Exceptional service in the national interest

SAND2014-1161C

Sandia National Laboratories

Flume Testing of Surrogate Waste Materials Leading to a Recommendation for the Lower Limit for TAUFAIL

Courtney Herrick and Michael Schuhen

Sandia National Laboratories

WM Symposia 2014

March 2 – March 6, 2014 ♦ Phoenix, Arizona

Session 075, Abstract 14172

U.S. DEPARTMENT OF ENERGY

NNSA National Nuclear Security Administration

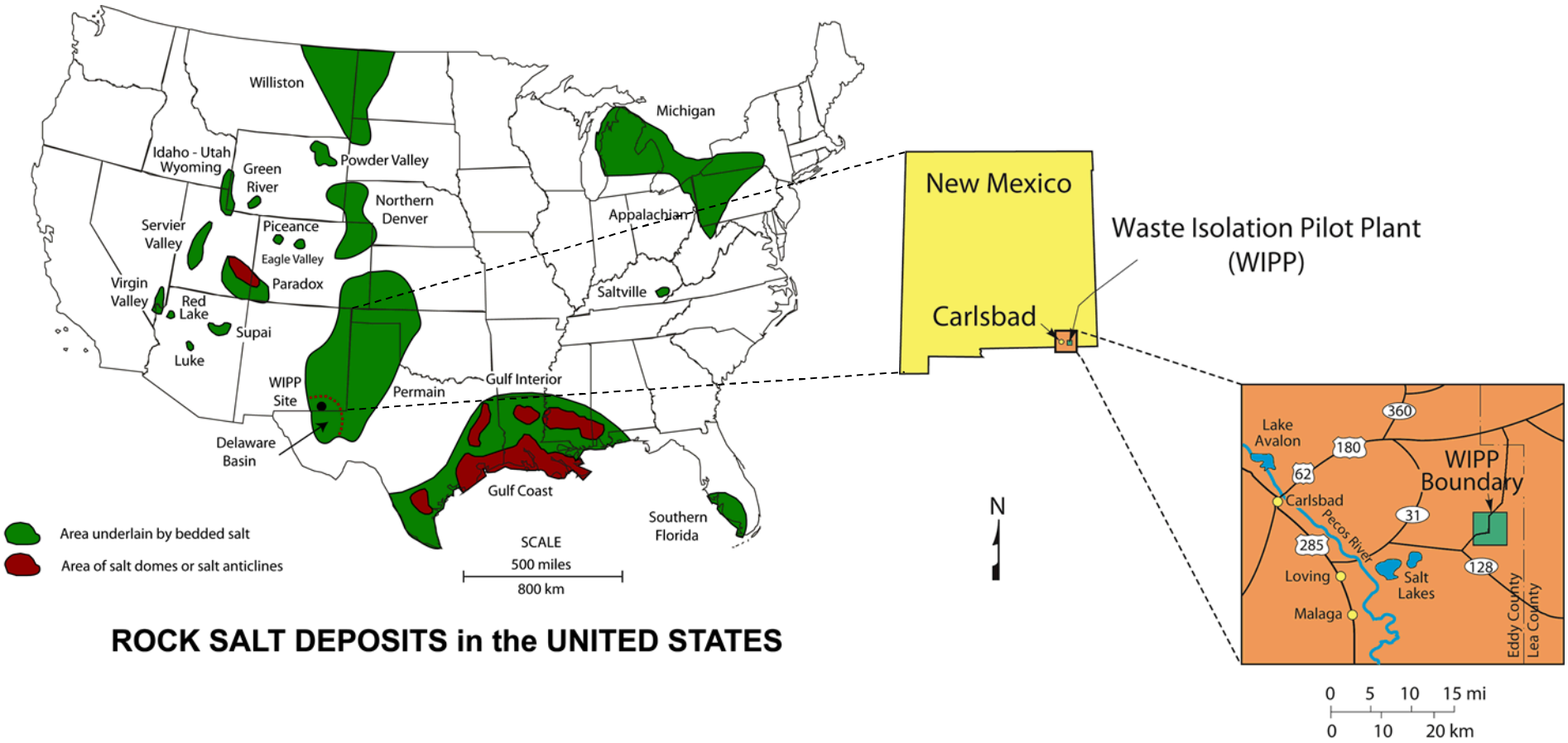
Sandia National Laboratories is a multi-program laboratory managed and operated by Sandia Corporation, a wholly owned subsidiary of Lockheed Martin Corporation, for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000. This research is funded by WIPP programs administered by the Office of Environmental Management (EM) of the U.S Department of Energy. SAND NO. 2014-1161C

