Impacts of an Additional Exhaust Shaft on WIPP Performance - 15170

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ABSTRACT

The Waste Isolation Pilot Plant (WIPP), located in southeastern New Mexico, has been developed by the U.S. Department of Energy (DOE) for the geologic (deep underground) disposal of transuranic (TRU) waste. WIPP performance assessment (PA) demonstrates repository performance from facility closure to 10,000 years after closure. The recent radiological release event at the WIPP site has temporarily halted waste emplacement activities at the facility. A modified ventilation system is envisioned that will provide sufficient airflow necessary for the resumption of full-rate disposal operations in the future. A primary component of the modified ventilation system is an additional exhaust shaft in the north end of the repository. There are four shafts currently in the repository north end, namely a salt handling shaft, an exhaust shaft, a waste shaft, and an air intake shaft. These shafts are combined into a single composite shaft in WIPP PA that captures the combined impacts of all of them. The proposed additional exhaust shaft is combined with the four existing shafts in the repository model to determine its impacts on long-term repository performance. Moreover, mined volume in the repository north end is modified in the repository representation so as to include additional drifts created to access the new shaft. Computed gas and brine flow behaviors corresponding to the repository with the additional exhaust shaft are compared to those obtained in the PA executed for the 2014 Compliance Recertification Application (the CRA-2014 PA). Results show that the repository with an additional exhaust shaft and drifts yields brine and gas flow behaviors similar to the current repository configuration. It is concluded that WIPP continues to satisfy regulatory compliance limits with the addition of an exhaust shaft and its access drifts, with compliance curves like those found in the CRA-2014 PA for total normalized releases.

INTRODUCTION

Repository shafts have been included in WIPP PA as a feature of the repository since the original Compliance Certification Application [6]. To date, repository shafts have yielded no releases that impact long-term performance of the facility when included in WIPP PA. To be clear, WIPP PA demonstrates repository performance from facility closure to 10,000 years after closure. The recent radiological release at the site impacts current operational aspects of the facility, but is outside the scope of WIPP PA. However, repository design changes made to allow for the resumption of waste disposal at the site potentially comprise features of the repository that must be included in PA. An additional exhaust shaft and its associated access drifts are such features.

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There are four shafts currently in the repository north end, namely a salt handling shaft, an exhaust shaft, a waste shaft, and an air intake shaft. These shafts are combined into a single shaft in WIPP PA that captures the combined impacts of all of them. The proposed additional exhaust shaft is combined with the four existing shafts in this analysis to determine its impacts (if any) on long-term repository performance. Moreover, mined volume in the repository north end is modified in the repository representation so as to include additional drifts created to access the new shaft. The dimensions used for the additional shaft are a 14 foot diameter and a height of 2150 feet (see Attachments 1 and 2 of [4]). Two drifts will be used to access the new shaft. Each drift is modeled as being 42 feet wide, 13 feet high, and 2,640 feet (½ mile) long (see Attachment 2 of [4]). The additional shafts are assumed to connect to the current repository operations area. The proposed exhaust shaft and associated drifts are similar to those that currently exist in the repository.

APPROACH

The code BRAGFLO is the WIPP PA code used to model brine and gas flow in and around the repository. The current numerical grid and material map used to represent the WIPP in BRAGFLO is modified to include the additional exhaust shaft and access drifts. The addition of an exhaust shaft and access drifts to the repository model used in WIPP PA has the potential of altering calculated brine and gas flow behaviors. BRAGFLO provides flow results for the undisturbed repository as well as several disturbance scenarios used to represent inadvertent human intrusion after facility closure. The scenarios include one undisturbed scenario (S1-BF), four scenarios that include a single inadvertent future drilling intrusion into the repository during the 10,000 year regulatory period (S2-BF to S5-BF), and one scenario investigating the effect of two intrusions into a single waste panel (S6-BF). Two types of intrusions, denoted as E1 and E2, are considered. An E1 intrusion assumes the borehole passes through a waste-filled panel and into a region of pressurized brine that may exist under the repository in the Castile formation. An E2 intrusion assumes that the borehole passes through the repository but does not encounter pressurized brine. Scenarios S2-BF and S3-BF model the effect of an E1 intrusion occurring at 350 years and 1000 years, respectively, after the repository is closed. Scenarios S4-BF and S5-BF model the effect of an E2 intrusion at 350 and 1000 years. Scenario S6-BF models an E2 intrusion occurring at 1000 years, followed by an E1 intrusion into the same panel at 2000 years. The six scenarios modeled by BRAGFLO are shown in Table 1.

Table 1: BRAGFLO Modeling Scenarios

Scenario	**Description**
S1-BF	Undisturbed Repository
S2-BF	E1 intrusion at 350 years
S3-BF	E1 intrusion at 1,000 years
S4-BF	E2 intrusion at 350 years
S5-BF	E2 intrusion at 1,000 years
S6-BF	E2 intrusion at 1,000 years; E1 intrusion at 2,000 years.

The most recent PA done to demonstrate WIPP regulatory compliance is that performed for the CRA-2014 [7]. The CRA-2014 PA considered four distinct cases (see Table 2), of which two potentially impact gas and brine flow behaviors calculated by BRAGFLO.

