

Disposal of Partitioning-Transmutation Wastes In A Yucca-Mountain-Type Repository With Separate Management of High-Heat Radionuclides (⁹⁰Sr and ¹³⁷Cs)

Charles W. Forsberg

Oak Ridge National Laboratory
P.O. Box 2008; Oak Ridge, TN 37831-6180
Tel: (865) 574-6783; Email: forsbergcw@ornl.gov

**4th Topical Meeting on Nuclear Applications of Accelerator Technology
American Nuclear Society Winter Meeting
Washington D.C.
November 14, 2000**

The submitted manuscript has been authored by a contractor of the U.S. Government under contract DE-AC05-00OR22725. Accordingly, the U.S. Government retains a nonexclusive, royalty-free license to publish or reproduce the published form of this contribution, or allow others to do so, for U.S. Government purposes.

Outline

- **Decay heat controls repository design**
- **Partitioning-transmutation (P-T) may be an enabling technology to alternative repository designs**
- **High-heat radionuclide (HHR) disposal**
- **Low-heat radionuclide (LHR) disposal**
- **Conclusions**

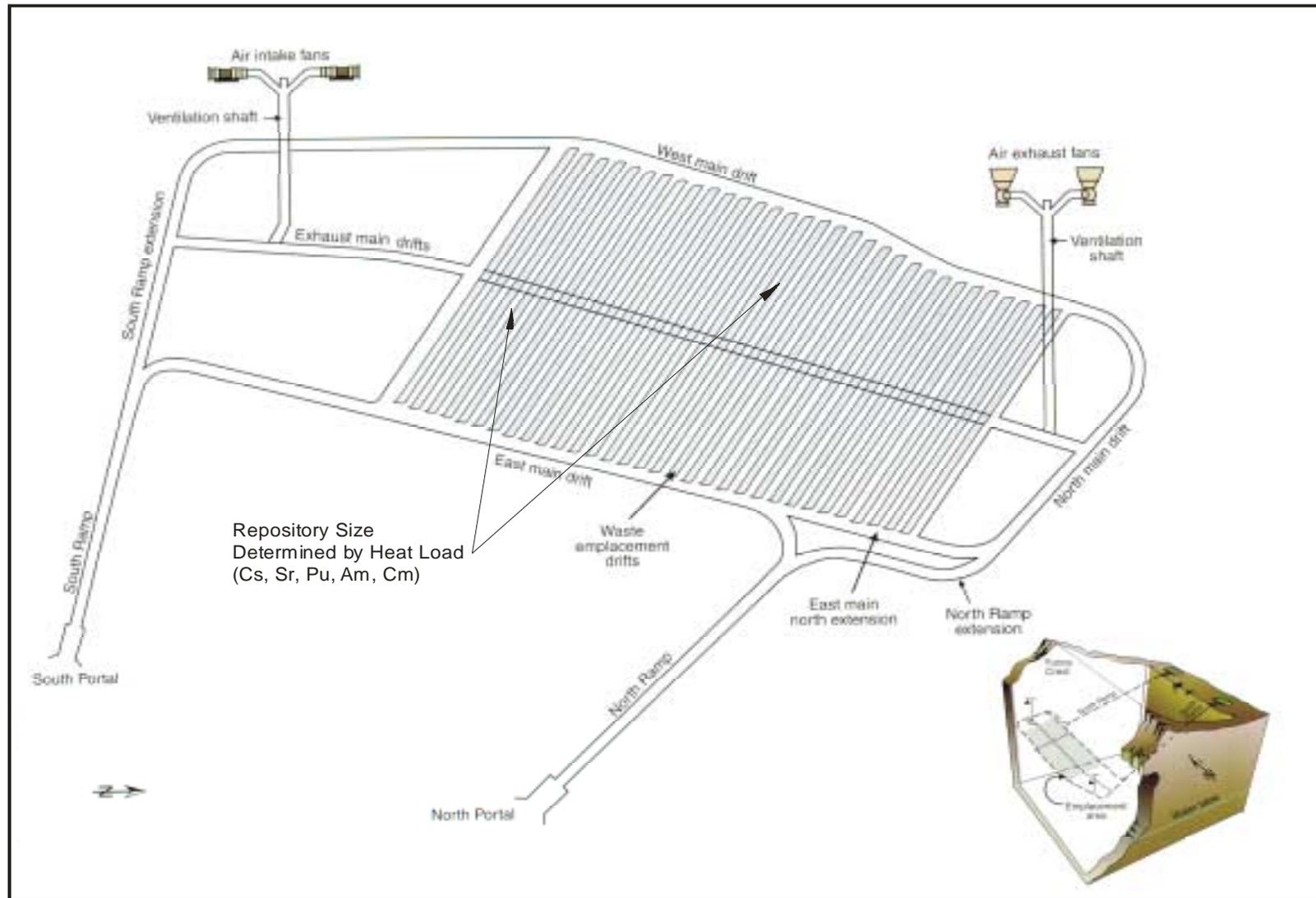
If Waste Volume Controlled Repository Design, Repositories Would Be Small And Cheap