Overview

- WIPP and performance assessment (PA) modeling
- Waste Shear Strength (TAUFAIL) and implementation history
- WIPP waste and surrogate waste materials
- Flume experiments on surrogate WIPP waste materials
- Recommendations and impact on Performance Assessment results

WIPP

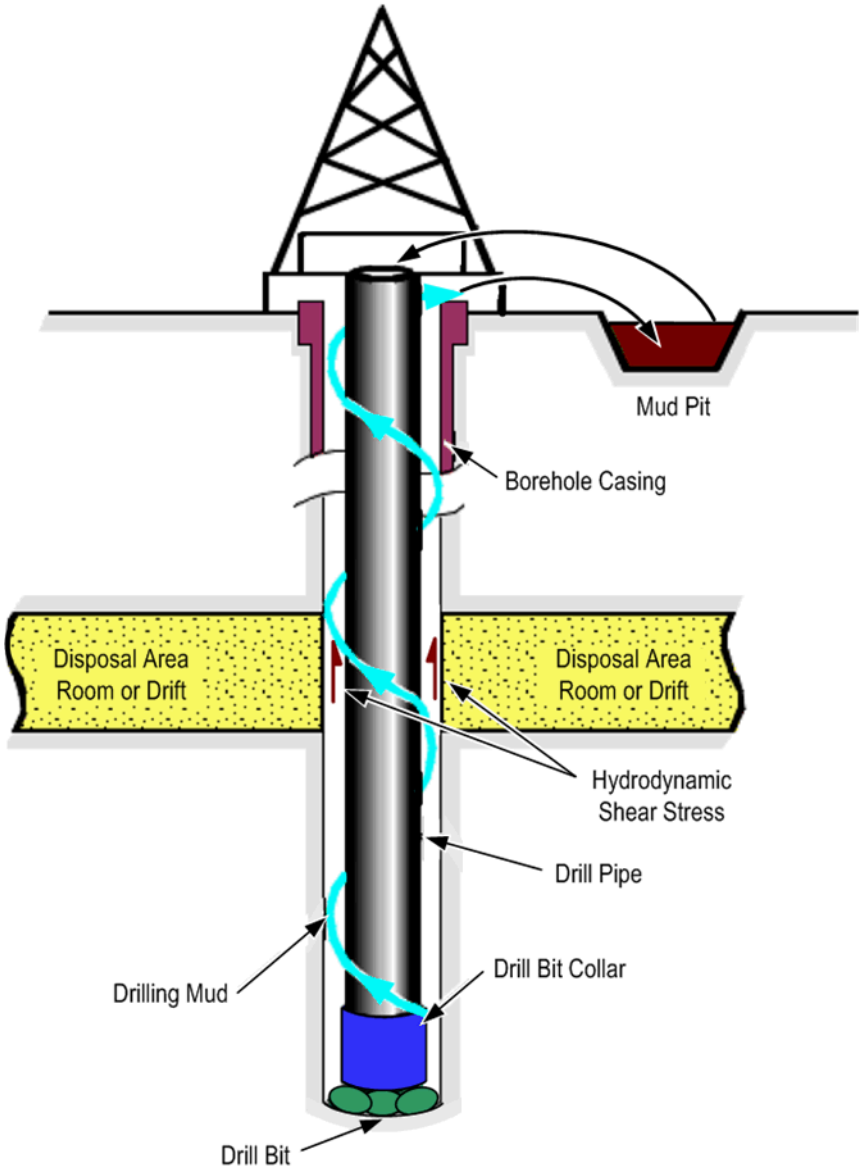
A deep geologic repository in the Salado bedded salt formation operated by the DOE as a disposal facility for defense-generated transuranic (TRU) radioactive waste



