measurements from past water analysis data and they were used in estimating corrosion rate of *Be* in 1994 LLW Performance Assessment (radionuclide transport and dose calculations). Also the sulfate ions (present in RWMC soil) cause substantial increase in corrosion. {#108, Raj Bhatt}

- Weren't the ATR *Be* blocks and shim cylinders buried in stainless steel trash liners in 20 foot tall concrete cylinders? The *Be* was never in direct contact with the surrounding soil. The corrosion test samples are direct buried in the soil. The corrosion test is not representative of the actual waste conditions. {#109, Jeff Brower}

    - Answer to comment 109. No the beryllium blocks were buried in open top, cask liner in soil. {#111, Raj Bhatt}

    - Answer to comment 109, the concrete vaults were not used until after the last *Be* blocks and shim cylinders were disposed. Soil vaults, holes bored in the soil and then backfilled with soil, were used prior to the construction of the first concrete vaults. {Roger Seitz} {#112, Kay Adler Flittonj}

    - Response to 109. The use of concrete vaults at the LLW pit did not start until after 1993. All ATR beryllium has been disposed in soil vaults or soil trenchs. Though metal waste canisters were used they are not water or air tight and have open expanded metal bottoms to allow canal water to drain when loading into shipping casks. {#118, Carlan Mullen}

- Could the reduced corrosion rate at the 4-foot level in later years be attributed to drier climate in those years? {#110, Glen Longhurst}

    - Re: #110 Currently the data at the 4' level is inconclusive. All data (both the 1-yr exposure and 3-yr exposure) is under 0.2%. The differences may be an initial soil moisture difference or other environmental factors we have yet to consider. After the 5-yr exposed coupons are evaluated, perhaps we will have a better understanding of the rates at the shallow level. {#123, Kay Adler Flitton}

- Any plans for controlled "in-lab" scaled tests of *Be* under various soil moisture temperature etc. conditions to examine various possible corrosion conditions? Accelerated tests? {#113, Gary Anderson}

    - Re: #113. Limited bench scale corrosion testing has been done, even some with $MgCl_2$. Currently no additional bench scale testing is schedule or funded and currently no accelerated tests are schedule. One comment: We have, in our test plan options for utilizing electrical resistance (real-time) probes and those probes could be used for an accelerated test. The probes, with exception to beryllium, are available currently for installation. We have investigated the possibility of making beryllium probes, but to date, we have not implemented that portion of the test plan. Part of the problem has been limited funding. {#131, Kay Adler Flitton}

- The RWMC PA corrosion rates included impact of MgCl and sulphate ions. The test location as far as I remember (when I was Project Manager) did not apply soil suppressant so CORROSION RATES in test case are lower. MgCl can induce severe corrosion. {#114, Raj Bhatt}

- Do these studies hope to correlate H-3 releases inherent with activated beryllium? {#115, Bryan M. Moyers}

    - Re: #115, Right now the active monitoring (Paul Ritter's talk) addresses H-3 releases. Hopefully, with the active monitoring and the continued corrosion test results we can correlate H-3 and other radionuclide releases. {#178, Kay Adler Flitton}

- Any predictive modeling being done to attempt to understand/match test setup conditions? {#116, Gary Anderson}

    - Answer to comments 115 and 116, For the performance assessment, it is assumed that releases from *Be* are controlled by the corrosion rate. Thus, the corrosion rate is expected to be correlated to the release rate that would be observed in the disposal facility. The corrosion experiment in conjunction with on-going monitoring will help to confirm the accuracy of this assumption. To date, comparisons of the performance assessment model predictions with concentrations of radionuclides in the subsurface confirm that the performance assessment predictions have been very conservative (i.e., the modeling used to determine compliance with performance objectives has over predicted migration from the disposed waste). {#120, Roger Seitz}

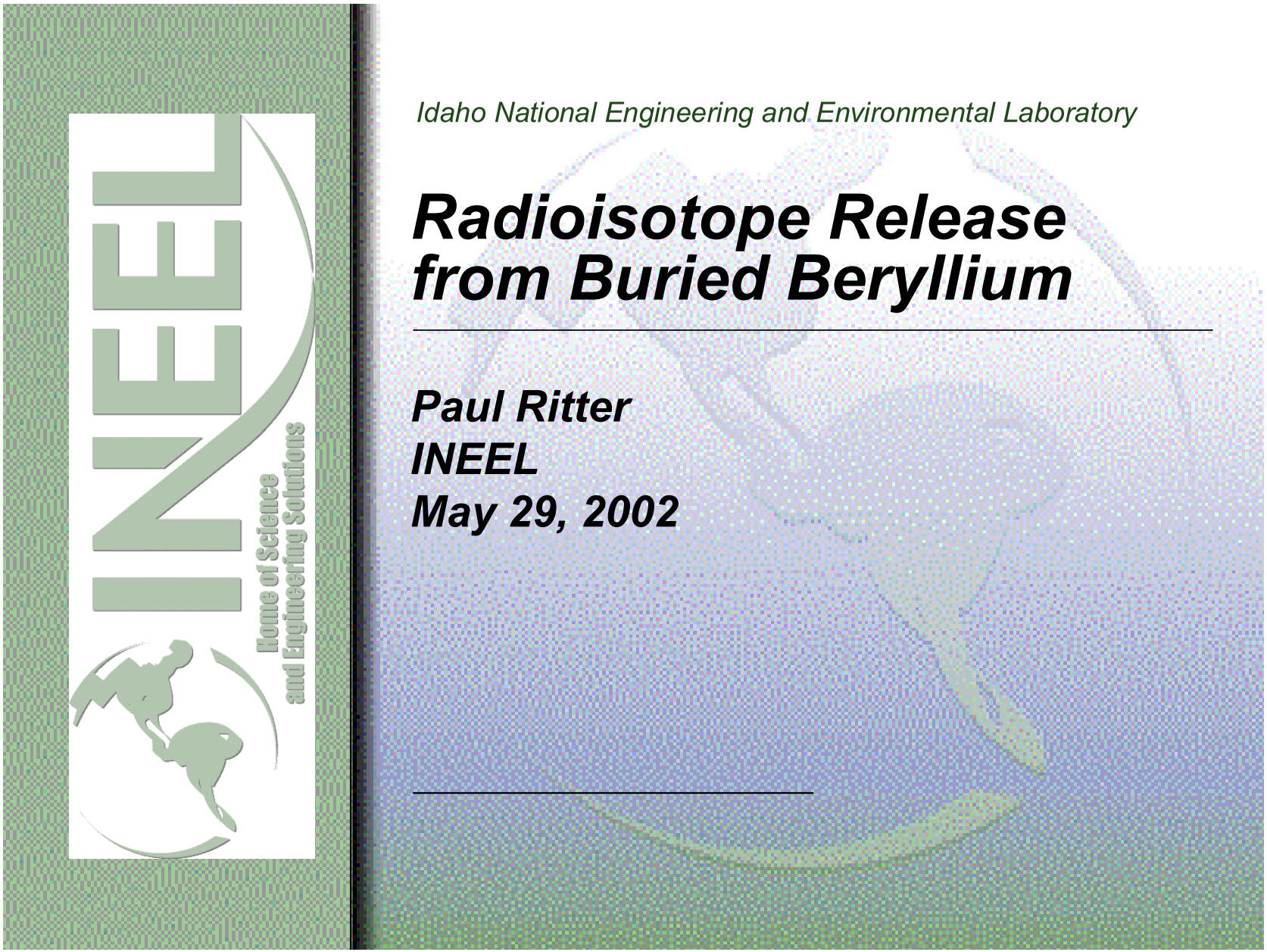
- How mobile is *Be* in the subsurface and what factors increase its mobility? Are the same factors that increase the corrosion rate the same factors that effect mobility? {#117, Sheryl Leeper}

    - Re: #117 From the results of the corrosion testing, the corrosion products on the beryllium metal surface is strongly adhering. The product has been run through analytical chemistry with the results mainly consisting of silicates and other beryllium compounds. We have not measured the thickness of the adhering layer although we are applying the lessons learned from each retrieval to gain additional information. If the same factors applicable to corrosion rate affect mobility, then one would expect to find evidence in the soil. We are planning on applying this theory in the field during the next excavation opportunity. {#134, Kay Adler Flitton}

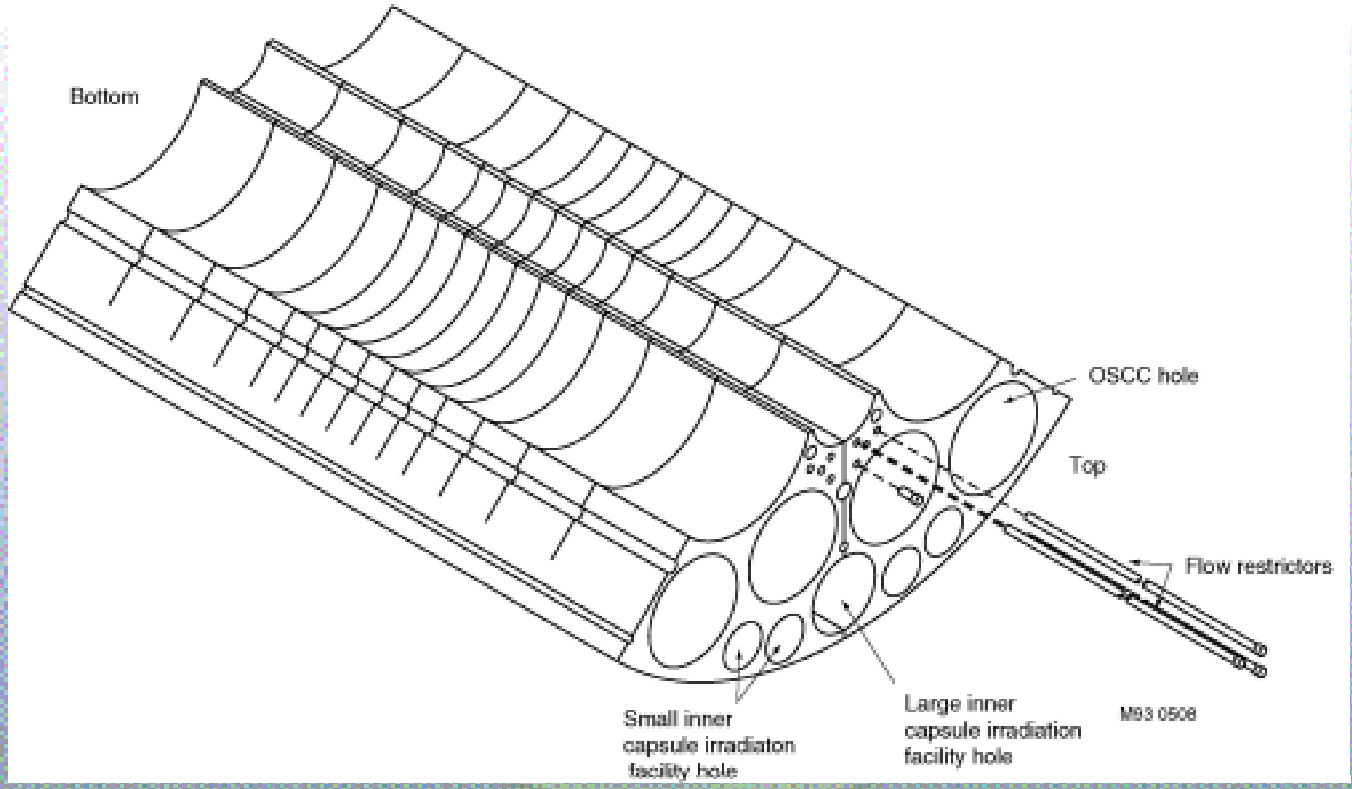
- What exactly does the sample weight change over time indicate? Are binding or changes in structure taken into account (ie: the silicate deposits evident at 3 years)? {#119, Linsey McDaniel}

    - Re #119 Weight change, in this case weight loss, indicates the amount of beryllium metal potentially being available for release into the environment. Typical underground corrosion rates are based on material loss applied overall (generally). This is a reasonable representation to determine how much material could be available to the environment. Further investigation is recommended to determine how

the material is bound in the soil matrix once corrosion happens. Also, further investigations need to take place to see if the beryllium and subsequently radionuclides that are not soluble (TCLP) may in fact be bound close to the disposal and not transportable. {#135, Kay Adler Flitton}


INEEL
Home of Science
and Engineering Solutions
Idaho National Engineering and Environmental Laboratory
Radioisotope Release
from Buried Beryllium
Paul Ritter
INEEL
May 29, 2002

ATR Be Reflector Blocks



1993 Be Disposal Conditions

- Activated beryllium (Be) neutron reflectors from the Advanced Test Reactor,
  - 293,000 Ci of elemental tritium (T_2, HT),
  - Approximately 10 Ci of ^{14}C,
  - Substantial inventories of less mobile radionuclides.
- Disposal in a soil auger hole at the Radioactive Waste Management Complex (RWMC),
  - 1.5 m diameter by 6.4 m deep, unlined,
  - Be in contact with native soil backfill material.

Purpose for Monitoring

RWMC Performance Assessment (PA):

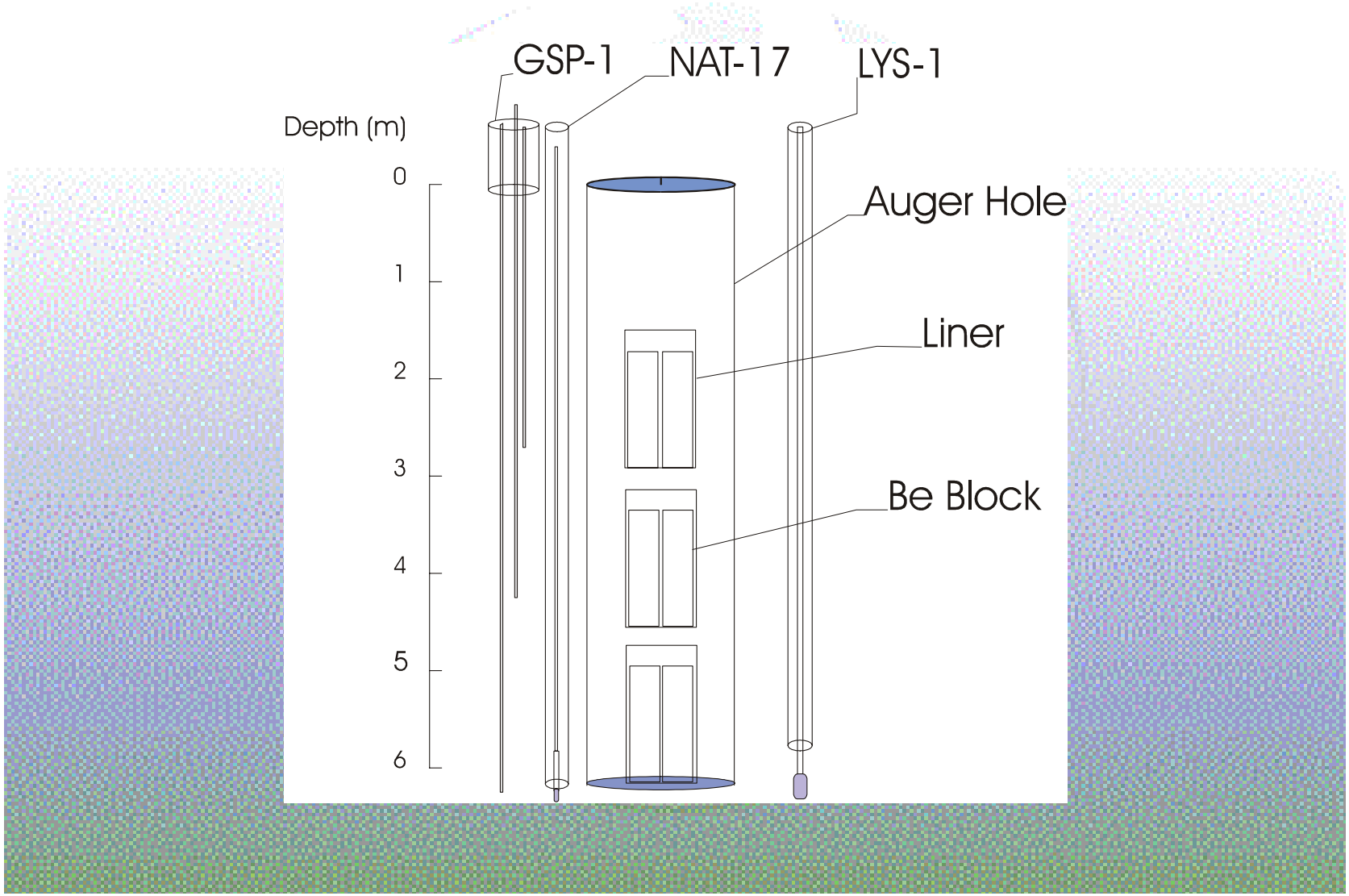
- *Identified radionuclide releases from Be as an important potential cause of dose,*
  - *PA modelers conservatively assumed that all ^{14}C and ^{3}H migrate to groundwater,*
  - *Migration of ^{14}C and ^{3}H to the atmosphere reduces overall dose,*
- *Made a commitment for long-term monitoring to support dose assessment model,*
- *Compliance with DOE Order 435.1, Chapter IV.*

Technical Objectives

- *Confirm that:*
  - *Estimated HT/T_2 release rate and corrosion modeling is reasonable*
  - *HT/T_2 oxidation to tritiated water (HTO) is essentially complete within ~1 m from the Be,*
- *Characterize migration through the soil and to the atmosphere,*
- *Develop baseline data for ^{3}H and ^{14}C concentrations for long-term monitoring.*

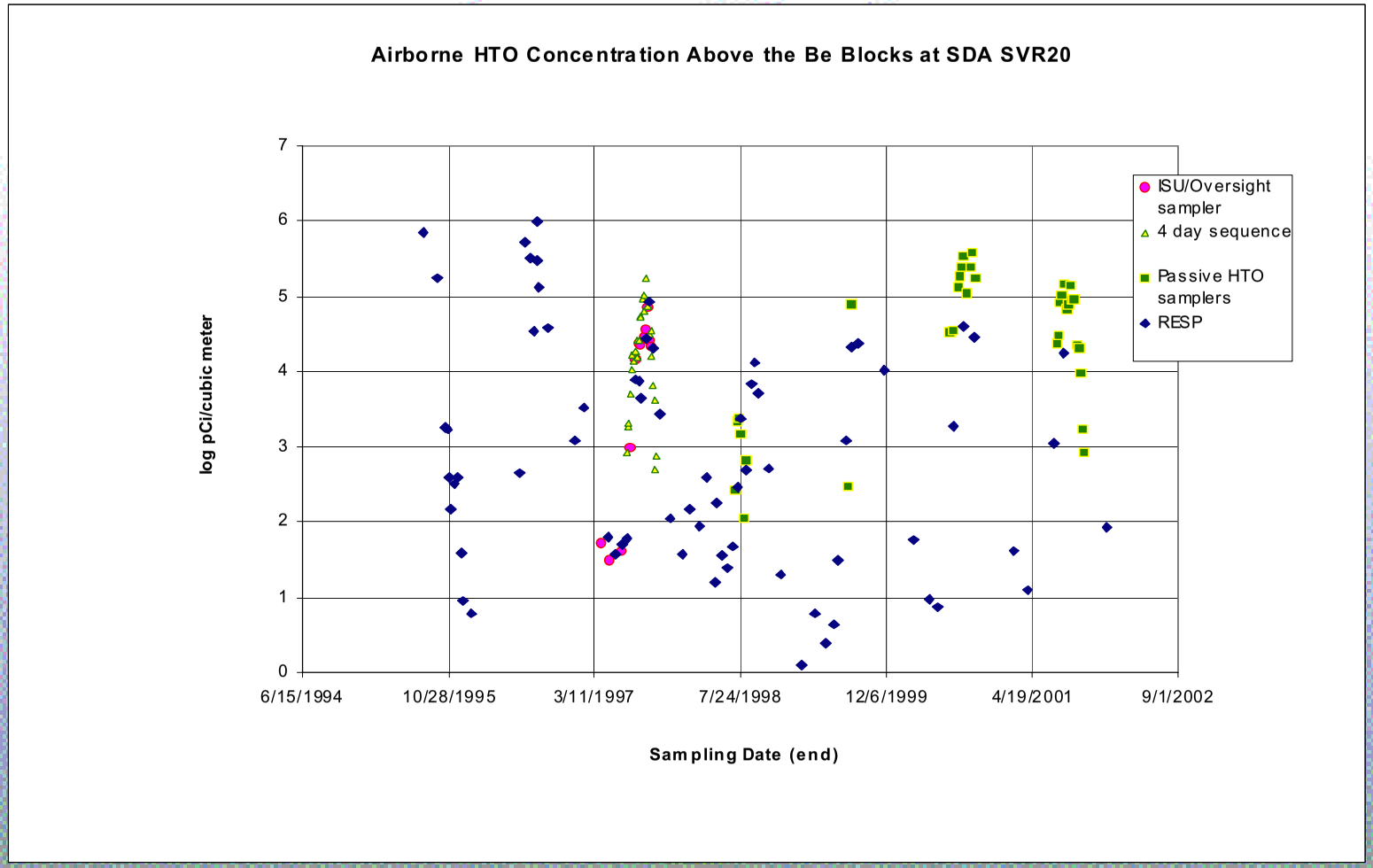
Instrumentation/Sampling Methods

- Sample collection
  - Soil pore gas $^{14}CO_2$, HT and HTO
  - Soil liquid (lysimeters)
  - HTO in surface soil moisture
  - Airborne HTO
- Instrumentation
  - Soil temperature (2 m and 6 m)
  - Soil moisture content (neutron probe)


