DOCKET: EPA-HQ-OAR-2001-0012-0774

EPA REVIEW OF DOE PEER REVIEW OF CONCEPTUAL CHANGES INCORPORATED IN THE APPA MODEL

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April 2023

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1.0 Introduction

The APPA model was developed by Sandia National Laboratories (SNL) to address changes in WIPP Performance Assessment (PA) resulting from the possible future addition of Waste Panels 11 through 19 to the WIPP repository design. The acronym APPA stands for Additional Panels Performance Assessment. Waste Panels 11 and 12 are planned to be added to the repository design to replace lost disposal volume in the original 10 panels and the remaining Panels 13 through 19 are conceptual. The design change required changes to the following WIPP conceptual models:

- Repository Fluid Flow Conceptual Model: The grid for the Salado flow model was modified to accommodate the nine additional panels;
- DBR Conceptual Model: The grid for computing direct brine releases (DBRs) was modified to accommodate the nine additional panels; and
- Disposal System Geometry Conceptual Model: The repository area and volume, and the logic for assigning panel neighbors, were updated to account for the nine additional panels.

Following a virtual orientation meeting on July 13, 2021, the peer panel met in-person in Carlsbad, New Mexico on July 20-22, 2021. EPA representatives attended the Carlsbad meeting as observers. The peer panel's findings are documented in the report *Additional Panels Performance Assessment (APPA) Changed Conceptual Models* (Falta et al. 2021), completed in December 2021.

This report provides a bulleted summary of EPA's review of the APPA Peer Review, its procedures, processes, and findings. Section 2 addresses the conduct of the review and Section 3 addresses the technical aspects. EPA's conclusions are presented in Section 4.

2.0 Conduct of the APPA Peer Review

2.1 Procedural Requirements

The peer review was conducted by the U.S. Department of Energy (DOE) pursuant to the requirements of the following documents:

- DOE Management Procedure MP 10.5, *Peer Review*, Rev. 10 (October 2018)
- DOE Peer Review Plan, DOE/CBFO-21-3629, *Additional Panels Performance Assessment (APPA) Changed Conceptual Models* (June 2021)

EPA requires peer reviews of WIPP conceptual models in 40 CFR §194.23(a)(3)(v) and requires those reviews to be conducted in a manner compatible with NUREG-1297 in 40 CFR §194.27. NUREG-1297, *Peer Review for High-Level Nuclear Waste Repositories*, is a guidance document prepared by the U.S. Nuclear Regulatory Commission (NRC).

EPA used a checklist to help confirm that DOE met the requirement of conformance with NUREG-1297. A copy of this checklist is presented in Attachment A. The checklist also

confirmed the appropriateness of the applicable DOE Management Procedure MP 10.5 and Peer Review Plan listed above.

2.2 Peer Panel Members

The Peer Review Group (PRG) consisted of the following members.

- Ronald W. Falta, Jr., PhD.
- Mengsu Hu, Ph.D.
- Edward M. Kwicklis, M.S.
- Carl I. Steefel, Ph.D.
- Sherilyn C. Williams-Stroud, Ph.D., P.G.
- John A. Thies, B.S. (Peer Panel Chairperson)

Documentation that the panel members met the procedural requirements for the peer review is presented in the peer panel's report (Falta et al. 2021).

2.3 Application, Scope, and Purpose of the Peer Review

- The intended application of the APPA is "…to quantify the long term performance of the repository with … a proposed repository layout that includes the two replacement Panels 11 and 12, and conceptual Panels 13-19…" (Falta et al. 2021, p. 3).
- "The scope of this peer review is to evaluate the adequacy of changes to the following conceptual models: Disposal System Geometry, Repository Fluid Flow, and Direct Brine Release." (Falta et al. 2021, p. 9).
- The intended purpose of the peer review is to determine whether "…the changed conceptual model [is] … adequate for its intended application" as defined above (Falta et al. 2021, p. 27).

EPA observes that the changes to be reviewed by the PRG are limited to:

1. Specific aspects of the three conceptual models identified in Section 1.0, and
2. The computational modifications needed to incorporate these changes in PA.

All other aspects of the APPA model are the same as in the CRA-2019 PA.

2.4 EPA Observations on Selected Elements of the PRG Review Process

<u>Alternative Conceptual and Modeling Approaches</u>

The PRG requested detailed evaluations of several alternative approaches, including:

- The influence of boundary conditions on DBR volumes in the DBR Conceptual Model (Falta et al. 2021, p. 22);
- The influence of the reduced volumes of the adjacent ("upper" or North Rest-of-Repository) and non-adjacent ("other" or West Rest of Repository) areas on DBR volumes in the APPA DBR Conceptual Model (Falta et al. 2021, p. 27); and
- The effect of z-direction cell flaring as a means of simulating excavated repository volumes in the Repository Fluid Flow Conceptual Model (Falta et al. 2021, p. 20).

<u>PRG Disposition of Alternative Approaches</u>

EPA observes the following:

- The PRG concluded that the influence of intrusion well boundary conditions on decreasing DBR volumes in the APPA DBR Conceptual Model was "small enough to be considered negligible" without presenting the numerical basis for this conclusion (Falta et al. 2021, p. 23);
- The PRG concluded that the influence of the reduced volumes of the adjacent ("upper" or North Rest-of-Repository) and non-adjacent ("other" or West-Rest-of-Repository) areas on decreasing DBR volumes in the APPA DBR Conceptual Model was "very minor" without presenting the numerical basis for this conclusion (Falta et al. 2021, p. 27);
- The PRG performed a detailed examination of the effect of z-direction grid flaring to accommodate increased repository volumes in the 2D Repository Fluid Flow Conceptual Model and concluded the results to be acceptable based on a finding that deviations from 3D PFLOTRAN results were "minor" without presenting the numerical basis for this conclusion (Falta et al. 2021, pp. 20 and 27).