Table 2: Cases Considered in the CRA-2014 PA

CRA-2014 PA Cases				
	Case CRA14-BL	Case CRA14-TP	Case CRA14-BV	Case CRA14-0
CRA-2014 PA changes included	**Replacement of Option D PCS with the ROMPCS** **Inclusion of additional mined volume in the WIPP experimental area** **Updated WIPP waste inventory parameters** Updated radionuclide solubilities and uncertainty, colloid parameters Updated drilling rate and plugging pattern parameters	Replacement of Option D PCS with the ROMPCS Inclusion of additional mined volume in the WIPP experimental area Updated WIPP waste inventory parameters Updated radionuclide solubilities and uncertainty, colloid parameters Updated drilling rate and plugging pattern parameters BOREHOLE:TAUFAIL and GLOBAL:PBRINE parameter distribution refinements	Replacement of Option D PCS with the ROMPCS Inclusion of additional mined volume in the WIPP experimental area Updated WIPP waste inventory parameters Updated radionuclide solubilities and uncertainty, colloid parameters Updated drilling rate and plugging pattern parameters BOREHOLE:TAUFAIL and GLOBAL:PBRINE parameter distribution refinements Variable Brine Volume Implementation	**Replacement of Option D PCS with the ROMPCS** **Inclusion of additional mined volume in the WIPP experimental area** **Updated WIPP waste inventory parameters** Updated radionuclide solubilities and uncertainty, colloid parameters Updated drilling rate and plugging pattern parameters BOREHOLE:TAUFAIL and GLOBAL:PBRINE parameter distribution refinements Variable Brine Volume Implementation **Update to parameter STEEL:CORRMCO2** **Refinement to Repository Water Balance Implementation**
Number of replicates	1	1	1	3

In Table 2, CRA-2014 PA modifications with red font are those that can have a direct impact on results calculated with BRAGFLO. Detailed descriptions of the four cases considered in the CRA-2014 PA can be found in [2], with a summary of results given in [3]. For this analysis, BRAGFLO calculations are performed for CRA-2014 PA cases CRA14-BL and CRA14-0 with the additional exhaust shaft and access drift volume included in the repository representation. Calculations corresponding to case CRA14-BL are denoted as SHFT14-BL in this analysis. Similarly, calculations corresponding to case CRA14-0 are denoted as SHFT14-0. In effect, case SHFT14-BL is case CRA14-BL with the proposed shaft and access drifts added. Similarly, case SHFT14-0 is case CRA14-0 with the proposed shaft and its drifts added. The motivation for this approach can be found in [4], with a detailed summary of results provided in [5].

Salado flow results obtained with BRAGFLO after including the proposed shaft and its access drifts in the repository representation are compared to those obtained in the CRA-2014 PA. Results are discussed in terms of overall means. As outlined in [4], replicate 1 results are generated for cases SHFT14-BL and CRA14-BL. Means and statistics presented for these two cases are generated over replicate 1, i.e. over 100 realizations. Three replicates are used to generate results for cases SHFT14-0 and CRA14-0. Means and statistics presented for these two cases are calculated over all three replicates, i.e. over 300 realizations.

RESULTS

Results are presented for undisturbed scenario S1-BF. Results associated with intrusions are presented for scenarios S2-BF and S4-BF, as these are representative of the intrusion types considered in scenarios S2-BF to S5-BF with the only differences being the timing of drilling intrusions. Results from BRAGFLO scenario S6-BF are also discussed.

Pressure

The two access drifts for the proposed exhaust shaft yield increased volume in the repository operations area. An expected outcome of increased volume is a reduction in pressure. When compared to cases CRA14-BL and CRA14-0 from the CRA-2014 PA, the increase in volume yields a reduction in mean pressure in the operations area. Mean pressure is lower in case SHFT14-BL as compared to case CRA14-BL for all scenarios modeled in BRAGFLO. The same is also true for cases SHFT14-0 and CRA14-0. Similar trends are seen for the repository experimental region.

Pressure reductions in the repository north end result in pressure reductions in repository waste regions, with these reductions being less pronounced with increasing distance from the operations area. Pressure reductions are much less pronounced for the southernmost waste panel, through which future hypothetical drilling intrusions are modeled to occur, as it has the greatest distance from the repository operations area. As seen in Figure 1, slight reductions are seen in the mean waste panel pressure for undisturbed conditions. For scenarios in which the repository undergoes a drilling intrusion, reductions in mean pressure are very slight. The mean pressure curves shown in Figure 2 to Figure 4 for cases SHFT14-BL and SHFT14-0 are almost identical to their counterparts from the CRA-2014 PA.

