U.S.NRC

United States Nuclear Regulatory Commission

Protecting People and the Environment

Saltstone Review
NRC Concerns

Review status of NRC staff review of the 2009 Saltstone PA

January 27, 2011

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Outline

- NDAA History of Saltstone Project
- 2009 Saltstone PA Review
- DOE Research
- Model Assumptions
- NRC Concerns
- Alternative Analyses
- Summary

History of Saltstone Project

NRC/DOE NDAA Activities

- 2005 NRC Review of Saltstone PA identified numerous key assumptions and data gaps
- TER concluded that the performance objectives could be met if key assumptions are valid
- Research has been developed further by DOE
- NRC has reviewed data as the reports have been made available
- NRC staff is currently reviewing the revised PA
- NRC has been reviewing 2009 PA since Nov 2009

History of Saltstone Project

Monitoring Plan - Factors for Assessing Compliance

- Factor 1: Oxidation of Saltstone
- Factor 2: Hydraulic Isolation of Saltstone
- Factor 3: Model Support
- Factor 4: Erosion Control Design
- Factor 5: Infiltration Barrier Performance
- Factor 6: Feed Tank Sampling
- Factor 7: Tank 48 Wasteform
- Factor 8: Removal Efficiencies

History of Saltstone Project

Timeline of NRC Concerns under NDAA

Date	Milestone
Dec 2006	NRC identified concerns and key assumptions in Technical Evaluation Report (TER)
Oct 2007	NRC identifies Open Issues regarding quality of wasteform
Mar 2009	Open issue identified by NRC regarding retention of technetium by saltstone
Aug 2009	NRC observed DOE LFRG review of Saltstone PA
Apr 2010	NRC issues Request for Additional Information (RAI) on 2009 PA
Apr 2010	Meeting with SRS to discuss RAIs. Site staff had few questions on the RAIs
Jul 2010	RAI response received
Sep 2010	Call with DOE to discuss RAI responses
Dec 2010	NRC issues second Request for Additional Information (RAI) on 2009 PA

NRC Review of 2009 PA

Key Points

- Integration of new data into updated PA
- Risk-informed review
  - Key factors
  - Updated information from monitoring
  - Base case
  - Alternative Analyses
- Requests for Additional Information
  - First round of RAIs sent to DOE April 2010
  - Second Round sent to DOE December 2010
  - Second round of RAIs pending

DOE Research

Results

Research Topic	Description of Results
Hydraulic properties of saltstone	• Research has indicated that the assumed hydraulic conductivity in the 2005 PA was optimistic
Physical integrity of saltstone	• Cracking of saltstone in Vault 4 has been observed • Core samples crumbled when removed from the monolith
Fracturing of vault walls	• 2005 PA assumed the vault walls would serve as a diffusive and flow barrier, but radioactive liquid has seeped through Vault 4 walls
Reduction and retention of technetium in saltstone	• To date, SRS lab experiments have not demonstrated that Tc is reduced and retained
Inventory of Th-230/Ra-226	• Ra-226 drives the dose in the current PA , but it was not identified as a key radionuclide in 2005 PA • 2005 PA assumed 0.0353 Ci Th-230 and 13 Ci Ra-226 for SDF • 2009 PA assumed 20 Ci Th-230 and 4.1 Ci Ra-226 for SDF

Research Quality

Experimental Data and References

- Experimental Data
  - Experimental conditions inconsistent with site conditions
  - Errors in experimental design and conduct
  - Inappropriate exclusion of data
  - Reliance on preliminary research for major assumptions
  - Limited site specific data
- References
  - Original source of data often not transparent due to lengthy reference chain
  - Cited reference sometimes does not support assumed value
  - Some experimental conditions for generic data differ significantly from saltstone
  - Original reference sometimes based on weak source (e.g., personal communication)
  - Use of expert elicitation not transparent

Model Assumptions

Base Case (Case A)

- Inconsistent with known conditions
- Limited model support
- Inadequate accounting of uncertainty (e.g., one-off sensitivity analyses)
- Technical concerns
  - Technetium reduction and retention
  - Hydraulic conductivity of saltstone and vaults
  - Moisture characteristic curves
  - Lateral drainage layer performance
  - Degradation of vaults and saltstone