GSP-1
NAT-17
LYS-1
Depth (m)
0
1
2
3
4
5
6
Auger Hole
Liner
Be Block

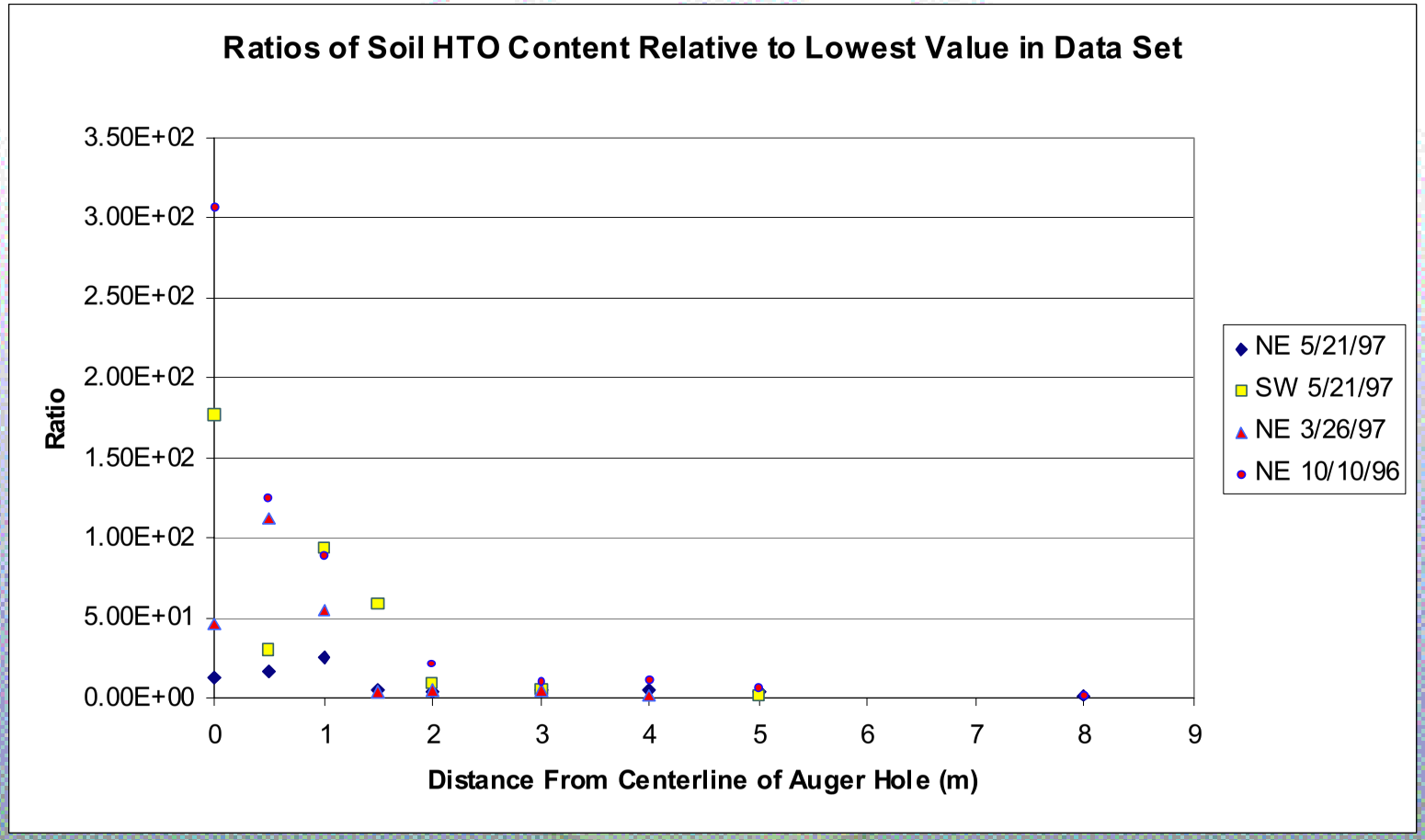
Results -- Airborne HTO

- Maximum concentrations (2 week average) up to 5% of DAC for workers,
- Pronounced seasonal effect
- Emissions of HTO on the order of 10 to 100 Ci/y; peak emission rates considerably greater,
- No apparent long-term trend in annual releases


Airborne HTO Concentration Above the Be Blocks at SDA SVR20
log pCi/cubic meter
0
1
2
3
4
5
6
7
6/15/1994
10/28/1995
3/11/1997
7/24/1998
12/6/1999
4/19/2001
9/1/2002
Sampling Date (end)
ISU/Oversight sampler
4 day sequence
Passive HTO samplers
RESP

Results -- Surface Soil Sampling

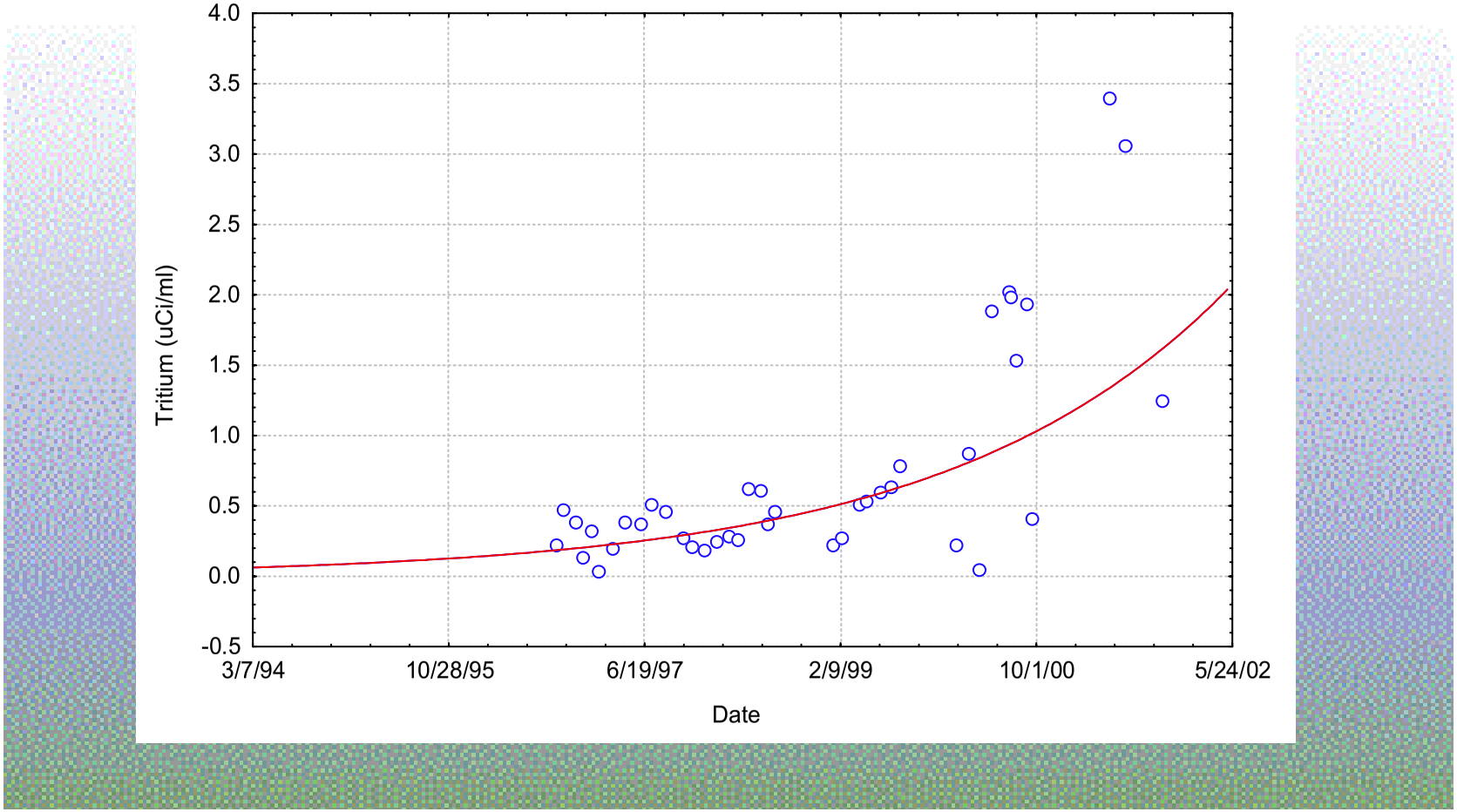
- *HTO concentration in surface soil moisture peaks in summer,*
- *HTO concentration in the area directly over the backfilled auger hole is generally greater than immediately outside the area.*


Ratios of Soil HTO Content Relative to Lowest Value in Data Set
Ratio
3.50E+02
3.00E+02
2.50E+02
2.00E+02
1.50E+02
1.00E+02
5.00E+01
0.00E+00
0
1
2
3
4
5
6
7
8
9
Distance From Centerline of Auger Hole (m)
NE 5/21/97
SW 5/21/97
NE 3/26/97
NE 10/10/96

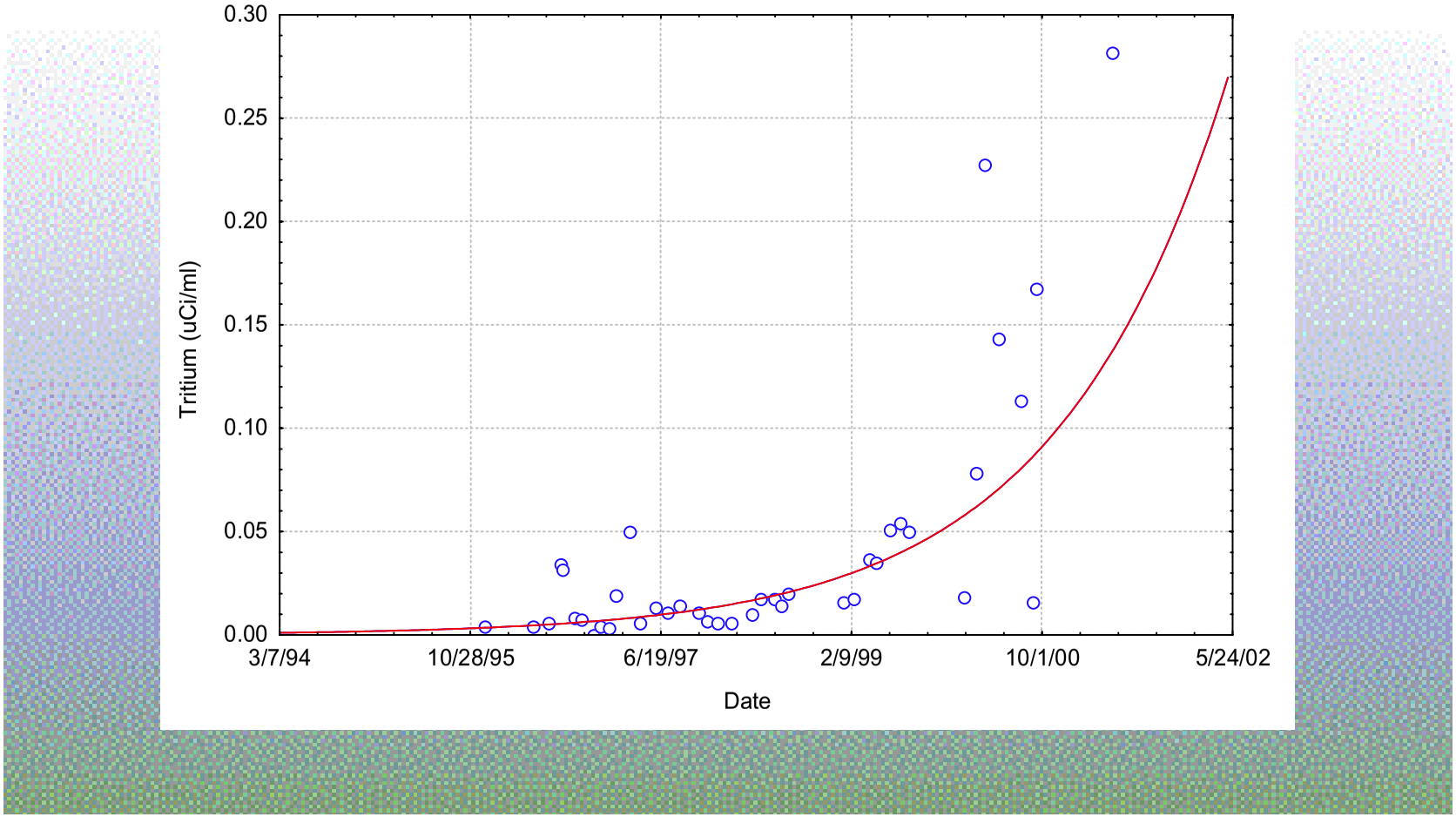
Results -- HTO in Soil Pore Gas

- *Apparent cyclic changes with lower HTO concentrations in cooler times of the year,*
- *No indication of advective transport in liquid phase beyond 4.7 m depth*
- *Vapor transport results in migration to air during hot, dry periods*

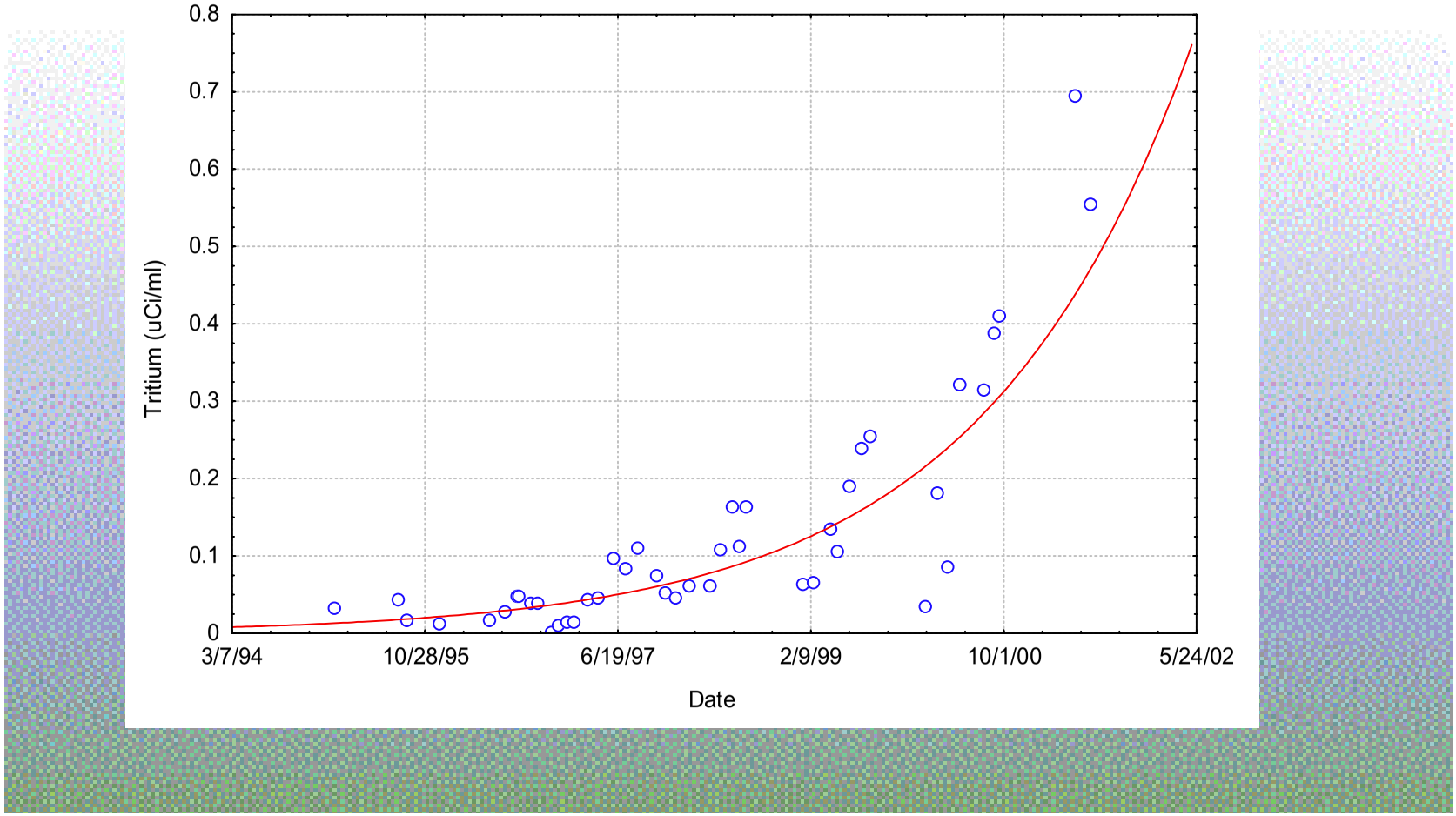
Concentration of HTO in soil moisture near activated Be -- 2.7 meters depth.



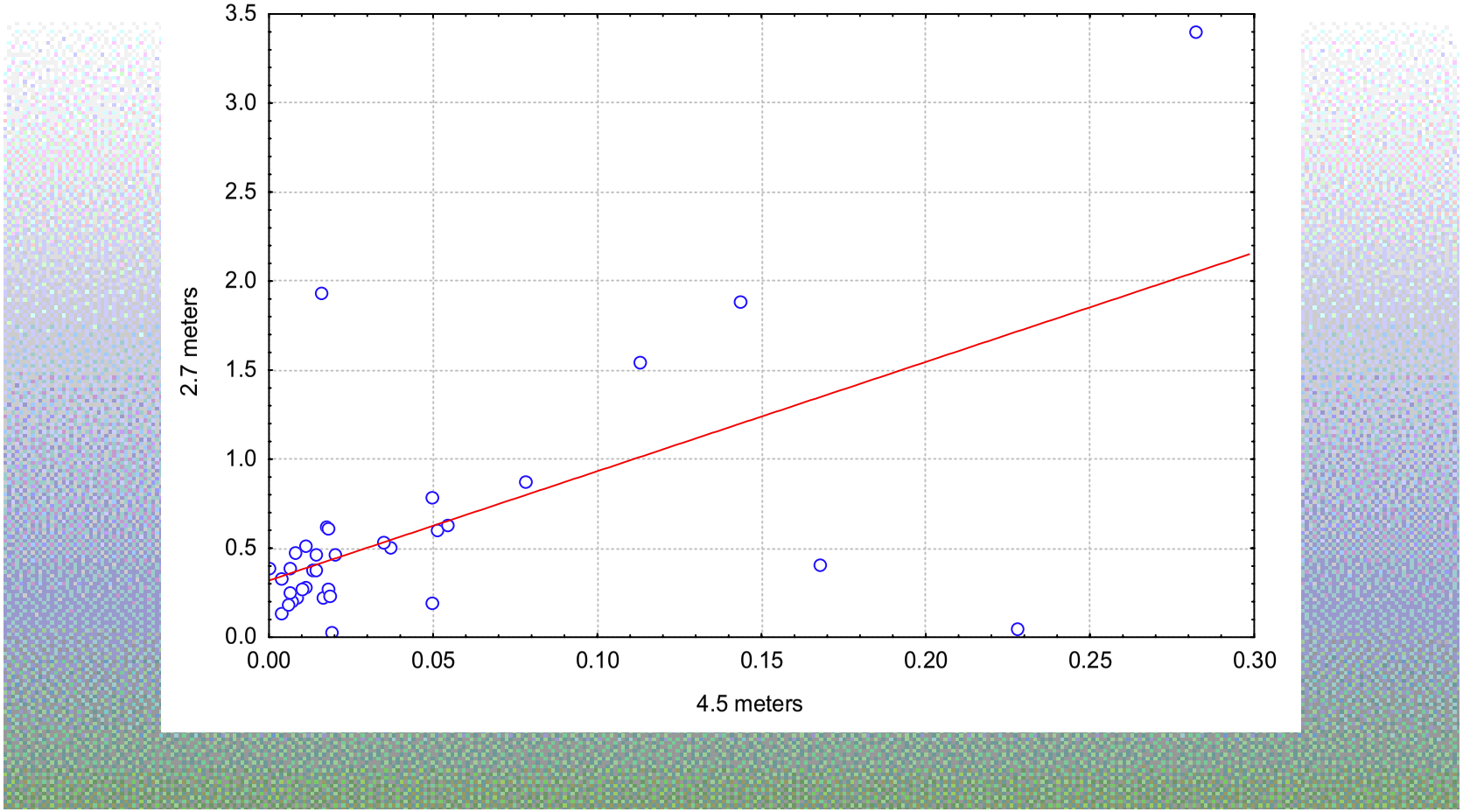
Concentration of HTO in soil moisture near activated Be – 4.5 meters depth.