The Agency's technical review of these conclusions is described in Section 3.

Comparison with CRA-2019 PA Results

The PRG wrote that "Results found in the APPA are compared to those obtained in the CRA-2019 PA … to assess repository performance in terms of the computational differences." (Falta 2021, p. 3).

EPA observes the following:

- The PRG treated the CRA-2019 PA in the manner of a baseline;
- The PRG was unaware that EPA would later determine that the CRA-2019 PA was not acceptable as a baseline;
- The concerns EPA identified with the CRA-2019 PA are also present in the APPA;
- EPA's CRA-2019 PA determination was based on aspects of that PA that were not accepted by EPA but were unrelated and not relevant to the conceptual changes reviewed by the PRG.

EPA concludes that comparisons between the APPA and the CRA-2019 PA, and the PRG's apparent reliance upon those comparisons in developing its findings, are acceptable because EPA's concerns with the CRA-2019 PA involve aspects of that PA that are not relevant to the changes reviewed by the PRG.

PRG Use of PFLOTRAN Results

- Comparison with PFLOTRAN results "built confidence" in BRAGFLO Salado flow model results (Falta et al. 2021, p. 26);
- The calculations of the APPA Salado flow model were "corroborated" by PFLOTRAN results (Falta et al. 2021, p. 27); and
- The PFLOTRAN code provided an "independent basis" for evaluating the abstractions that were necessary when using the 2D BRAGFLO code (Falta et al. 2021, p. 32).

EPA observes that the PRG appears to have assumed, without supporting justification, that the 3D PFLOTRAN results were relevant and superior to the 2D APPA results, and therefore added confidence to the APPA results. The validity of this assumption is further discussed in Section 3.

PRG Caucus Notes

Preparation of notes to document PGR caucuses is a requirement of NUREG-1297. EPA requested those notes from DOE because they were not included in the PRG's report by Falta et al. (2021), as has been customary. Caucuses were held by the PRG on July 20 and 21, 2021. Upon review, EPA found that the notes compiled during those caucuses satisfy the NUREG requirements. The notes provided additional insights into the PRG's deliberations and are presented in Attachment B of this report.

3.0 Technical Review

PRG Stated Objective

The Peer Review Panel reviewed the three changed conceptual models in detail, including the assumptions and scientific information used as the basis to change the models. They considered alternative models, areas of uncertainty associated with the models, adequacy of the models, accuracy of the models, and validity of the conclusions reached. The Panel also made an assessment of the information used to change the models and whether the conceptual models are adequate for implementation in PA.

3.1 Disposal System Geometry Conceptual Model

3.1.1 PRG Conclusions Regarding General Modeling Assumptions

PRG conclusions regarding general assumptions in the Disposal System Geometry conceptual model include (Falta et al. 2021, p. 12):

(1) The three-dimensional system can be represented by two-dimensional simplifications, in which volume is represented by assigning a thickness to each two-dimensional grid cell.

(2) Horizontal convergent or divergent flows in the rock outside the repository can be represented by divergent flaring of the two-dimensional grid to the north and south away from the repository.

(3) Details of features within the repository such as the waste panels, shafts, and panel closures can be represented by simplified features in the computational grid.

(4) The entire repository can be represented by the simplified floor plan used in the computational model.

(5) The effects on flow and transport of a randomly placed intrusion borehole can be represented by modeling one intrusion at a designated location in the modeling grid.

(6) Convergent or divergent flows within the repository can be represented by the volumetric flaring of grid cells around the borehole feature.

Basis for PRG Conclusions

It is difficult to ascertain the basis for the PRG's conclusions with respect to these six general assumptions. It would have been helpful if the PRG had presented their findings, with respect to the validity of these assumptions, in a similar manner to the basis for their conclusions for the specific assumptions listed below.

EPA Observations

Each of the six Disposal System Geometry assumptions listed above applies equally to the 10-panel legacy BRAGFLO conceptual model introduced in the CCA and accepted by EPA in the 1998 certification of WIPP. It is therefore reasonable to accept these conclusions pending further review of their impact on the DBR and Repository Fluid Flow conceptual models discussed below.

3.1.2 PRG Conclusions Regarding Distance to Grid Boundary

As discussed by the PRG, in an effort to save on computation time, Day (2019) recommended reducing the distance from the Land Withdrawal Boundary (LWB) to the grid boundary from 20,000 m to 10,000 m, as the extra volume does not impact the model results. A study was done by modifying CRA-2019 Salado Flow grid to determine the impacts of this reduction in distance (Falta et al. 2021, p. 20).

Basis for PRG Conclusions

With respect to the location of the grid boundary, the PRG concludes "A larger distance to grid boundary than 10,000 m beyond the LWB … was tested by using a shorter distance and comparing the results of brine pressure and saturation in the waste panel and the volume of brine flow up the borehole. It was concluded that moving the grid boundary from 20,000 m to 10,000 m beyond the LWB has little effect on the output metrics that drive releases in APPA. Thus, the distance to the grid is reduced from 20,000 m to 10,000 m in the new grid." (Falta et al. 2021, p. 26).

EPA Observations

Although the results from Day (2019) indicate relative insensitivity of APPA Salado Flow model results to the location of the far-field boundaries, it is not clear what supporting work was performed demonstrating the lack of boundary effects on the DBR calculations, although they are most likely minimal. This is further discussed in Section 3.1.4.

