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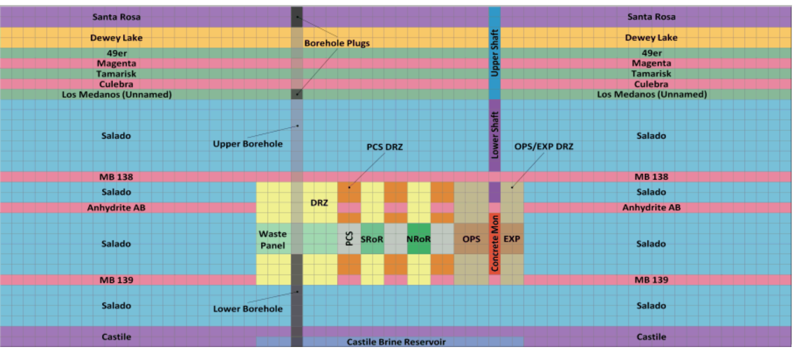

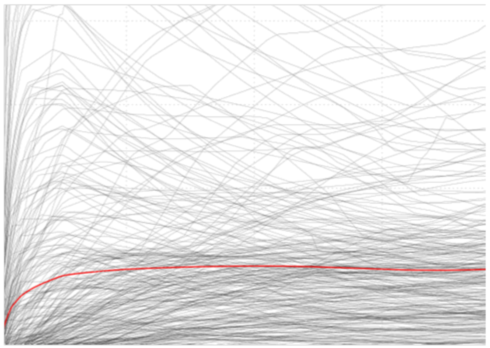

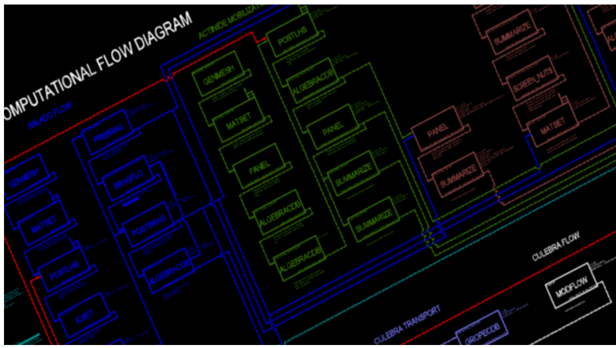

Operations and Experimental Area Sensitivity Study

Final Report Briefing

June 17, 2016

Presented by:
Brad Day
Sandia Carlsbad
Performance Assessment Dept.

U.S. DEPARTMENT OF ENERGY

NNSA National Nuclear Security Administration

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Outline

- Background
- Modeling Approach
- Results
  - Waste panel and Operations/Experimental area brine pressures
  - Waste panel and Operations/Experimental area brine saturations
  - Waste panel and Operations/Experimental area brine/gas flows
  - Brine and gas flows across the northernmost panel closure
  - Releases
- Conclusions

Background

- Current PA implementation of Operations (OPS) and Experimental (EXP) cavities uses a constant porosity of 0.18, corresponding to a hydrostatic pressure of 7.8 MPa at 10,000 years based on work by Arguello (1994)[a]
  - Past sensitivity analyses used a porosity surface developed for empty rooms to include effects of gas in the void as a restorative force to resist closure
  - FEP DR-3 supported the use of a constant, rather than time-varying, porosity because calculations had shown Performance Assessment (PA) was insensitive to the description of void closure utilized
- EPA (2016)[b] requested a final sensitivity study to evaluate the OPS/EXP and associated DRZ at a lower porosity, with increased residual brine and gas saturations, and with two-phase flow properties activated
  - Final set of EPA OPS/EXP study parameters were influenced by a series of previous calculations presented to the EPA on 2/2/2016[c]

[a] Arguello, J.G. 1994, Memorandum to B.M. Butcher, Backfill Sensitivity Study – Creep Closure Behaviors of an "Equivalent" Empty Room at the North End of WIPP Subjected to Gas Generation", Sandia National Laboratories
[b] EPA 2016, Letter correspondence dated 2/29/16 from Tom Peake, EPA, to Russ Patterson, CBFO, Subject: EPA Requested Sensitivity Analysis Parameters, ERMS 565676, Sandia National Laboratories, Carlsbad, NM
[c] Day, B., Zeitler, T., 2016, Non-Waste Area Sensitivity Study, DOE/EPA Technical Exchange Meeting, February 2, 2016, SAND2016-1217PE, Sandia National Laboratories, Carlsbad, NM.

Modeling Approach

- Perform a full 3-replicate PA evaluation (CRA14_SEN2) utilizing EPA parameters
  - OPS/EXP Cavities

Experimental and Operations Areas													
Material	Time (yr)	POROSITY	PRMX_LOG PRMY_LOG PRMZ_LOG	COMP_RCK	PORE_DIS	CAP_MOD	PCT_A	PCT_EXP	RELP_MOD	SAT_IBRN	SAT_RBRN	SAT_RGAS
CRA14 (Camphouse 2013)[d]												
CAVITY_3	-5 - 0	1	-10	0	0.7	1	0	0	11	0	0	0
OPS_AREA	0 - 10,000	0.18	-11	0	0.7	1	0	0	11	0	0	0
EXP_AREA	0 - 10,000	0.18	-11	0	0.7	1	0	0	11	0	0	0
CRA14_SEN2 (EPA 2016)[b]												
CAVITY_3	-5 - 0	S_HALITE + 1/2*STDEV	S_HALITE + 1	S_HALITE	0.7	2	0.56	-0.346	4	0.95	0.6	0.398
OPS_AREA	0 - 10,000	S_HALITE + 1/2*STDEV	S_HALITE + 1	S_HALITE	0.7	2	0.56	-0.346	4	0.95	0.6	0.398
EXP_AREA	0 - 10,000	S_HALITE + 1/2*STDEV	S_HALITE + 1	S_HALITE	0.7	2	0.56	-0.346	4	0.95	0.6	0.398

[d] Camphouse, R.C. 2013. Analysis Plan for the 2014 WIPP Compliance Recertification Application Performance Assessment. Sandia National Laboratories, Carlsbad, NM. ERMS 559198.

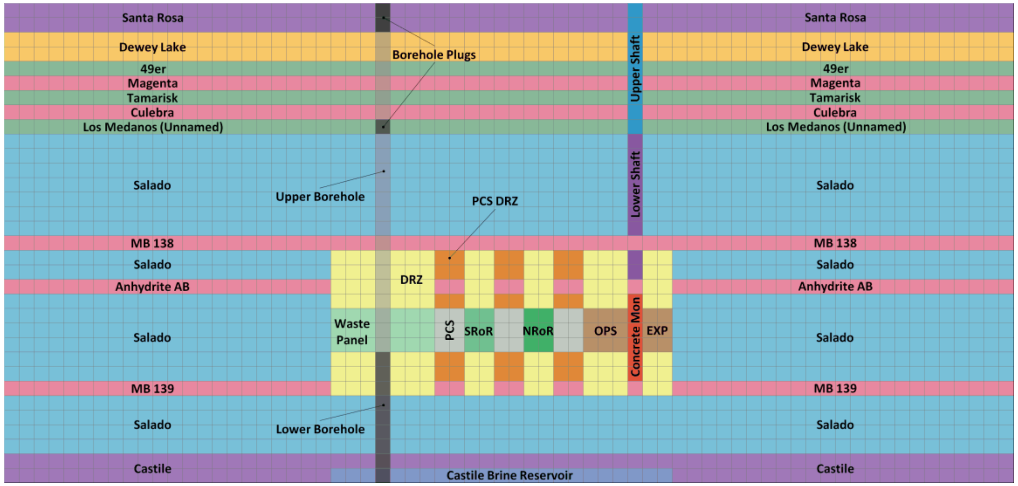
Modeling Approach (cont.)