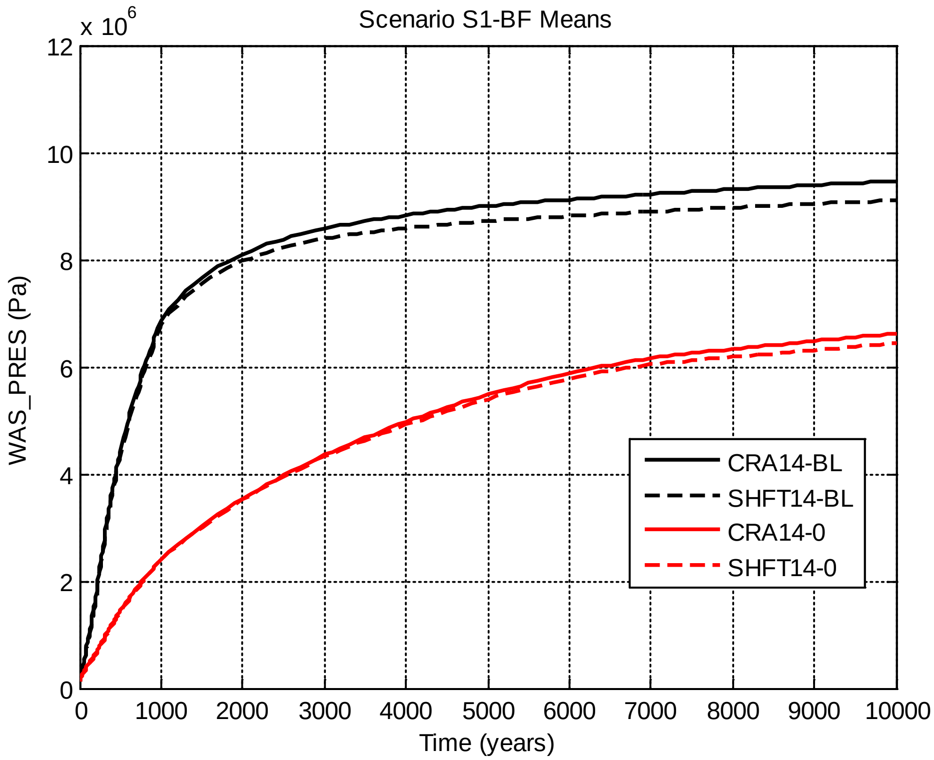

Figure 1: Pressure Means for the Waste Panel, Scenario S1-BF

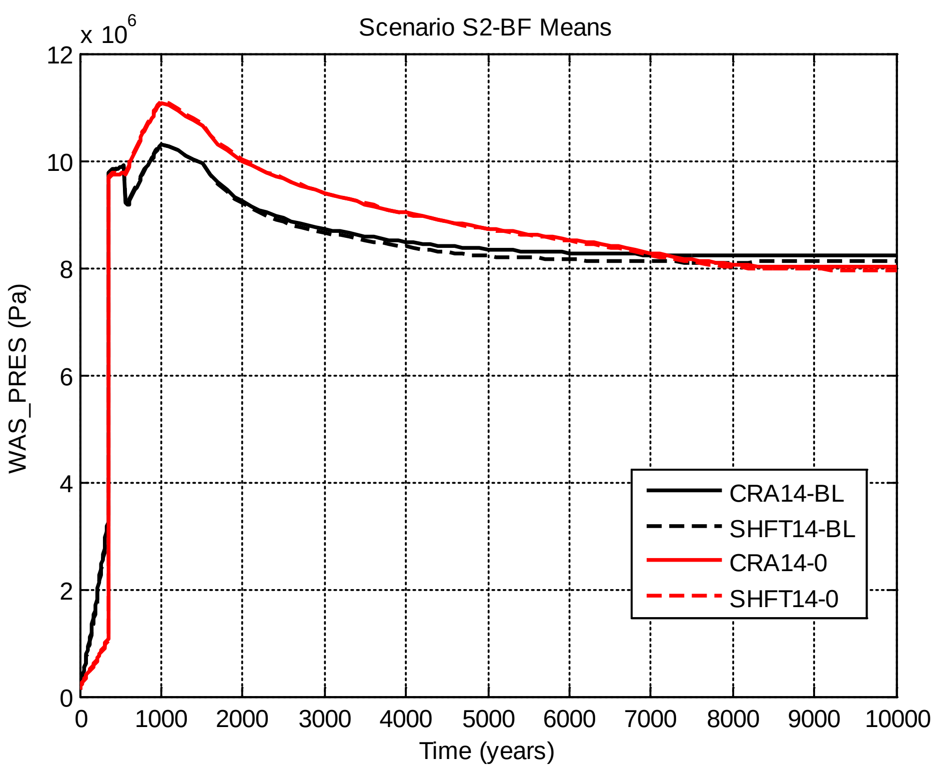

Figure 2: Pressure Means for the Waste Panel, Scenario S2-BF

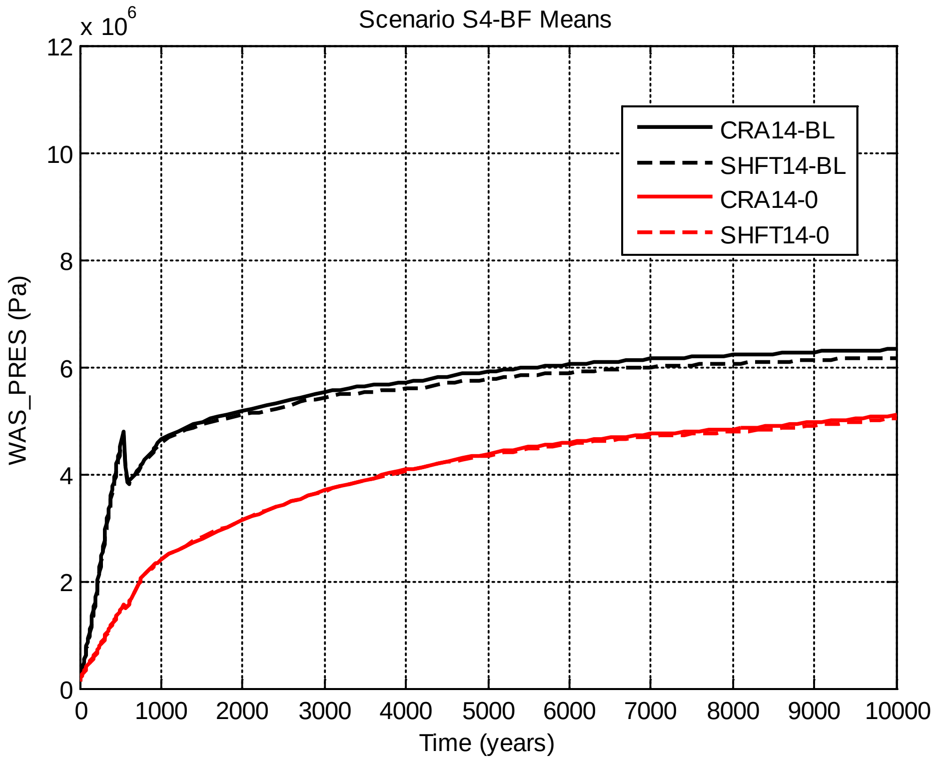

Figure 3: Pressure Means for the Waste Panel, Scenario S4-BF

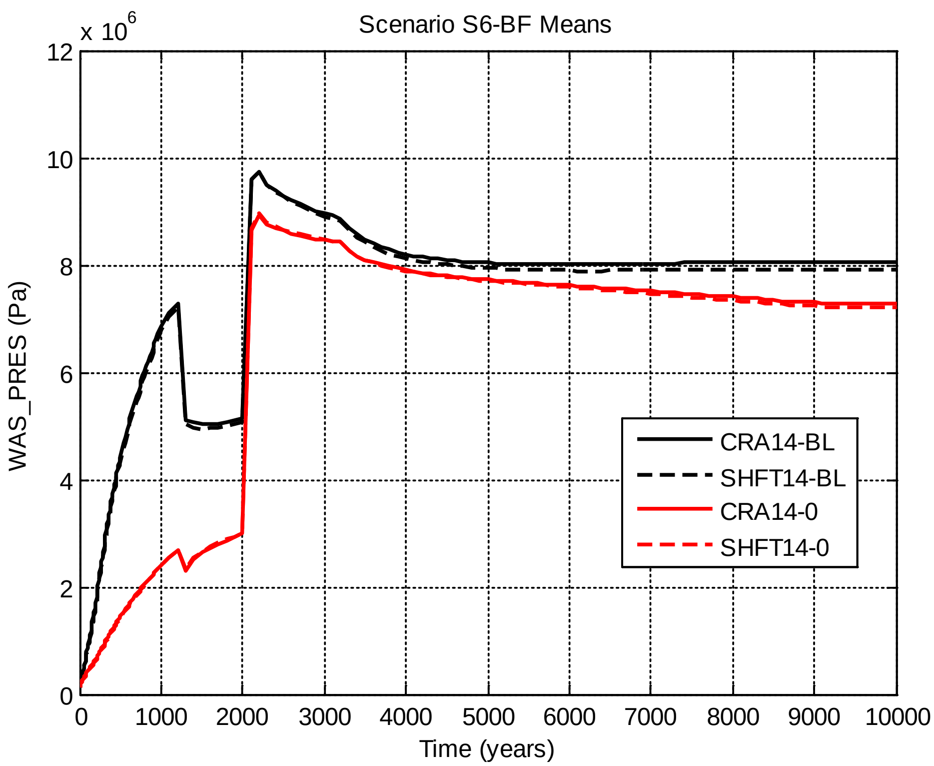

Figure 4: Pressure Means for the Waste Panel, Scenario S6-BF

Brine Flow

Pressure reductions in repository waste regions typically result in increased brine inflow to those areas. As seen in the pressure results already discussed, the addition of the two access drifts for the proposed exhaust shaft lowers the mean pressure in repository waste regions. Mean brine inflows to repository waste regions are slightly elevated in all scenarios when the new shaft and its drifts are included in the BRAGFLO grid. Mean brine inflows to the southernmost waste panel modeled in BRAGFLO are very slightly increased when the additional shaft and access drifts are included in the repository representation. Mean pressures in the southernmost waste panel are nearly identical to, but slightly lower than, those seen in the CRA-2014 PA when the proposed shaft and its access drifts are added. The distance of the southernmost waste panel from the repository north end essentially insulates it from impacts associated with the proposed shaft and its access drifts (see [5]). The mean brine inflow to the waste panel obtained for case SHFT14-BL is nearly identical to that found for case CRA14-BL, over all BRAGFLO scenarios. The same behavior is also true for cases SHFT14-0 and CRA14-0. Representative brine inflow results for the intruded waste panel are shown in Figure 5 and Figure 6.

The addition of the proposed exhaust shaft and its access drifts yields lower mean pressures in the operations and experimental regions. The composite shaft is located between these regions in the BRAGFLO repository representation. Pressure reductions in the operations and experimental regions lead to a reduction in pressure around the shaft base. Consequently, the cumulative volume of brine ejected up the composite shaft is reduced when the additional exhaust shaft and its drifts are added to the BRAGFLO grid. Mean brine flows up the repository shafts are very small in the CRA-2014 PA results, less than 6 m^3 over 10,000 years in all scenarios, and are even smaller when the additional shaft and access drifts are included in the repository representation. A representative result of mean cumulative brine flow up the composite shaft is shown in Figure 7. Results for the other scenarios considered in BRAGFLO are very similar to those seen in that figure.

Mean brine flows up the intrusion borehole are only slightly impacted by the additional shaft and its access drifts. As already discussed, pressures in, and brine inflows to, the southernmost waste panel are barely affected by the addition of the proposed exhaust shaft and its access drifts. Consequently, mean brine flows up the intrusion borehole are nearly identical to results found in the CRA-2014 PA. A representative result of cumulative brine flow up the intrusion borehole is shown in Figure 8.