3.1.3 PRG Conclusions Regarding the APPA Salado Flow Grid

The PRG outlined the following specific assumptions pertaining to the APPA Salado Flow Grid (Falta et al. 2021, p. 24)

(1) A 2D flared grid can be used to reasonably approximate a 3D grid;

(2) Instead of using a full-scale grid with explicit representation of all the repositories with all of the waste panels, a lumped grid is used;
(3) A 1° dip from the north (WRoR) to south is assumed;
(4) Panel 9 is assumed to contain waste; and
(5) Borehole intrusion is only represented in the Waste Panel.

Basis for PRG Conclusions

"For Assumption (1), the validity and effectiveness [of a 2D flared grid] have been shown in previous simulations (such as in CRA-2019 PA). In addition, the comparison of results incorporating the new panels between the 2D BRAGFLO and the 3D PFLOTRAN results corroborate the assumption as being reasonable." (Falta et al. 2021, p. 24).

"For Assumption (2), King (2021a) has carefully compared the lumped results with those that were calculated by the separate grid approach and it was shown that the lumped approach, though not fully representing the geometry, can adequately represent the communication between the Old South and the New West repositories." (Falta et al. 2021, p. 24).

"For Assumption (3), the 1° dip from the north all the way to the south would over-estimate the flow to the south. But the 1° dip is equivalent to a gradient of elevation head (as a component of hydraulic gradient) of 0.017, which is relatively small compared with the gradient of brine and gas. King (2021a) stated the advantage of applying this 1° dip is the dip forces a low point in the repository representation to allow an intrusion to be modeled in a worst-case event of being downdip from the rest of the repository. As noted in the Salado Flow section, the multiple closures between the north and south end also limit the flow from north to south, and thus the importance of this 1° dip is limited." (Falta et al. 2021, p. 24).

"For Assumption (4), King (2021a) concluded that modeling Panel 9 with waste will tend to move waste down dip and increase gas generation, leading to relatively conservative results. An advantage of modeling Panel 9 with waste is that panel 9 then can be combined with the SRoR, without additional gridding effort to represent Panel 9 independently in the Salado flow calculations."

"For Assumption (5), King (2021a) concluded that representing west intrusions with south intrusions will tend to produce higher brine pressures and saturations for releases leading to relatively conservative results. The advantage of assuming a single borehole intrusion instead of both in the south and west is that the computational cost can be dramatically reduced. This approach, being conservative and efficient, is reasonable." (Falta et al. 2021, p. 24).

With respect to several alternative interpretations of the Salado flow grid (e.g., independent grids, placement of boundary conditions, abandon the flared grid approach) the PRG note "However, the agreement of Salado flow results by BRAGFLO and PFLOTRAN built confidence in using such a lumped representation with proper flaring and coarser grid, all of which were needed to keep the computational cost reasonable for the APPA analysis." (Falta et al. 2021, p. 26).

EPA Observations

- Although the PRG does not provide a citation for the PFLOTRAN work they are referring to in Assumption 1, the citation is LaForce, T., et. al. (2021). This work does not show a comparison of the results which are, however, provided in a PowerPoint presentation by Seth King, Tara LaForce, and Michael Feng dated July 2021 (King et. al, 2021).

- Slide 5 of the King et. al. (2021) presentation shows the percentage of PFLOTRAN simulations completed. However, there is no corresponding information for BRAGFLO simulations.

- The PRG accepted the validity of the 2D vs 3D APPA Salado Flow Grid largely on the corroboration between the 3D PFLOTRAN and 2D BRAGLO results. EPA is currently reviewing the adequacy of the verification/validation testing of PFLOTRAN since DOE must demonstrate on an ongoing basis that PA computer software complies with regulations outlined in 40 CFR 194.23. Furthermore, the PRG could have approved the APPA even without the PFLOTRAN results because they were able to use the CRA19 PA as a baseline to demonstrate conservatism.

- The focus of the PRG review was on the total volumes of the additional panels and access drifts, the hydraulic connections between these volumes and the adjacent DRZ, Salado and Salado interbeds, and the presence of panel closures separating each additional panel from the access drifts.

- The PRG recognized that material properties would change with time but did not comment on the implications of non-waste areas not creeping closed. However, this treatment of non-waste areas was unchanged from the CRA-2019 PA and was not within the scope of the peer review.

3.1.4 PRG Conclusions Regarding Changes to the APPA DBR Grid

With respect to the DBR grid only including the area immediately surrounding the waste panels, and the outer boundary is assumed to be no-flow, the PRG concluded “In general, boundary effects could be important to consider, but the extreme permeability contrast between the intruded waste panels and the intact halite combined with the short duration (3-4.5 days) of a DBR greatly reduce the impact of the outer boundary condition. The volume-averaged brine pressure and saturation from the Salado flow calculation are used as the initial condition to carry out the near-field DBR calculation.” (Falta et al. 2021, p. 21).

“Based on the limited flow communication across panel closures during a short DBR event, and on the comparison with the two-grid approach, the Peer Review Panel agrees that it is reasonable to use the single DBR grid with representative areas for the SRoR/NRoR and the WRoR.” (Falta et al. 2021, p. 22).

EPA observations:

- The volumes of the NRoR and WRoR in the APPA DBR grid are smaller than the true volumes and are not "representative." As stated above, the PRG concluded the impact of this was "very minor." Although the basis of their conclusion was not clearly documented, it is accepted by EPA because the locations of the NRoR and WRoR waste panels are distant from the hypothetical intrusion borehole in the Waste Panel and are separated from that borehole by two or more sets of panel closures, leaving them relatively unaffected by a short duration DBR event.

- Although the PRG did not request a numerical analysis for confirming that the no-flow boundaries have minimum impact on the results, EPA concurs with their rationale and conclusion of minimal impact.