PA Modeling

- The DOE demonstrates compliance with containment requirements by means or performance assessment (PA) calculations conducted by Sandia National Laboratories (SNL)
  - A system of computer codes incorporating 24 peer-reviewed conceptual models
- The DOE has identified aspects of WIPP PA that could be refined by incorporating the results of ongoing repository investigations into their models
  - Provide a more accurate representation of the repository system and better, but still conservative, predictions of its long term performance
- The DOE has proposed to modify the waste shear strength parameter TAUFAIL in the Cuttings and Cavings model

Waste Shear Strength (TAUFAIL)



- The cavings component of a direct release is caused by shearing action of the drilling fluid on the waste
- The borehole diameter is assumed to grow until the fluid's shear stress on the borehole wall is equal to the shear strength of the waste
- Waste shear strength (TAUFAIL) is the ability of the waste to resist hydraulic erosion

TAUFAIL Implementation History

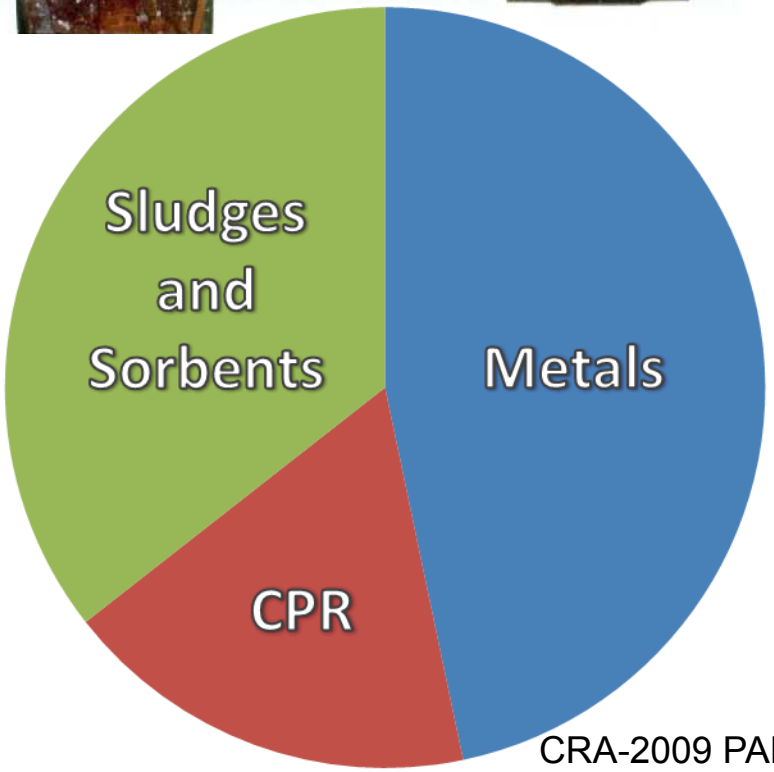
	CCA	PAVT – present
Range	0.05 – 10 Pa	0.05 – 77 Pa
Distribution	uniform	log-uniform

CCA – Compliance Certification Application
PAVT – Performance Assessment Verification Test

- The lower value of 0.05 Pa is from a literature review
  - One test of San Francisco Bay mud
- The upper value of 77 Pa is from a Shield's Parameter analysis using the results of an Expert Panel Elicitation on WIPP waste particle size distributions
- A log-uniform distribution is assigned to the range
  - Equal weighting over many orders of magnitude

WIPP Waste

- Metals
  - Steel containers, iron-based metals, aluminum-based metals, …
- Cellulosics, Plastics, and Rubbers (CPR)
  - Paper, cardboard, polyethylene, PVC, packaging materials, …
- Sludges and Sorbents
  - Cement, concrete, solidified inorganic and organic materials, soils,…



