

Exceptional service in the national interest



Variation of the Deep Borehole Reference Design for Disposal of Vitrified High Level Waste

Mark J. Rigali
Sandia National Laboratories

Used Fuel Disposition Annual Working Group Meeting
Las Vegas, NV
June 9-11, 2015



Sandia National Laboratories is a multi-program laboratory managed and operated by Sandia Corporation, a wholly owned subsidiary of Lockheed Martin Corporation, for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000. SAND NO. 2015-XXXX XX

Vitrified High Level Waste: A Challenge for Deep Borehole Disposal



*Relative to the reference design, disposal vitrified HLW in deep boreholes will require:

- The redesign of treatment plants to accommodate smaller diameter glass logs.
- Approximately four times as many reduced volume canisters would have to be created and handled.
- Existing waste at West Valley and Savannah River would require reprocessing and repackaging into smaller canisters

Or could we modify the deep borehole design to accommodate the current canister design???

*U.S. Department of Energy (DOE), 2014, *Evaluation of Options for Permanent Geologic Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste in Support of a Comprehensive National Nuclear Fuel Cycle Strategy*, FCRD-USED-2013-000371, U.S. Department of Energy, Washington, DC.

Large Diameter Deep Boreholes



The Cannikin Example – 5 Megaton Spartan Missile Detonation

- First major project under the National Environmental Policy Act of 1969, which required the preparation of an “Official Environmental Impact Statement.”
- Largest mined shaft in the United States with a single elevator to 6,000 feet.
- Deepest 90-inch hole—6,150 feet (1,875 meters)
- Cased hole using 54" casing
- Largest load lowered downhole—over 400 tons.
- Largest emplacement drill rig—1,000 ton mast.
- Drilled in hard rock (volcanics)
- Drilled without blow out preventer (BOP)

Deep Mine Shafts -Penna #3 shaft (LaRonde, Canada)

- Deepest single-lift shaft in the western hemisphere
- Depth: 2,259 meters
- Circular hole 5.5m diameter
- Drilled in hard rock (volcanics)



Large Diameter Deep Boreholes

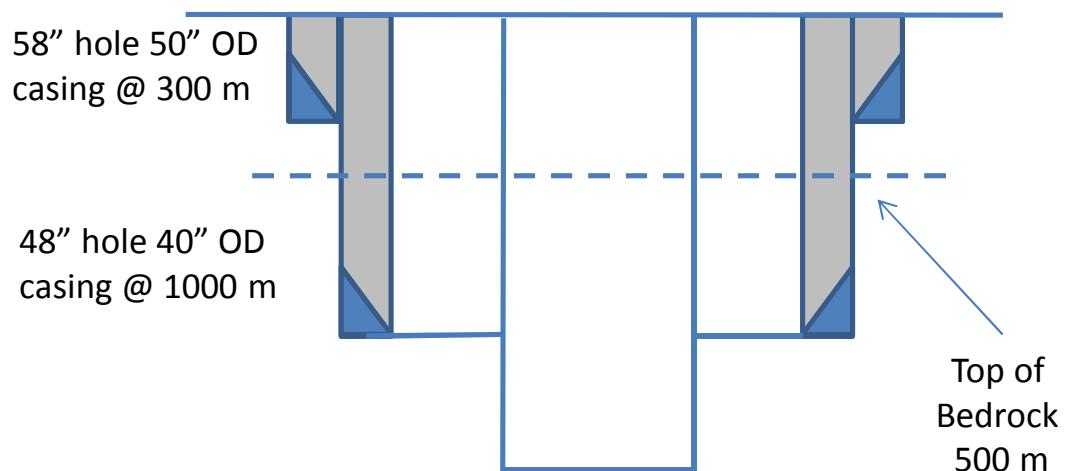
Beswick et al., 2014* propose the following design:



Depth (m)	Hole Diameter (in.)	Casing Diameter (in.)
0-500	60	54
500-1000	48	40
1500-2500	36	30
2500-5000	24 to 26	20

*Beswick A.J., Gibb, F.G., and Kravis, K.P. (2014) Deep borehole disposal of nuclear waste: engineering challenges. *Proceedings of the Institution of Civil Engineers*, 167, EN12. p.47-66.

Preliminary Large Diameter Deep Borehole Design For Vitrified HLW



Depth (m)	Hole Diameter (in.)	Casing Diameter (in.)	Casing Thickness (in.)	Casing Weight (lbs)
0-300	58	50	1	515,059
300-1000	48	40	1	2,049,705
1000-3000	36	30	0.75	2,306,102

Considerations for Very Large Borehole Design

- Proposed depth to bedrock is shallow relative to reference design (500-1000 m).
- The borehole redesign will likely require non-standard drilling equipment and techniques.
 - Largest available BOP is 30"
 - Hydraulic jacking system to lower casing
 - Large diameter bits (36" and greater)
- Characterization borehole becomes critical for the decision to proceed with drilling disposal borehole(s).
 - Stress state of rocks at depth
 - Over-pressured formations and well blow out risk
 - Establishing acceptable geochemical and hydrological conditions at 1500-3000 m.
- Can the current canisters (and canister designs) be emplaced in a deep borehole?
- Shallow borehole depths may necessitate an increased reliance on waste form and waste package performance.
- Very preliminary cost estimates suggest significant cost increase (50 million) in cost per borehole over the reference design.
- Current and Projected vitrified HLW can be disposed of in ~150 boreholes.

Questions/Comments/Discussion