3.1.5 PRG Conclusions Regarding Flow to Intruding Boreholes in the APPA DBR Grid

"The conclusion of comparing the original and refined grids for DBR calculations is that the refined grid with waste material surrounding the intruded grid cell tends to produce slightly larger DBR volumes than the unrefined grid. The slightly larger DBR releases result in a shift to the right in the mean DBR CCDF at lower probabilities, but the effect is small enough to be considered negligible." (Falta et al. 2021, p. 23).

Basis for PRG Conclusions

"At the request of the Peer Review Panel, King (2021e) conducted supplementary numerical simulations with a refined grid where the single column of grid cells that made up a room with a wellbore intrusion in the APPA grid was split into three columns of grid cells with the wellbore intrusion placed in the center column…" (Falta et al. 2021, p. 22).

From King (2021e); see grid refinement below (Note: red dot is the intruding borehole location):

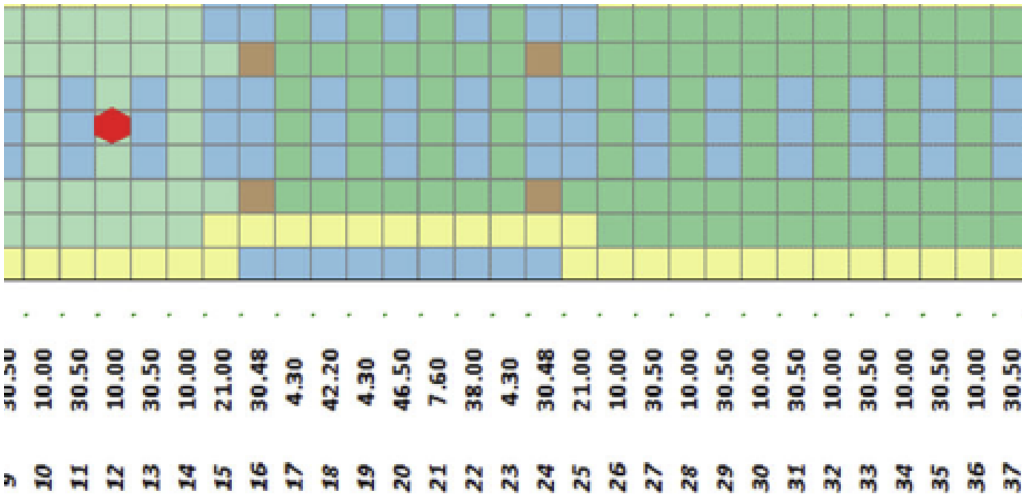


Figure 1 APPA BRAGFLO-DBR grid

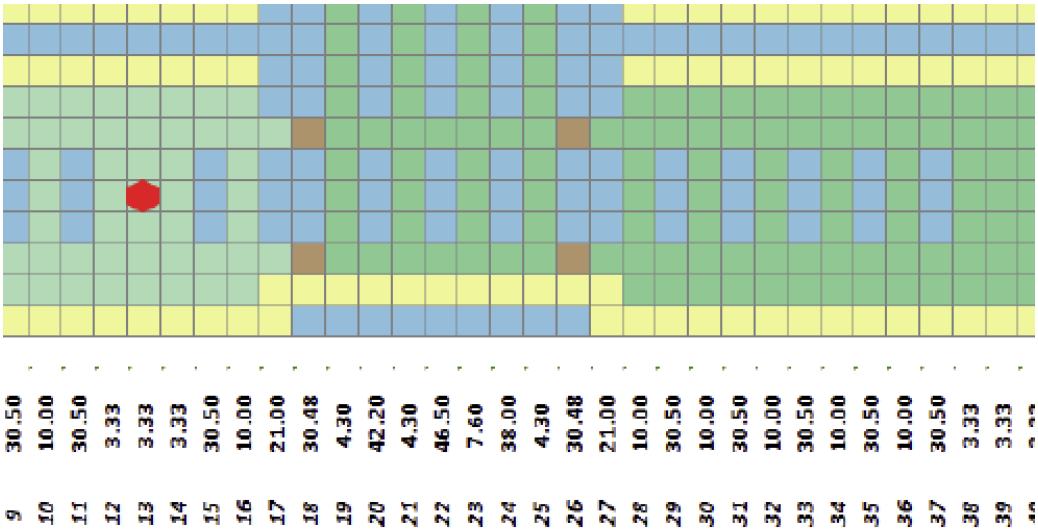


Figure 2 Refined BRAGFLO-DBR grid

The refined grid shown above indicates slightly higher releases than the APPA analysis for most events.