Brine Saturation

Changes to brine inflow in repository waste areas can impact the brine saturation of the waste. Mean brine inflows to the repository waste region are only slightly increased by the addition of the proposed shaft and its access drifts. As a result, there is very little difference between brine saturations calculated in this analysis for repository waste regions and those from the CRA-2014 PA. The additional shaft and its access drifts have a negligible impact on the mean brine saturations seen in repository waste regions. Representative results for the hypothetically intruded waste panel are shown in Figure 9 and Figure 10.

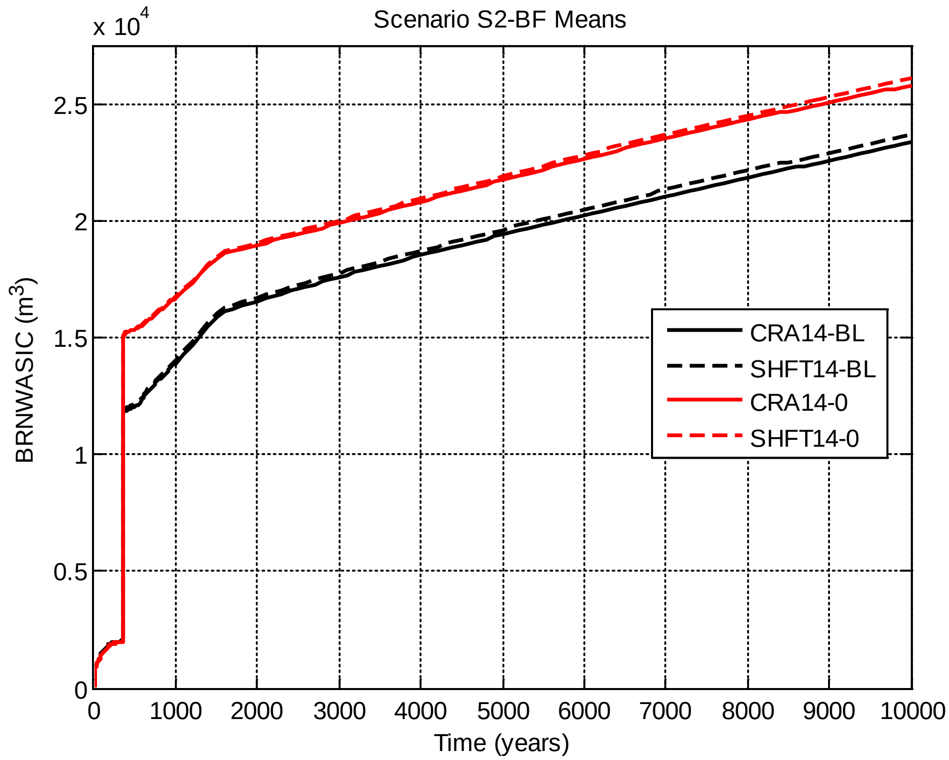

Figure 5: Cumulative Brine Inflow to the Waste Panel, Scenario S2-BF

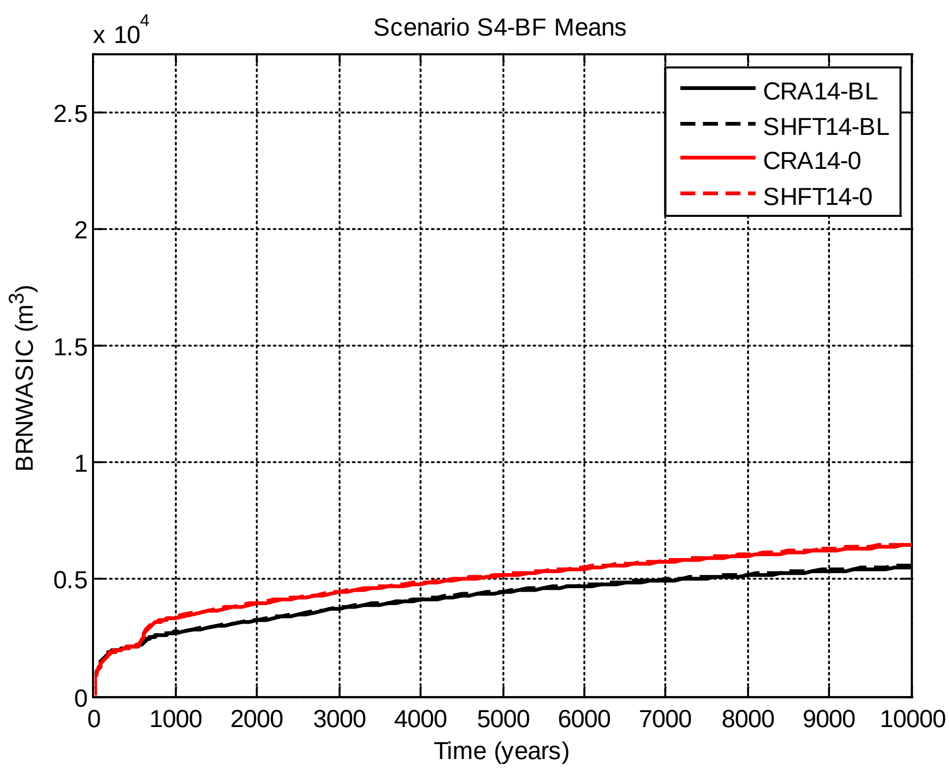

Figure 6: Cumulative Brine Inflow to the Waste Panel, Scenario S4-BF