- OPS/EXP DRZ

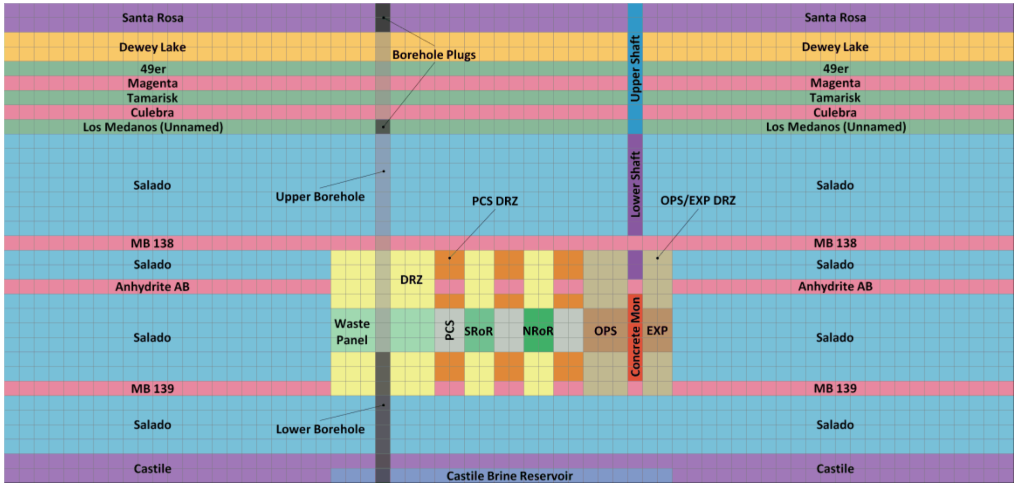
Disturbed Rock Zone Adjoining Experimental and Operations Areas													
Material	Time (yr)	POROSITY	PRMX_LOG PRMY_LOG PRMZ_LOG	COMP_RCK	PORE_DIS	CAP_MOD	PCT_A	PCT_EXP	RELP_MOD	SAT_IBRN	SAT_RBRN	SAT_RGAS
CRA14 (Camphouse 2013)[d]												
DRZ_0	-5 - 0	S_HALITE + 0.0029	-17	7.41E-10	0.7	1	0	0	4	1	0	0
DRZ_1	0 - 10,000	S_HALITE + 0.0029	sampled	7.41E-10	0.7	1	0	0	4	N/A	0	0
CRA14_SEN2 (EPA 2016)[b]												
DRZ_OE_0	-5 - 0	S_HALITE	S_HALITE	S_HALITE	0.7	2	0.56	-0.346	4	0.95	0.6	0.398
DRZ_OE_1	0 - 10,000	S_HALITE	S_HALITE	S_HALITE	0.7	2	0.56	-0.346	4	0.95	0.6	0.398

Modeling Approach (cont.)