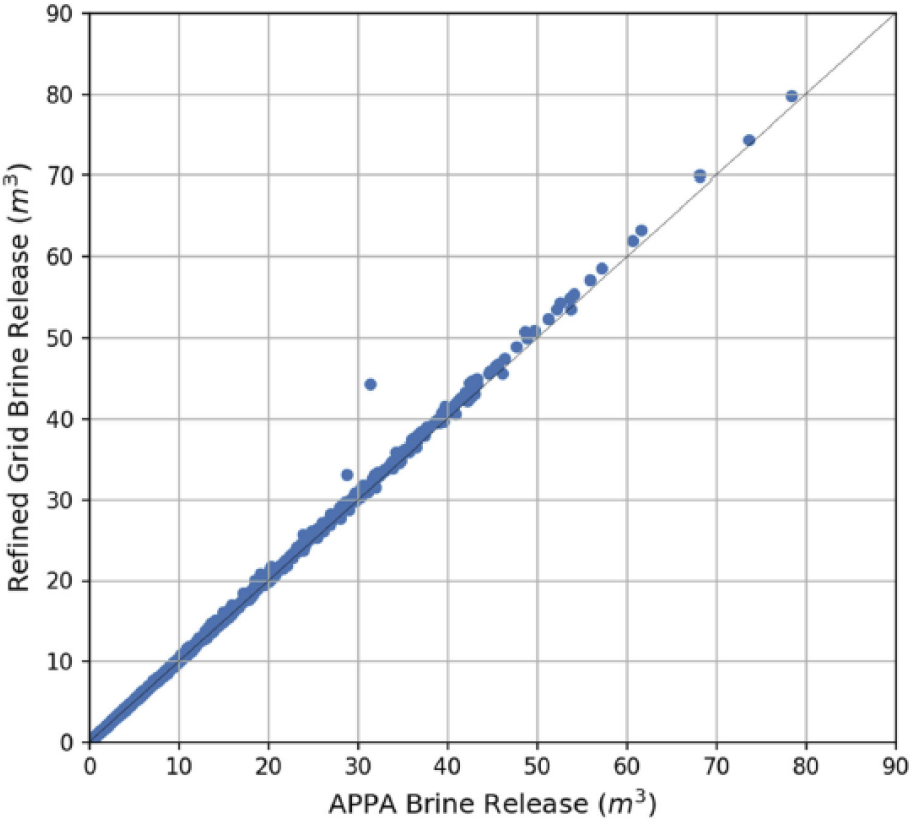


Figure 3 Non-zero releases volumes

EPA Observation(s)

Although the small differences in releases resulted in a slight increase in mean DBR releases and in total releases at low probabilities, the refined grid results are materially the same as the coarser grid.

3.2 Repository Fluid Flow Conceptual Model

3.2.1 PRG Conclusions Regarding APPA BRAGFLO Model Changes

- The PRG states "Because none of the unchanged aspects of the CRA-2019 BRAGFLO Repository Fluid Flow model are within the scope of this APPA Changed Conceptual Models Peer Review, the comments presented below pertain to the changed geometry in the APPA BRAGFLO model that resulted from the inclusion of waste Panels 11-19 in the revised BRAGFLO grid." (Falta et al. 2021, p. 29).

Basis for PRG Conclusions

- The PRG states "Even making use of PFLOTRAN, an examination of the impact of the closures is useful. This issue was raised by EPA observers, who argued that contaminated

brine was not present in the Experimental and Operations areas in the original CRA-2019 model, but now with the inclusion of the western panels, it is asserted that there would be contaminated brine in those locations that should be accounted for. While it is true that the western drifts are fully connected with the Experimental and Operations areas (Figure 4-3), Zeitler (2021) noted that panel closures consisting of Run-Of-Mine Panel Closure System (ROMPCS) would impede flow of contaminated brine into these connected areas. And, it could be argued, if contaminated brine from the western waste panels does flow into the Experimental and Operations areas, radionuclide concentrations are likely to be low because any contaminated brine would be largely diluted by uncontaminated brine that also made its way into the areas from the DRZ above the excavated areas. The important role of the closures was highlighted during the peer review in a "simulation movie" provided by Seth King, the set of snapshots over time clearly showed how brine flow from north to south is limited or eliminated by the ROMPCS (Figure 4-4). The brine in individual waste panels is thus largely derived from the DRZ above, and brine and gas saturations are modified over time by interactions with overlying, and in some cases, underlying formations. Because of the ROMPCS in place, flow between various waste-bearing sections of the excavated repository will be minor and likely even negligible." (Falta et al. 2021, p. 30).

- The PRG states "From Figure 4-3, it is apparent that brine pressures and gas saturations will be impacted by the open areas within the repository to the extent that the closures function as expected, producing a very low permeability in as little as 50 to 100 years." (Falta et al. 2021, p. 30).

- The PRG states "The favorable comparisons of the distributions of gas saturation and brine pressure calculated for different repository features with the 2D BRAGFLO and 3D PFLOTRAN models supports the conclusion that the simplifications in the 2D BRAGFLO model are adequate to approximate the gas and brine flow system behavior." (Falta et al. 2021, p. 32).

- The PRG states "A second significant assumption in the APPA performance assessment is that it is not necessary to consider borehole intrusion scenarios in the Experimental and Operations areas because they lack solid waste and the panel closures in place and/or planned will significantly limit the flow of brine from adjacent waste panels. As noted by Todd Zeitler in his response to a query/comment from the EPA," borehole intrusions in these areas do not need to be considered because of:

    1) lack of potential releases due to cuttings, cavings, or spallings due to no solid waste in those areas; 2) relatively low volume of contaminated brine that is expected to migrate through the panel closures into those areas from the waste disposal area; and 3) the dilution of radionuclide concentrations in the contaminated brine from mixing with uncontaminated brine in those areas." (Falta et al. 2021, p. 33).

- The overall conclusion reached by the APPA PRG is that the flared 2D BRAGFLO model used in the APPA is adequate for calculating radionuclide releases from existing

waste emplacement Panels 1-10 and potential future waste emplacement Panels 11-19 in the currently undeveloped western area of the repository (Falta et al. 2021, p. 37). The PRG notes that the above statement is subject to the following constraints:

- The nature of the waste stream in Panels 11-19 does not significantly differ from that already emplaced in Panels 1-10, and

- The hydro stratigraphy and rock properties in the relatively unexplored western repository area are similar to those that exist in the vicinity of Panels 1-10. It is expected that any changes in the waste stream or in the rock properties in the western repository area would be reflected in future PAs when these become better understood.

