THE PERFORMANCE ASSESSMENT AND THE DESIGN OF AN INTERMEDIATE LEVEL TRITIUM DISPOSAL VAULT (U)

by

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THE PERFORMANCE ASSESSMENT AND THE DESIGN OF AN INTERMEDIATE LEVEL TRITIUM DISPOSAL VAULT

#1
My name is Andy Yu. I work for the Westinghouse Savannah River Company at the Savannah River Laboratory. The topic of my talk today is "the Performance Assessment and the Design of an Intermediate Level Tritium Disposal Vault". Jim Cook, Tom Butcher and I did this work for the Waste Management and Environmental Restoration Department at the Savannah River Site.

#2
In this talk, I am going to show you how groundwater modeling has affected the design of a tritium disposal vault at SRS and this new vault will meet the regulatory performance requirements.

I am going to brief you with the performance assessment and the vault design followed by a short discussion and the conclusion.

#3
SRS is a DOE nuclear material production facility operated by Westinghouse located in Aiken, South Carolina. The primary mission for SRS is to safely produce tritium and plutonium while protecting the employee and public health and the environment.

#4
This is an SRS site map. Traditionally, low level radioactive wastes generated at SRS were disposed in earthen trenches at the Burial Ground. Trench Burial will be discontinued in order to comply with DOE Orders 5820.2A and 5400.4.
The low level wastes generated in the future will be disposed in subgrade concrete vaults. These vaults are now under construction in a 100-acre site north of the existing Burial Ground. This new site is called the Burial Ground Expansion or the E-Area.

This is an artists' conception of the E-Area vaults. Low level wastes will be categorized and disposed in different types of vaults according to their contents and radioactivity. This large vault is a Low Activity Waste Vault. This is a long-lived radionuclide storage building. This is an intermediate level non-tritium vault. Right adjacent to it is the focus of this talk, the Intermediate Level Tritium Vault, or ILTV.

This slide shows a 75-ton gantry crane is ready to load some tritium crucibles into the ILTV. An ILTV is 56 feet long, 48 feet wide and 28 feet deep. There are two cells in an ILTV. One cell will accommodate 142 spent melt tritium crucibles in a silo system. The other cell will accommodate other forms of tritium wastes. The expected maximum inventory for an ILTV is 100,000 Curies. Most of the activity comes from the tritium crucibles.
In the performance assessment, I will describe the model, the groundwater pathway, the history match of a lysimeter test for model validation, three groundwater scenarios, and the predicted tritium concentrations.

The model used for the performance assessment is the PATHRAE code developed for EPA by Rogers and Associates. The code can be used to calculate radiological doses via ten exposure events or pathways.

PATHRAE was used to model the exposure events for the trench burial of 100,000 Curies of tritium crucibles. Site specific data at SRS Burial Ground was used for the modeling.

This table shows the peak doses for the important pathways. Modeling results indicate that except for the groundwater to well scenario, the impact of all other pathways are insignificant. Therefore, from now on, I will focus only on the groundwater scenario.
The groundwater scenario starts with water infiltration into the waste, leaching out the contaminants, traveling through the vadose zone, and recharge to the groundwater. It is assumed that a well is drilled into the aquifer and the well water is used for living and farming activities.

Like most groundwater models, PATHRAE predicts the tritium concentrations at the well. It is assumed that a person drinks two liters of this water every day and for 365 days a year. This annual Curie consumption is converted to a radiological dose by multiplying a dose conversion factor. The regulatory dose limit for a single radionuclide is 4 mrem/yr. Using ICRP-30 dose methodology, the corresponding tritium concentration is 90,000 pCi/L or 90 pCi/mL.

The greatest uncertainty about the model prediction is: How much tritium is released from the waste forms in a time period? or the leach rate. In this study, the leach rate was obtained by the history match of a lysimeter test.

A lysimeter test was initiated at the SRS when three spent melt crucibles were placed in a lysimeter in November, 1973. The lysimeter was lined so that all percolate water would flow to the sump. Percolate water was collected every week. Its volume was measured and the tritium concentration was analyzed. This test continued for more than 10 years.
The cumulative amount of tritium release was matched by PATHRAE. By trial and error, a reasonable match was obtained using an initial inventory of 400 Curies and a leach rate of 30% per year. The best history match parameters were used to predict the performance of three disposal scenarios.

The disposal scenarios are:

1. **Trench Burial.** This is the previous practice. There is no vault, no closure cap. Annual infiltration is 38 centimeters.

2. **Perched Water Intrusion.** Perched water intrusion may result from a poorly designed vault or a poorly placed vault. Water invades through the cracks in the bottom slab and contact two feet of waste.

3. **100 Year Storage.** This is the state-of-the-art tritium disposal technology at SRS. The tritium wastes are stored in an ILTV. The clay cap reduces the infiltration to 1.37 cm/yr.