- BRAGFLO Grids



CRA14



CRA14_SEN2

Results

— CRA14

— CRA14_SEN2 – ϕ reduced, k reduced, k_r nonlinear, C_p nonzero, s_r increased

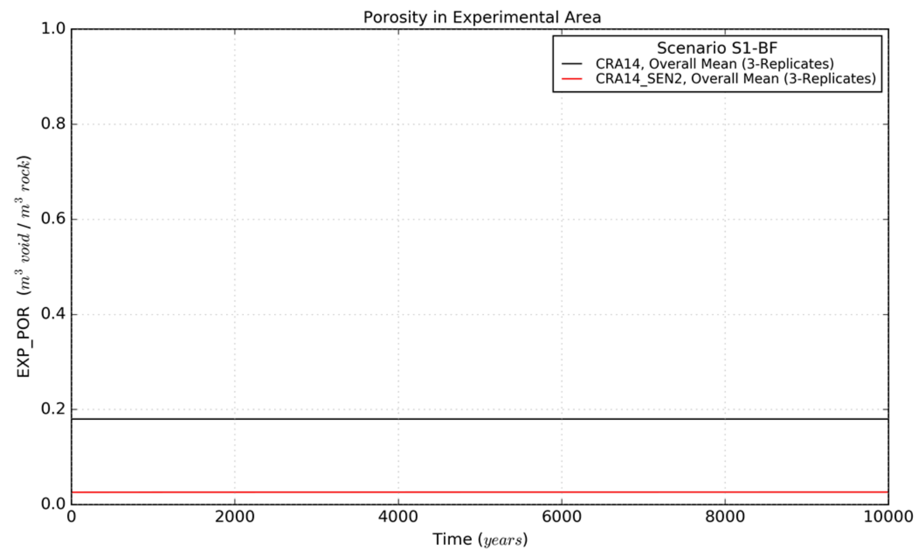
ϕ = porosity

k = permeability

k_r = relative permeability

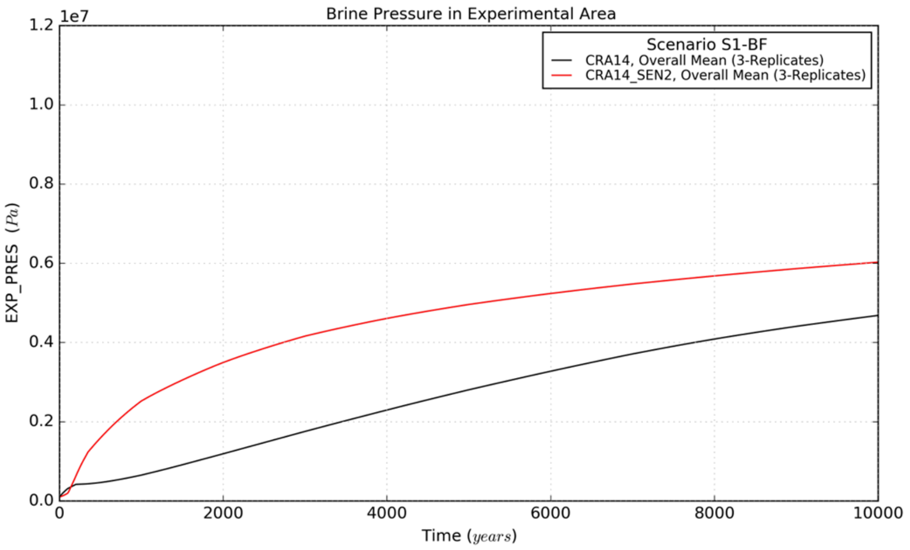
C_p = capillary pressure

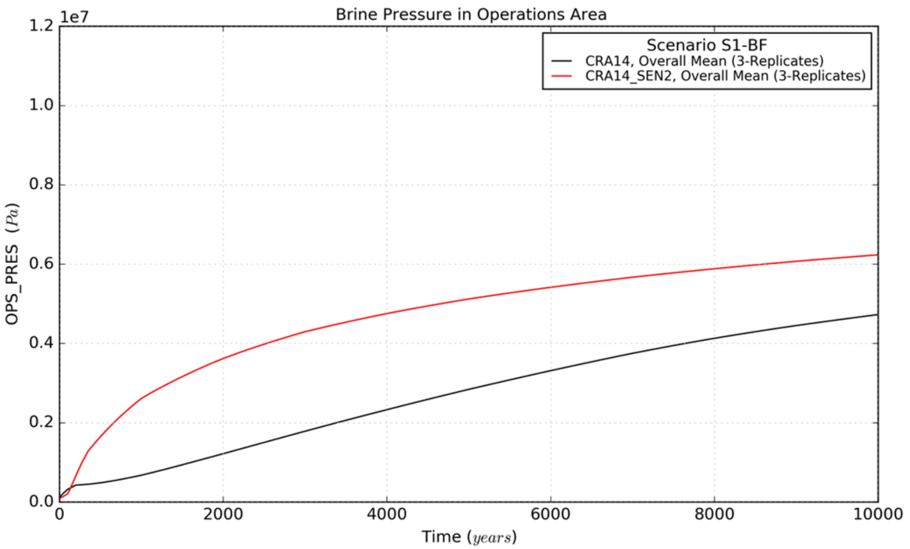
s_r = residual saturation



OPS/EXP Pressures – Scenario 1

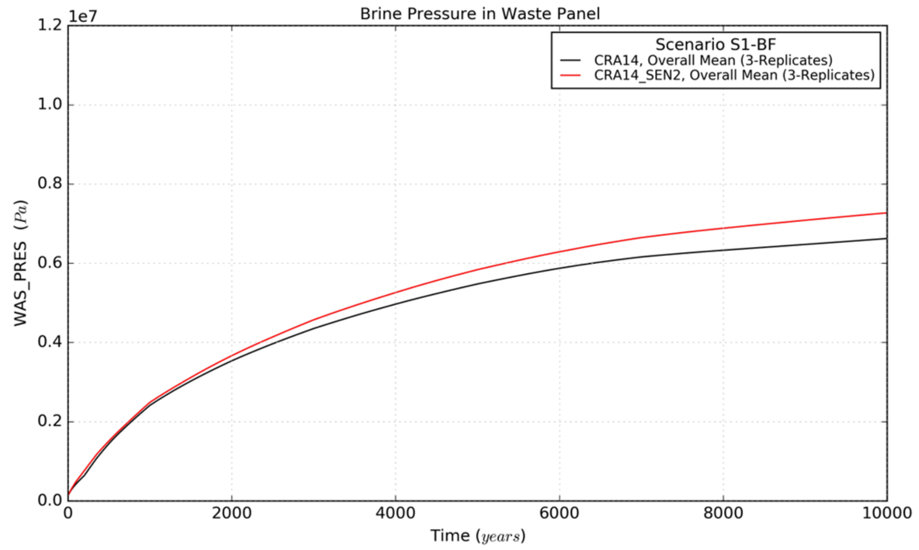
- Increase in pressure results from a decrease in porosity and permeability, increase in initial and residual brine saturations, increase in residual gas saturations, and application of capillary-pressure effects on relative permeability which decreases pore volume and brine and gas flows within OPS/EXP
- Scenario 1 EXP_PRES Function Average
  - CRA14 - 2.67E+06
  - CRA14_SEN2 - 4.53E+06
  - Increase = 70%
- Scenario 1 OPS_PRES Function Average
  - CRA14 - 2.70E+06
  - CRA14_SEN2 - 4.69E+06
  - Increase = 74%
- Scenarios 2 thru 6 follow similar trends

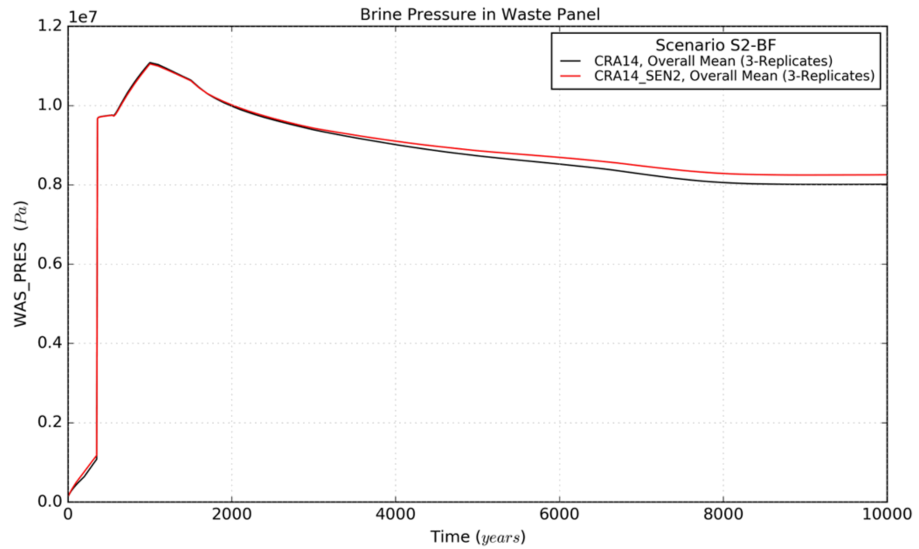




Waste Panel Pressures – Scenarios 1,2

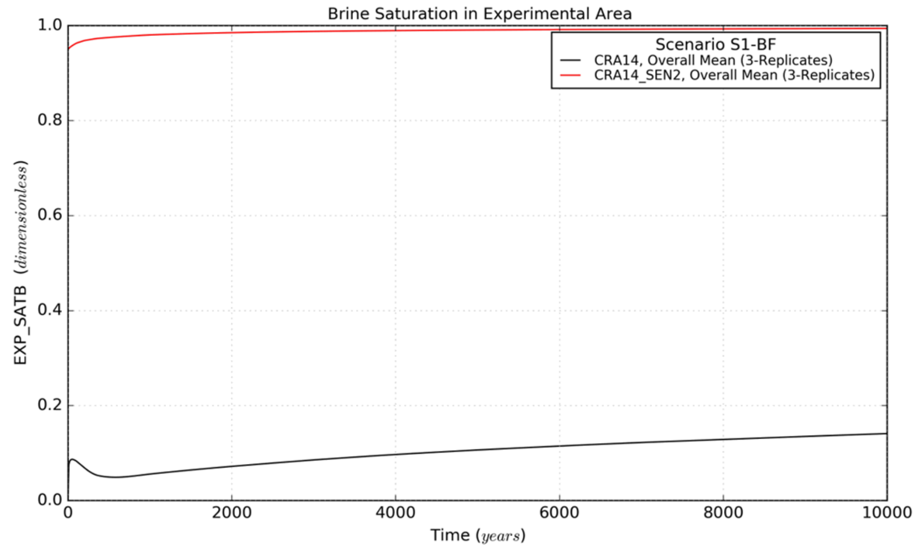
- Increase in pressure results from reduced gas flows northward to the OPS/EXP areas
- Scenario 1 WAS_PRES Function Average
  - CRA14 - 4.92E+06
  - CRA14_SEN2 - 5.27E+06
  - Increase = 7%
- Scenario 2 WAS_PRES Function Average
  - CRA14 - 8.64E+06
  - CRA14_SEN2 - 8.76E+06
  - Increase = 12%
- South rest of repository (SROR) and north rest of repository (NROR) follow similar trends for all scenarios (increases enhanced to north)
- Scenarios 3 thru 6 follow similar trends