Model Assumptions

Technetium Release from Saltstone

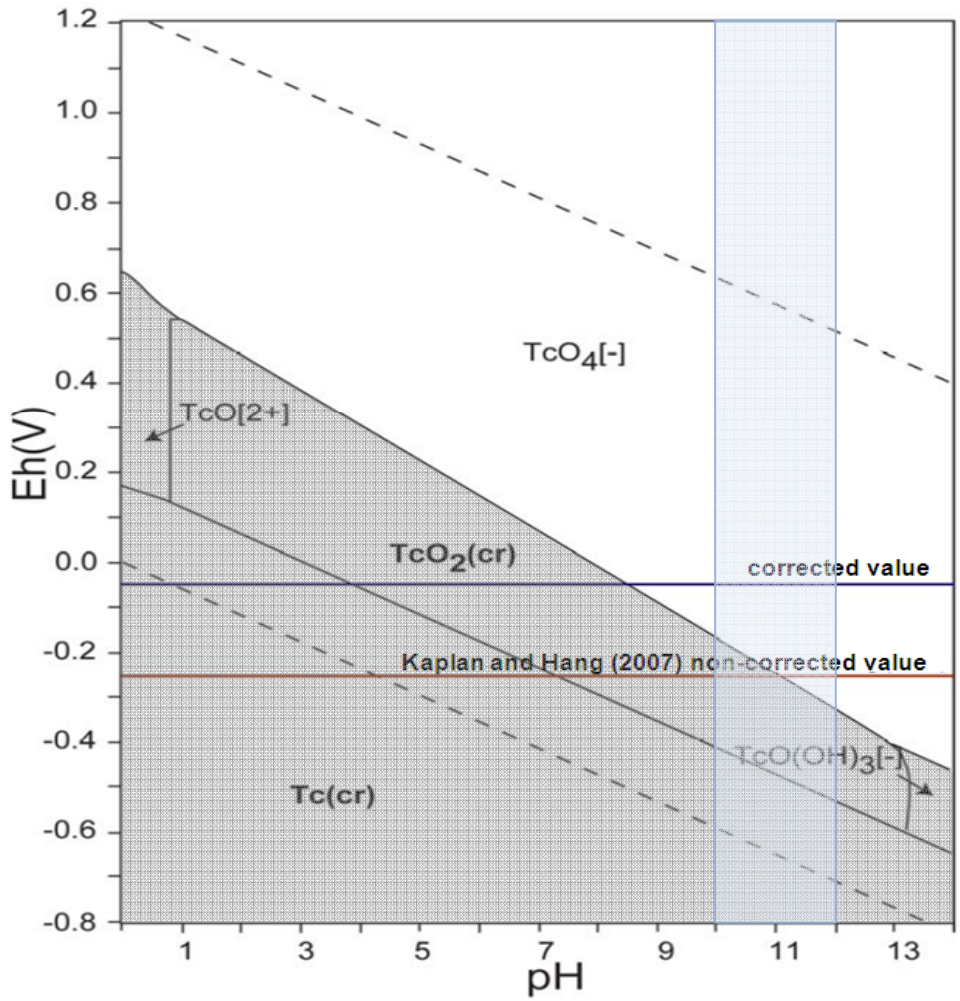
- The release of technetium is based on its oxidation state. Under reducing conditions, it is expected that technetium will sorb strongly. If technetium is not reduced and retained, the dose is likely to be high.
- Saltstone contains slag to create reducing conditions and retain technetium, but based on the data received to date the reduction and retention of Tc-99 in saltstone is not clear.

Assumed K_d values - (mL/g)		K_d Values Measured by SRS - (mL/g)		
2005 PA (1)	2009 PA (1)	SRNS-STI-2008-00045 sample exposed to air (2)	SRNS-STI-2008-00045 sample under N_2 (3)	SRNL-STI-2009-00636 (4)
1000	1000 – 5000	0.16 - 0.93	6.5 - 91.3	9.1 - 56

(1) based on literature information published by Bradbury and Sarrott (1995). The basis for these values is a report by Bayliss et al. that contained a strong reducing agent, sodium dithionite. In addition, this paper appears to be a conference presentation and may not have been peer reviewed.
(2) from Table 2
(3) from Table 3. Note that this data is reported with the following comment : "quality of the spectra generated for the analyses was compromised by the U-233 peak shift into the Tc-99 region of the spectra“
(4) note that this K_d value is reported incorrectly in the abstract to this document