- **Yucca Mountain (YM) is designed to accept 70,000 t of spent nuclear fuel (SNF) and high-level waste (HLW)**
- **All wastes could be placed in a cube with dimensions of 30 m on a side**
- **The cost would be less than a billion dollars**

Repositories Are Expensive Because Of Radioactive Decay Heat

- **Temperature limits control design**
 - Higher temperatures degrade waste forms, waste packages (WPs), and geology
 - Performance is degraded
 - Performance uncertainties increase
- **Temperature is limited by spreading SNF and HLW over a large area**
 - 11,000 WPs
 - 100 km of disposal tunnels (5.5 m in diameter)

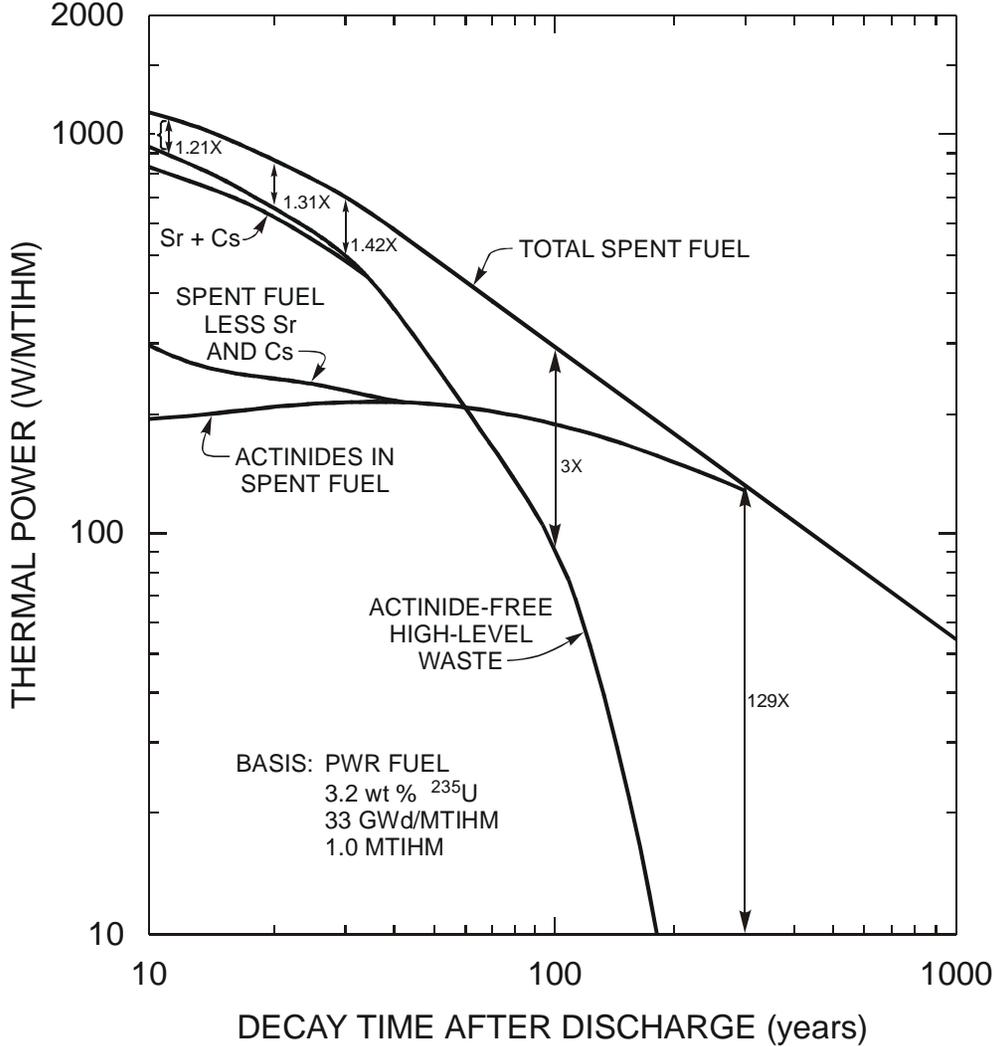
Proposed Yucca Mountain Repository



If Repository Cost Or Performance Is To Be Impacted By Changing The Fuel Cycle, Changes In Decay Heat Management Are Required