A 100-yr storage period will be implemented. During this period, any leachate will be extracted, the vault will be vented, and the performance of the vault will be carefully monitored. After 100 years, the model assumes the vault is no longer in place which means it has the properties of the soil. However, the clay cap is still in place.
This figure shows the predicted tritium doses and concentrations at the one-meter well. Please notice, the Y axis is in logarithmic scale. Tritium release for the Trench Burial and the Perched Water Intrusion scenarios are fast. Predicted peak doses far exceeded the 4 mrem/yr EPA Drinking Water Standard. For the 100 Year Storage Scenario, tritium did not reach the groundwater until 150 years later. This is because of the 100 year storage period and the reduced infiltration. Predicted peak dose is only 1 mrem/yr.

From a Waste Management point of view. The groundwater impact of tritium disposal is affected by the initial inventory, the vault design, and the operational alternatives. In the next few minutes, I would like to show you the ILTV design that would justify the storage and the disposal of 100,000 Curies of tritium wastes.
The ILTV was designed by Bechtel Savannah River Inc. and the C. T. Main Inc. The materials used for the vault construction will maximize structural strength and minimize cracks. All interior walls will be lined with a drainage net. The bottom 14 inches of the vault will be filled with crushed stones with a layer of geotextile fabric in between. If there is any perched water, this will prevent water from direct contact of the wastes.

The bottom slab of the vault is at least two and half feet thick and will be sloped. An internal leachate collection system comprised of drainage pipes, sumps, and riser pipes will remove excess water from within the ILTV. The leachate will be analyzed for tritium concentrations. The vault will also have a subdrainage system. These systems insure that there would be no water level buildup in the vault.

A temporary steel raincover with gutters and sloped top will protect the wastes from rain during the 20-year operation period. A permanent concrete roof designed to support the weight of the cap will be constructed during final closure.

As you can see, the design criteria for the ILTV is to keep water from contacting the waste during the operation and after closure. If the wastes can be kept dry, the leach rate would be minimal.

The assumptions used for the ILTV performance assessment are conservative. For example, we assumed that the vault is gone after 100 years. In reality, it may still be quite functional.
In conclusion, with the ILTV design criteria, and the 100-year storage period, we will be able to meet all of the DOE Order 5820.2A performance objective. This will give SRS maximum protection of the human health and the environment.
The Performance Assessment and The Design of an Intermediate Level Tritium Disposal Vault

SAVANNAH RIVER SITE

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Outline

• Introduction
• Performance Assessment
• Vault Design
• Discussion
• Conclusion
Performance Assessment

- Model Description
- Groundwater Pathway
- Model Validation
- Groundwater Scenarios
- Predicted Tritium Concentrations
## Predicted Peak Doses via Various Pathways

(TRENCH BURIAL)

<table>
<thead>
<tr>
<th>Pathway</th>
<th>Peak Dose (mrem/yr)</th>
<th>Peak Time (year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Groundwater to River at 750 m</td>
<td>$1.1 \times 10^{-3}$</td>
<td>29.0</td>
</tr>
<tr>
<td>Groundwater to Well at 1.0 m</td>
<td>$4.1 \times 10^4$</td>
<td>5.3</td>
</tr>
<tr>
<td>Food Grown Onsite</td>
<td>0.</td>
<td></td>
</tr>
<tr>
<td>Biointrusion</td>
<td>0.</td>
<td></td>
</tr>
<tr>
<td>Dust Inhalation Onsite</td>
<td>$2.0 \times 10^{-5}$</td>
<td>0.</td>
</tr>
<tr>
<td>Atmospheric Transport Offsite</td>
<td>$9.4 \times 10^{-2}$</td>
<td>0.</td>
</tr>
</tbody>
</table>
Spent Melt Lysimeter
A History Match of Tritium Lysimeter Data

PATHRAE Run
Inventory = 400 Ci
Leach Rate = 0.3 yr⁻¹
## Disposal Scenarios

<table>
<thead>
<tr>
<th>Trench Burial</th>
<th>No Vault, No Cap Previous Practice</th>
<th>38.1 cm/yr Infiltration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perched Water Intrusion</td>
<td>May Result From Poor Vault Design</td>
<td>Water Invades Bottom Two Feet of Waste</td>
</tr>
<tr>
<td>100-Year Storage</td>
<td>Vault, Cap, Sump, and Drain</td>
<td>1.37 cm/yr Infiltration</td>
</tr>
</tbody>
</table>
Predicted Groundwater Tritium Doses and Concentrations at the One-Meter Well
(Initial Inventory = 100,000 Ci)
A Schematic of the Intermediate Level
Tritium Disposal Vault

- Temp Steel Raincover
- Drainage Net
- Reinforced Concrete Wall
- 6" Crushed Stone
- Geotextile Fabric
- 8" Crushed Stone
- 2"-6" (Min) Thick Reinforced Concrete Slab
- Gravel Subdrain
- Pipe (Leachate Collection)
- Sump
- Perforated Drain Pipe
- 5% Slope
Conclusion

With the intermediate level tritium vault design criteria and 100-year storage period, we will be able to meet all of the DOE Order 5820.2A performance objectives.