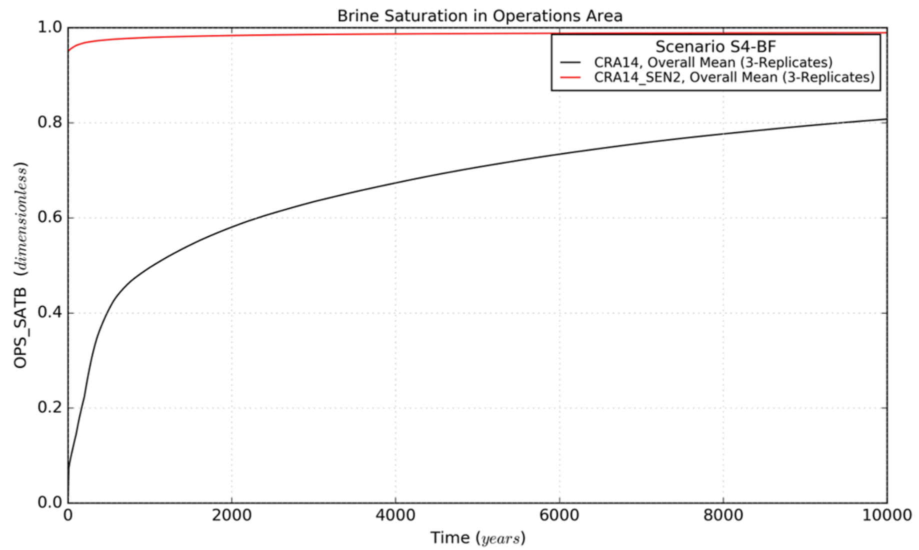




OPS/EXP Saturations – Scenario 1

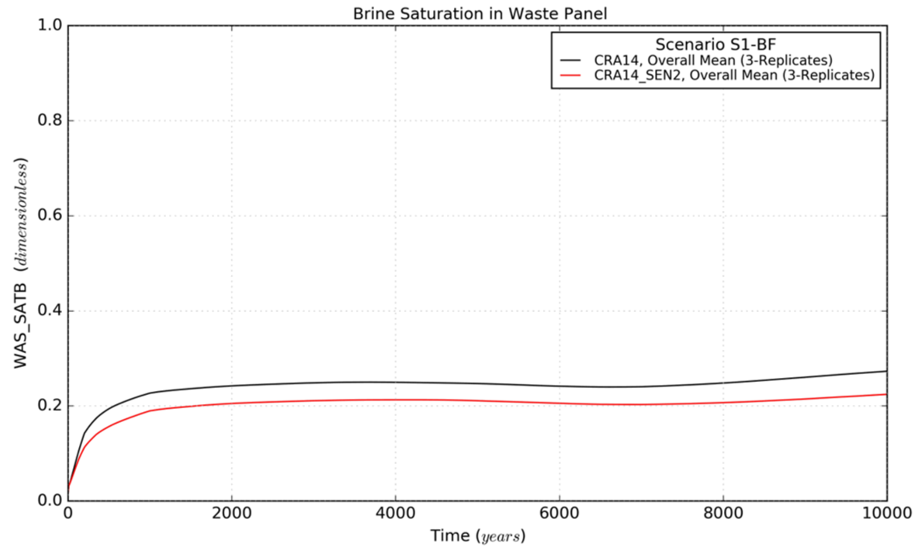
- Increase in brine saturation results from an increased initial saturation and modified parameters that restrict brine flow within the greatly reduced pore volumes in OPS/EXP
- Scenario 1 EXP_SATB Function Average
  - CRA14 - 1.02E-01
  - CRA14_SEN2 - 9.89E-01
  - Increase = 870%
- Scenario 1 OPS_SATB Function Average
  - CRA14 - 6.67E-01
  - CRA14_SEN2 - 9.86E-01
  - Increase = 48%
- Scenarios 2 thru 6 follow similar trends
- Note that saturations are increased but total brine volumes are essentially unchanged in EXP and reduced in OPS

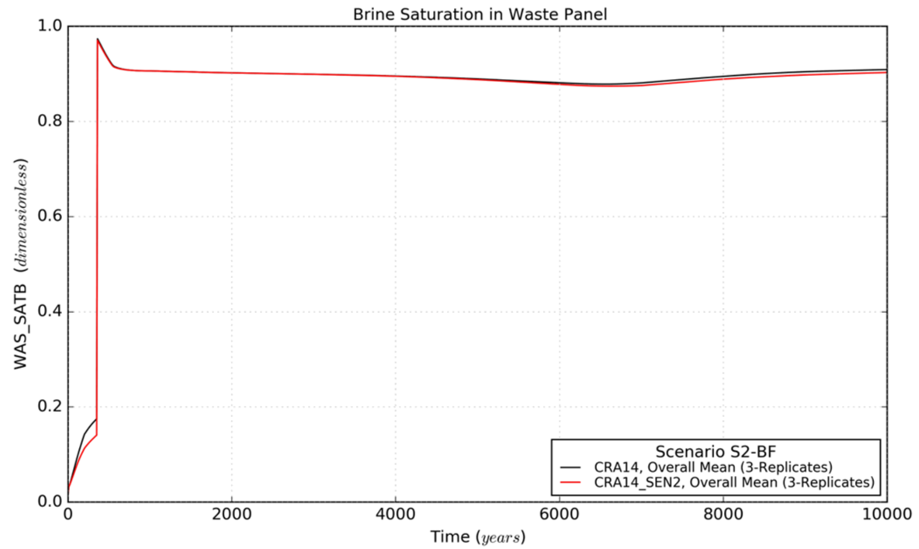




Waste Panel Saturations – Scenarios 1,2

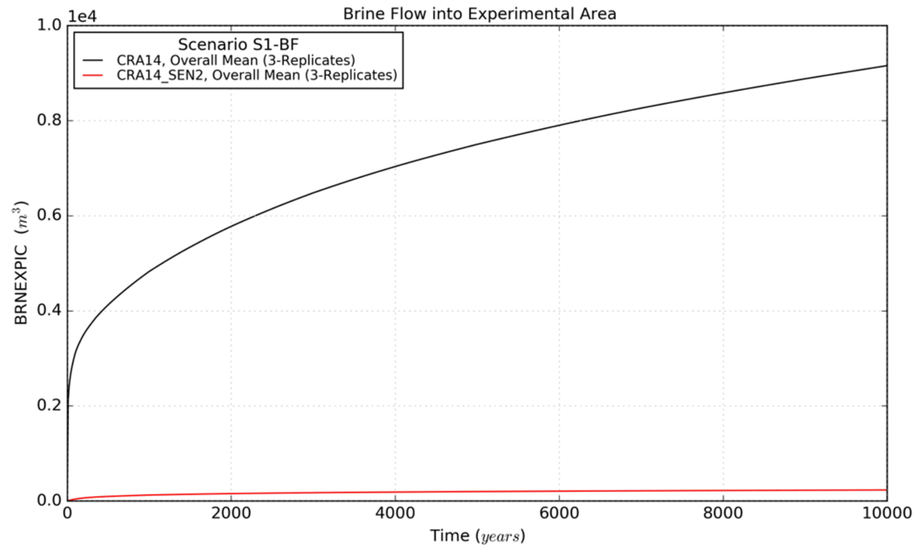
- Reduced brine saturation results from an increased pressure within the waste panel
- Scenario 1 WAS_SATB Function Average
  - CRA14 - 2.40E-01
  - CRA14_SEN2 - 2.02E-01
  - Decrease = 16%
- Scenario 2 WAS_SATB Function Average
  - CRA14 - 8.69E-01
  - CRA14_SEN2 - 8.66E-01
  - Decrease = 1%
- Scenarios 3 thru 6 follow similar trends