- **Five HHRs generate the decay heat**
 - Long-lived (Pu, Am, and Cm)
 - Shorter-lived (^{90}Sr and ^{137}Cs)
- **Partitioning-transmutation (P-T), if successful, will destroy long-lived HHRs**
- **Destruction of long-lived, heat-generating radionuclides creates new wastes with characteristics different from previous wastes**

Decay Heat From SNF



Alternative Repository Concept For Low-Actinide Wastes

- **Waste is chemically separated into two separate fractions**
 - HHRs (^{90}Sr and ^{137}Cs)
 - Very-low-heat radionuclides (VLHRs)
- **Design repository with separate sections for disposal of each waste fraction**
- **Use lower-cost, higher-performance disposal methods that are optimized for each waste fraction**

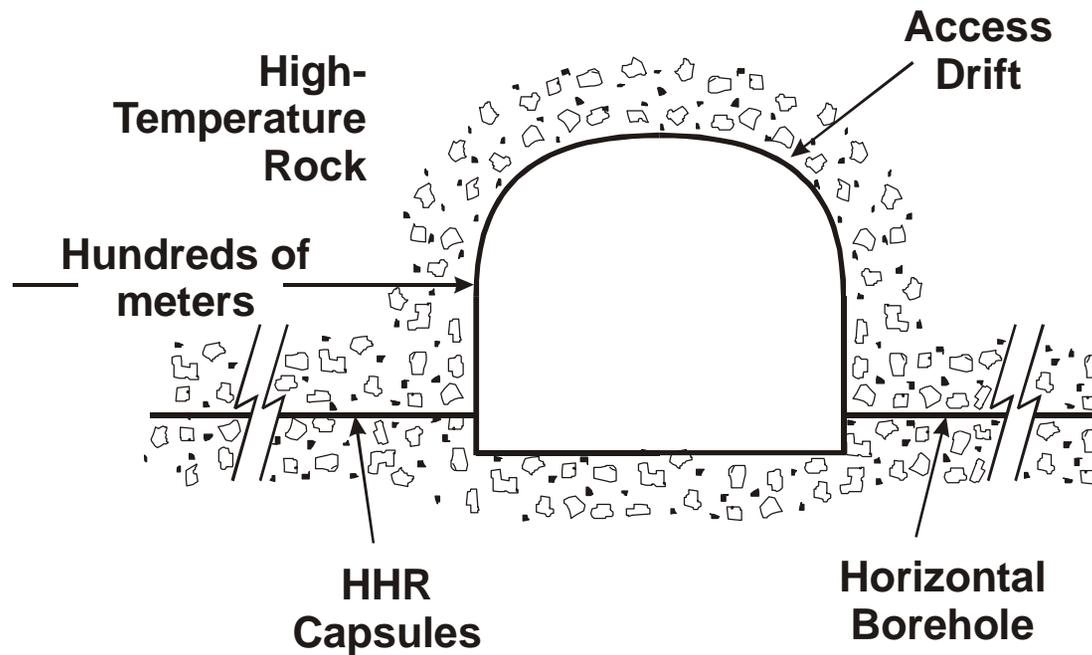
The Properties Of ^{90}Sr And ^{137}Cs Enable The Use Of Low-Cost Disposal Methods