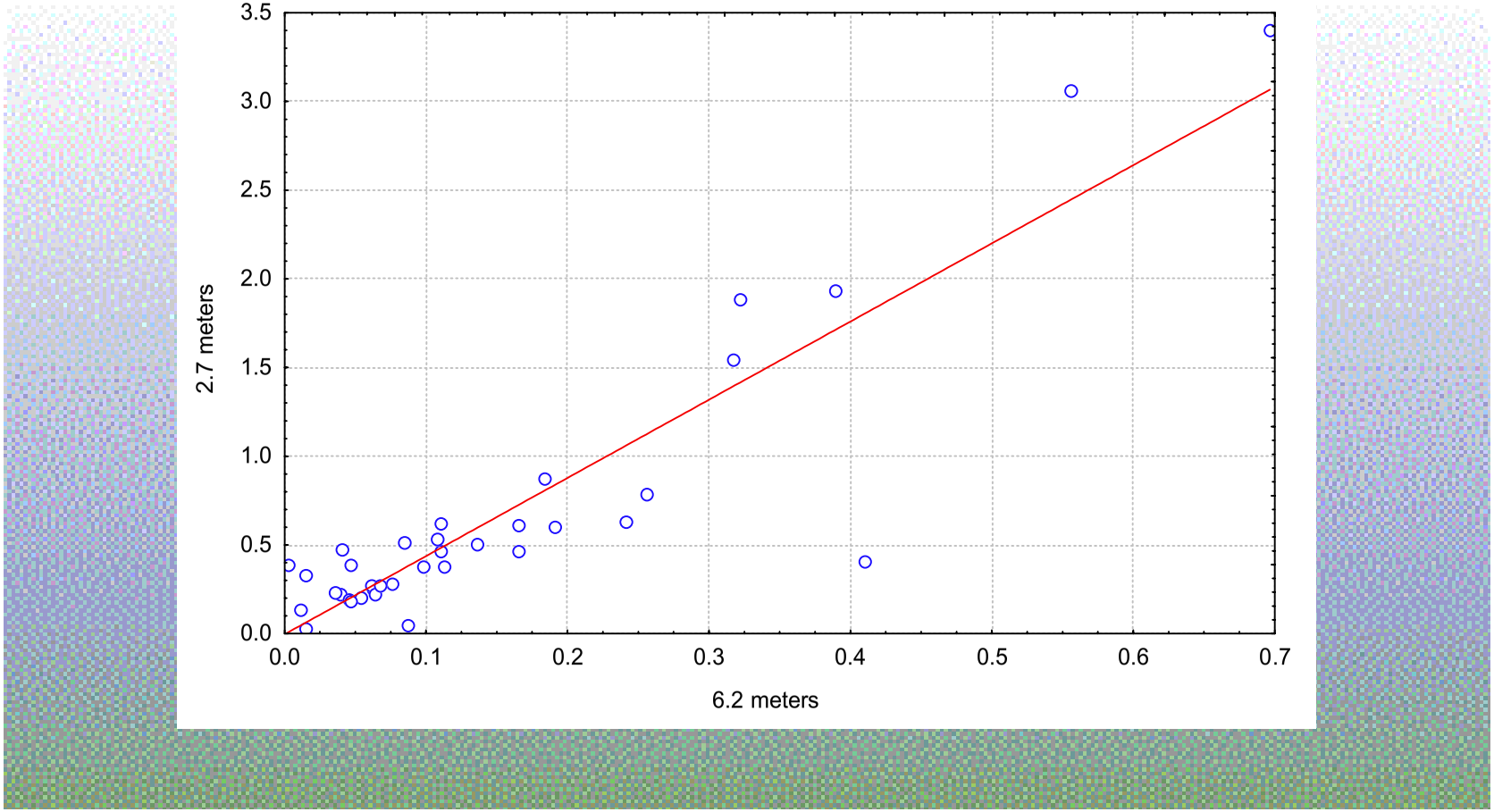
Concentration of HTO in soil moisture near activated Be – 6.3 meters depth.



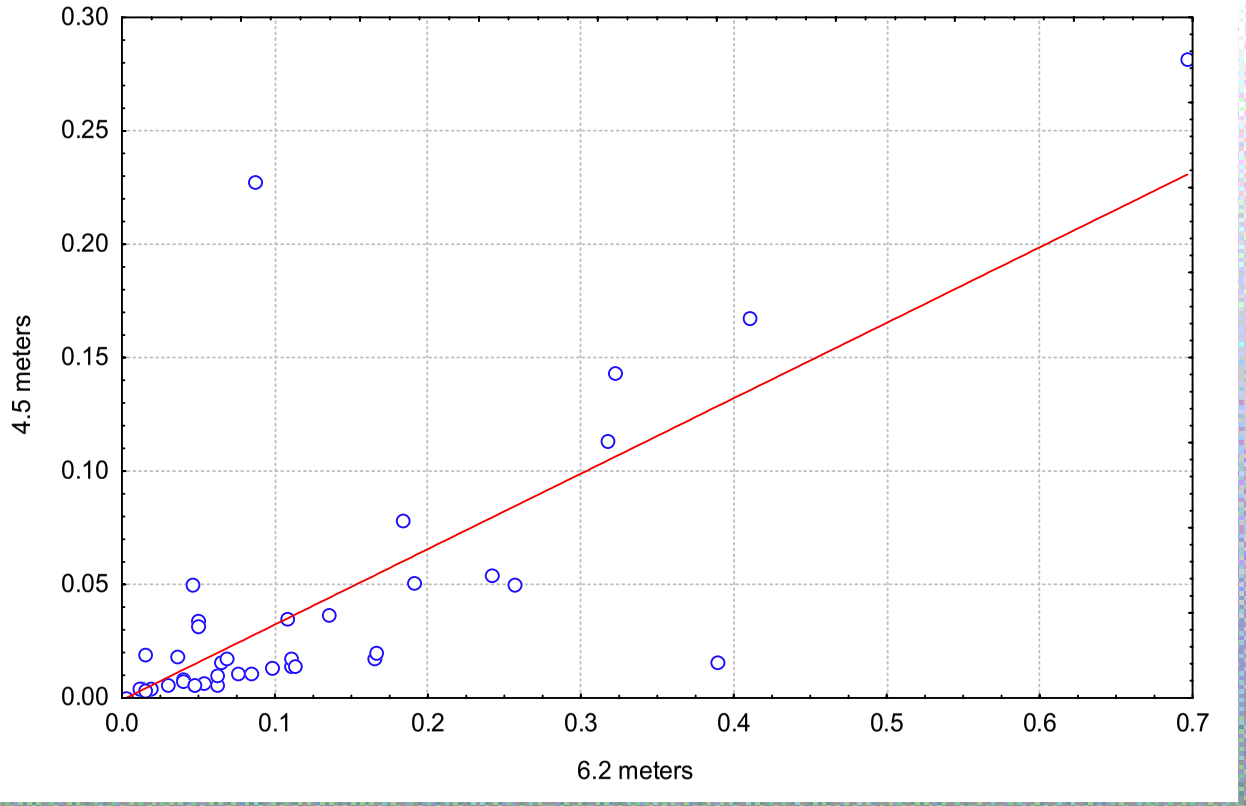
Correlation of concentrations of HTO in soil moisture at 2.7 and 4.5 meter depths.



Correlation of concentrations of HTO in soil moisture at 2.7 and 6.2 meter depths.



Correlation of concentrations of HTO in soil moisture at 4.5 and 6.2 meter depths.



Results -- ^{14}C in Soil Pore Gas

- ^{14}C activity per gram C was measured in $^{14}CO_2$ from pore gas samples,
  - Range from 10 to 100 nCi/g; on the order of 10^4 times current background
- Amounts/concentrations in solid phase CO_x can't be determined from soil gas samples

Results -- HT/HTO in Soil Gas

- *Expect rapid oxidation in surface soil, but no information concerning oxidation in deep soil, high radiation fields.*
- *Initial measurements show HT/HTO ratio is less than 0.015 at ~60 cm distance from the Be.*

Conclusions

- *HTO concentration in soil moisture is increasing, possibly because of increasing corrosion rate*
- *Substantial HTO migration to atmosphere,*
- *Soil within auger hole is preferred path for HTO migration,*
- *HT oxidation is effectively complete at relatively short range from the Be,*
- *Substantial ^{14}C releases -- more and different measurements required to estimate total released.*

Comments on Radioactive Isotope Release from Buried Beryllium

- Did the barometric pressure have any effect on mobility and release in the soil vapor phase? {#121, Sheryl Leeper}

    - Ritter response to question 121 -- I suspect that barometric pumping is an important process that causes HTO migration through (up and down) the soil column, particularly in the disturbed soil in the auger hole. The net effect of barometric pumping would be dispersion of the HTO that would, over periods of weeks, look like diffusion. {#144, Paul Ritter}

- Has there been any contacts made at other disposal facilities where beryllium has been disposed to see if any soil gas monitoring has been performed to see what might be happening at those disposals? {#124, Carlan Mullen}

- Any measurements of other radionuclides? {#125, Gary Anderson}

    - Ritter response to question 125 - no; I think that we'd need to collect soil liquid samples, because most (all?) of the other radionuclides migrate only in solution or perhaps suspension in the liquid phase. Liquid samples are difficult (often impossible) to collect from the unsaturated soil zone. {#147, Paul Ritter}

- When was the beryllium disposed that is being studied in the soil vault? {#126, Carlan Mullen}

    - Answer to comment 126 - *Be* was disposed in 1993. {#127, Raj Bhatt}

- Potential for measuring concentrations of nuclides in water beneath soil vault that has passed through? {#128, Gary Anderson}

    - Ritter response to question 128 -- I haven't seriously considered asking for installation of liquid sampling ports (suction lysimeters) beneath the auger hole, but I think that the ports could be installed without any serious safety problems. Actually getting liquid from the soil depends on soil conditions that you can't predict or control, so there would always be the risk of putting in a 'dry hole'. {#154, Paul Ritter}

- My understanding is that the C-14 is predominately in the non-*Be* metal components attached to the ATR *Be* blocks and shim cylinders. Is C-14 a significant source in the *Be*? One of the proposals to dispose of the ATR *Be* blocks and shim cylinders was to remove the non-*Be* metal components to meet the greater than Class C limitations. Is this possible? {#130, Jeff Brower}

    - Answer to comment 130: The :C-14 in *Be* is due to the nitrogen impurity in *Be*. Approximately 2 Ci/block or shim cylinder is produced due to irradiation of *Be*. There might be additional C-14 in attachments. {#137, Raj Bhatt}

- Ritter response to comment 130 -- I thought the reason for considering removing the non-*Be* components is to get rid of the long-lived niobium (93 or 94?). I think that the ~10 Ci estimate that I used for my presentation is associated with the beryllium, and comes from neutron reactions with nitrogen impurities in the beryllium. {#142, Paul Ritter}

THE WIPP Remote Handled Transuranic Waste program

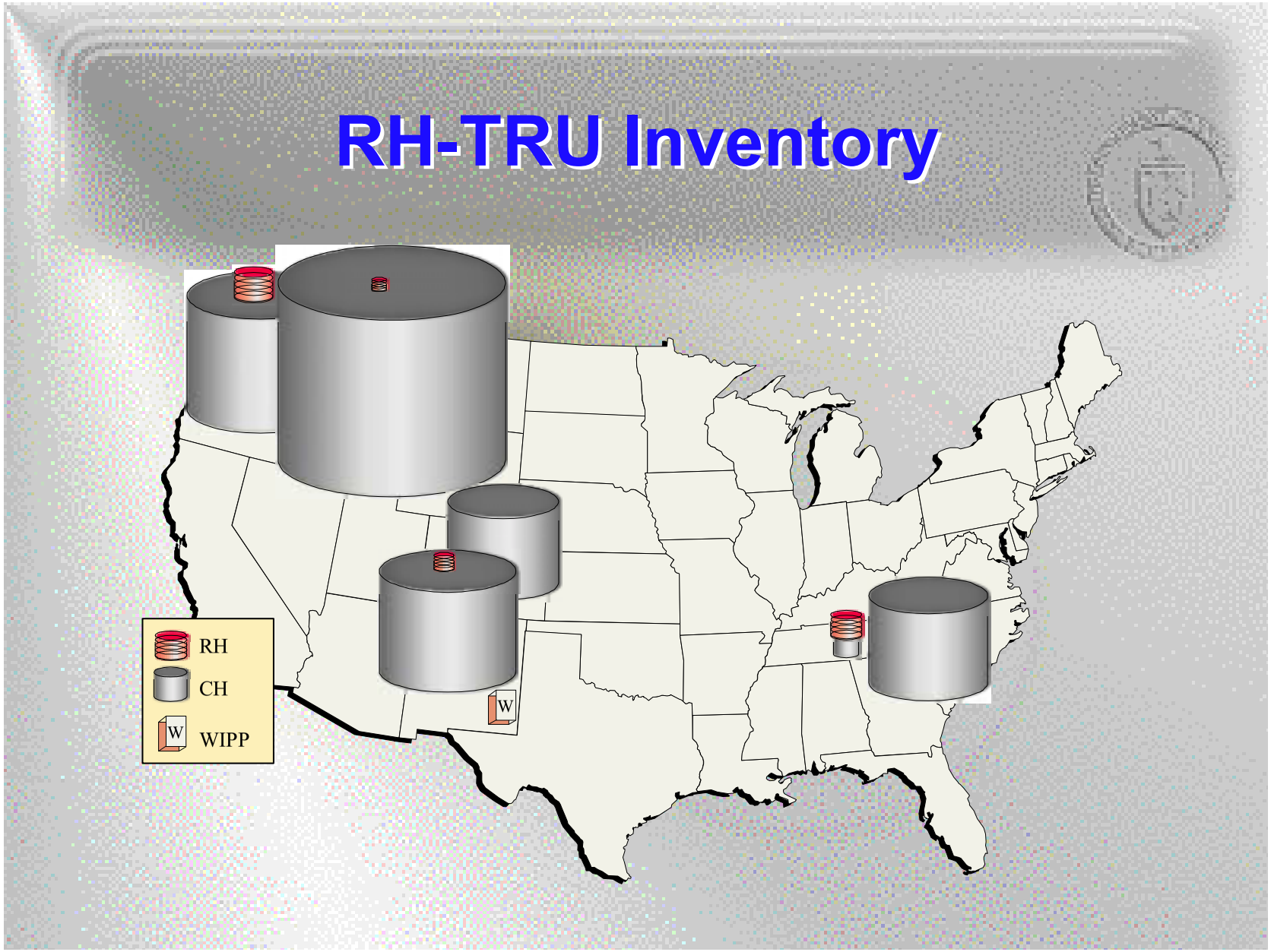
Where we are and where we are going

Dr. Clayton Gist, Manager
RH-TRU Waste Program
Carlsbad Field Office

- You've carefully thought out all the angles.
- You've done it a thousand times.
- It comes naturally to you.
- You know what you're doing, its what you've been trained to do your whole life.
- Nothing could possibly go wrong, right ?

Think Again.


Remote Handled Waste
Inventory


RH-TRU Inventory
RH
CH
W
WIPP
W

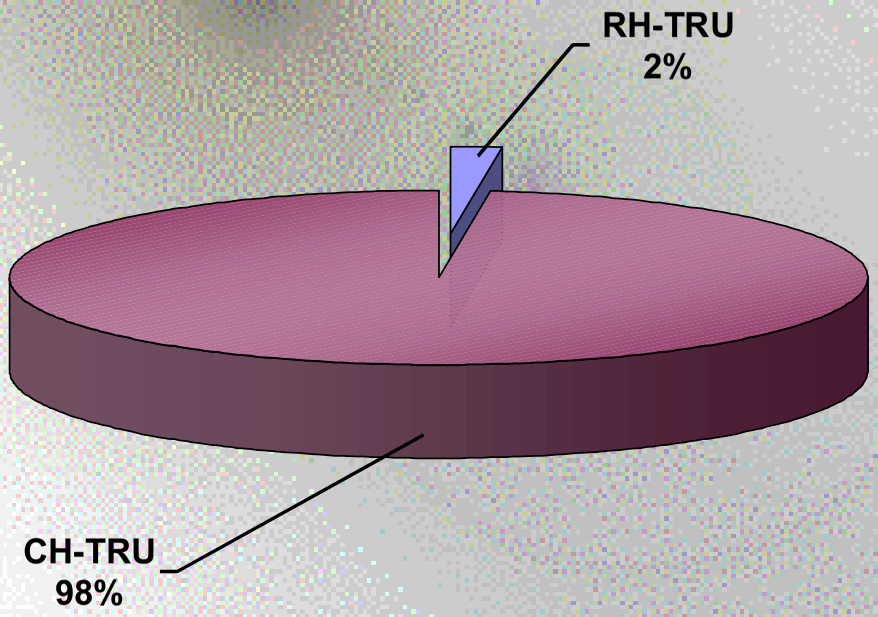
RH-TRU Inventory *(cont.)*

Updated RH-TRU Inventory Summary
Stored, Projected, and Anticipated Disposal Volumes
10/12/01

SITE NAME	RH-TRU Waste Volume (m^3)			
	Stored	Projected	Total	Planned Disposal
Hanford Reservation	207.0	938.0	1,145.0	1,048.0
Idaho National Engineering and Environmental Laboratory	84.0	101.3	185.3	275.2
Los Alamos National Laboratory	99.5	24.0	123.5	120.0
Oak Ridge National Laboratory	1,306.0	288.6	1,594.6	453.4
Total	**1,696.5**	**1,351.9**	**3,048.4**	**1,896.6**
Small-Quantity Sites				
Argonne National Laboratory - East	2.0	8.0	10.0	10.0
Argonne National Laboratory - West	1.1	5.0	6.1	6.1
Battelle Columbus Laboratories	0.0	20.8	20.8	20.8
Bettis Atomic Power Laboratory	3.0	0.0	3.0	3.0
Energy Technology Engineering Center	8.7	0.0	8.7	5.5
General Electric-Vallecitos Nuclear Center	11.8	0.0	11.8	11.8
Knolls Atomic Power Laboratory	3.7	6.8	10.5	10.5
Sandia National Laboratories	1.5	24.0	25.5	
West Valley Demonstration Project	470.5	8.4	478.9	
Total Waste Volumes	**2,197.3**	**1,400.9**	**3,598.2**	**1,964.3**

RH-TRU Inventory *(cont.)*

Comparison of Revised RH-TRU Volume Estimates
(10/12/01)



RH-TRU Inventory *(cont.)*

Updated RH-TRU Inventory Summary Activity Estimates
Most of the RH Activity is in Oak Ridge
10/12/01

Site Name	Estimated Stored Activity (Ci)
Hanford Reservation	36,000
Idaho National Engineering and Environmental Laboratory	6,360
Los Alamos National Laboratory	10,700
Oak Ridge National Laboratory	587,000
Total	
Small-Quantity Sites	
Argonne National Laboratory - East	NR
Argonne National Laboratory - West	NR
Battelle Columbus Laboratories	5,800
Bettis Atomic Power Laboratory	16,300
Energy Technology Engineering Center	8
General Electric-Vallecitos Nuclear Center	NR
Knolls Atomic Power Laboratory	118
Sandia National Laboratories	
West Valley Demonstration Project	
Total Waste Activity	**662,286**

RH-TRU Inventory *(cont.)*

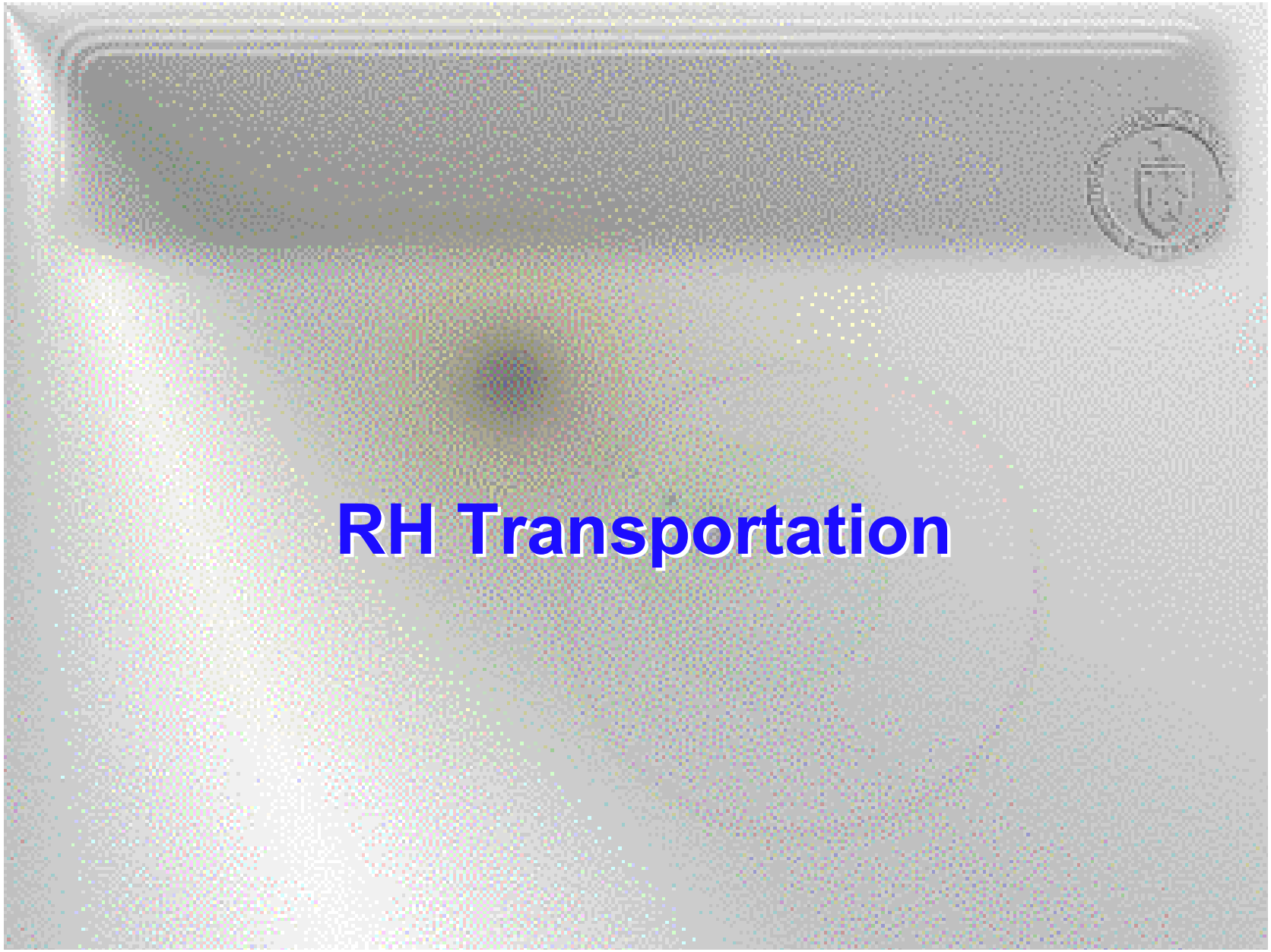
Site Name	Major Reported Radionuclides
Hanford Reservation	Co-60, Ba-137m, Cs-137, Sr-90, Y-90, Am-241, Am-243, Np-237, Pu-238, Pu-239, Pu-240, Pu-241, Pu-242
Idaho National Engineering and Environmental Laboratory	Co-60, Tc-99, Ba-137m, Cs-137, Sr-90, Y-90, Am-241, Pu-238, U-235
Los Alamos National Laboratory	Ba-137m, Cs-137, Sr-90, Y-90, Am-241, Pu-238, Pu-239
Oak Ridge National Laboratory	Co-60, Ba-137m, Cs-137, Sr-90, Y-90, Eu-152, Eu-154, Am-241, Pu-238, Pu-239, Pu-241, Cm-244
Small-Quantity Sites	
Argonne National Laboratory - East	Ba-137m, Cs-137, Co-60, Sr-90, Y-90, Pu-241
Argonne National Laboratory - West	Co-60, Cs-137, Ba-137m, Sr-90, Y-90, Am-241, Pu-239, U-235, U-238
Battelle Columbus Laboratories	Ba-137m, Cs-137, Sr-90, Y-90, Am-241, Pu-239, Pu-240, Pu-241
Bettis Atomic Power Laboratory	Ba-137m, Cs-137, Co-60, Sr-90, Y-90, Pu-241
Energy Technology Engineering Center	Ba-137m, Cs-137, Co-60, Sr-90, Y-90, Pu-241
General Electric-Vallecitos Nuclear Center	Ba-137m, Cs-137, Co-60, Sr-90, Y-90, Pu-241
Knolls Atomic Power Laboratory	Ba-137m, Cs-137, Sr-90, Y-90
Sandia National Laboratories	Am-241
West Valley Demonstration Project	Ba-137m, Cs-137, Sr-90, Y-90