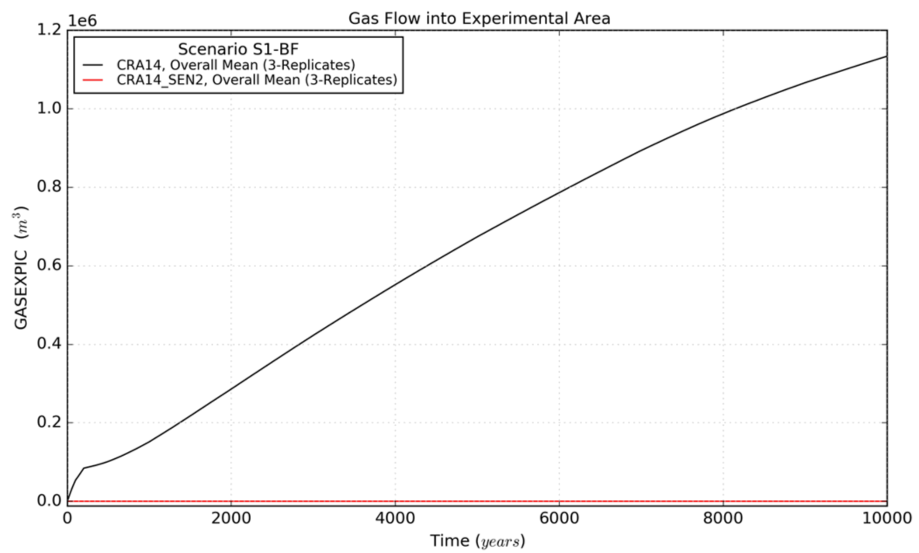




OPS/EXP Brine/Gas Flow – Scenario 1

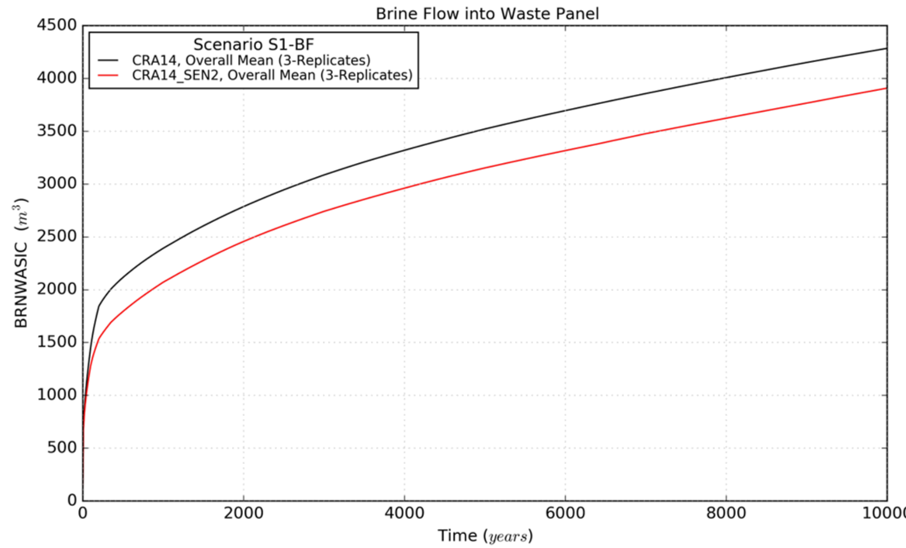
- Significant decrease in brine and gas inflow results from modified parameters that restrict brine and gas flow within the greatly reduced pore volumes in OPS/EXP
- Scenario 1 BRNEXPIC Function Average
  - CRA14 - 7.15E+03
  - CRA14_SEN2 - 1.86E+02
  - Decrease = 3744%
- Scenario 1 GASEXPIC Function Average
  - CRA14 - 6.42E+05
  - CRA14_SEN2 - 0
  - Decrease = Infinite%
- Gas flow into OPS is not entirely eliminated but significantly reduced for Scenario 1
- Brine and gas inflow for OPS/EXP Scenarios 2 thru 6 follow similar trends

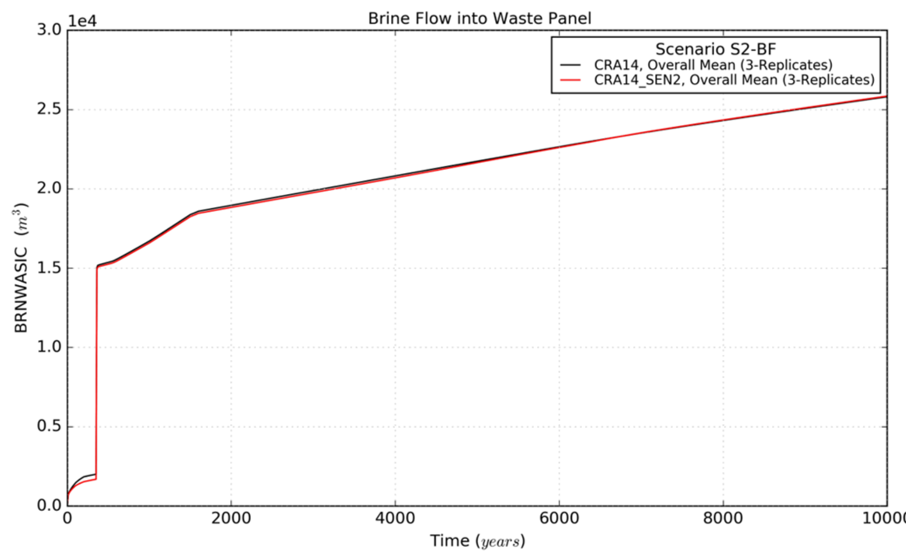




Waste Panel Brine Flow – Scenarios 1,2

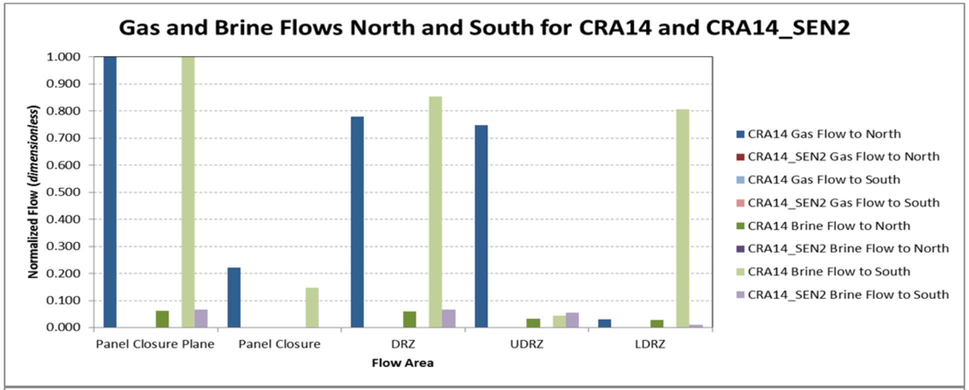
- Reduced brine inflow results from an increased pressure within the waste panel
- Scenario 1 BRNWASIC Function Average
  - CRA14 - 3.38E+03
  - CRA14_SEN2 - 3.02E+03
  - Decrease = 11%
- Scenario 2 BRNWASIC Function Average
  - CRA14 - 2.09E+04
  - CRA14_SEN2 - 2.09E+04
  - Decrease = 0%
- Magnitude of inflow reduction is significantly less for scenarios with Castile brine intrusions
- Scenarios 3 thru 6 follow similar trends