- **Shorter half-lives (~30 years)**
 - Simplified prediction of long-term behavior
 - No expensive long-lived WPs
- **Small volumes (4.2 kg/t of SNF)**
 - Package in small capsules
 - Low-volume borehole disposal becomes viable

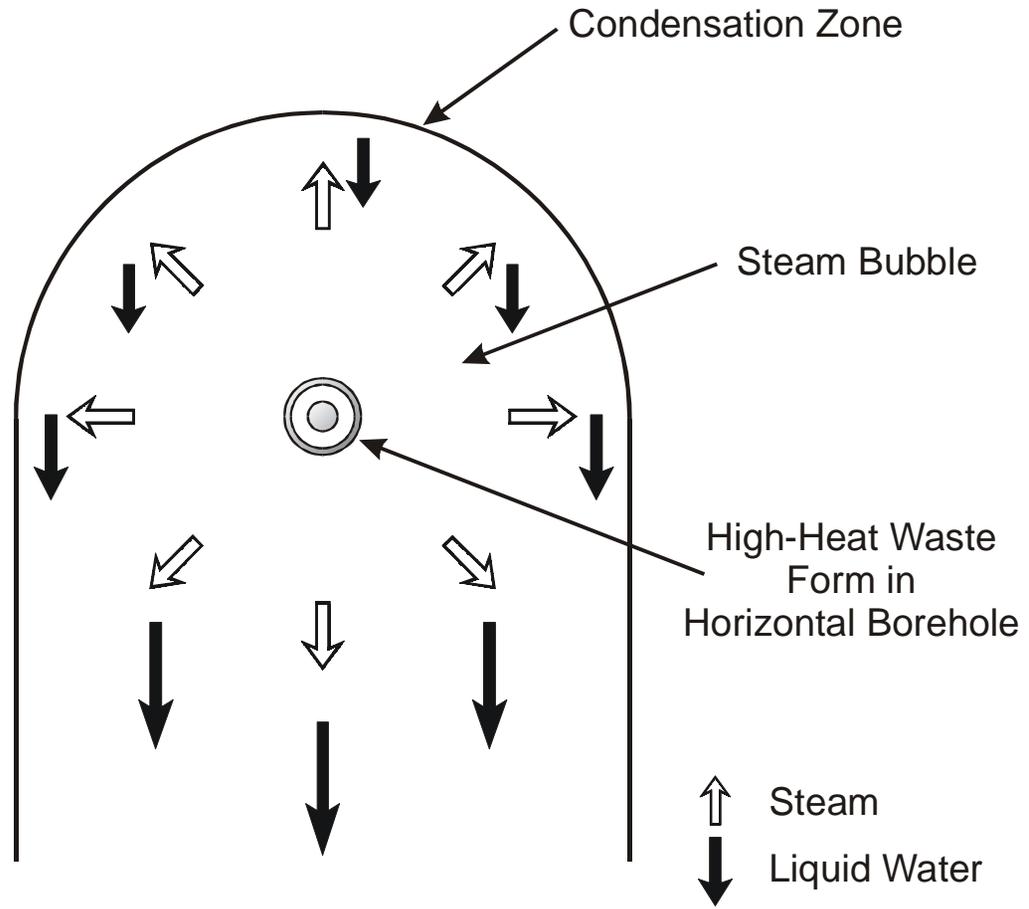
HHRs (^{90}Sr and ^{137}Cs) Could Be Disposed Of In An Extended-Dry Repository

- **HHRs could be placed in long, horizontal boreholes**
- **Boreholes could be placed close together**
- **Decay heat raises temperatures above boiling point of water for millennia**
- **No radionuclide transport occurs if there is no liquid water to transport radionuclides**
- **HHRs decay completely before cool-down of the large mass of rock**
- **Low-cost boreholes replace tunnels as a method to limit repository temperatures**