EPA Observations:

- The PRG assumption that the brine in the Experimental and Operations areas may be at lower concentrations due to dilution does not consider that ultimate compliance is based on mass-flux rather than on concentrations and the borehole releases may be greater with greater amounts of brine regardless of whether the concentrations may be lower. Although EPA did not have access to Seth King's simulated movie, the Agency accepts that mass-flux releases from borehole intrusions into Exp/Ops areas are likely to be small because of the isolating effects of panel closures and because DBRs and Culebra flow are the only viable release pathways for such boreholes. Most such releases would occur following Castile brine encounters that inundate these areas with uncontaminated brine and significantly reduce concentrations.

- EPA agrees with the two constraints identified by the PRG. Understanding the distribution of rock properties and the waste inventory among panels and/or rooms will be important components of future PA reviews, particularly in evaluating the current assumption of homogeneity of the Salado and of waste activity within the panels and rooms.

3.3 Direct Brine Release Conceptual Model

3.3.1 PRG Conclusions Regarding APPA BRAGFLO-DBR Model Grid Changes

- The PRG states "The APPA BRAGFLO-DBR model grid is similar to the CRA-2019 and previous DBR grids, but conceptually it takes a different approach. The APPA DBR grid now represents not only the original Panels 1-10, but also the additional Panels 11-19 in the west area. Past DBR grids modeled the entire waste volume, but in the APPA, only part of the extended repository area (panels 11-19) is included, and represented by two panels, and waste Panels 1, 2, 7, 8, and 10 have been consolidated into two panels." (Falta et al. 2021, p. 41).

Basis for PRG Conclusions

- The PRG states "The APPA DBR results are similar to the CRA-2019 results. The APPA has more DBR events with brine volumes less than 40 m^3 than the CRA-2019. This difference is attributed to the additional category of "other" releases from nonadjacent panels, and to the general increase in brine saturation in most areas of the repository from the BRAGFLO Salado Flow model (King, 2021c, d)" (Falta et al. 2021, p. 41).

- The PRG states "Overall, the new conceptualization used in the APPA to simulate direct brine releases is reasonable, and consistent with past PA approaches." (Falta et al. 2021, p. 42).

EPA Observations:

- The increase in small volume DBR events is to be expected given the increase in the number of waste panels with ROM salt closures and is not a defect of the model.

- The new "neighbors" relationships as stated in PRG Report Table 4-1 conform with the rules described by Falta et al. (2021, p. 39), which are reasonable.

4.0 EPA Conclusions Regarding the APPA Peer Review

- Within the constraints of its scope, the conclusions reached by the APPA Peer Review Panel were reasonable and appropriate.

- Parts of the APPA model that were not changed are the same as in the CRA-2019 PA model, which EPA did not accept as a baseline. The PRG's use of the CRA-2019 PA as a baseline was acceptable because the Agency's concerns with that PA were unrelated and therefore not relevant to the changes made in the APPA model.

- The APPA Peer Review was conducted in accordance with the requirements of 40 CFR §194.23(a)(3)(v) and 40 CFR §194.27 and is therefore accepted by EPA as fulfilling those requirements. However, the concerns expressed by EPA in the CRA-2019 TSDs and FR Notice regarding the future use of the CRA-2019 PA model also apply to the APPA model and must be resolved before EPA can consider the APPA model as appropriate for supporting regulatory decisions.

5.0 References

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Attachment A EPA Review Requirement Checklist For Additional Panels Performance Assessment Peer Review

#	Question	EPA Comment (Objective Evidence)	Result
	194.27 Rule Requirements		
1	40 CFR 194.27 (a) Any compliance application shall include documentation of peer review that has been conducted, in a manner required by this section, for: (1) Conceptual models selected and developed by the Department; (2) Waste characterization analyses as required in Section 194.42(b); and (3) Engineered barrier evaluation as required in Section 194.44. **Is this Peer Review a review of one of the topics listed above?**	This Peer Review is a review of changes to three conceptual models selected and developed by the Department, consistent with Item (1) of this requirement, as described in Section 1 of the Waste Isolation Pilot Plant, Additional Panels Performance Assessment (APPA) Changed Conceptual Models Peer Review Report (Falta et al. 2021).	Met
2	40 CFR 194.27 (b) Peer review processes required in paragraph (a) of this section, and conducted subsequent to the promulgation of this part, shall be conducted in a manner that is compatible with NUREG-1297, "Peer Review for High-Level Nuclear Waste Repositories," published February 1988. (Incorporation by reference as specified in Section 194.5.) **Do the Peer Review procedure documents verify that the peer review performed is compatible with NUREG-1297?** (See NUREG-1297 requirements below)	The Peer Review was conducted in accordance with DOE's Management Procedure CBFO MP 10.5 REV. 10 (DOE/CBFO 2018). This procedure was developed consistent with the guidance in NUREG-1297. This procedure was implemented for the subject Peer Review by the *Additional Panels Performance Assessment (APPA) Changed Conceptual Models Peer Review Plan* (DOE/CBFO 2021), where it is stated in Section 5.0 that the Peer Review will be conducted in accordance with NUREG-1297.	Met