NRC Concerns

Pourbaix Diagram - Technetium



Eh-pH Diagram of the System Tc-O-H

NRC Concerns

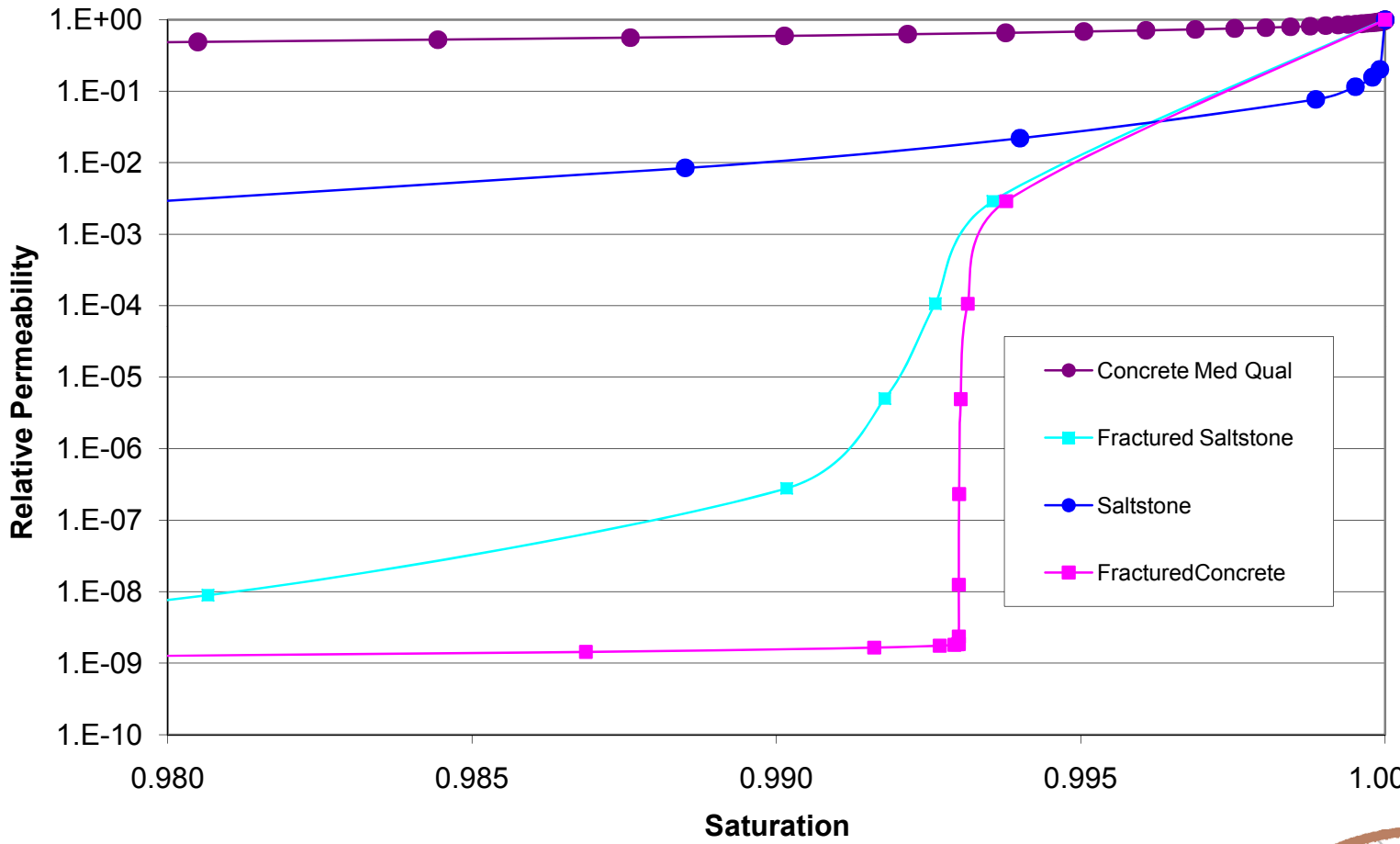
Hydraulic Conductivity

Years	Assumed Hydraulic Conductivity, K at SRS (cm/s)		Hydraulic Conductivity Measurements – (cm/s)			
	2005 PA	2009 PA	WSRC-STI-2007-00649[1] (no CO_2)	WSRC-STI-2008-00421[1]	WSRC-STI-2009-00419[1,2] (at 60°C)	Core Sample
Initial	1.0 E-11	2.0 E-9	6.0 E-9 to 3.0 E-8	1.2 E-9 to 8.8 E-8	8.6 E-7	TBD
10000	1.0 E-9	2.0 E-9	--	--	--	--