HHRs (^{90}Sr and ^{137}Cs) Repository With Boreholes (Rather Than Tunnels) Used To Distribute Decay Heat Load



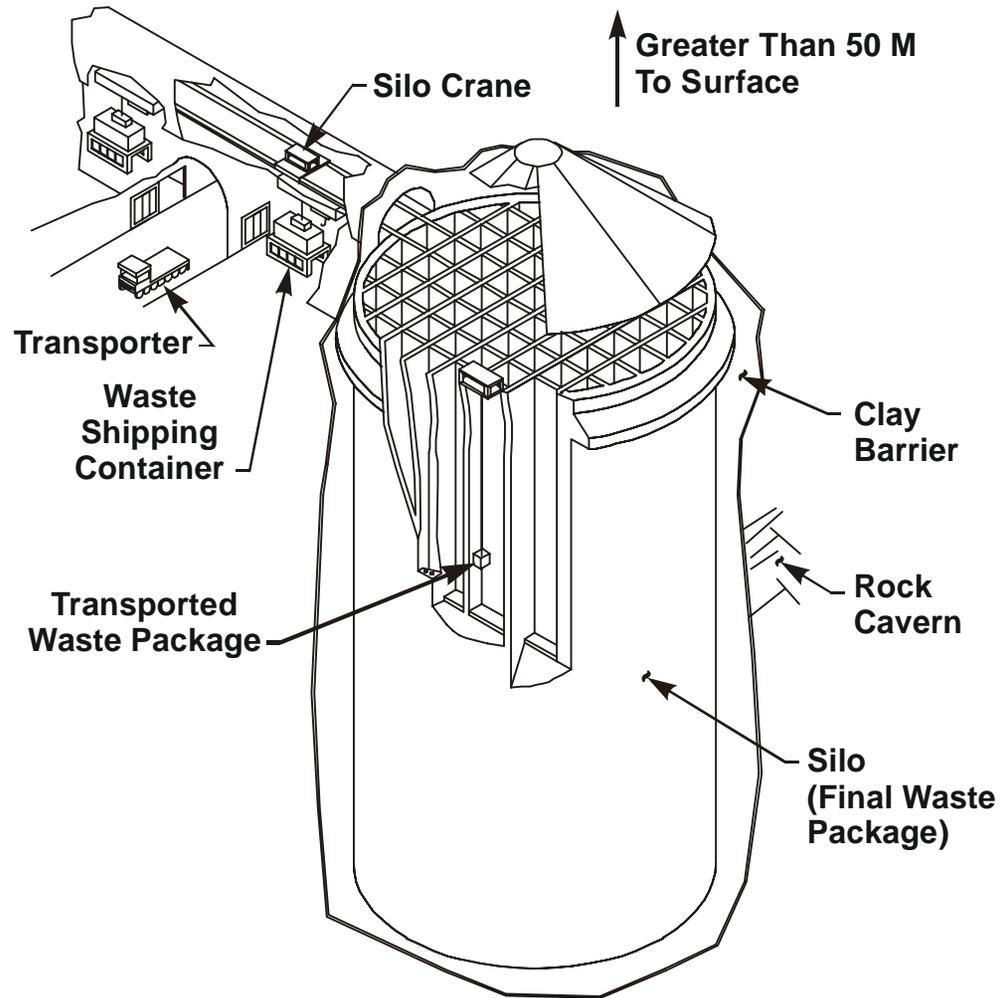
In Repositories Above the Water Table, The Extended-Dry Repository Concept Creates A “Hydrothermal Umbrella” Over The HHRs And Diverts Water