#	Question	EPA Comment (Objective Evidence)	Result
3	40 CFR 194.27 (c) Any compliance application shall: (1) Include information that demonstrates that peer review processes required in paragraph (a), and conducted prior to the implementation of the promulgation of this part, were conducted in accordance with an alternate process substantially equivalent in effect to NUREG-1297 and approved by the Administrator or the Administrator's authorized representative. **Is this peer review substantially equivalent in effect to NUREG-1297" and has the Agency approved the procedures used in this peer review?**	Not applicable. The subject Peer Review was not conducted prior to the implementation of the promulgation of 40 CFR 194.27.	N/A
4	40 CFR 194.27 (c) Any compliance application shall: (2) Document any peer review processes conducted in addition to those required pursuant to paragraph (a) of this section. Such documentation shall include formal requests, from the Department to outside review groups or individuals, to review or comment on any information used to support compliance applications, and the responses from such groups or individuals. **Does the Department document processes as noted in (2) above?**	Peer Review processes have been documented in accordance with Section 9.0 of the *Additional Panels Performance Assessment (APPA) Changed Conceptual Models Peer Review Plan* (DOE/CBFO 2021), which requires comprehensive documentation and records retention for all aspects of the Peer Review. These records include documentation of formal DOE requests to independent, outside individuals to be peer panel members and the responses of those individuals. These records are included as appendices in the final Peer Review Report.	Met
	Applicability of Peer Review		
5	Is there documentation that the peer review is used when the adequacy of information or the suitability of procedures and methods essential to showing that the repository system meets or exceeds its performance requirements with respect to safety and waste isolation cannot otherwise be established through testing, alternative calculations, or reference to previously established standards and practices? NUREG-1297 Section IV. 1. a.	The scope of the Peer Review, as described in Section 4.1 of the *Additional Panels Performance Assessment (APPA) Changed Conceptual Models Peer Review Plan* (DOE/CBFO 2021), indicates that the adequacy of information and the suitability of procedures and methods employed to achieve the purpose of the subject conceptual models cannot otherwise be established through testing, alternative calculations, or reference to previously established standards and practices.	Met

#	Question	EPA Comment (Objective Evidence)	Result
6	Is there documentation that the peer review is being conducted in response to one or more of the following conditions? (a) Critical interpretations or decisions will be made in the face of significant uncertainty, including the planning for data collection, research, or exploratory testing (b) Decisions or interpretations having significant impact on performance assessment conclusions (c) Novel or beyond the state-of-the-art testing, plans and procedures, or analyses are or will be utilized (d) Detailed technical criteria or standard industry procedures do not exist or are being developed (e) Results of test are not reproducible or repeatable (f) Data or interpretation are ambiguous (g) Data adequacy is questionable such as, data may not have been collected in conformance with an established QA program NUREG-1297 Section IV. 1. b.	Not applicable. Section 2 of the *Additional Panels Performance Assessment (APPA) Changed Conceptual Models Peer Review Plan* (DOE/CBFO 2021) documents that the review was conducted in response to an EPA requirement that any significant changes to previously peer-reviewed conceptual models be peer-reviewed a second time prior to DOE approval and incorporation into WIPP performance assessment.	N/A
7	Is this peer review being performed because the adequacy of a critical body of information can be established by alternate means, but there is disagreement within the cognizant technical community regarding the applicability or appropriateness of the alternate means? NUREG-1297 Section IV. 1. c	Not applicable. This Peer Review is being performed for the reason identified in Item 6 above.	N/A

#	Question	EPA Comment (Objective Evidence)	Result
	Structure of Peer Review Group		
8	(a) Is the size of the peer review group (PRG) consistent with the complexity, importance, and uncertainty of the work reviewed? (b) Do the collective technical expertise and qualifications of the PRG members span the technical issues and areas involved in the work reviewed, including differing bodies of scientific thought? (c) Is the representation of the PRG proportional to the technical areas more central to the work to be reviewed? (d) Does the PRG represent major schools of scientific thought? (e) Has the potential for partiality been minimized by selection of peers to provide balance in the PRG?	(a) The six-member PRG identified for this review is consistent with the scope of the review as identified in Section 4.1 of the *Additional Panels Performance Assessment (APPA) Changed Conceptual Models Peer Review Plan* (DOE/CBFO 2021). (b) The collective technical expertise and qualifications of the PRG members, as documented in the experience of peer panel members (Falta et al. 2021, p. vi), adequately span the technical issues and areas involved in the work, including differing bodies of scientific thought. (c) The representation of the PRG is adequately proportioned to the technical areas more central to the work to be reviewed, as documented in the scope of the Peer Review Report (Falta et al. 2021, Section 1). (d) The PRG adequately represents major schools of scientific thought, as documented in the experience of peer panel members in Falta et al. (2021, p. vi). (e) The potential for partiality has been minimized by the selection of peers who are adequately representative of major schools of scientific thought and independent of the project, as documented in Falta et al. (2021, p. vi).	Met
	Acceptability of Peers		
9	Technical Requirement: Does each reviewer have recognized and verifiable technical credentials in the technical area covered? NUREG-1297 Section IV. 3. a.	The technical credentials of each reviewer, as documented in the Peer Review Report (Falta et al. 2021, p. vi), are recognized and verifiable.	Met
10	Independence Requirement: Is the PRG independent of the original work to be reviewed? For PRG members not totally independent, is an adequate documented rationale provided? NUREG-1297 Section IV. 3. b.	Section 5 of the Peer Review Plan (DOE/CBFO 2021) requires the peer panel members to be independent of the original work being reviewed. Documentation that the PRG members had no involvement in and are therefore totally independent of the original work to be reviewed is provided in the Peer Review Report (Falta et al. 2021, p. vi).	Met