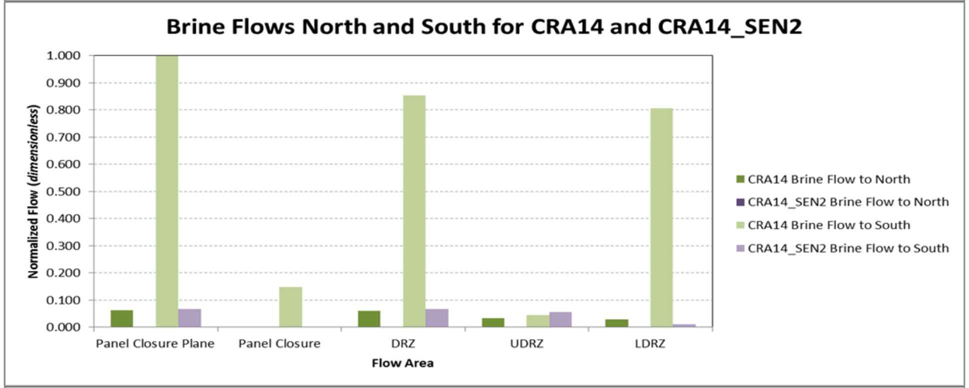


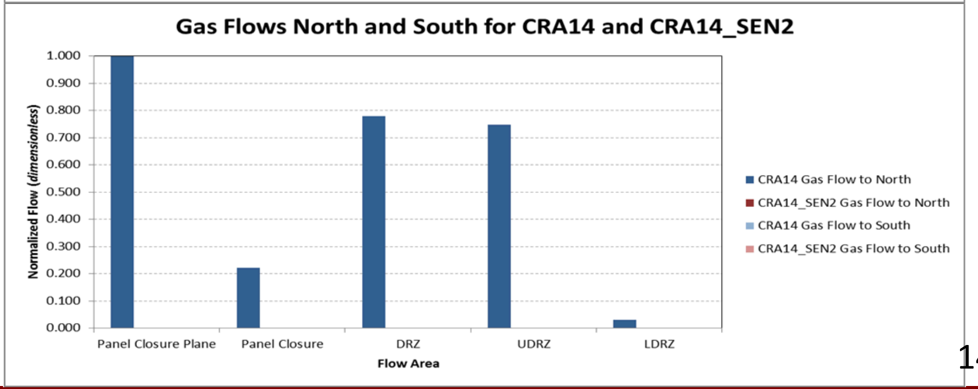


Brine/Gas Flow Across Northernmost Panel Closure – Scenario 1

- Evaluated for north and south flows across:
  - entire panel closure plane (panel closure plus upper and lower DRZ)
  - panel closure
  - panel closure DRZ (upper and lower DRZ)
  - upper DRZ
  - lower DRZ
- Normalized by the maximum gas and brine flow in either direction across the full planes
- CRA14
  - Brine flows predominantly south with 80% through the lower DRZ
  - Gas flows predominantly north with 75% through the upper DRZ
- CRA14_SEN2
  - Brine flow is <7% of CRA14; flows south and within lower DRZ
  - Gas flow is essentially zero
- Scenarios 2 through 6 follow similar trends