[1]Samples did not account for (i) scale, (ii) field-emplacement, (iii) CO_2, (iv) permeability evolution
[2]Accounted for organics, admixtures, and a cure temperature of 60°C

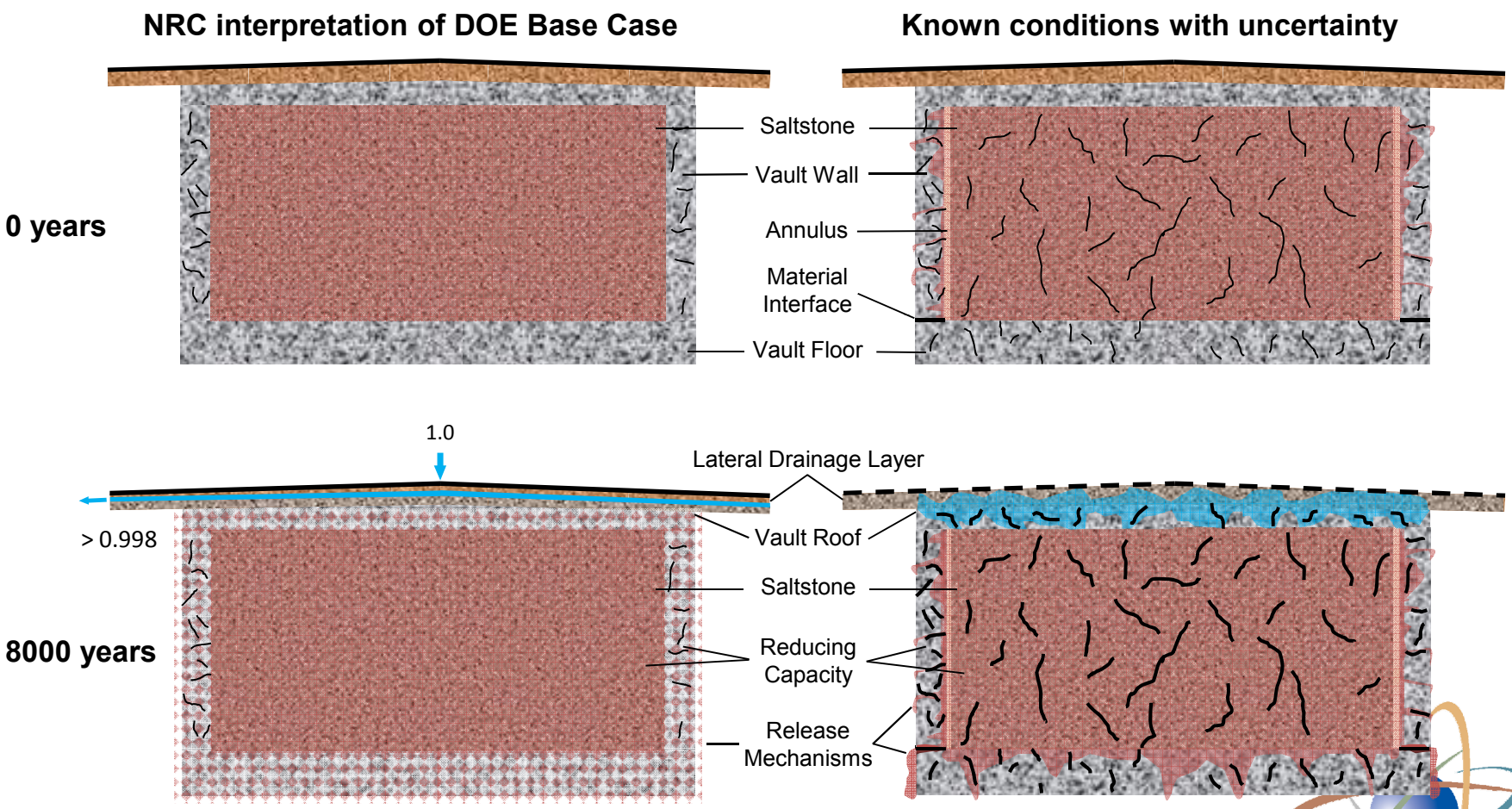
NRC Concerns

Moisture Characteristic Curves



NRC Concerns

Conceptual Model - Vault 4



NRC Concerns

Revisions to Base Case

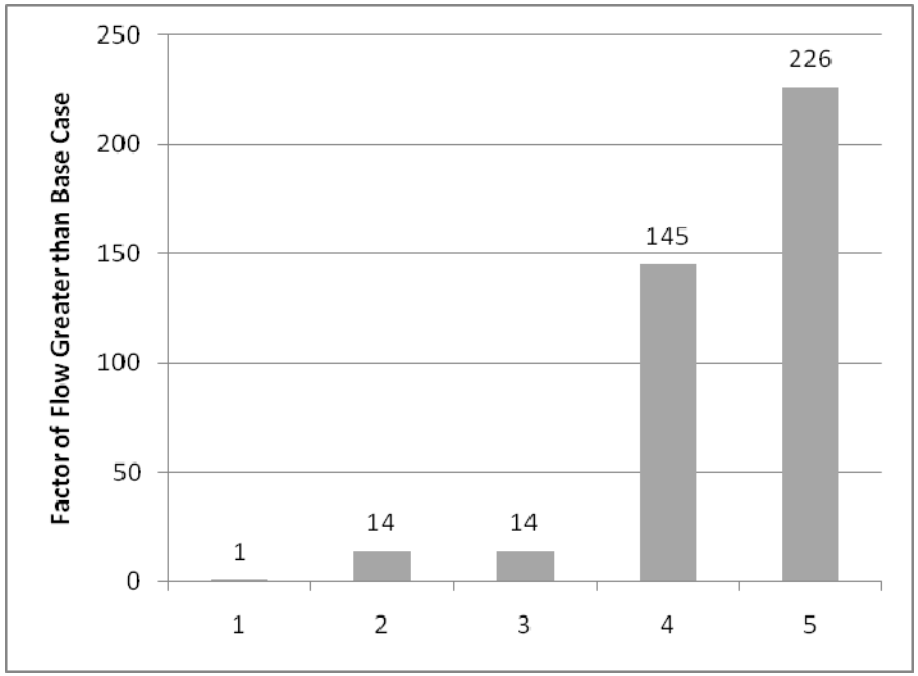
Revisions:

- Moisture characteristic curves (MCC) for cementitious materials
- Hydraulic conductivity (K) for lateral drainage layer (LDL) , clean grout, and saltstone

Outstanding:

- Fracturing of saltstone and vaults
- Flow through the walls
- Hydraulic conductivity values that account for degradation, scale, field-emplacement, CO_2 contamination, and permeability evolution

Flow through saltstone grout at 500 years



1 – Base Case

2 – Revised:
- MCC for Saltstone and Clean Grout

3 – Revised:
- LDL

4 – Revised:
- K for Saltstone and Clean Grout

5 – Revised:
- LDL
- K and MCC for Saltstone and Clean Grout

NRC Concerns

Alternative Analyses

- Synergistic Case
  - Assumptions
    - Earlier degradation of the closure cap
    - Degradation of the vaults at year 500
    - Fractured saltstone at closure
  - Conservatism of the synergistic case is unclear (e.g., flow through saltstone, reducing capacity, biosphere parameters)
- Hybrid Approach
  - Concerns with implementation (e.g., coupling of PORFLOW and GoldSim models, probability of cases, benchmarking of certain radionuclides)
  - Limited bases for parameter distributions (e.g., inventory, K_d values)

NRC Concerns

Summary

- NDAA History of Saltstone Project
  - Monitoring plan based on TER for 2005 WD
  - DOE has performed research in the area of key factors
  - NRC reviews research as it is available
  - Previous assumptions demonstrate optimistic bias
  - NRC has been reviewing 2009 PA since Nov 2009

NRC Concerns

Summary (cont.)

- NRC has requested additional information to address questions and concerns:
  - Review was risk-informed and focused on key assumptions
  - Current RAIs address the following issues:
    - Degree of compatibility between the conceptual model and mathematical model
      - As built conditions
      - Degradation processes over time
      - Flow through system
    - Basis for key data and parameters assumed in the model
    - Additional model support for key assumptions in the model