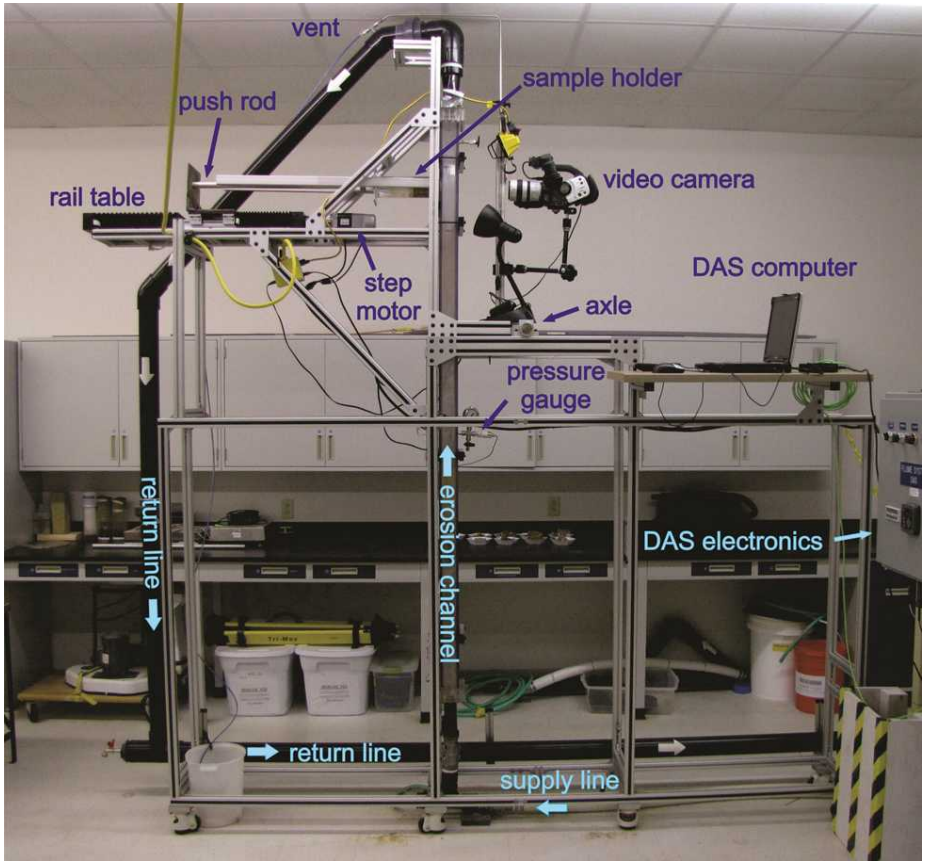
Surrogate Waste Materials

- Hansen et al. (1997) considered degradation of each constituent
- Surrogate materials represents the most degraded state conceivable for the waste, far weaker than any possible future condition
  - ample brine availability
  - extensive microbial activity
  - massive corrosion and degradation
  - absence of cementation, mineral precipitation, salt encapsulation, compaction effects, and more durable packaging

Sample Preparation

- Recipes simulate 50, 75, and 100% degraded waste by weight
  - See paper for constituent characteristics and weight percentages
- Two compactions pressures were used – 2.3 and 5.0 MPa
- Five samples of each recipe and compaction pressure
- Samples were fabricated in the SNL Geomechanics Laboratory under WIPP Quality Assurance guidelines
- Surrogate 50% degraded waste material was accepted for developing material parameter values for the Spallings model
  - Spallings Conceptual Model Peer Review Panel
  - Incorporated into WIPP recertification and other PAs since the CRA-2004 PABC