RH-TRU Inventory *(cont.)*

- **Dose rates**
  - **Greater than 200 mrem/h**
  - **Less than 1000 rem/h**
  - **Only 5% by volume greater than 100 rem/h**
- **Information from sites support these limits**

RH-TRU Inventory
Conclusion

- **Updated RH-TRU inventory information within the envelope of**
  - **Original design basis assumptions**
  - **Safety and NEPA analyses**
  - **Regulatory and legal limitations**


RH Transportation

RH-TRU Waste Transportation

- RH-TRU waste transportation to WIPP only in packages approved by U.S. Nuclear Regulatory Commission (NRC)
- Baseline approach to RH-TRU waste transportation to WIPP uses the RH 72-B cask
- Recently developed option for RH-TRU waste transportation to WIPP uses the CNS 10-160B cask

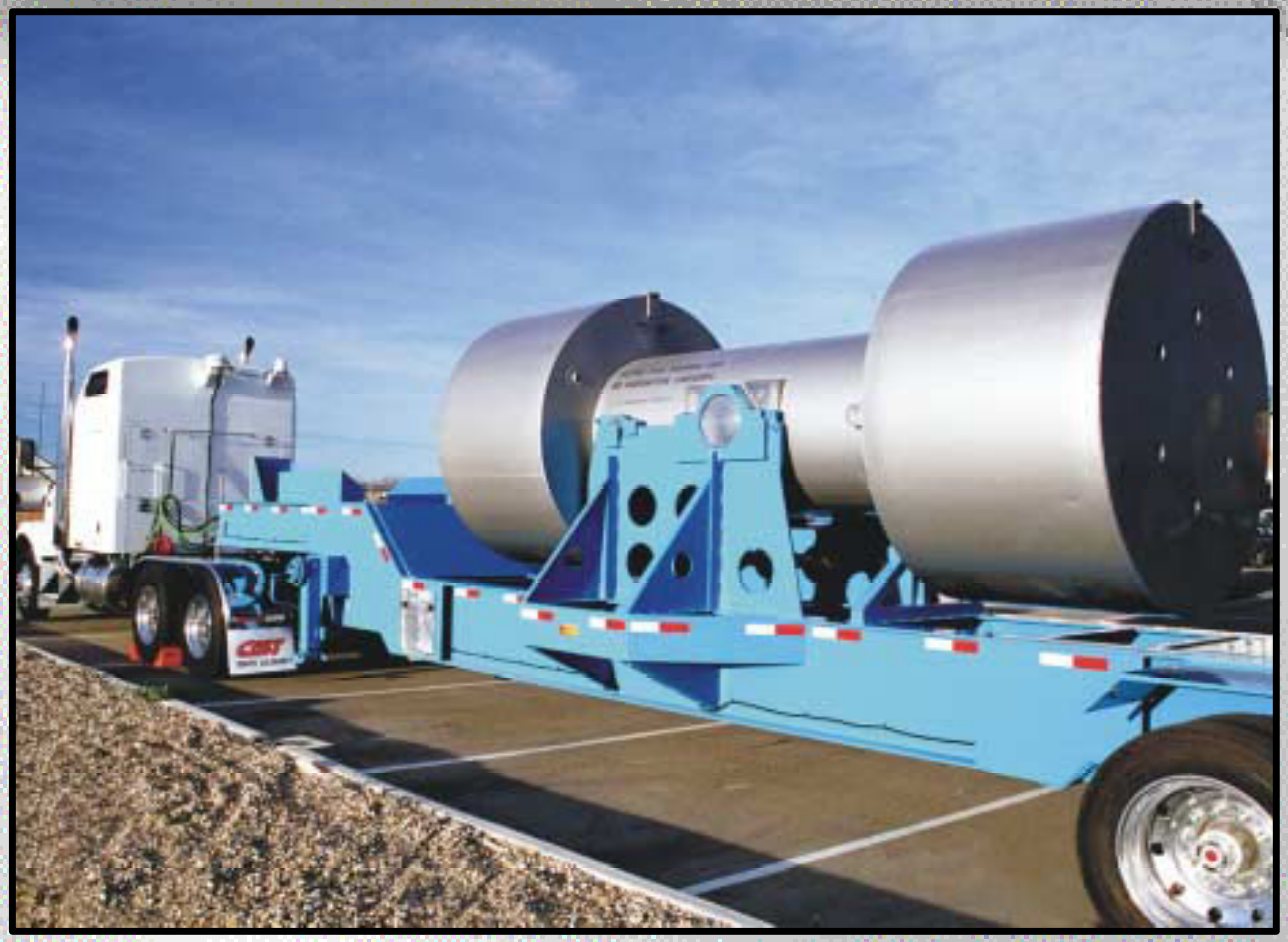
RH 72-B Cask

- Type B packaging licensed by the NRC on March 3, 2000, for transport of RH-TRU waste
- Current 72-B cask Certificate of Compliance (C of C) allows RH-TRU waste shipment from:
  - Battelle Columbus Laboratories
  - Energy Technology Engineering Center
  - Los Alamos National Laboratory
  - Oak Ridge National Laboratory

RH 72-B Cask *(cont.)*

- **Safety Analysis Report for Packaging modification submitted to NRC on August 29, 2001, to expand authorized contents**
  - **Include waste from Idaho National Engineering and Environmental Laboratory and Hanford**
  - **Expand dose rate compliance methodologies**
  - **Update and expand criticality compliance methodologies**
  - **Incorporate selected TRUPACT-II Rev. 19 TRAMPAC initiatives**

RH 72-B Cask *(cont.)*



CNS 10-160B Cask

- Type B packaging licensed by NRC as low-level waste transportation cask
- Licensed for RH-TRU waste by NRC on February 27, 2001
- Current 10-160B cask C of C allows RH-TRU waste shipment from:
  - Battelle Columbus Laboratories
- An application to amend C of C to increase limit to 3,000 (vs. 2000) times A2 values was approved by NRC on August 10, 2001

CNS 10-160B Cask *(cont.)*

Type and Requirements

- Typical RH-TRU waste streams include:
  - Solid inorganic and organic materials (e.g., generated by decontamination and decommissioning activities)
  - Cemented inorganic process solids
  - Solidified aqueous waste
- 72-B and 10-160B casks have similar payload requirements

Physical Properties

- Container descriptions
  - 72-B cask payload = 1 RH-TRU waste canister (can contain up to three 55-gallon drums)
  - 10-160B cask payload = ten 55-gallon drums
- Maximum weights
  - 72-B cask and contents = 45,000 lbs.
    - Canister = 8,000 lbs.
  - 10-160B cask and contents = 72,000 lbs.
    - Contents = 14,500 lbs.
    - 55-gallon drum = 1,000 lbs.

Physical Properties *(cont.)*

- **Container marking**
  - Unique container identification number
- **Filter vents**
  - Waste containers must be vented or filtered to meet specifications
- **Liquids**
  - Limited to <1% (volume) of payload container

Physical Properties *(cont.)*

- **Sharp or heavy objects**
  - **Must be blocked, braced, or suitably packaged to provide puncture protection for payload container**
- **Sealed containers**
  - **>4 liters in size are prohibited (except metal containers packaging solid inorganic waste)**

Chemical Properties

- **Pyrophoric materials**
  - **Limited to <1% (weight) pyrophorics**
- **Explosives, corrosives, and compressed gases are prohibited**
- **Chemical composition/compatibility**
  - **Chemical composition restricted per approved RH-TRU Waste Content Code ensures chemical compatibility**
  - **Limited to <5% (weight) total trace chemicals/materials (occurring in quantities <1% [weight])**

Gas Generation Properties

- Hydrogen gas generation is key concern for NRC
- NRC limit is 5% (volume) hydrogen
  - NRC IE Information Notice No. 84-72, "Clarification of Conditions for Waste Shipments Subject to Hydrogen Gas Generation" (1984)
  - NUREG-1609, "Standard Review Plan for Transportation Packages for Radioactive Material" (1999)
  - NUREG/CR-6673, "Hydrogen Generation in TRU Waste Transportation Packages" (2000)
- Limit applies in the innermost layer of confinement

Gas Generation Properties *(cont.)*

- 5% limit on hydrogen concentration
  - Option 1: Convert 5% hydrogen limit to hydrogen gas generation rate limit
    - Compliance demonstrated by measurement or testing (e.g., headspace concentration measurement can be used to derive hydrogen gas generation rate and compared to limit corresponding to 5% hydrogen concentration)

Gas Generation Properties *(cont.)*

- **5% Limit on hydrogen concentration *(cont.)***
  - **Option 2: Convert 5% hydrogen limit to decay heat limit**
    - **Compliance demonstrated analytically by:**
      - **Assigning conservative G value* to waste form (based on chemical composition)**
      - **Release rate of hydrogen from confinement layers**
      - **Decay and ingrowth of radioactive isotopes**
    - **G value - number of molecules of hydrogen generated per 100 electron volts of energy absorbed**

Gas Generation Properties *(cont.)*

- **Decay heat limits per cask**
  - ≤50 watts (W) per 72-B cask
  - ≤100 W per 10-160B cask
- **Flammable volatile organic compounds**
  - ≤500 parts per million in container headspace per 72-B cask
    - (Current application under NRC review proposes compliance with mixture lower explosive limit (MLEL) instead of 500 ppm limit)
  - ≤500 parts per million in container headspace per 10-160B cask

Nuclear Properties

- Nuclear criticality
  - ≤325 fissile gram equivalents per 72-B cask
    - Current application under NRC review proposes 72-B cask transport of contents limited to maximum enrichment of 0.96% U-235 fissile equivalent mass as an option to above for specific payloads
  - Mass limits of 10 CFR 71.53 per 10-160B cask
- Total plutonium
  - No additional limit for 72-B cask
  - ≤20 curies total plutonium per 10-160B cask

Nuclear Properties *(cont.)*

- **Normal Conditions of Transport (NCT) radiation dose rates (for both packages)**
  - **≤200 mrem/hour at the surface**
  - **≤10 mrem/hour at 2 meters from side of package**

Comparison of Transportation Requirements for 72-B and 10-160B Casks

Parameter	72-B Cask	10-160B Cask
Payload	1 RH-TRU waste canister (may overpack three 55-gallon drums)	Ten 55-gallon drums
Maximum Total Weight of Contents	8,000 lbs.	14,500 lbs.
Maximum Gross Weight	45,000 lbs.	72,000 lbs.
Gas Generation Requirements	Hydrogen concentration limited to 5% by volume in any layer of confinement during the maximum 60-day shipping period	
Fissile Gram Equivalent Limits	• ≤325 grams Pu-239 fissile gram equivalent • (≤0.96% U-235 fissile equivalent mass proposed)	Contents may include fissile material provided the mass limits of 10 CFR 71.53 are not exceeded
Activity Limit	• Individual radionuclide activity limits are established to ensure compliance with HAC dose rate limit (1 rem per hour at 1 meter as specified by 10 CFR 71.51) • (HAC dose rate limit compliance by meeting normal conditions dose rate limits is proposed for specific payloads constrained in terms of form and configuration)	• Type B quantity of radioactive material not to exceed 3,000 times A_2 values • No neutron generators
Total Pressure	Maximum design internal pressure of 150 pounds per square inch gauge (psig)	Package design limit of 31.2 psig
Cask Decay Heat Limits	50 watts (W)	100 W
Pu Limits	None	20 curies
Flammable VOCs	• 500 ppm • (Compliance with mixture lower explosive limit proposed instead of 500 ppm limit)	500 ppm


Acceptable Knowledge

Steps Toward Acceptable Knowledge Standardization

- Understanding acceptable knowledge as a process and not a database
- Understanding the regulatory role of the acceptable knowledge process
- Delineating specific acceptable knowledge information needs for RH-TRU decision making
  - What information
  - How much information
  - Quality of the information

Steps Toward Acceptable Knowledge Standardization

- Understanding acceptable knowledge as a process and not a database
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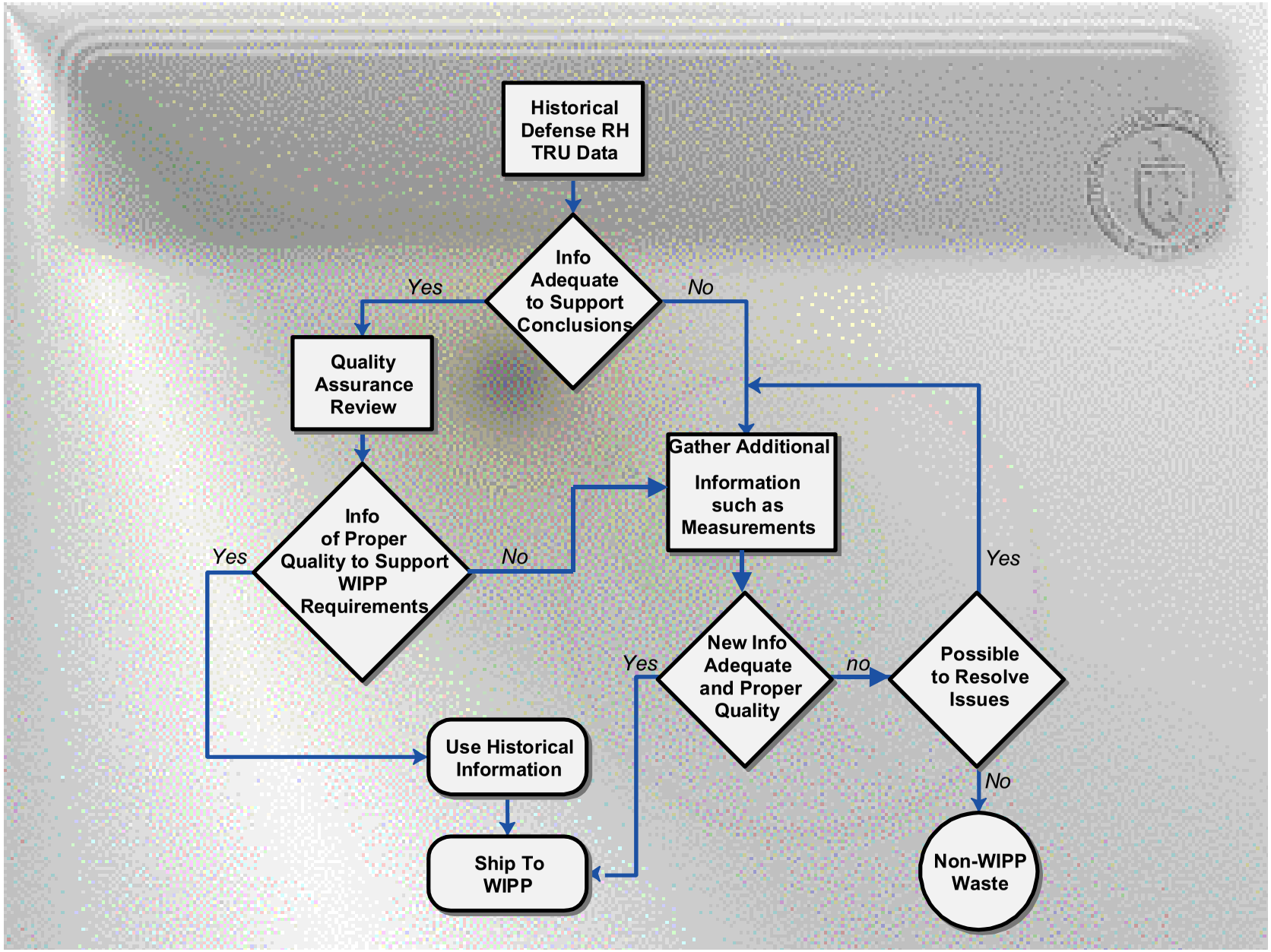
  - How much information
  - Quality of the information

Elements of the AK Process

- AK Information and Decision-Making
- AK Procedures
- AK Information Confirmation
- AK Auditing

AK Process Satisfies Several Regulatory Requirements

- **RCRA**
  (as implemented at WIPP by NMED)
  - **40 CFR 262.11**
  - **40 CFR 264.13**
- **EPA-ORIA**
  - **40 CFR 194.24**
- **Others**


Historical Defense RH TRU Data
Info Adequate to Support Conclusions
Yes
No
Quality Assurance Review
Info of Proper Quality to Support WIPP Requirements
Yes
No
Gather Additional Information such as Measurements
New Info Adequate and Proper Quality
Yes
no
Possible to Resolve Issues
Yes
No
Use Historical Information
Ship To WIPP
Non-WIPP Waste

Data Quality Objectives (DQOs)

DQOs are qualitative and quantitative statements that clarify program technical and quality objectives, define appropriate types of data, and specify tolerable levels of potential decision errors that will be used as the basis for establishing the quality and quantity of data needed to support decisions

Information Needed for WIPP

- RCRA-related DQO
  - Prohibited items
  - Physical form
  - Hazardous waste number
- 40 CFR 191/194-related DQO
  - Cellulosics, plastic, rubber
  - Liquids
  - Surface dose rate
  - TRU activity
  - Total activity

Sources of Acceptable Knowledge Information

- Acceptable knowledge information used by others for decisions
  - Generators
  - Intermediate facilities
  - Transporters
- New information
  - Gather additional acceptable knowledge information
  - Collect new information (testing)

Determining Acceptable Knowledge Information Adequacy for Decision Making

- Satisfying each DQO
  - What specific information must be collected
  - How much information is sufficient

RCRA Acceptable Knowledge Standard

DATA QUALITY OBJECTIVE		WHAT AK INFORMATION SATISFIES THE DATA QUALITY OBJECTIVE	TYPE OF AK INFORMATION NEEDED	HOW MUCH AK INFORMATION IS NEEDED
PHYSICAL FORM	S3000	+ Description of the waste generating process + Packaging logs + Tracking information + Testing results (if applicable)	+ Written documentation on processes + Video tapes + Packaging database + Records of testing	+ Segregate waste into waste streams and Summary Category Groups + Relate 100% of the containers to a waste stream
	S4000			
	S5000			
HAZARDOUS WASTE NUMBERS		+ 40 CFR 262.11 determination + Test results (if applicable)	+ Written documentation on hazardous waste determination	+ Assign hazardous waste numbers to the waste stream
PROHIBITED ITEMS	LIQUIDS	+ Description of the waste generating process + Packaging and/or repackaging logs + Procurement documentation + Site procedures prohibiting or controlling items + Oversight responsibilities and program implementation + Organizational responsibilities for prohibited items + Training records + Nonconformance process implementation information + Testing results + Description of treatment processes	+ Written documentation that procedures were in place and were followed + Training records + Assessment reports + Nonconformance reports + Packaging database + Testing records (if applicable) + Treatment records (if applicable)	+ Documentation must relate to 100% of the containers in the waste stream
	PYROPHORIC MATERIALS			
	INCOMPATIBLE WASTE			
	EXPLOSIVES			
	COMPRESSED GASES			
	PCB>50 ppm			

40 CFR 191/194 Acceptable Knowledge Standard

DATA QUALITY OBJECTIVE		WHAT AK INFORMATION SATISFIES THE DQO	TYPE OF AK INFORMATION NEEDED	HOW MUCH AK INFORMATION IS NEEDED
PHYSICAL FORM	S3000	+ Description of the waste generating process + Packaging logs + Tracking information + Procurement records + Test results (if applicable)	+ Written documentation on processes + Video tapes + Packaging database + Records of testing	+ Segregate waste into waste streams and Summary Category Groups + Relate 100% of the containers to a waste stream + Assign 50% of weight of container to cellulosic, plastic, rubber for S5000 waste
PHYSICAL FORM	S4000			
PHYSICAL FORM	S5000			
RESIDUAL LIQUIDS				+ Determine that liquids do not exceed 1% volume on a container or waste stream basis
DOSE RATE		+ Description of the waste generating process + Testing results	+ Written documentation + Testing records	+ Document that 100% of the containers belong to the waste stream + Determine if dose rate limits are exceeded by any container
TRU ACTIVITY		+ Description of the waste generating process + Testing results	+ Written documentation + Testing records	+ Document that 100% of the containers belong to the waste stream + Determine that waste is TRU waste on a waste stream basis + Determine total TRU activity on a waste stream or container basis
TOTAL ACTIVITY		+ Description of the waste generating process + Testing results	+ Written documentation + Testing records	+ Document that 100% of the containers belong to the waste stream + Determine compliance with limit on a waste stream basis