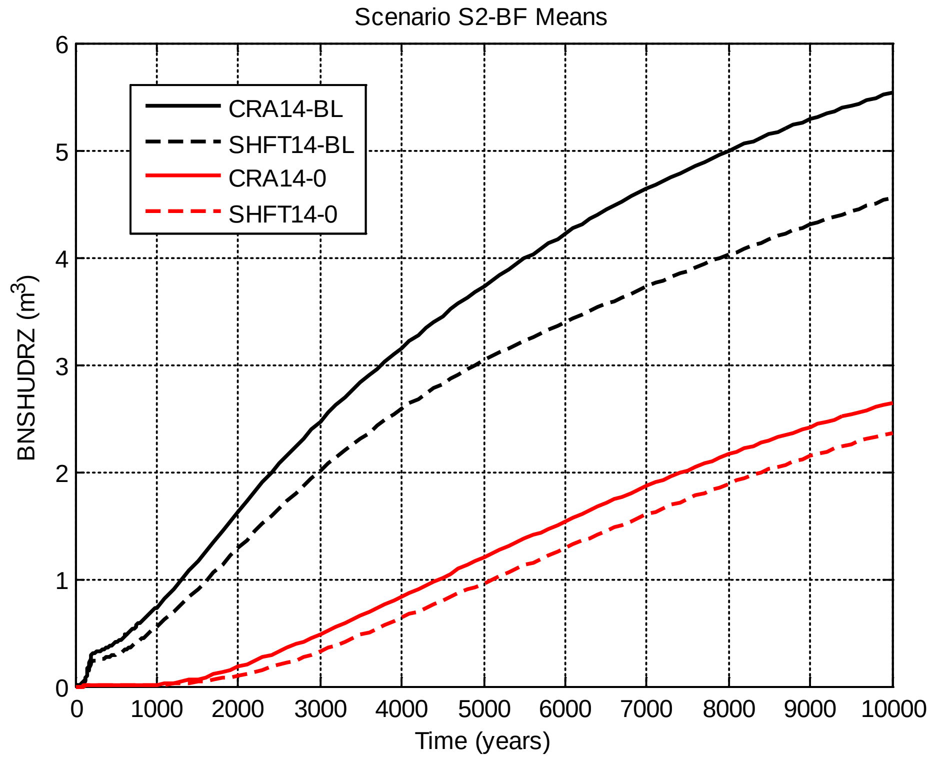

Figure 7: Cumulative Brine Flow up the Composite Shaft, Scenario S2-BF

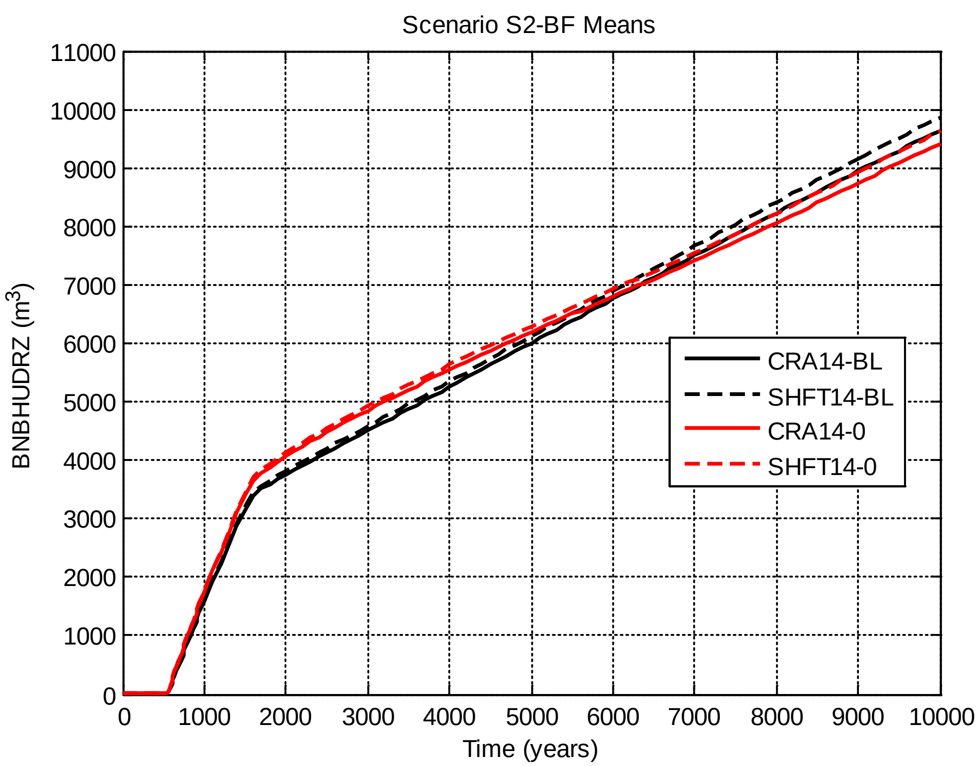

Figure 8: Cumulative Brine Flow up the Borehole, Scenario S2-BF

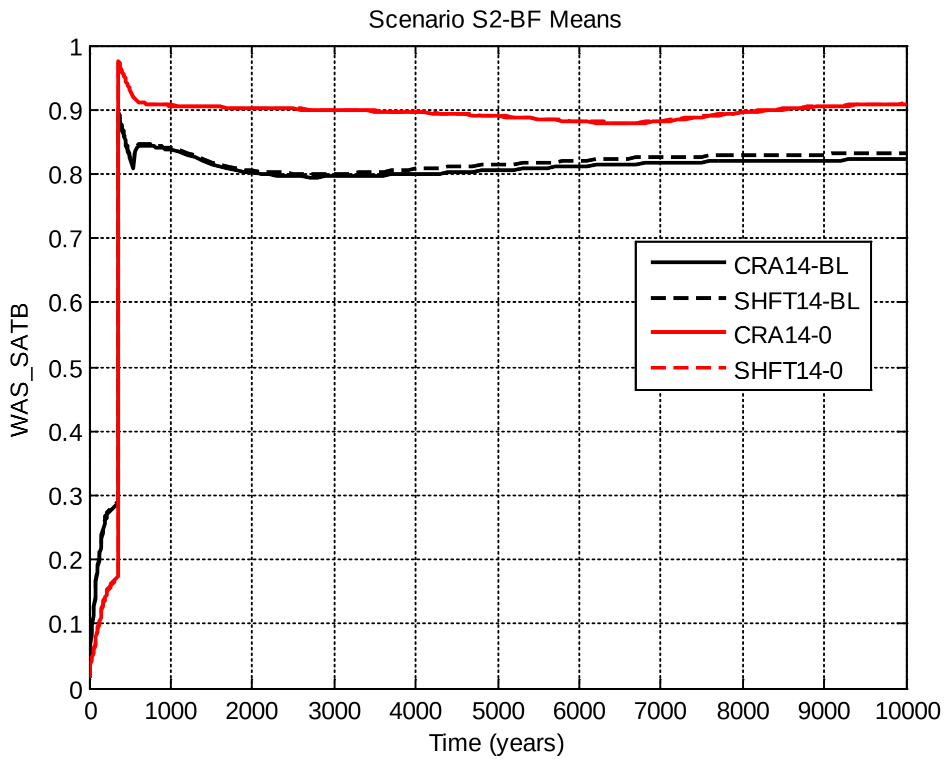

Figure 9: Mean Brine Saturations for the Waste Panel, Scenario S2-BF

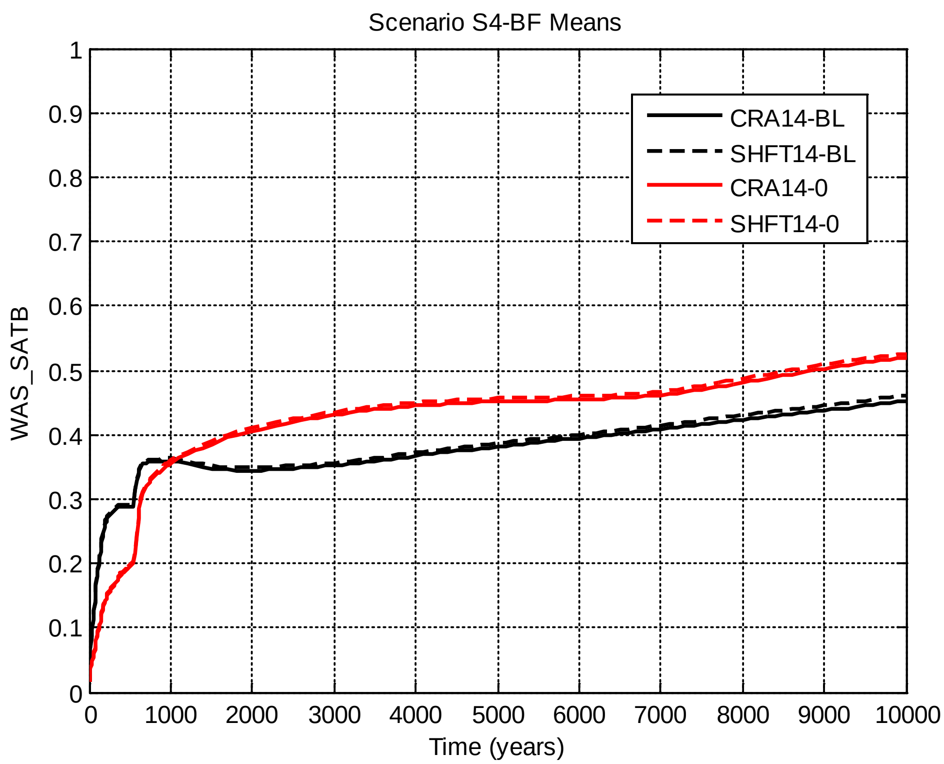

Figure 10: Mean Brine Saturations for the Waste Panel, Scenario S4-BF

IMPACTS TO REGULATORY COMPLIANCE

From the results previously discussed, the impacts of the additional shaft and its access drifts are a slight pressure reduction in repository waste regions accompanied by very slight increases to brine saturation (on average). Cumulative brine flows up the composite repository shaft decrease (on average) while flows up the intrusion borehole are primarily unaffected. For the release mechanisms considered in WIPP PA, cuttings and cavings are not dependent on repository pressures or brine saturations, and so are not impacted at all by the additional shaft and drifts. Spallings releases are a function of repository pressure and the waste inventory. Reductions in pressure necessarily translate to reduced spallings release volumes. As a result, spallings releases will be reduced with the addition of the additional shaft and its access drifts, as compared to CRA-2014 PA results.

Brine flows up the intrusion borehole obtained in this analysis and the CRA-2014 PA are nearly identical. Consequently, volumes of brine flowing up the borehole to the Culebra are primarily unaffected by the proposed shaft and drifts. Thus, transport releases through the Culebra and across the land withdrawal boundary will be negligibly different from results calculated in the CRA-2014 PA.