Vertical Flume



Test Section

Fluid Supply

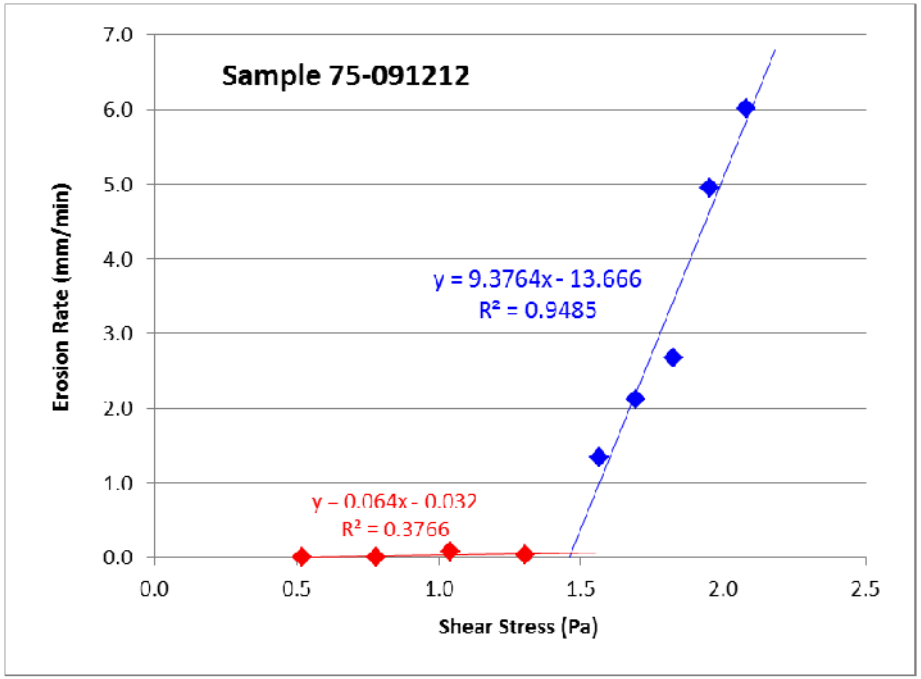
Average Shear Strength Results

Sample Type [percent degradation, compaction pressure]	Average Shear Strength [Pa]		
	UF, bilinear	UCSB, linear	UCSB, power law
100%, 2.3 MPa	0.17 *	0.21 *	0.22 *
100%, 5.0 MPa	----- *	----- *	----- *
75%, 2.3 MPa	1.53	1.38	1.49
75%, 5.0 MPa	2.17	1.81	1.97
50%, 2.3 MPa	2.22	2.58	2.85
50%, 5.0 MPa	5.05	5.10	5.29

* Only one test result for surrogate 100% degraded waste samples was considered reliable due to sample holder deformation, friction, and gasket interference

Observations

- With almost no exceptions, the erosion behavior of the surrogate waste samples occurred in a bilinear manner
  - UF method considered more applicable to present results
- All three methods of analysis produced similar results



- The less the surrogate material represents degradation of the waste, the stronger the material
- The more compaction the materials were subjected to, the better able they are to resist erosion