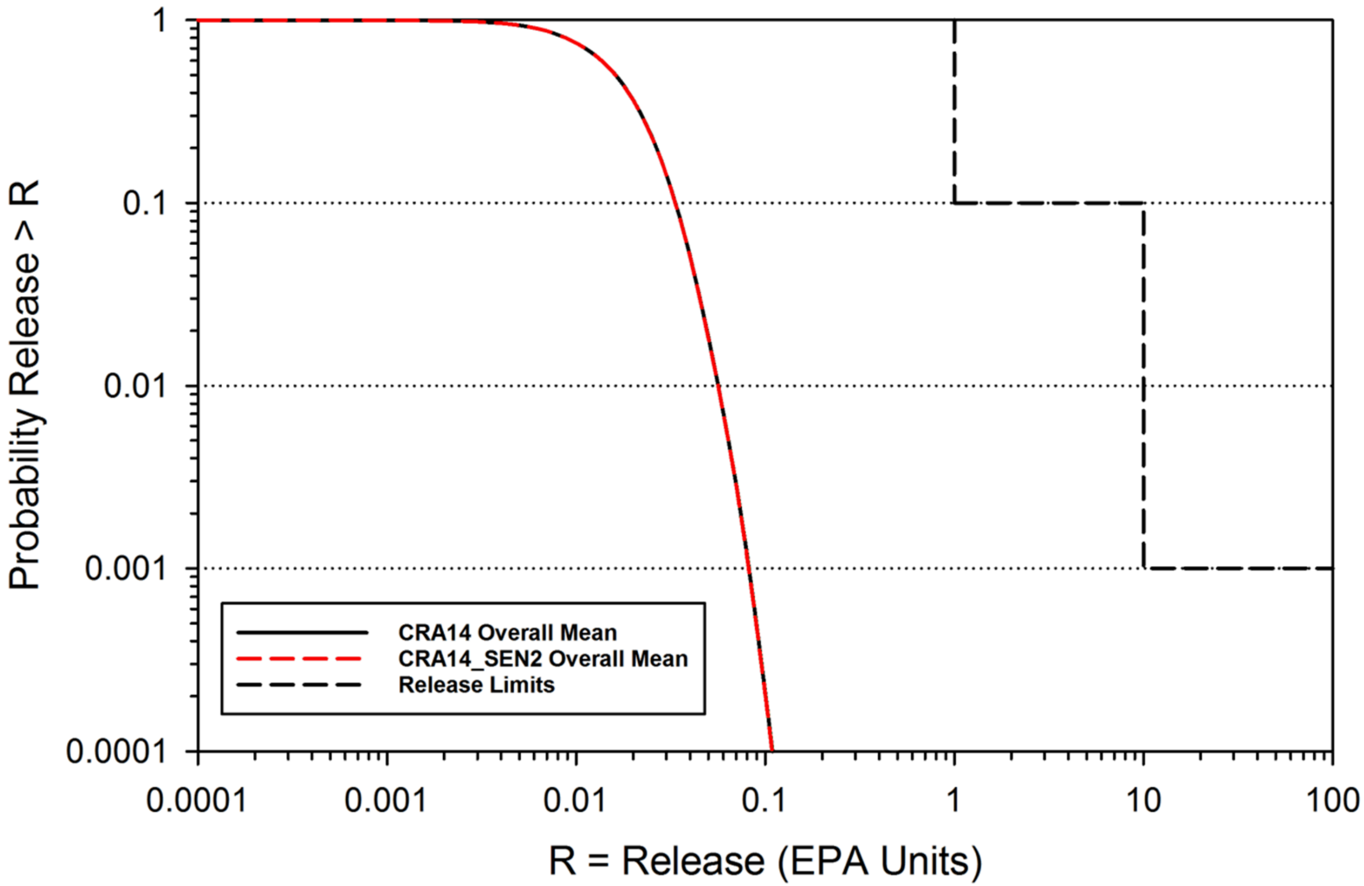






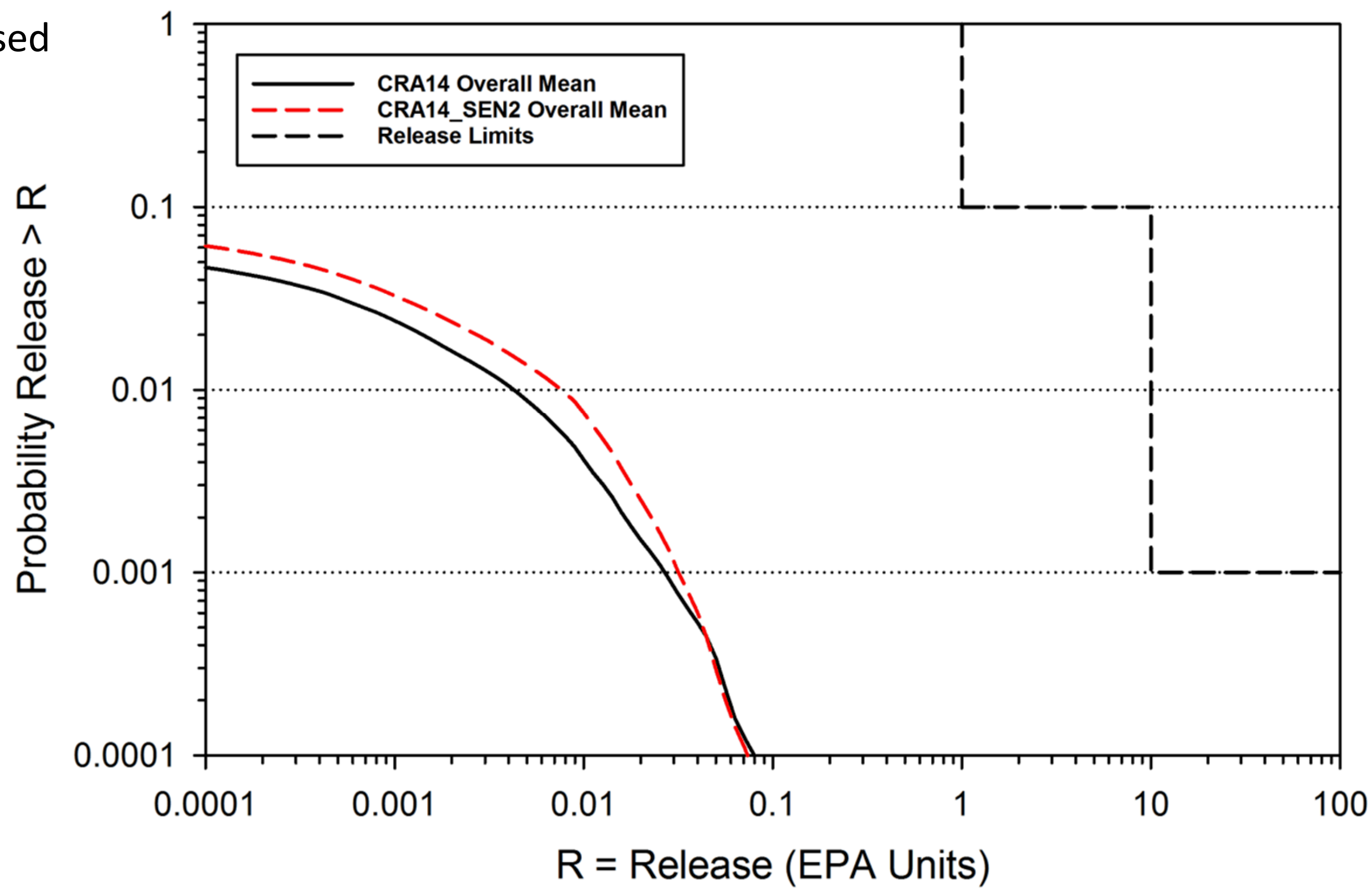
Cuttings and Cavings Releases

- Overall Mean CCDFs (3-replicate)
- No change, as expected



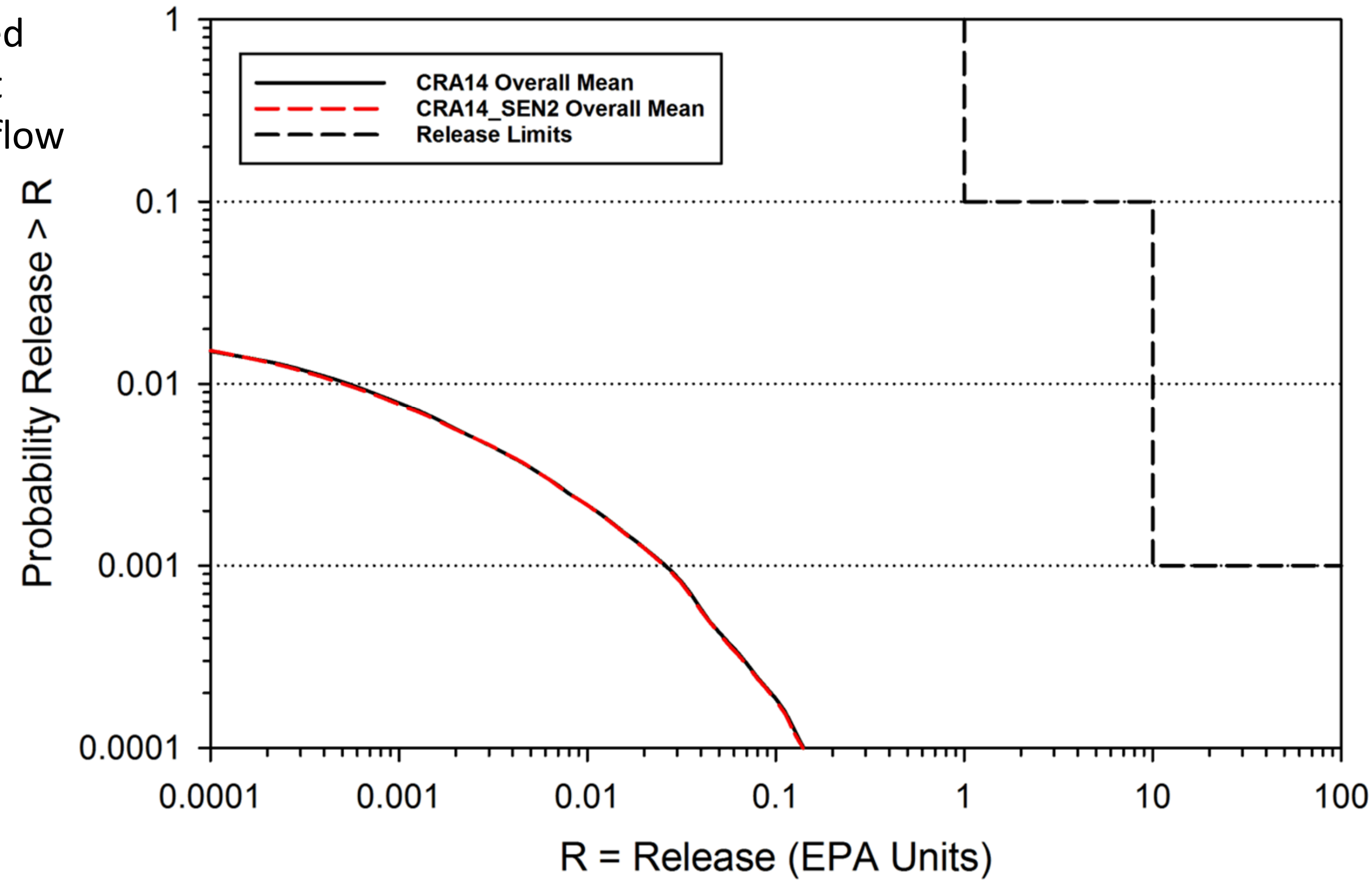
Spallings Releases

- Overall Mean CCDFs (3-replicate)
- Marginally increased due to increased pressure in waste areas