Summary

Achieving Acceptable Knowledge Process Standardization

- **Acceptable knowledge information "standards"**
  - **DQO-based (explicitly defined)**
  - **Type specified**
  - **Amount stipulated**
  - **Quality assured**
- **Implementation**
  - **Standardized acceptable knowledge procedures**
  - **Standardized acceptable knowledge monitoring**
    - **All components of the acceptable knowledge process are audited**

CH-TRU AK Information Accuracy

- How good is acceptable knowledge information?
  - The WIPP CH-TRU permit requires generator sites to prepare an Acceptable Knowledge Information Accuracy Report (Attachment B4-3e)
  - Two measures are specified:
    - Percentage of waste containers that require reassignment to a new Waste Matrix Code
    - Percentage of waste containers that require designation of different hazardous waste numbers

CH-TRU AK Information Accuracy *(cont.)*

- Acceptable knowledge information accuracy is determined as the result of Acceptable Knowledge Information Confirmation (Attachment B4-3d)
- Generators are to use radiography or visual examination, headspace gas sampling and analysis, and/or solids sampling and analysis to confirm acceptable knowledge information accuracy

CH-TRU AK Information Accuracy *(cont.)*

- **Effectiveness of the CH-TRU acceptable knowledge process is demonstrated by the Acceptable Knowledge Information Accuracy Reports from the various generator/storage sites**

CH-TRU AK Information Accuracy *(cont.)*

Waste Matrix Code				Hazardous Waste Number		
Site	New WMC	Total	Accuracy	New HWN	Total	Accuracy
RFETS	7	4,683	99.85%	142	4,226	96.6%
INEEL	113	21,359	99.47%	Note 1	3,492	80%
SRS	28	592	95%	0	592	100%
LANL	7	849	99%	17	253	93%
Hanford	0	300	100%	0	300	100%

Note 1 INEEL did not assign new codes on a container basis

PROPOSED RH-AK Information Accuracy

- 10% of the waste is “confirmed”
  - Radiography
  - Visual examination
- Parameters compared
  - Physical form
  - Prohibited items
  - Waste Matrix Code (including indicators of hazardous waste)
- 25% action level


Proposed Waste Streams
for
Certification

Proposed Waste Streams

- Battelle of Columbus
- ETEC
- ORNL

Surveillance Procedures

- Performed in accordance with Carlsbad Field Office (CBFO) Management Procedure MP-10.2, *Surveillances*
- This procedure implements the requirements of the CBFO Quality Assurance Program Document (QAPD)

Technical Elements Assessed

- Acceptable knowledge
- Radiological characterization
- Visual examination (VE)

BCLDP Surveillance Overall ConclusionsPath Forward (Con't)

- The surveillance team concluded that BCLDP can quantify the five waste attributes of interest using AK, in concert with visual examination during packaging and dose rate measurements

Comments on The WIPP Remote Handled Transuranic Waste Program

- How difficult will it be to get INEEL authorized for RH-72B shipments? {#138, Glen Longhurst}

    - Response to 138: It would be a bit of a challenge to get the *Be* material certified for the RH-72B. The *Be* would be difficult to get past the HAC analysis. {#161, Clayton Gist}

- What would it take to get INEEL certified to ship *Be* blocks or OSCC using the RH-72B cask. {#139, Brian Anderson}

    - Response to comment 139: The current limit for Co-60 in RH 72-B cask is 32 Ci. The beryllium block when removed from reactor contains about 220 Ci of Co-60. What that means is even if we are certified, *Be* blocks will need about 20 years (or about five half-lives for Co-60) before it can be shipped. Also only one block can be shipped at time. Decay heat can be another problem. {#141, Raj Bhatt}

    - Re 139: ATR currently has 2.5 MCi of Tritium in the *Be* waste in the ATR Canal. WIPP is highly unlikely to accept ATR *Be* waste if their total radionuclide inventory limit is 5.1MCi (from an earlier presentation). {#143, Jeff Brower}

    - Re: 143, 141. If we have to wait 20 years cooling period to ship *Be* components, the Tritium decay from a 12.33 yr half-life will be reduced to less than half, or about 1 MCi, which should help out a bit. {#146, Brian Anderson}

    - Re:139- Once the WIPP Facility is certified to receive the RH, then the *Be* program must go through the certification process and get into line with the other shippers. {#167, Clayton Gist}

    - Re 139- You are correct since we must satisfy the needs of multiple shipping sites and must take that responsibility into consideration while evaluate the needs of the *Be* program. {#171, Clayton Gist}

- I thought I read somewhere that disposal in WIPP was in Rh-72B liner canisters. Is that correct? If not, what containers are used? {#140, Glen Longhurst}

    - Re #140- Yes that is correct, the 72-B canisters are the disposal containers. {#170, Clayton Gist}

- How long is WIPP to be operational? Earlier, we saw where HFIR has another 48 years of life, ATR may have a similar life expectancy. This indicates a beryllium disposal path needed well into the future. What, if anything is planned beyond WIPP? {#145, Kay Adler Flitton}

    - Re 145- The WIPP facility will operate at a near capacity level until the current inventory of legacy waste(both CH and RH waste) has been disposed. This is currently perceived to completed on or about 2015. There after it will operate at a reduced level as long as needed. {#172, Clayton Gist}

- Does all the *Be* in inventory from INEEL and Oak Ridge meet the definition of "defense waste"? {#148, Nate Chipman}

    - Re #148- I don't know. Some of the material has been designated as defense. {#173, Clayton Gist}

- No plans for additional types of casks. {#151, Buck West}

    - Re #151- Correct there are no plans to certify other casks. {#174, Clayton Gist}

- Issue of WIPP closure before *Be* decays enough to allow for placement within total inventory on Curies {#152, Gary Anderson}

- WIPP will close down several years after Hanford is done. But will operate at a reduced level. {#155, Buck West}

- Copy of criteria (letter) for determining defense related. {#157, Gary Anderson} [see Attachment 1]

- Noted it is probable WIPP will remain open longer than 30 years even though currently planned to close earlier by law? Bases or clarification? {#159, Gary Anderson}

    - Re #159- The planned closure of thirty years is a planning date not a commitment by law. {#175, Clayton Gist}

- Comment of a better alternative than WIPP longer term for *Be* disposal (RH-TRU) noted, but not further described. What was/is the alternative? {#160, Gary Anderson}

- How will WIPP RH TRU program coordinate placement of RH TRU with CH TRU program? Will the schedule and logistics of disposing of RH TRU prior to placement of CH TRU exclude acceptance of ATR *Be* reflector blocks that require 20 years of decay prior to shipment to WIPP? {#164, Julie Conner}

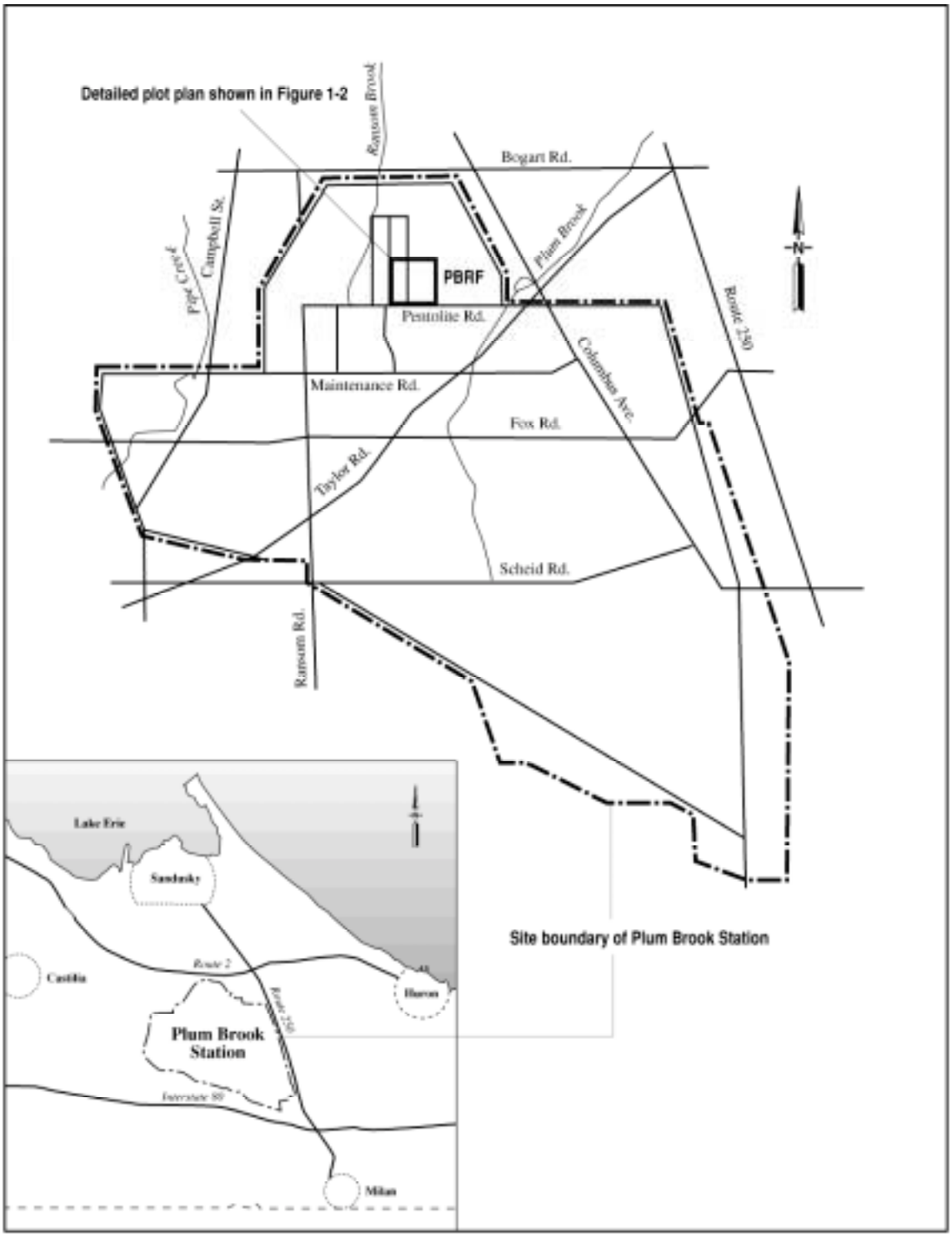
    - Re #164- The RH waste must be in place in a given room in the facility before CH can be put in place. Therefore, time is the enemy of RH placement and the 20-yr. decay time may be an impediment to disposal because of lack of space. {#177, Clayton Gist}

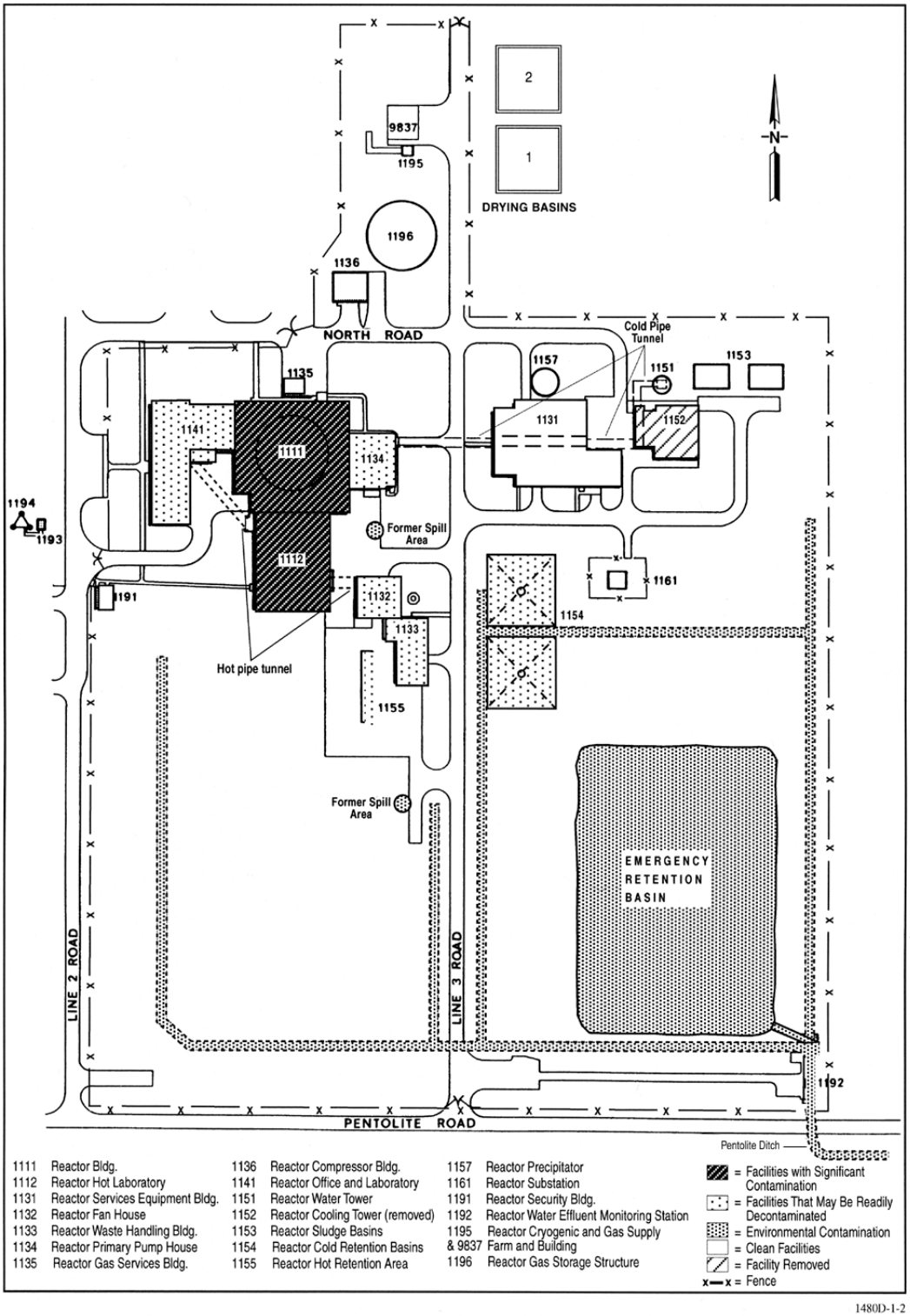
Other comments/presentations as requested by attendees

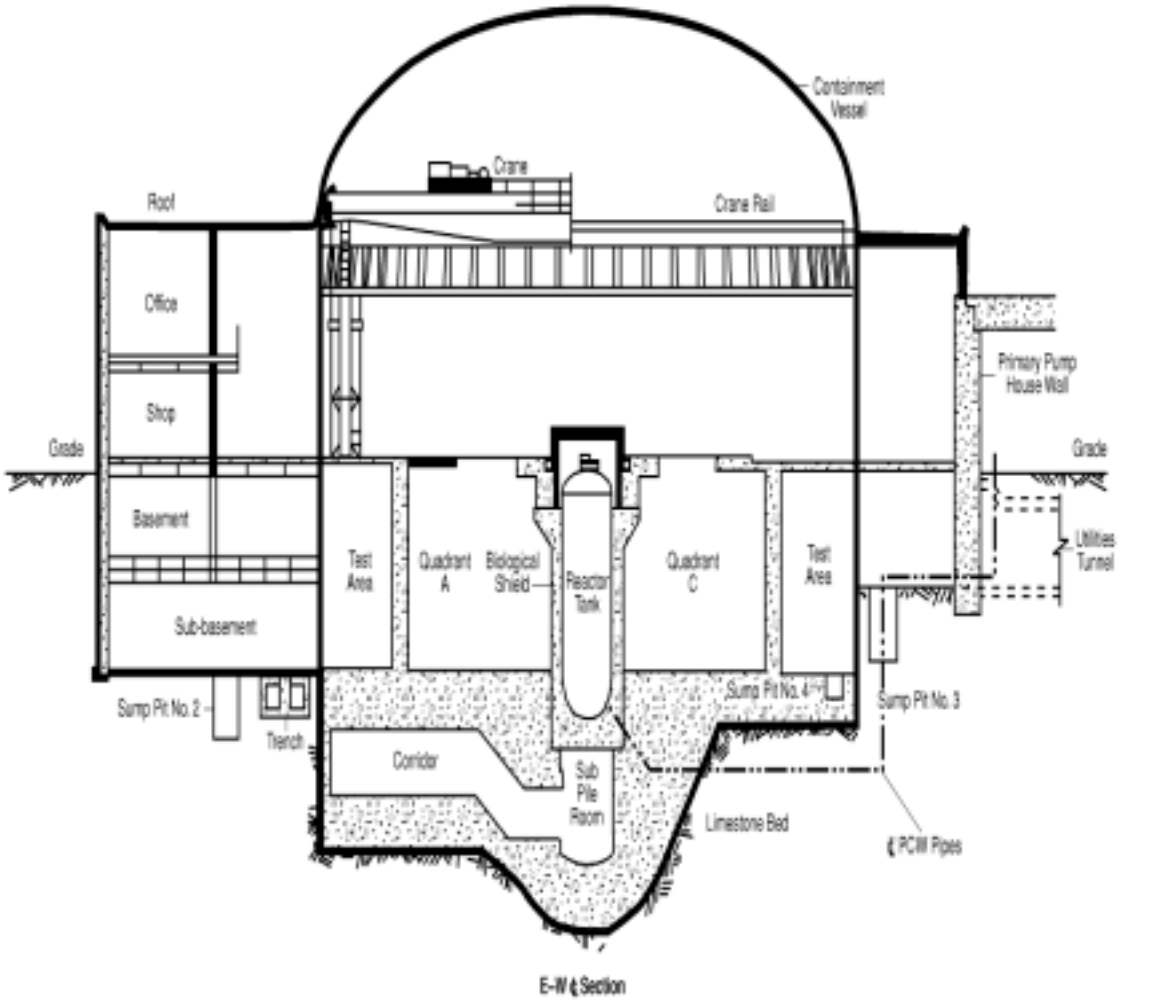
General Comments

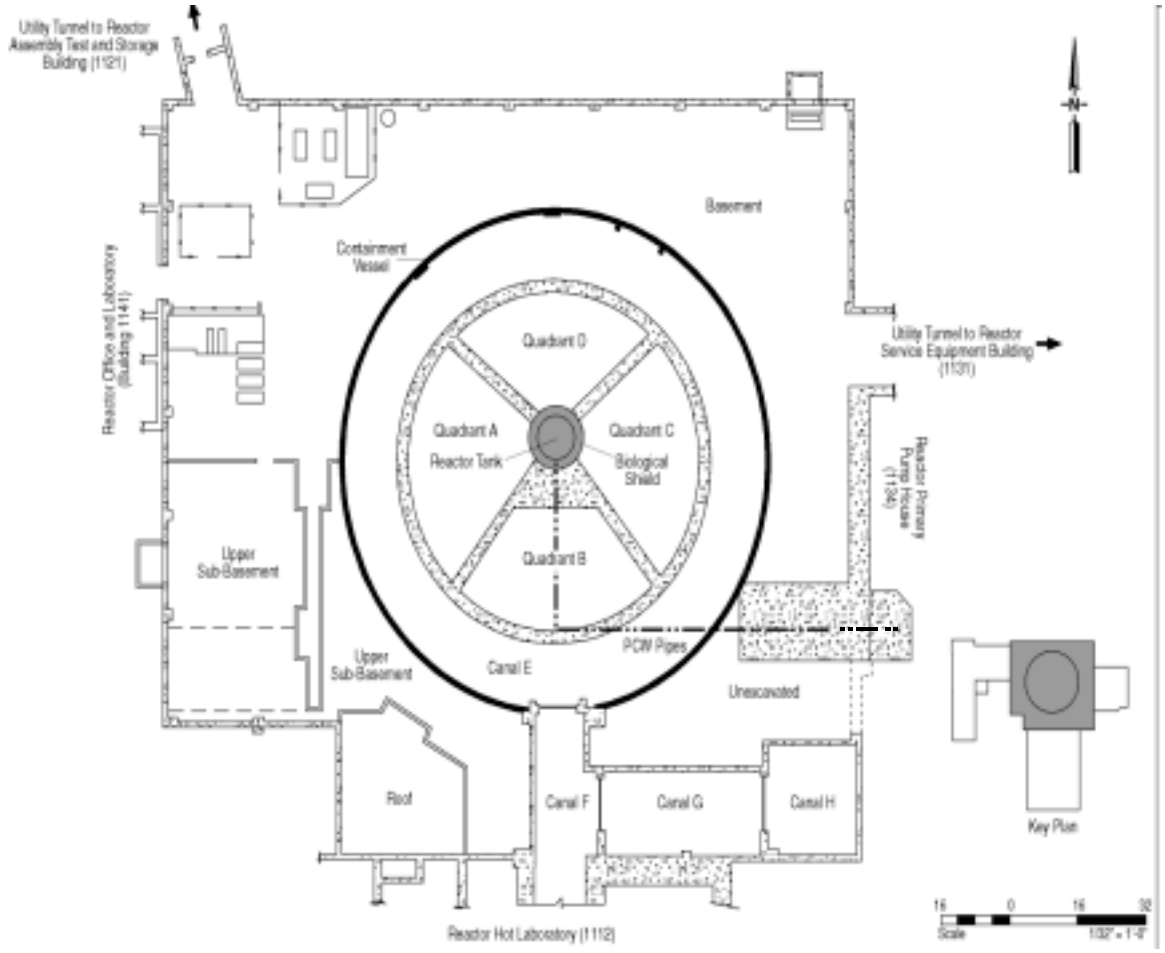
- Is a copy of the slide show presentation(s) going to be forwarded along with the Meeting Notes? {#28, Sheryl Leeper}