Direct brine releases (DBRs) require sufficient waste panel pressure and brine saturation in order to occur. The repository pressure near the drilling location must exceed the hydrostatic pressure of the drilling fluid, which is specified to be 8 MPa in WIPP PA. The brine saturation in the intruded panel must exceed the residual brine saturation of the waste, a sampled parameter in WIPP PA. As seen, the proposed shaft and its drifts tend to slightly decrease waste region pressure while very slightly increasing waste region brine saturation as compared to the CRA-2014 PA. The combination of slight pressure decrease and very slight brine saturation increase in repository waste regions was also seen in the salt disposal investigation (SDI) impact assessment [1]. Indeed, the pressure and brine saturation changes seen in this study are very similar to those seen in the SDI analysis. In the SDI analysis, a focused PA was undertaken to determine the compliance impact resulting from additional excavated volume in the repository north end. It was seen that additional excavated volume in the north end yields slight pressure reductions in repository waste regions accompanied by very slight increases to waste region brine saturation (on average). These changes had a negligible impact on DBRs, and essentially no impact to regulatory compliance. From this, we conclude that the proposed exhaust shaft and its access drifts have a negligible impact on DBRs, and compliance results found in the CRA-2014 PA are primarily unaffected by the addition of another shaft and its access drifts. For reference, the compliance curves obtained for case CRA14-0 (the full compliance calculation of the CRA-2014 PA) are shown in Figure 11. The WIPP will continue to meet regulatory compliance with the proposed additional exhaust shaft and access drifts.

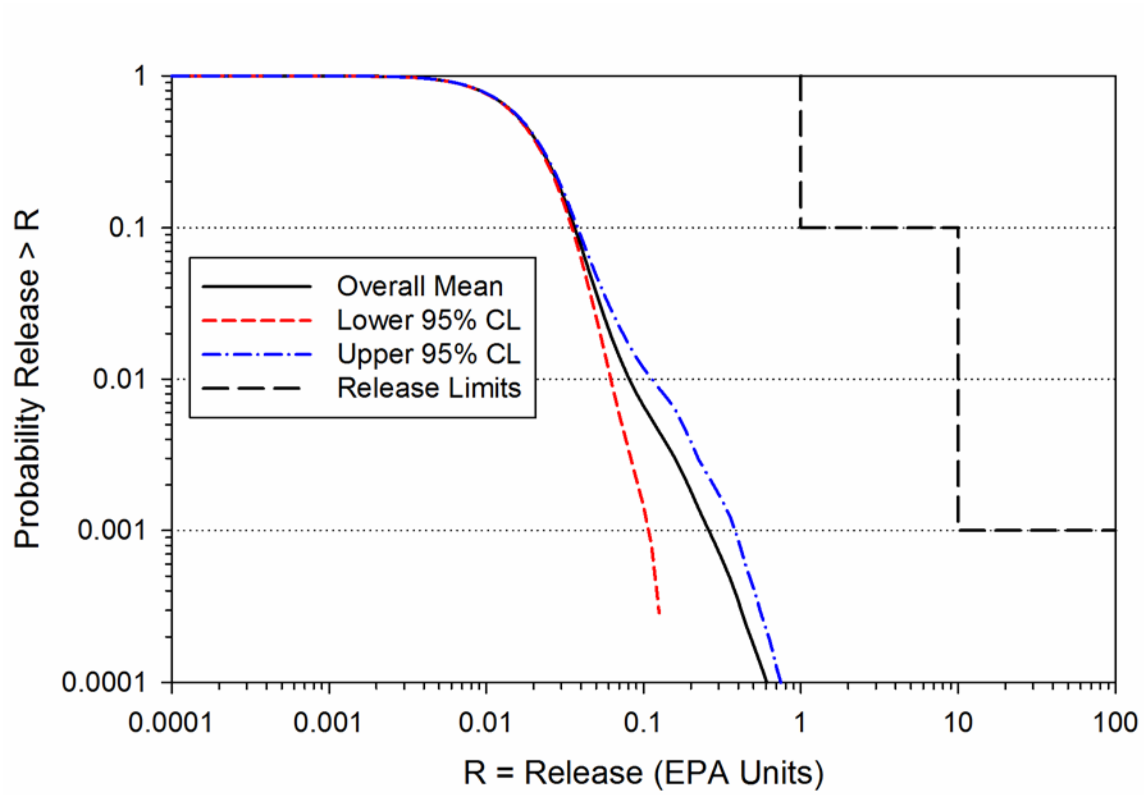

Figure 11: CRA-2014 PA Confidence Limits on Overall Mean for Total Normalized Releases

SUMMARY

The recent radiological release event at the WIPP site has temporarily halted waste emplacement activities at the facility. A modified ventilation system is envisioned that will provide sufficient airflow necessary for the resumption of full-rate disposal operations in the future. A primary component of the modified ventilation system is an additional exhaust shaft and two access drifts in the north end of the repository. The repository representation used in WIPP PA was modified to include the additional shaft and its drifts. The increased volume in the WIPP north end translated to a reduction in pressure (on average) in that region. Slight pressure reductions were also seen in repository waste regions, with reductions being less pronounced with increased distance from the north end. The slight pressure reductions in repository waste regions yielded very slightly increased brine saturations (on average) in those areas. Brine flows up the borehole during a hypothetical drilling intrusion were nearly identical to those found in the CRA-2014 PA. Brine flows up the composite repository shaft were decreased as compared to the CRA-2014 PA due to the pressure reduction in the north end of the repository. The combination of slightly reduced waste region pressure (on average) and very slightly increased brine saturation was also seen in the SDI impact assessment, where it was found that these slight changes have no noticeable impact on regulatory compliance. It is concluded that WIPP continues to satisfy regulatory compliance limits with the addition of an exhaust shaft and its access drifts, with compliance curves like those found in the CRA-2014 PA for total normalized releases.

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