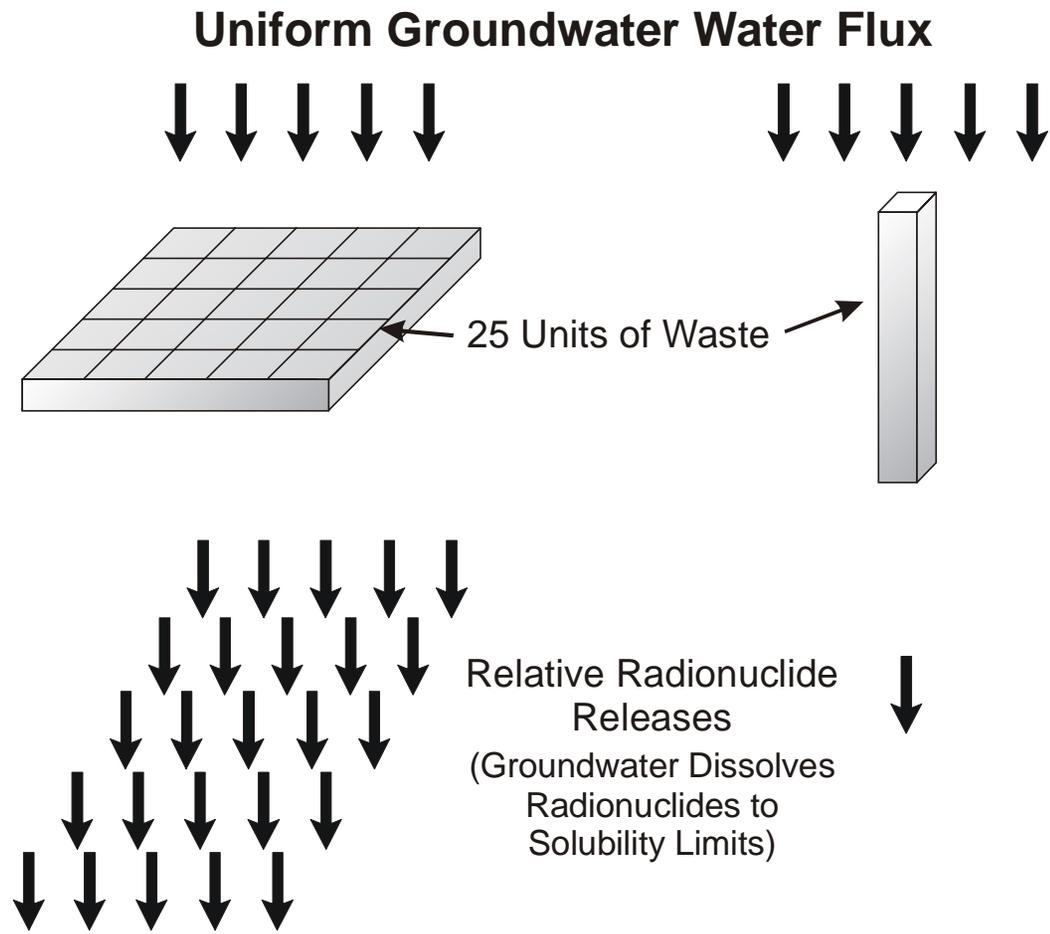
Very-Low-Heat Radionuclides May Be Disposed Of In Silos

- **With low decay heat, no need exists to spread the wastes over kilometers of tunnels and thousands of WPs**
- **Silos replace WPs**
 - Better performance
 - Significantly lower costs (up to 10,000 t of SNF wastes per silo)
- **Significant European experience with silos**