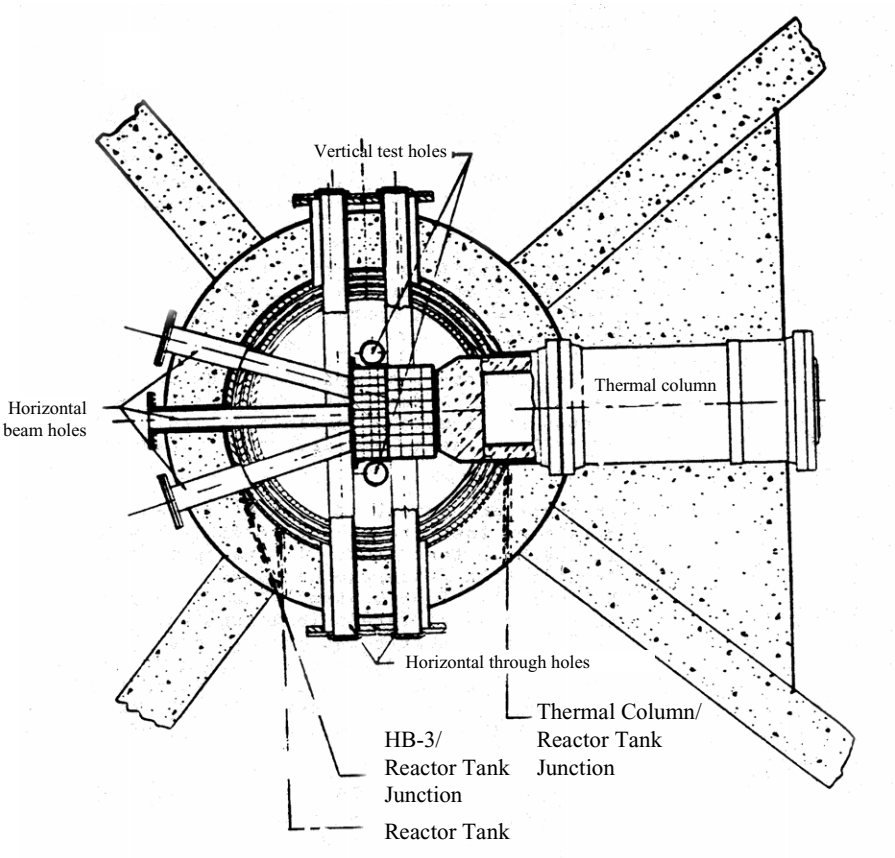
    - In response to #28 - Yes all material will be included in the workshop report. The workshop record will probably be issued as a CD. {#41, Buck West}

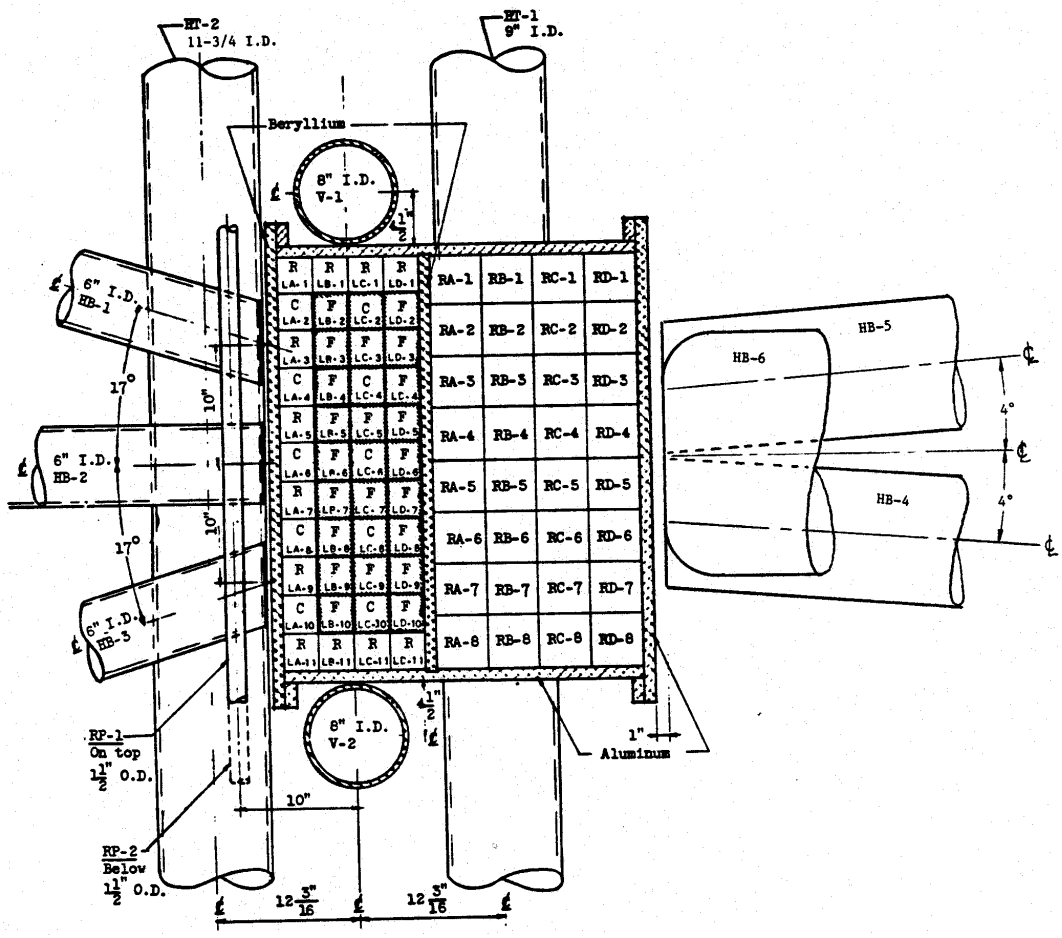

Detailed plot plan shown in Figure 1-2
Ramsom Brook
Bogart Rd.
Pipe Creek
Campbell St.
PBRF
Plum Brook
Pennolite Rd.
Route 250
Maintenance Rd.
Columbus Ave.
Fox Rd.
Taylor Rd.
Scheid Rd.
Ramsom Rd.
Lake Erie
Sandusky
Castalia
Route 2
Huron
Route 250
Plum Brook Station
Interstate 80
Milan
Site boundary of Plum Brook Station
1480D-1

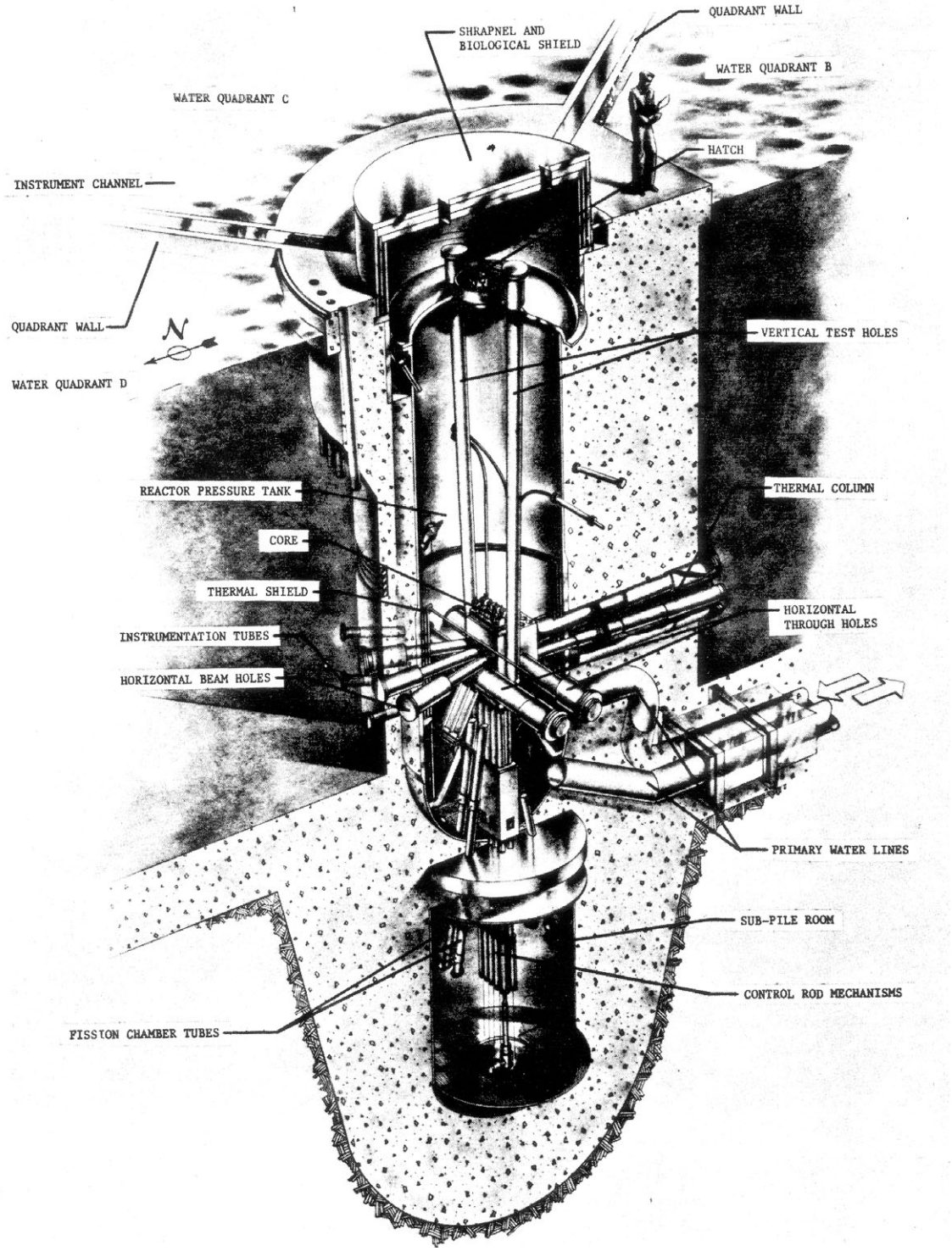

2
1
DRYING BASINS
N
9837
1195
1196
1136
NORTH ROAD
Cold Pipe Tunnel
1157
1151
1153
1135
1141
1111
1134
1131
1152
1194
1193
Former Spill Area
1112
1191
1132
1133
1161
1154
Hot pipe tunnel
1155
Former Spill Area
EMERGENCY RETENTION BASIN
LINE 2 ROAD
LINE 3 ROAD
1192
PENTOLITE ROAD
Pentolite Ditch
1111 Reactor Bldg.
1112 Reactor Hot Laboratory
1131 Reactor Services Equipment Bldg.
1132 Reactor Fan House
1133 Reactor Waste Handling Bldg.
1134 Reactor Primary Pump House
1135 Reactor Gas Services Bldg.
1136 Reactor Compressor Bldg.
1141 Reactor Office and Laboratory
1151 Reactor Water Tower
1152 Reactor Cooling Tower (removed)
1153 Reactor Sludge Basins
1154 Reactor Cold Retention Basins
1155 Reactor Hot Retention Area
1157 Reactor Precipitator
1161 Reactor Substation
1191 Reactor Security Bldg.
1192 Reactor Water Effluent Monitoring Station
1195 & 9837 Reactor Cryogenic and Gas Supply Farm and Building
1196 Reactor Gas Storage Structure
= Facilities with Significant Contamination
= Facilities That May Be Readily Decontaminated
= Environmental Contamination
= Clean Facilities
= Facility Removed
x—x = Fence
1480D-1-2

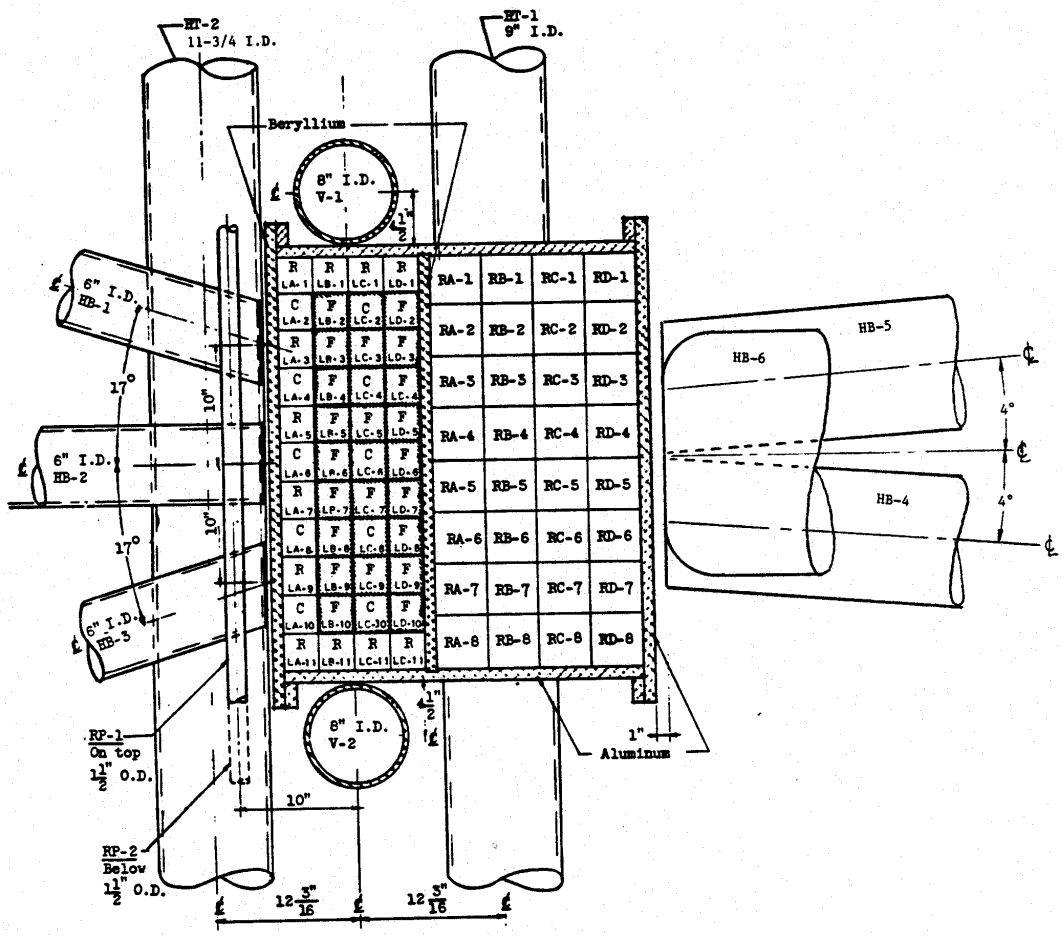

Containment Vessel
Crane
Crane Rail
Roof
Office
Shop
Basement
Sub-basement
Grade
Primary Pump House Wall
Grade
Utilities Tunnel
Test Area
Quadrant A
Biological Shield
Reactor Tank
Quadrant C
Test Area
Sump Pit No. 2
Trench
Corridor
Sub Pile Room
Sump Pit No. 4
Sump Pit No. 3
Limestone Bed
PCW Pipes
E-W ℄ Section


Utility Tunnel to Reactor Assembly Test and Storage Building (1121)
Basement
Containment Vessel
Reactor Office and Laboratory (Building 1141)
Quadrant D
Quadrant A
Reactor Tank
Quadrant C
Biological Shield
Quadrant B
Utility Tunnel to Reactor Service Equipment Building (1131)
Reactor Primary Pump House (1134)
Upper Sub-Basement
Upper Sub-Basement
Canal E
PCW Pipes
Unexcavated
Roof
Canal F
Canal G
Canal H
Reactor Hot Laboratory (1112)
Key Plan
Scale
1/32" = 1'-0"


Vertical test holes
Horizontal beam holes
Thermal column
Horizontal through holes
Thermal Column/ Reactor Tank Junction
HB-3/ Reactor Tank Junction
Reactor Tank


ET-2
11-3/4 I.D.
ET-1
9" I.D.
Beryllium
8" I.D.
V-1
6" I.D.
HB-1
17°
10"
6" I.D.
HB-2
17°
10"
6" I.D.
HB-3
RP-1
On top
1½" O.D.
RP-2
Below
1½" O.D.
8" I.D.
V-2
10"
12 3/16
12 3/16
1"
Aluminum
HB-5
HB-6
HB-4
4°
4°
RA-1 RB-1 RC-1 RD-1
RA-2 RB-2 RC-2 RD-2
RA-3 RB-3 RC-3 RD-3
RA-4 RB-4 RC-4 RD-4
RA-5 RB-5 RC-5 RD-5
RA-6 RB-6 RC-6 RD-6
RA-7 RB-7 RC-7 RD-7
RA-8 RB-8 RC-8 RD-8


QUADRANT WALL
SHRAPNEL AND
BIOLOGICAL SHIELD
WATER QUADRANT B
WATER QUADRANT C
HATCH
INSTRUMENT CHANNEL
QUADRANT WALL
N
VERTICAL TEST HOLES
WATER QUADRANT D
REACTOR PRESSURE TANK
THERMAL COLUMN
CORE
THERMAL SHIELD
HORIZONTAL
THROUGH HOLES
INSTRUMENTATION TUBES
HORIZONTAL BEAM HOLES
PRIMARY WATER LINES
SUB-PILE ROOM
CONTROL ROD MECHANISMS
FISSION CHAMBER TUBES


ET-2
11-3/4 I.D.
ET-1
9" I.D.
Beryllium
8" I.D.
V-1
6" I.D.
HB-1
6" I.D.
HB-2
6" I.D.
HB-3
17°
17°
10"
10"
RP-1
On top
1½" O.D.
RP-2
Below
1½" O.D.
8" I.D.
V-2
10"
12 3/16
12 3/16
1"
Aluminum
HB-5
HB-6
HB-4
4°
4°
RA-1 RB-1 RC-1 RD-1
RA-2 RB-2 RC-2 RD-2
RA-3 RB-3 RC-3 RD-3
RA-4 RB-4 RC-4 RD-4
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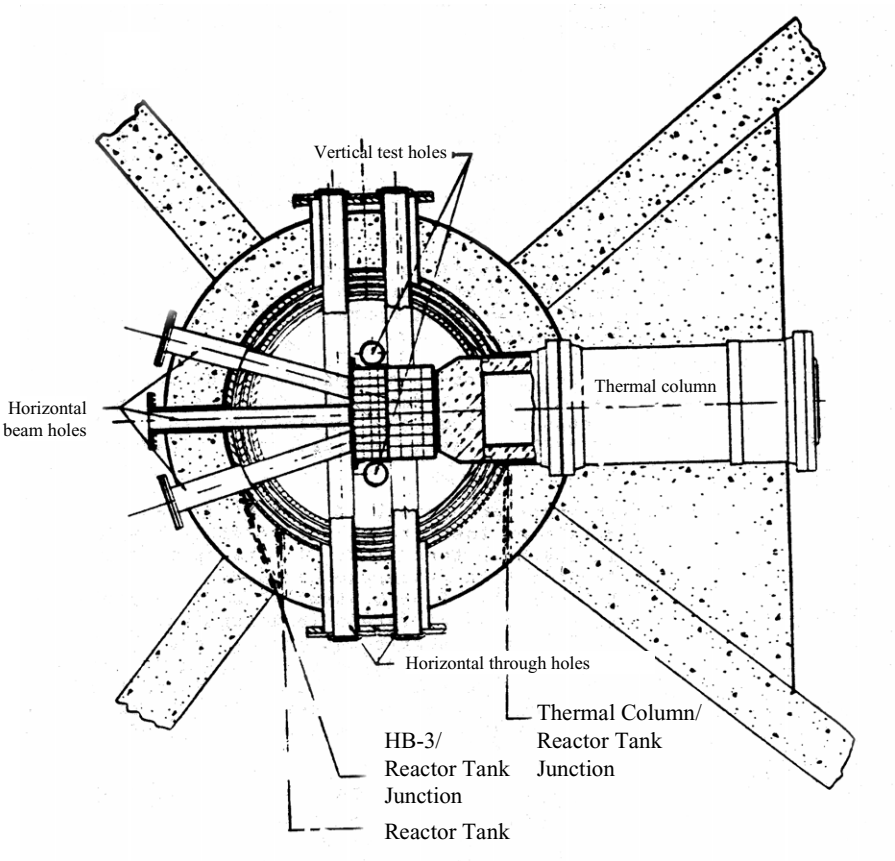
RA-8 RB-8 RC-8 RD-8


Vertical test holes
Horizontal beam holes
Thermal column
Horizontal through holes
Thermal Column/ Reactor Tank Junction
HB-3/ Reactor Tank Junction
Reactor Tank

Comments on Plum Brook Reactor Beryllium

- Reactor was operated from 1962 to 1973. {#162, Buck West}
- *Be* plates will not fit into any commercial transport casks. {#163, Buck West}
- Several unknowns about the *Be* plates and what will happen once they start handling the plates. {#165, Buck West}
- One of the plates was found to be bowed and cracked. This plate is now in hot storage on site. {#166, Buck West}
- At Sandusky, they are in the early stages of studying the plates and described the issues associated with the plates. {#168, Buck West}
- Planned disposal at Barnwell, SC, criteria for disposal of irradiated *Be* likely assumes its low level waste (less than 100 nCi/g transuranics). {#169, Gary Anderson}
- Ritter question - With regard to your smearable tritium problem, have you taken any air samples to see if you have airborne tritium associated with particles and/or water vapor? It wouldn't be too difficult to set up a sampler to pass air through a particle filter and then trap water vapor for analysis. {#179, Paul Ritter}

GUIDED DISCUSSION RESULTS

Problem Definition

What are disposal concerns at facilities such as the High Flux Isotope Reactor (HFIR) and the Missouri University Research Reactor (MURR), which also use beryllium reflectors?