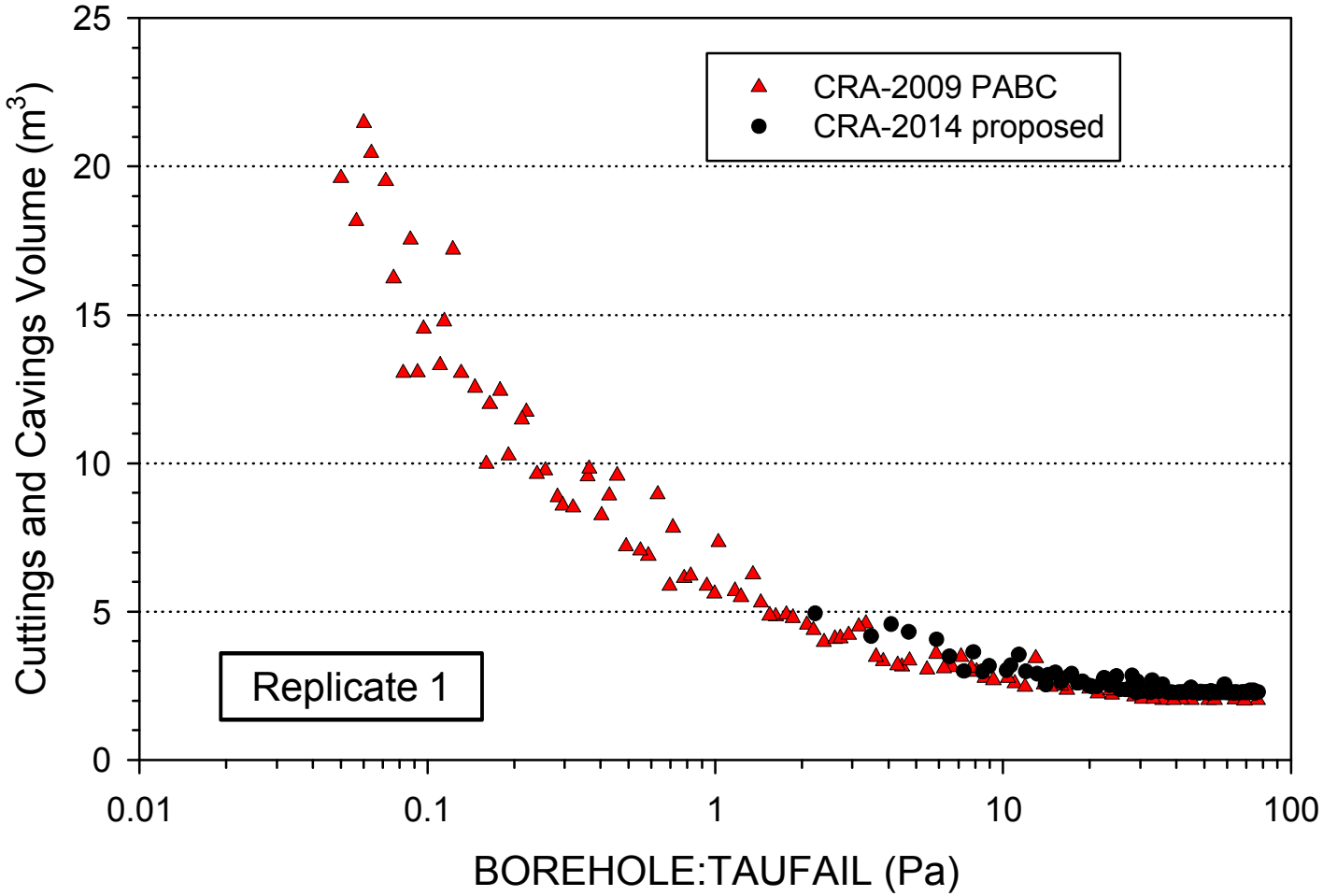
Recommendations

- Use of surrogate 50% degraded waste material, compacted at 5 MPa accepted previously
- Back-calculation of BRAGFLO results gives a consistent 4.3-4.4 MPa stress on the waste stack regardless of the PA scenario
- Due to strong compaction pressure dependence, DOE recommends using 2.3 MPa compaction pressure results
  - Lower limit of TAUFAIL : 2.22 Pa
  - Range of TAUFAIL : 2.22 – 77 Pa
  - Probability distribution of TAUFAIL : Uniform
    - Appropriate when all that is known about a parameter is its range
    - The maximum entropy distribution

Impact

- The proposed two changes to the parameter TAUFAIL – raising the lower limit and using a uniform distribution – will generally result in higher sampled shear strength values
- Higher shear strength values result in smaller cavings volumes
  - The borehole diameter is assumed to grow until the hydrodynamic shear stress on the borehole wall is equal to the shear strength of the waste
  - A higher shear strength results in a smaller diameter for the hypothetical eroded borehole

Comparison with CRA-2009 PABC



References

- Hansen, F.D., M.K. Knowles, T.W. Thompson, M. Gross, J.D. McLennan, and J.F. Schatz. *Description and Evaluation of a Mechanistically Based Conceptual Model for Spall*. SAND97-1369. Sandia National Laboratories, Albuquerque, NM. (1997).

Questions?