Swedish SFR Silo For Intermediate-Level Radioactive Waste



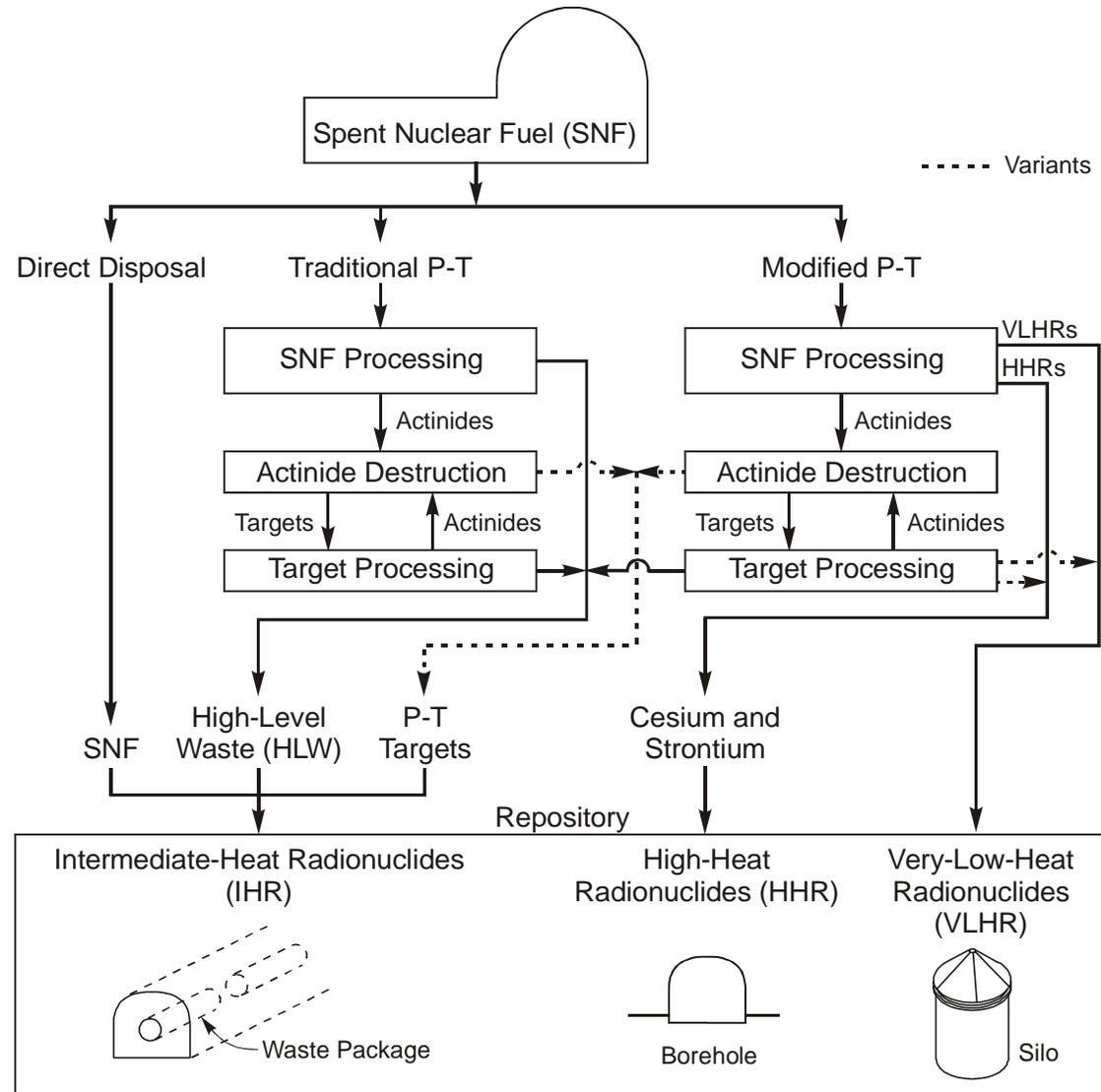
The Geometry Of The Waste (Surface-To-Volume Ratio) Strongly Impacts Radionuclide Releases



P-T May Create Options For Smaller, Lower-Cost Repositories

- **Alternative repository design**
 - Extended-dry repository for ^{90}Sr and ^{137}Cs
 - Silos for VLHRs
 - Section for intermediate-heat radionuclides (section of existing repository)
- **Improved repository economics**
 - Boreholes replace tunnels
 - Silos replaces WPs
- **Added cost: separation of ^{90}Sr and ^{137}Cs**

Alternative Waste Management Options



Conclusions

- **Radioactive decay heat controls repository design (cost and performance)**
- **P-T destroys long-lived HHRs**
- **The destruction of long-lived HHRs creates new repository options**
 - **Separate disposal of ^{90}Sr and ^{137}Cs**
 - **Silo disposal of VLHR**
- **P-T studies should consider alternative repository designs**