- Many facilities using *Be* reflectors may not be aware of the activated impurities issues. They don't yet recognize a problem may exist with their current disposal path. {#31, Gary Anderson}

- They have TRU waste and are apparently barred from using WIPP. Any other final repository for TRU Waste not known. {#32, Lawrence E. Miller}

- HIFR *Be* to be dispositioned when reactor is closed. That's a long time from now. What disposal facility will be open in 40+ years? {#36, Nate Chipman}

- Does the *Be* from other reactors at Oak Ridge follow the same disposition path as the *Be* from HIFR? {#42, Nate Chipman}

- Characterization of the potential level of radionuclides from activation of impurities is needed for each of the *Be* reflected reactors. Some may not have the potential transuranics problems from Uranium, or the C-14 from nitrogen. {#44, Gary Anderson}

- Depending upon activation and operational flux levels, *Be* components will have differing levels of TRU in contaminants. Need a way to identify what the *Be* contains, and categorize into waste classifications. Need to go back and understand what was already disposed of, to facilitate management of the disposed (buried components). Need to determine interim storage capabilities, and ultimate long term disposal options. {#47, Brian Anderson}

- MURR *Be* inventory is not defense related so the WIPP disposal option is not available. There appears to be no clear path forward for this material. {#54, Nate Chipman}

- There may be other research reactors and foreign reactors in the same situation - no path to disposal - DOE has an agreement with some research and foreign reactors for the spent fuels, could the beryllium be included? {#91, Kay Adler Flitton}

- Disposal concerns at ORNL are a lack of home for the waste materials. We addressed the problem by initiating agreements to transfer the reflectors to temporary storage on-site. The agreement requires the reflectors to be returned to the generating facility prior to or immediately after reactor shutdown. {#57, WEHill }

- Current disposal sites, e.g. Barnwell in USA, and other locations around the world, accepting irradiated *Be* as RH LLW may not recognize that the materials may be greater than class C for various reasons (transuranics, carbon-14 sum of nucllides) {#58, Gary Anderson}

- First there are sampling concerns (or modeling) to determine if TRU exists and at what levels. Next - If high TRU then where can the materials be disposed. If under NRC license (like MURR) then WIPP cannot accept. Presently, there are no disposal locations that can accept, so then where do you store/stockpile the materials onsite for a prolonged period of time. Key issue is to begin writing campaign to include this type of waste at Yucca Mt. {#60, Sheryl Leeper}

- MURR has an irradiated reflector in storage in the reactor pool that was removed in 1997. It was in the reactor for 26,000 MWD's. The reflector in operation now will be removed in 2005. With the new awareness of potential TRU and C14, a disposal path needs to be identified. {#62, Charlie McKibben}

- PBRF - #1 Identify original chemical assay information for beryllium plates currently in the defueled core. (Intent is to rule out TRU disposal concern).

  #2 Rule out Part 61and TRU nuclides of concern through physical sampling. This requires engineering assessment and development of "in-place" sampling techniques (i.e. underwater vs. remote handling without water shielding, sample technique that doesn't risk fracturing *Be* plates without complicating dismantlement, etc.).

  #3 Identify all commercial burial site requirements and appropriate burial containers (preferably avoiding *Be*-plate size reduction) for H-3 associated with beryllium plates. {#71, Bryan M. Moyers}

- Question: PBRF is in the process of establishing all burial site relationships. Is it now appropriate to discuss the TRU and C-14 issues with commercial burial sites, or is it best to wait for an official DOE/Scientific position to be published? {#84, Bryan M. Moyers}

What inventories of irradiated beryllium, other than at operating reactors, will need to be disposed of?

- Conceptual fusion reactors will be using rather massive quantities of *Be*, perhaps as much as several tens of cubic meters each. This material will also become irradiated and require disposal. {#28, Glen Longhurst}

- Legacy *Be* from shutdown or decommissioned reactor facilities such as the Materials Test Reactor (MTR) and the Engineering Test Reactor (ETR). {#33, Jeff Brower}

- Beryllium core components in the MTR and ETR and ETRC reactors at the INEEL. Components from previous ATR cores currently stored in the canal. {#35, David Gibby}

- At the INEEL, other significant inventories include *Be* from the Materials Test Reactor and the Engineering Test Reactor. {#39, Julie Conner}

- INEEL ETR, MTR, and ATRC, at D&D. Some inventories may be characterized as LLW or TRU. Thus needing two different waste stream disposal paths. {#40, Carlan Mullen}

- *Be* from low power critical facilities. Do these low power facilities have the same issues as the high power facilities? {#41, Jeff Brower}

- Older shut reactors, such as ETR, MTR, Plum Brook contain irradiated *Be* components. {#53, Brian Anderson}

- A future generator which hasn't been discussed is the Spallation Neutron Source in Oak Ridge. This facility comes on-line in 2006 and has a lot of beryllium reflector material which will become activated. Other sources could include buried material which is retrieved. {#64, WE Hill }

- ATR has two other kinds of beryllium not discussed at this work shop. Beryllium capsules from early years of operation and i hole capsule plugs the capsules are small quantities (grams) The I-hole plugs are 3 to 5 inches diameter and 50 inches long, that are no longer used, but not yet declared as waste. {#87, Charles Brooks}

- PBRF has a total of 9 plates, for an estimated weight total of less than 4000 lbs. {#89, Bryan M. Moyers}

- Potentially hundreds to thousands of sealed neutron sources (Pu*Be*). Los Alamos had a program to retrieve and disposition. There may be some cross over to this workshop. {#95, Nate Chipman}

What concerns exist for irradiated beryllium that has already been disposed of as low-level waste assuming it is TRU but not RCRA hazardous?

- The identification of irradiated beryllium being classified as TRU waste will necessitate additional analysis and modeling for Performance Assessments (PA)s and Risk Assessments (RA)s at the burial grounds and disposal areas. {#37, Kay Adler Flitton}

- Will it be "grandfathered" and left where it is or will it have to be retrieved and disposed of under current EPA rules? {#38, Lawrence E. Miller}

- It makes no difference if it is "pure TRU" or mixed TRU. Based on agreements with the regulators, if it comes to WIPP it will be subject to the regulatory requirements of the RCRA Permit. {#49, Clayton Gist}

- Commercial low level waste disposal facilities will need to do an assessment as to whether they legally can dispose of the now TRU waste, whether they can get an exemption of some kind for the legacy disposal, or whether they need to remediate the disposals. {#50, Kay Adler Flitton}

- Financial and political liability. Release of TRU constituents to and transport within the environment. Potential retrieval and storage. {#55, David Gibby}

- Characterize the waste as to risk to public, workers, and environment, per CERCLA, or as agreed to with local or state regulatory agencies having primacy. Follow prescribed processes

to complete Risk Assessments, RI/FS, and ROD processes as to how to address the material. Concerns exist such as irradiation history, contaminants in the *Be*, length of time for decay, buildup, etc. {#68, Brian Anderson}

- At the INEEL SDA the disposed beryllium will be included as part of the radiological source term in the WAG-7 Comprehensive RI/FS under the interagency agreement under CERCLA. Where beryllium has been disposed at commercial disposal facilities the beryllium that has been disposed should be characterized with the new TRU information and then if found to be TRU then appropriate actions should be taken. I have no idea what the actions might be if the beryllium is TRU. As far as real risk from the beryllium if TRU they likely will not be too great because the levels of TRU in the beryllium are small. {#70, Carlan Mullen}

- Yesterday's discussion resulted in a couple of questions on transport issues related to disposed irradiated beryllium. The mobility of beryllium in the underground environment and hence the radionuclide release were addressed. Currently, the state of knowledge is insufficient to determine whether "hot-spot" remediation should take place or whether the legacy burials should remain undisturbed. There is a need to obtain further scientific data from the field to help determine a path forward. {#72, Kay Adler Flitton}

- The Pit 9 agreement with the State of Idaho provides for a legal interpretation by the Court's on the applicability of buried waste to the Idaho Settlement Agreement. If buried waste is included in the Idaho Settlement Agreement, how will this affect the path-forward? {#73, Julie Conner}

- When does a material become TRU? If it's not TRU at the time of generation can it be called non-TRU, even if analyses show it will be TRU in 30 years. {#74, WE Hill }

- Mobility of TRU in the environment. The materials may be corroding but is the *Be*, and more importantly the nuclides, moving through the environment and creating conditions above acceptable risk levels {#77, Sheryl Leeper}

- The RI/FS for the SDA at the INEEL is scheduled for release very soon. Is this new characterization information significant enough to delay in the issuance? {#80, Kay Adler Flitton}

- If the legacy burials were to be recovered, where would they be stored? Would they just go directly to WIPP? {#82, Kay Adler Flitton}

What is a reasonable upper bound on expenditures to identify a disposal solution? What is the total life-cycle cost attributable to beryllium using presently available or foreseeable material grades and disposal methods?

- A reasonable upper bound to cost should be the cost of the beryllium components. To spend more on it would not be cost effective. Total life cycle cost should factor in the cost of replacement components for the future lifetime of the particular reactor, plus the disposal cost. {#34, Loren Jacobson}

- We should be willing to spend at least as much on finding a solution as the financial threat posed by the problem. If failure to find a solution would mean a reactor must shut down, then a modest fraction of the value of the mission of that reactor would not be an unreasonable sum to spend finding a solution. {#43, Glen Longhurst}

- Can MURR continue to dispose of irradiated *Be* at Barnwell. {#63, Glen Longhurst}

- What implications exist for Barnwell when they learn they may have accepted TRU waste. {#67, Glen Longhurst}

- The lower bound is far more obvious. No action is the minimum cost. {#69, Jeff Brower}

- What will be required by either ATR or HFIR before they would order a beryllium reflector fabricated from S-65 material? {#75, Charlie McKibben}

- I think the upper limit on expenditures is dependent upon what are the ramifications of no path forward for beryllium disposal. If that meant that ATR could not continue to operate within regulatory limits, the funding limit would be higher than if the impact were only that interim storage would be required. {#76, Charles Brooks}

- I believe it is a national need to keep materials test reactors in operation. This is apparent at ATR because of the continued support and the operational planning assumption (2050) being used. Therefore interim storage costs for 100 years should be upper bounds for evaluating disposal option solution costs. {#79, Carlan Mullen}

- Logic has been eliminated from environmental solutions by law. A reasonable upper bound on the cost would be as prioritized by risk to public, workers, and environment, compared to all other risks at the site, or even within the DOE complex. Life cycle costs could be substantially reduced by procuring higher quality material up front that will eliminate the TRU waste problem after irradiation. Existing separation processes to remove TRU contaminants and tritium from *Be* components after irradiation would provide a renewable source of material that appears to be in extremely short supply. {#83, Brian Anderson}

- An upper bound needs to be established based on a life-cycle cost analysis. Multiple options including recovery of H-3 and TRU should also be evaluated. Storage costs (for decay prior to disposal) should also be considered; as well as, the cost of replacing the *Be* reflectors at intervals that allow the TRU concentrations to remain below TRU limits. {#88, Julie Conner}

What is the problem?

- Long term supply of high quality beryllium for DOE applications. {#29, Don Kaczynski}

- The disposition of *Be* in a logical and effective manner. In this process both the disposal and recycling aspects of the problem should be considered. {#30, Clayton Gist}

- The problem seems to have arisen from the fact that it was not appreciated what would happen to various beryllium impurities following long term in-reactor exposure. Then the problem became how to dispose of beryllium with radioactive constituents that it did not have before. {#45, Loren Jacobson}

- The problem is finding what is required to keep high performance research reactors operating so that they can provide their unique contributions in science and technology that increases quality of life. This includes educating decision-makers to what is at risk and what reasonable solutions are possible. {#46, Charlie McKibben}

- The problem is facilities are generating waste materials that are not addressed by regulations and/or protocols for disposal. This has resulted in materials like activated beryllium becoming orphaned at generator sites due to a lack of a disposal path. {#48, WE Hill }

- ATR has SEVERAL potential problems. 1. What is the path forward for disposal of beryllium components? 2. What is the best interim storage option? 3. Is there a problem with continuing to generate the waste if there is no immediate path forward for disposal? {#51, Charles Brooks}

- There is no approved path forward for the disposal of radiated *Be* waste. {#52, Jeff Brower}

- The problem is that we apparently don't have a life cycle management strategy/plan within DOE for procurement, use, and final disposition of *Be* in all its applications with in DOE. Also, the various grades of *Be* available and the varying impurity contents just muddy the waters and make things complicated for applications where *Be* is irradiated, mostly as reactor reflectors. {#56, Lawrence E. Miller}

- The source for new *Be* contains impurities which are not acceptable for reactor applications. Is there a cost effective method for removing these impurities? {#61, Jeff Brower}

- Apparently there is no path for ensuring that we have a domestic supply under U.S. control after 2011. Appears to be a "strategic material" which is not being recognized as such by senior Administration Officials or Congress. Needs to be treated as a strategic asset. {#65, Lawrence E. Miller}

- While working the path forward for disposal, what legal/regulatory obstacles exist that would potentially threaten or delay continued operations that generate *Be* waste (core internals change-out at the ATR)? {#66, Bruce Criswell}

- It appears we have no path for disposal of irradiated beryllium because of the combined transuranic and gamma-field issues. We seem to be unsure whether that situation threatens continued reactor operation. There is a need for an organized program with sufficient support to find a way to (1) fit this material into an existing pathway, (2) modify material already irradiated so it will fit into an existing pathway, and (3) prevent future problems by removing its cause. {#81, Buck West}

- The path for dispositioning *Be* could cross several DOE "stovepipes". *Be* inventories have been generated at "defense" related facilities, they may now be held in EM "owned" or operated facilities or sites, and the disposal path is to an "RW" repository. Who owns the problem, and who pays for any R&D, packaging, shipping, and disposal? {#78, Nate Chipman}

- Why dispose of these materials in unretrievable sites -- why not dispose of at sites where the materials can be retrieved and potentially reused in the future (once technology catches up for removal of impurities, use with impurities, etc.) {#85, Sheryl Leeper}

- Will this "new" issue with its associated potential costs adversely impact reactor programs/operation? {#86, David Gibby}

- The disposal path problem is larger than beryllium waste. There are numerous waste streams without a disposal path that are activated. Many of these waste streams would have the same or similar disposal paths if they could be worked together. (High activity SST, Inconel, graphite, beryllium) {#90, Carlan Mullen}

- 1) How do we make sure that continued reactor operations with existing *Be* components on hand and planned to be used is legally and regulatorily approved? 2) What do we do about the buried *Be* components to comply with existing environmental regulations? 3) What do we do with the irradiated *Be* components that are in storage currently, or that will be generated in the near future, as to compliant interim storage and ultimate long term Treatment, Storage, or Disposal, hopefully in that order? 4) Is there a cost effective way to eliminate the source of the problem for future *Be* components, so that the current TRU disposal dilemma can be avoided? {#97, Brian Anderson}

General comments

- There are other metals that do not have disposal path similar to *Be*. The problem is larger than just *Be*. {#94, Buck West}

- Before everyone gets hung up on "disposal" of irradiated *Be* material, we should consider options for treatment for recycle, and retrievable storage, before we get locked into non-retrievable disposal. {#96, Brian Anderson}

- At one time there was a beryllium coordinating committee that included representation of all users and producers. It would be useful to re-establish this committee. {#98, Loren Jacobson}

- Beryllium strategy committee, with representatives of the government departments with concerns, was disbanded - perhaps this needs to be implemented again. (comment from Loren Jacobson) {#99, Kay Adler Flitton}

Problem Consequences

What are the feasibility, cost, and programmatic impact if "Defense" classification is required for research reactor beryllium to be disposed of at WIPP?

- Prog: Defense classification could open the door to DNFSB oversight at TRA. {#101, Brian Anderson}
- Cost: Doubtful this would be significant. {#104, Brian Anderson}
- I believe ATR waste beryllium could be classified as defense related waste, even though ATR is not a defense related facility. If true, there is no impact to ATR. {#106, Charles Brooks}
- Feasibility: Not considered a major obstacle. {#107, Brian Anderson}
- WIPP is a valuable asset to the US for disposition of TRU waste. Shipping just one HFIR permanent beryllium reflector to WIPP would use up 5% of their total curie allocation for about a micro-curie of TRU. It's hard to justify utilizing a valuable resource like WIPP in that manner. WE Hill {#114, WE Hill}

What would be the consequences of failing to move now to resolve issues of disposal for irradiated beryllium?

- Generator facilities, field office capabilities (hot shops and cells) are being D&D'd which may be important to the strategy needed to disposition beryllium. {#102, Carlan Mullen}
- No path forward for disposal would impose interim storage. Right now the available storage is limited. What would be the costs for developing interim storage facilities? How would the storage facilities be regulated? {#110, Kay Adler Flitton}
- We seem to have accepted for years the philosophy that our successors will be able to deal with these issues more successfully than we can. {#111, Glen Longhurst}
- Long term interim storage costs at generator sites will continue at higher life-cycle costs than eventual disposal. I think we just have to look at spent fuel and high level waste as examples of cost the problems. The only difference is the beryllium is a fairly small volume and appears to have less health and environmental release risk. {#112, Carlan Mullen}
- There is a process to authorize continuing operation with no path to disposal. This is deemed doable for the current CIC cycle. Failure to identify a path to disposition could eventually preclude continuance of reactor operations. {#113, Brian Anderson}
- Path forward to disposal may close--such as missing dates for inclusion of material in license application for HLW repository. {#115, Nate Chipman}

- Cannot under DOE rules continue to generate a waste with no path for disposal (can continue to generate while developing a path). Reactor or other operations generating such a waste could not continue. {#116, Gary Anderson}

- This could eventually cause the shutdown of major irradiation reactors that are now being used to produce radioisotopes that are being used in new radiopharmaceuticals that are showing success in treating cancer and adding quality of life those suffering from cancer. {#118, Charlie McKibben}

- Individual generator problem solving will likely cost much more than a national solution. With out a national solution individual generators will solve the immediate storage problem to allow continued operation to meet programmatic objectives. {#119, Carlan Mullen}

- Reactors that generate *Be* with "no path to disposal", i.e. orphan waste may be unable to continue operations. An exemption to allow continued production of "no path to disposal" waste will likely be attainable in the near-term (as long as there is an active program to develop a disposition path). However in the long-term; this issue may shut down reactor operations. The consequence would be that the U.S. would loose the capability to perform nuclear fuel and material research; and, produce medical and strategic isotopes. {#120, Julie Conner}

- Allowing this problem to languish without progress to resolution will increase likelihood of higher level decisions to eliminate the source of the problem. {#121, David Gibby}

- Increased cost associated with short/intermediate term storage. Another potential negative public relations issue. {#123, Bruce Criswell}

- There is no immediate consequence for interim wet storage of irradiated beryllium storage. Efficient use of deep section of the ATR canal, using stackable containers will allow atr to operate for another 50 years. The concern is a regulatory question, i.e., whether we shall be allowed to continue storing it in the canal and continuing reactor operations. We do no believe it is necessary to store the beryllium dry and that would be costly solution, particuarly if the waste beryllium must later be repackaged to meet transportation and/or final destination site packaging requirements. {#130, Charles Brooks}

- Negative stakeholder (public and regulatory) perceptions of DOE would arise, that ultimately impact continued operations funding and future nuclear operations. Public and Regulators perceptions of DOE would again be that DOE is attempting to avoid dealing with a problem {#131, Gary Anderson}

- New reactors utilizing this material may be hindered from being developed if life-cycle issues such as disposal paths are not resolved. Our aging nuclear infrastructure may rely on solving this issue if we, as a country, pursues future nuclear energy options. {#132, Kay Adler Flitton}

If a disposal pathway cannot be found, can reactors continue to generate this waste stream?

- There should be a way to ensure continued operation provided work is in progress to find a solution. {#105, Glen Longhurst}

- DOE Orders provide a mechanism for continued generation of waste with no identified path for disposal where programmatic need justifies the continued generation. This will allow for continued operation of the reactors in the near term. However, work needs to progress on identifying a viable disposal path or operation of affected reactors in the future could be impacted. {#108, David Gibby}

- There is a process to obtain authorization to continue to generate a "waste with no path to disposal." TRA is pursuing this process, and expect to obtain relief to support the next CIC cycle. Beyond that, there is no guarantee we could get another exemption. Hopefully by then, there will be a new management strategy that will identify a disposition path. {#128, Brian Anderson}

- In the near-term an exemption can likely be sought and approved. However, progress must be demonstrated toward developing a disposition path in order for the federal government to continue to allow generation, i.e. replacing *Be* in operating reactors. {#134, Julie Conner}

What are the consequences of the problem(s)?