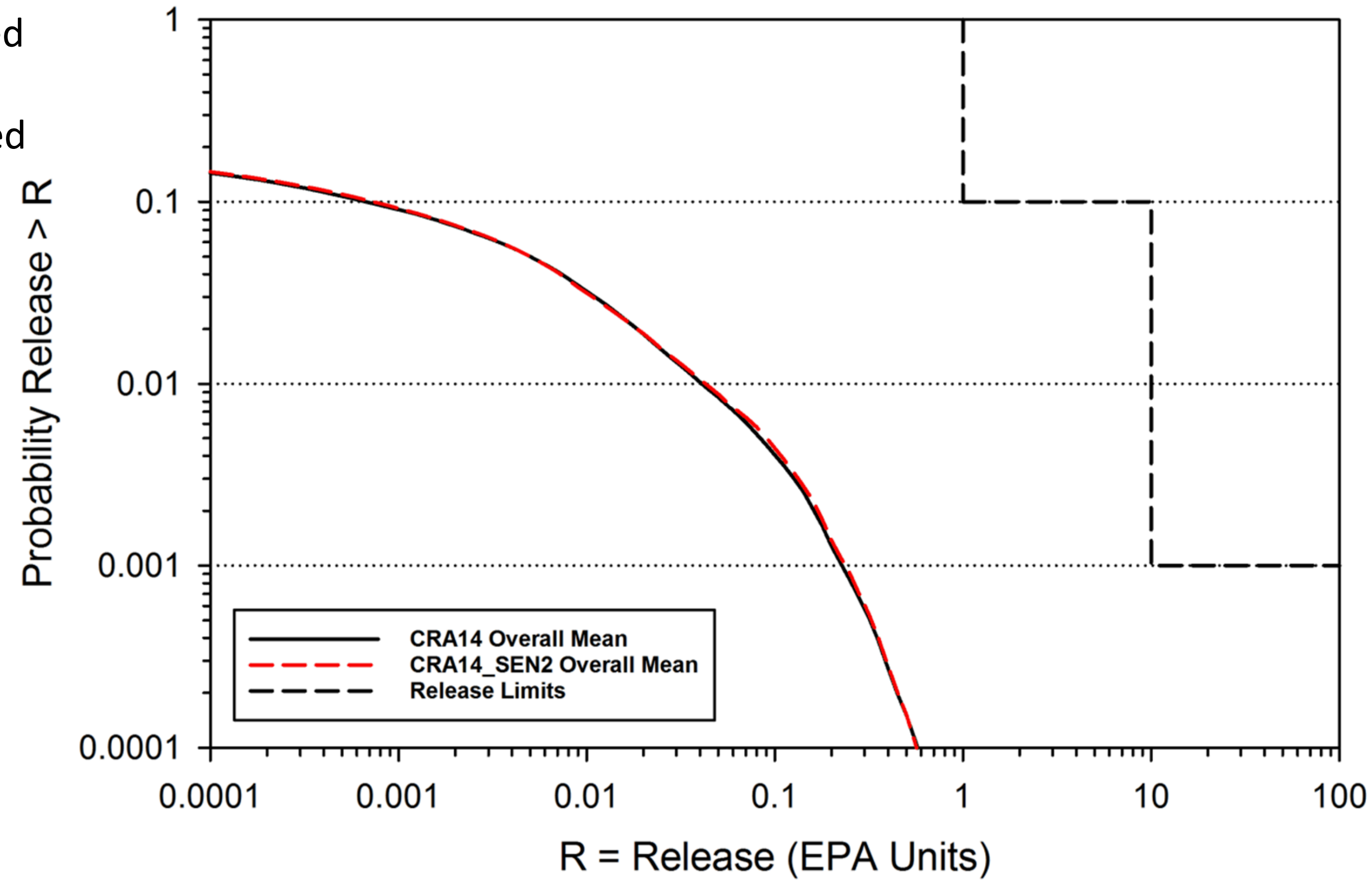
From Culebra Releases

- Overall Mean CCDFs (3-replicate)
- Negligibly changed due to equivalent amount of brine flow up the borehole



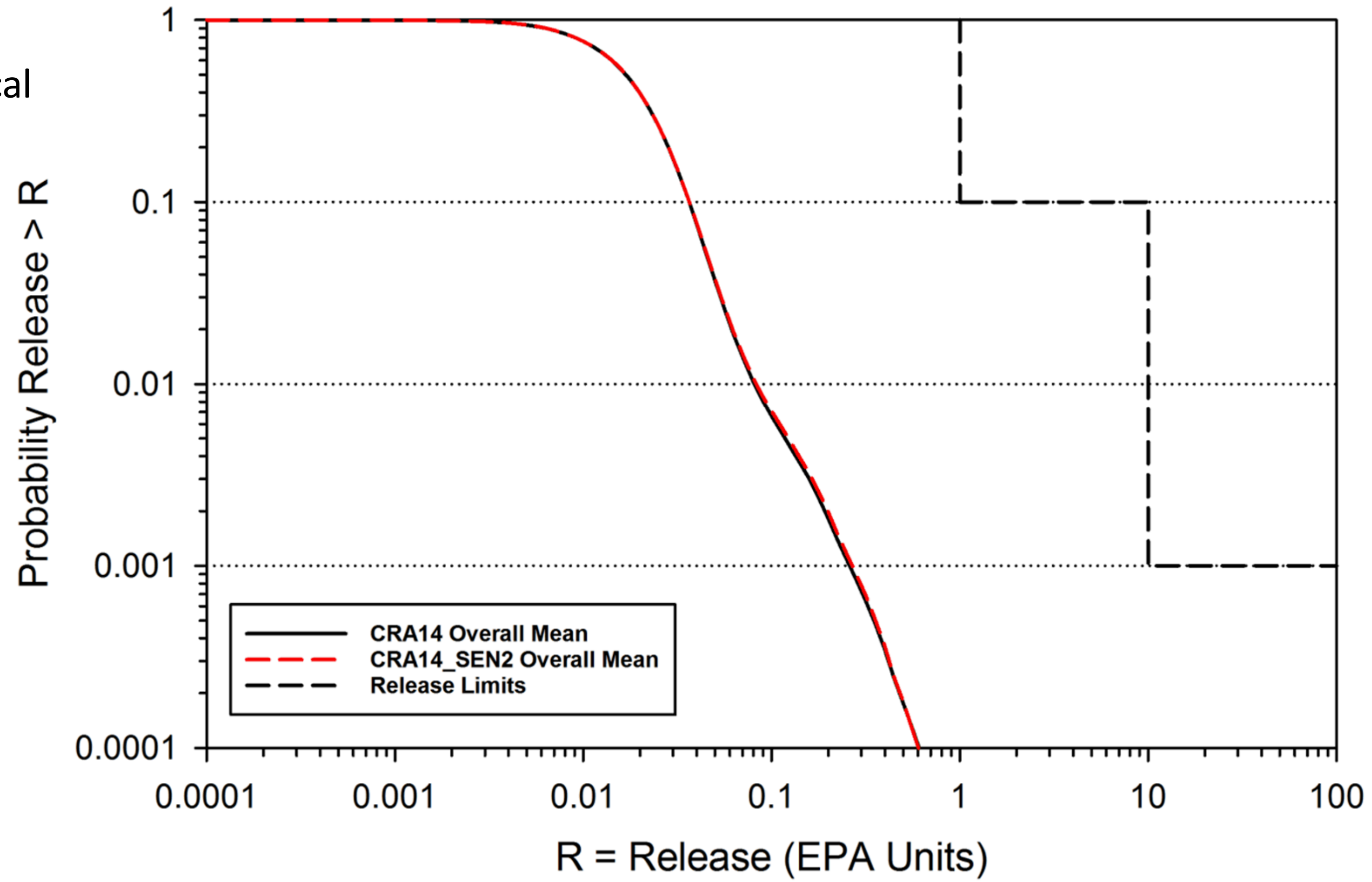
Direct Brine Releases

- Overall Mean CCDFs (3-replicate)
- Minimally changed due to trade-off between increased waste panel pressures and reduced waste panel saturations



Total Releases

- Overall Mean CCDFs (3-replicate)
- 0.1 Probability essentially identical
- 0.001 Probability minimally increased by 4% for CRA14_SEN2
- Upper 95% confidence limit significantly reduced by 20% for CRA14_SEN2



Conclusions

- The modeling assumptions associated with the operations and experimental areas of the repository have an insignificant effect on the prediction of total releases from the repository and/or adequacy of the current (CRA14) model to demonstrate compliance with the regulatory limits