- The political sensitivities about continued reactor operations may be exacerbated by disclosure of this additional complication. Some may push strongly to close the reactors now rather than waiting several decades. That still leaves already disposed material and currently on-hand material to deal with. {#103, Glen Longhurst}

- Loss of domestic beryllium metal supply, and loss of operational reactors needing beryllium could result from failure to address the problems raised by this group. However, other potential users of beryllium would also be affected, and should be weighing in soon on their own supply issues. Again, this entire situation should stimulate formation of a national beryllium coordinating committee to bring appropriate focus on the problem and obtain attention of high level decision making authority. {#109, Loren Jacobson}

- There may be substantial cost impacts at DOE disposal facilities (e.g., RWMC) and at commercial facilities (e.g, Barnwell, SC) for remediation. {#117, Glen Longhurst}

- This is a low volume waste stream with high cost consequences if not solved in the immediate future. {#122, Carlan Mullen}

- Long term Regulatory Constipation of Operating Reactors without adequate storage space for materials that cannot be dispositioned. Eventual inability to continue operation. Lack of future domestic supply of unirradiated *Be* metal, forcing purchase from unreliable sources. Performance fails to meet national security needs without *Be* metal for future systems. {#124, Brian Anderson}

- HFIR looked at replacing the reflector with heavy water prior to this latest beryllium outage. The logistics, costs, and other impacts were of a magnitude that we kept the reactor beryllium reflected. Neutronically, it is essential to continued operation. Consequences of loss of beryllium supply are potentially severe. It is not clear that a supply problem is imminent, a domestic supply loss may be imminent. On-site storage will be the consequence of not solving the problem. {#125, WE Hill}

- Opportunities will be lost or not identified if a national strategy for beryllium disposition is not developed to guide the individual generators in managing the beryllium disposal. {#126, Carlan Mullen}

- Eventually cripple or completely shutdown many highly sensitive and strategically important defense and basic research programs within DOE, DOD, and NASA that would cascade down to cause negative impacts on other important areas for the U.S. {#127, Lawrence E. Miller}

- If reactors utilizing *Be* cannot continue operation, what are the consequences to the Navy, national defense, educational research, future education of a new generation of nuclear engineers, etc.? Pick any one, its like "for lack of a nail a war was lost" {#129, Nate Chipman}

- Higher disposal costs would result in higher costs to customers. {#133, David Gibby}

Can the problem(s) be prevented, mitigated, or resolved?

- Dispose beryllium at Yucca Mt. instead of WIPP. While not intended for disposal at Yucca, special case waste was analyzed and it was not specifically excluded. The key at this point will be to work with Yucca as they prepare the permit application. {#17, Buck West}

- Reprocessing of used material. {#153, Buck West}

- Find and use an alternative to beryllium for reflectors in reactors. {#154, Buck West}

What actions should we be taking?

- eek and develop a national/international program that can support education, research, negotiations, etc.

- In order to get high level attention and political support; the affected agencies should acquire an independent organization like NAS, etc to evaluate the problem and propose a solution. {#149, Julie Conner}

National strategy for beryllium supply and cycle.

- Develop methods for removing undesired impurities before use {#141, Loren Jacobson}

- define/characterize the existing problem inventory of *Be* waste via modeling and sample analyses {#142, Gary Anderson}

- Develop interim storage facilities for irradiated *Be*. {#143, Jeff Brower}

- Pursue disposal of irradiated *Be* at Yucca Mt. {#145, Jeff Brower}

- Formulate a National life-cycle strategy prepared by the beryllium coordination committee. (INEEL take the lead in preparing a proposal (scope, cost and schedule) that starts up the coordination committee) {#146, Carlan Mullen}

- Develop interim storage standards and practices that would allow for the safe storage of material (perhaps dry storage) until a strategic plan including recycle and disposal can be formulated and implemented. {#148, Nate Chipman}

- Define practical disposition options/paths and requirements/barriers to acceptance for current stored and near term generated. {#151, Gary Anderson}

Establish a beryllium coordinating committee to develop a national strategy for supply, use, and disposition of beryllium.

- National Working Group to educate the Nation on Strategic *Be* Needs. {#139, Brian Anderson}

- Re-establish the beryllium Coordinating Committee {#137, Loren Jacobson}

- This problem is too big for this two day session to come up with any solution. This two days has been invaluable in sensitizing me to the problem. Establish a *Be* Working Group with membership of all stakeholders to hold a series of meetings with the goal of preparing a straw-man national strategy for *Be* procurement, application and disposal along with complete justifications. This straw-man would be used to inform the high-level decision-makers. {#150, Lawrence E. Miller}

Seek exemption for disposal of existing beryllium based on low risk and small quantities, while pursuing new beryllium that is free of undesirable impurities.

Develop/provide interim guidance to generators in the short term until a national strategy can be developed.

DOE F 1326.8
(8-89)
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United States Government Department of En

memorandum

DATE: October 17, 1996

REPLY TO ATTN OF: EM-36

SUBJECT: Implementation Guidance Concerning "Atomic Energy Defense Activities" as Used in the Waste Isolation Pilot Plant Land Withdrawal Act

TO: Distribution

The purpose of this memorandum is to provide guidance concerning the meaning of the term "atomic energy defense activities" as used in the Waste Isolation Pilot Plant (WIPP) Land Withdrawal Act (LWA). Under the LWA, WIPP is authorized to receive for disposal only materials generated by atomic energy defense activities. After reviewing the relevant statutes and legislative history, the Office of General Counsel (GC) has concluded in the attached memorandum that the term "atomic energy defense activities" as used in the LWA has the same meaning as provided in section 2 of the Nuclear Waste Policy Act of 1982 (NWPA) (42 U.S.C. §10101). Under the NWPA definition, atomic energy defense activities cover defense activities and related cleanup activities, performed in whole or in part, in carrying out the following functions:

- naval reactors development;
- weapons activities including defense inertial confinement fusion;
- verification and control technology;
- defense nuclear materials production;
- defense nuclear waste and materials by-products management;
- defense nuclear materials security and safeguards and security investigations; and
- defense research and development.

This definition does not extend to materials generated by DOE's purely civilian atomic energy activities and programs.

At sites where civilian and defense TRU waste, generated in the past, has been commingled for storage and the defense portion cannot be separated out for disposal, the commingled waste can be disposed of at WIPP because the storage activities at these sites historically have been performed in part to carry out defense nuclear waste management and, therefore, fall within the NWPA definition. For the future, however, to remain faithful to the congressional intent, TRU waste generated in defense nuclear activities should be segregated from TRU waste generated in civilian nuclear activities, and only the defense portion should be shipped to WIPP.

The attached interpretation of the term "atomic energy defense activities" represents the Department's position on TRU waste disposal at WIPP. DOE sites preparing TRU wastes for disposal at WIPP shall carry out their activities in accordance with this guidance and the attached interpretation.

Stephen P. Cowan
Deputy Assistant Secretary
for Waste Management
Environmental Management

Attachment

DISTRIBUTION:

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Department of Energy
Washington, DC 20585

September 9, 1996

MEMORANDUM FOR: AL ALM
ASSISTANT SECRETARY
FOR ENVIRONMENTAL MANAGEMENT

GEORGE DIALS
MANAGER
CARLSBAD AREA OFFICE

FROM: ROBERT R. NORDHAUS
GENERAL COUNSEL

SUBJECT: Interpretation of the Term "Atomic Energy Defense Activities" As Used In the Waste Isolation Pilot Plant Land Withdrawal Act

INTRODUCTION

The Department of Energy (DOE) is proposing to begin the disposal phase at the Waste Isolation Pilot Plant (WIPP), the nation's first deep-geologic nuclear waste repository, in 1998. A question has arisen concerning the meaning of the term "atomic energy defense activities" as that term is used in the Waste Isolation Pilot Plant Land Withdrawal Act (LWA), Pub. L. No. 102-579, 106 Stat. 477 (1992), to define the source of waste that may be disposed at WIPP. The purpose of this memorandum is to determine the scope of that term so that the Office of Environmental Management and the Carlsbad Area Office can provide technical guidance to the sites around the complex as to what transuranic (TRU) waste qualifies for disposal at WIPP.

FACTUAL BACKGROUND

In 1979, Congress authorized WIPP as a "research and development facility to demonstrate the safe disposal of radioactive waste resulting from defense activities and programs of the United States." Department of Energy National Security and Military Applications of Nuclear Energy Authorization Act (DOE National Security Act), Pub. L. No. 96-164, § 213 (emphasis added). On July 1, 1981, DOE agreed with the State of New Mexico to limit WIPP to the disposal of defense transuranic waste.[1]

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[1] The Agreement for Consultation and Cooperation between DOE and New Mexico settled the litigation known as State of New Mexico v. Dep't of Energy, Civil Action No. 81-0363 JB. Among other things, the Agreement excludes "any radioactive waste generated by the commercial nuclear power industry" from its definition of WIPP eligible "defense waste." Article II - Definitions at E.

On October 30, 1992, Congress enacted the LWA, withdrawing the land surrounding WIPP for exclusive use by DOE and expressly defining WIPP's mission as the disposal of transuranic waste generated by "atomic energy defense activities:"

> The term "WIPP" means the Waste Isolation Pilot Plant project authorized under section 213 of the Department of Energy National Security and Military Applications of Nuclear Energy Authorization Act of 1980 (Pub. L. 96-164; 93 St. 1259, 1265) to demonstrate the safe disposal of radioactive waste materials generated by atomic energy defense activities.

Pub. L. No. 102-579, § 2(21) (emphasis added).[2]

DOE has historically defined the TRU waste eligible for WIPP as follows:

> Defense waste
> Nuclear waste deriving from the manufacture of nuclear weapons and operation of naval reactors. Associated activities such as the research in the weapons laboratories also produce defense waste.[3]

Recently, the Carlsbad Area Office has suggested, based upon its reading of the Atomic Energy Act of 1954 (AEA), 42 U.S.C. §§ 2011, et seq., that for purposes of determining what waste qualifies for WIPP, the term "atomic energy defense activities" as used in § 2(21) of the LWA could be interpreted to include any transuranic waste generated by any DOE atomic energy activity. Under the suggested interpretation, only TRU waste generated by the commercial nuclear power industry would be barred from WIPP, and that by operation of the 1988 Agreement between DOE and New Mexico, not by the definition in § 2(21). This suggestion is derived from a portion of the Congressional declaration of policy in the AEA at 42 U.S.C. § 2011(a) ("...the development, use and control of atomic energy shall be directed so as to make the

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[2] TRU waste is waste that contains alpha particle emitting radionuclides with atomic numbers greater than that of uranium (92), and half lives greater than 20 years, in concentrations greater than 100 nanocuries per gram of waste. TRU waste is primarily generated by research and development activities, plutonium recovery, weapons manufacturing, environmental restoration, and decontamination and decommissioning projects.

[3] See, e.g., First Supplement to the WIPP Environmental Impact Statement (SEIS I) (1990) Glossary at 5. The SEIS I also recognized that "[t]he post-1970 generated TRU waste proposed to be disposed of at the WIPP results primarily from defense-related plutonium reprocessing and fabrication as well as defense-related research activities at DOE facilities." SEIS at GLO-5 and 1-1, 2-8. Most recently, the February 1996 Implementation Plan of the WIPP Disposal Phase Supplemental Environmental Impact Statement (SEIS II) defined defense waste identically to SEIS I. SEIS II, Glossary at vii.

maximum contribution to the general welfare, subject at all times to the paramount objective of making the maximum contribution to the common defense and security") and 42 U.S.C. § 2102(a) ("the development, utilization and control of atomic energy for military and for all other purposes are vital to the common defense and security").

The suggested interpretation would define WIPP-eligible waste broadly enough to make all TRU waste generated by DOE eligible for disposal and thereby free WIPP and the generator sites from the need to determine the origin of their TRU waste.

CONCLUSION

The term "atomic energy defense activities" permits WIPP to dispose of defense TRU waste resulting from all of the noncivilian activities and programs of DOE, including weapons production, naval reactors, defense research and development, associated defense environmental restoration and waste management, and other defense-related activities, as defined more specifically in the Nuclear Waste Policy Act, from which the term was borrowed. The information available to the Office of General Counsel indicates that, as so understood, "atomic energy defense" TRU waste represents the overwhelming majority of the Department's TRU waste. On the other hand, neither the applicable statutory provisions, the legislative history or the Department's own historic interpretations of the term permit an interpretation of "atomic energy defense activities" that would extend WIPP's mission to the disposal of waste from DOE's purely civilian atomic energy activities and programs.

ANALYSIS

The express terms of § 2(21) of the LWA indicate that Congress intended WIPP to provide for the disposal of waste from "defense" activities. If Congress intended that all TRU waste -- from both the civilian and defense programs and activities of the Department -- be eligible for WIPP, it could (and presumably would) have said had so. Indeed, in § 7(b)(5) of the LWA, Congress directed the Secretary to submit "recommendations for the disposal of all transuranic waste under the control of the Secretary...." (emphasis added). Application of the principle of statutory construction known by the maxim "*expressio unius est exclusio alterius*" suggests that where Congress uses a general term in one provision, here by providing for a report addressing "all" waste under the Secretary's control in § 7(b)(5), and limits another provision, here by restricting WIPP to waste from defense activities in § 2(21), Congress is deemed to have intended the limitation it expressed. On the other hand, Congress appears to have intended TRU waste from all of the Department's defense-related activities to qualify for disposal at WIPP.

The legislative history of both the LWA and the DOE National Security Act supports the conclusion that Congress did not intend to permit disposal of all of the Department's TRU waste at WIPP, but instead specifically intended WIPP to handle the Department's defense TRU waste.

A. The DOE National Security Act

Since the passage of the DOE National Security Act in 1979, WIPP's mission has been described as the disposal of "defense waste:"

> The Secretary of Energy shall proceed with the Waste Isolation Pilot Plant construction project authorized to be carried out in the Delaware Basin of Southeast New Mexico (project 77-13-f) in accordance with the authorization of such project as modified by this section. Notwithstanding any other provision of law, the Waste Isolation Pilot Plant is authorized as a defense activity of the Department of Energy, administered by the Assistant Secretary of Energy for Defense Programs, for the express purpose of providing a research and development facility to demonstrate the safe disposal of radioactive wastes resulting from the defense activities and programs of the United States exempted from regulation by the Nuclear Regulatory Commission.

Pub. L. No. 96-164, § 213 (emphasis added).

In the Conference Report accompanying the DOE National Security Act, the joint conferees indicated that they understood "defense waste" to include waste from the production of nuclear weapons:

> The process of producing nuclear weapons yields byproducts, customarily referred to as nuclear wastes, that are hazardous in certain regimes and which should be isolated from the biosphere on a permanent basis. Defense nuclear wastes have been accumulating and safely stored at temporary storage sites over the past 35 years. The issue of the ultimate disposal of nuclear waste is one of the most troublesome challenges of our time. The United States has not yet decided the issue of how to permanently store nuclear wastes resulting from various national defense programs. The right combination of public concern, technology and resource application is needed in order to produce a decision. Such a decision will not be simple, and the WIPP will contribute but one small piece to that decision.

H. R. Rep. No.702, 96th Cong., 1st Sess., at 18 (1979).

The conferees also expressly rejected the Administration's proposal to dispose of commercial waste at WIPP:

> The WIPP, originally authorized in 1976, was conceived as a research, development and demonstration project for the storage of defense waste. Since that time, the Administration has proposed changes to the mission of the WIPP regularly, first to include the storage of 1,000 spent fuel assemblies from commercial reactors, and later a commercial type "intermediate scale facility"

> where defense nuclear wastes would be stored for the payment of a "fee." This constant attempt to change the purpose of WIPP has resulted in delay and confusion.

Id.

B. The Land Withdrawal Act

On October 30, 1992, Congress reaffirmed the nature of WIPP's mission as a repository for defense waste when it passed the LWA:

> The term "WIPP" means the Waste Isolation Pilot Plant project authorized under section 213 of the Department of Energy National Security and Military Applications of Nuclear Energy Authorization Act of 1980 (Pub. L. 96-164; 93 Stat. 1259, 1265) to demonstrate the safe disposal of radioactive waste materials generated by atomic energy defense activities.

Pub. L. No. 102-579, § 2(21) (emphasis added).

The history of the LWA indicates that Congress intended the term "atomic energy defense activities" to distinguish defense activities from civilian atomic energy activities. Both the Senate version of the LWA, S. 1671, and the version of H.R. 2637 offered by the House Armed Services Committee proposed to expressly define "atomic energy defense activity" as having "the same meaning as is provided in section 2 of the Nuclear Waste Policy Act of 1982 (NWPA) (42 U.S.C. 10101)."[4] The NWPA defines the term "atomic energy defense activity" to cover a broad range of defense activities:

> (3) The term "atomic energy defense activity" means any activity of the Secretary [of Energy] performed in whole or in part in carrying out any of the following functions:
>
> (A) naval reactors development;
>
> (B) weapons activities including defense inertial confinement fusion;
>
> (C) verification and control technology;
>
> (D) defense nuclear materials production;

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[4] As originally introduced in the House on June 13, 1991, H.R. 2637 defined WIPP at § 2(17) as a "project ... to demonstrate the safe disposal of radioactive waste materials generated by defense programs."

(E) defense nuclear waste and materials by-products management;

(F) defense nuclear materials security and safeguards and security investigations; and

(G) defense research and development.

42 U.S.C. § 10101(3) (emphasis added). At the same time, however, the NWPA clearly distinguishes between civilian and defense nuclear activities. Specifically, the NWPA defines "civilian nuclear activity" as any atomic energy activity other than a defense activity. 42 U.S.C. §10101(5).[5]

While the express reference to the NWPA definition was not included in the final text of the LWA, it appears from the history of the Senate and House proceedings that Congress adopted the term "atomic energy defense activities," the same term Congress had used in the NWPA, in order to limit waste that could be disposed of at WIPP to waste from "defense activities" as that term has been traditionally understood. For example, the Senate Report describes WIPP's mission and scope as follows:

> The Waste Isolation Pilot Plant is a research and development facility of the Department of Energy authorized by Public Law 96-164 for the purpose of demonstration of the safe disposal of radioactive waste generated by DOE's nuclear weapons production activities.
>
> The United States has been generating radioactive waste in its national defense programs since the 1940's. . . . The transuranic waste that would be emplaced at WIPP results primarily from plutonium reprocessing and fabrication, as well as from research and development activities at various DOE facilities.

S. Rep. No. 196, 102d Cong., 2d Sess., at 15 (1991) (emphasis added).

The Senate Report includes two letters from Secretary of Energy Watkins, dated October 4 and 15, 1991, respectively. Neither letter raises any issue with respect to the nature of transuranic

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[5] Some of DOE's sites have historically performed both defense and civilian atomic energy activities and have stored their TRU waste from both together. The language in the NWPA, which defines "atomic energy defense activity" to include "any activity . . . performed in whole or in part in carrying out . . . defense nuclear waste and materials by-products management," would allow disposal of such historically co-mingled waste at WIPP because the activity has been "in part" defense nuclear waste management. To avoid any abuse of this provision of the NWPA, however, TRU waste resulting from defense activities should be segregated from TRU waste resulting from civilian nuclear activities where it is feasible to do so, and only the defense waste portion should be shipped to WIPP.

waste that may be emplaced at WIPP. Indeed, both letters appear to proceed from the assumption that the definition of waste in the proposed legislation was acceptable. Id at 34-37.[6]

The full Senate considered the bill on November 5, 1991. In the debate, Senator Bennett Johnston, Chairman of the Committee on Energy and Natural Resources, described WIPP as follows:

> The Waste Isolation Pilot Plant is a research and development facility of the Department of Energy that was authorized by Public Law 96-164 for the purpose of demonstrating the safe disposal of radioactive waste generated by DOE's nuclear weapons production activities. . . . The facility is now ready to open to begin the experimental program. During that program, DOE will conduct a series of experiments to evaluate the facility's ability to comply with the environmental laws governing the safe storage and disposal of nuclear waste. . . .The transuranic waste that will be emplaced at WIPP results primarily from plutonium reprocessing and fabrication, as well as from research and development at various DOE facilities. . . . This is a major milestone in the Department's efforts to demonstrate that we have the technology necessary to store and dispose safely the byproducts of our Nation's nuclear weapons.

137 Cong. Rec. S15988 (daily ed. November 5, 1991) (emphasis added).

The House was equally clear in its view of WIPP's role as a repository for waste from defense activities, not simply "any" atomic energy activity. See, e.g., Report of the Committee on Interior and Insular Affairs, H. R. Rep. No. 241, Part 1, 2d Cong., 1st Sess., at 12-14 (1991), discussing both the defense waste program and the history of WIPP. There, as in the Senate, the Secretary of Energy lodged DOE's comments on H.R. 2637 and did not dispute the committee's characterization of the defense waste planned for disposal at WIPP. Id. at 24-29.

There is no suggestion in the legislative history that, in referring to "atomic energy defense activity," Congress was harkening back to the broad notion of "common defense and security" referenced in the Atomic Energy Act. Rather, the repeated references by Congress to the Department's nuclear weapons production activities in describing WIPP's mission, and the absence of any reference to the Department's civilian nuclear programs throughout this legislative history, reinforce the conclusion that the LWA reference to "atomic energy defense activities" was intended to connote the common "national defense" sense of the phrase rather than a broad notion of "the common defense and security."

Even without the legislative history indicating that Congress borrowed the term directly from the NWPA, principles of *in pari materia* dictate that the same term dealing with the same general

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[6] The same is true for the Statement of Leo P. Duffy, Director of Environmental Restoration and Waste Management. S. Rep. No. 196 at 37.

subject matter be interpreted to have the same meaning, absent an indiction that Congress intended otherwise. In this instance, no such intent appears. Thus, the term "atomic energy defense activities" as used in the LWA should be interpreted to cover the same broad array of defense activities and related cleanup activities described in the NWPA as falling within that term.[7] This is entirely consistent with the definition of defense nuclear waste historically used by WIPP, *i.e.*, waste derived "from the manufacture of nuclear weapons and operation of naval reactors" and "[a]ssociated activities such as the research in the weapons laboratories." A broader interpretation that would include waste from DOE's civilian atomic energy activities, based on references in the AEA to the "common defense and security" interests served by the development of peaceful uses of nuclear power, is not supported by the language of the statute, the legislative history, or the Department's own historic interpretation of the term.

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[7] As the legislative history of the NWPA's definition of "atomic energy defense activities" makes clear, TRU waste generated by the DOE Environmental Management program in its cleanup and management of weapons production waste qualifies for disposal at WIPP because it is so "closely intertwined" with defense production activities.

TRU WASTE DECISION TREE