#	Question	EPA Comment (Objective Evidence)	Result
	Peer Review Process		
11	Does the PRG chairperson determine the peer review process used? NUREG-1297 Section IV. 4.	EPA observed the PRG chairperson to lead the peer panel and determine the manner in which the peer review meetings and caucuses were conducted. The overall peer review process was conducted in compliance with the applicable Peer Review Procedure (DOE/CBFO 2018) and Peer Review Plan (DOE/CBFO 2021), and with the current revision of DOE/CBFO-94-1012, *Quality Assurance Program Document*, Sections 1.1.2.5, and 5.4.	Met
12	Does the PRG evaluate and report on the following? (a) validity of assumptions; (b) alternate interpretations; (c) uncertainty of results and consequences if wrong; (d) appropriateness and limitations of methodology and procedures; (e) adequacy of application; (f) accuracy of calculations; (g) validity of conclusions; and (h) adequacy of requirements and criteria. NUREG-1297 Section IV. 4.	As documented in the Final Peer Review Report (Falta et al. 2021, p. vi), the peer review process consisted of an in-depth analysis and evaluation of each of Items (a) through (h). Additional discussion of EPA observations of the PRG's evaluations is provided in the body of the Agency's summary report to which this table is attached.	Met
13	Does the peer review process show that full and frank discussions between the PRG and the performers of the work are encouraged? NUREG-1297 Section IV. 4.	Full and frank discussions were observed by EPA to be held between the PRG and the performers of the work being reviewed.	Met
14	Are procedures developed for the peer review process? NUREG-1297 Section IV. 4.	The peer review process was conducted in compliance with the applicable Peer Review Procedure (DOE/CBFO 2018) and Peer Review Plan (DOE/CBFO 2021), and with the current revision of DOE/CBFO-94-1012, *Quality Assurance Program Document*, Sections 1.1.2.5, and 5.4.	Met
15	Are written minutes of meetings, deliberations, and activities of the PRG prepared? NUREG-1297 Section IV. 4.	Written minutes of meetings, deliberations, and activities of the PRG were prepared and archived as described in Section 5.6 of the APPA Peer Review Plan. (DOE/CBFO 2021). Copies are presented in Attachment C.	Met

#	Question	EPA Comment (Objective Evidence)	Result
16	Do procedures provide methods for initiating a peer review? NUREG-1297 Section IV. 4.	The process for initiating a peer review is provided in Section 5.2 of DOE Management Procedure CBFO MP 10.5 REV. 10.	Met
17	Do procedures require a planning document that describes the work reviewed, the size and spectrum of the PRG, the method chosen, and the schedule? NUREG-1297 Section IV. 4.	Section 5.2.1 and Attachment I Section A6.1 of DOE Management Procedure CBFO MP 10.5 REV. 10 require the preparation of a planning document that describes the work reviewed, the size and spectrum of the PRG, the method chosen, and the schedule. The requirements of this procedure were satisfactorily addressed in the APPA Peer Review Plan. (DOE/CBFO 2021).	Met
	Peer Review Report		
18	Is a written report documenting the results of the peer review issued and signed by each member of the PRG? NUREG-1297 Section IV. 5.	A final Peer Review Report documenting the results of the peer review was issued in December 2021. This report was signed by each member of the PRG.	Met
19	Does the report clearly state the work or issue reviewed and the conclusions reached by the peer review process? NUREG-1297 Section IV. 5.	Section 1 of the final Peer Review Report clearly states the work reviewed. The conclusions reached by the PRG are clearly stated throughout the document.	Met
20	Does the report include individual statements by PRG members reflecting dissenting views and comments, as appropriate? NUREG-1297 Section IV. 5.	Section 5 of the final Peer Review Report states that no dissenting views were expressed by members of the PRG.	Met
21	Does the report contain a listing of the reviewers and any acceptability information for each member of the PRG, including potential technical and/or organizational partiality NUREG-1297 Section IV. 5.	The reviewers and their acceptability as members of the PRG, including potential technical and/or organizational partialities, are documented in the attachments to the final Peer Review Report.	Met

#	Question	EPA Comment (Objective Evidence)	Result
	NUREG Discussion		
22	Does the QA organization provide surveillance of the peer review process to ensure that procedures conform to NUREG-1297 and that they are followed by the PRG? NUREG-1297 Section V.	CBFO provided a QA surveillance of the entire peer review process as documented in Surveillance Report S-21-22 dated April 28, 2022. The report confirmed that the procedures conformed to NUREG-1297 and that they were followed by the PRG. No concerns or conditions adverse to quality were identified during this surveillance.	Met
23	Is this peer review used in a confirmatory sense? NUREG-1297 Section V.	The peer review was conducted to confirm the adequacy of conceptual model changes in the new APPA model for incorporation into the suite of WIPP performance assessment models.	Met

Attachment B Peer Panel Caucus Notes

John A Thies
07/20/20

John A. Thies
Peer Review Chairman

07/20/21 Caucus Notes

Conflicts

- None identified

Issues

- Some confusion over the number of panels evaluated, but cleared up and not really impacting the conceptual modes.

Concerns

- Reflected in Questions

Questions

With the focus being the 3 of the 24 WIPP conceptual models being peer reviewed:

1. In general, how are you demonstrating that your conceptual model abstractions are valid?
2. Please explain the ~~1%~~ 1° last 07/21/21 "dip" in more detail.
   a. Generally, how would the PA outcome be different if there were no dip?
   b. Does the dip have a time dependent influence on the PA, i.e., how quickly gas and brine migrate within the repository?
   c. Can you prepare a simple diagram (showing gas, brine, and other pertinent factors) that explains how the singe borehole penetration and repository dip result in a conservative PA?

Responded Seth King to by 07/21/21

3. How does gas pressure impact permeability and porosity? Cliff Hansen presentation
4. How does the cavity actinide concentration (mobility) model work?
   a. Is it based on a mass balance with an assumed dissolution rate and a brine volume and brine inflow/outflow rates?
5. Is the brine pocket hypothetically intersected intersected by a borehole within the fracture network? Cliff Hansen
6. How is brine reservoir pressure determined? Cliff Hansen 11-17 MPA ~12 Borehole observations 50-85% of lithostatic
7. Salt creep is a key factor in the generation of high gas and brine pressure in the cavity, yet the rate of creep is dependent on the pressure.
   a. How are the geomechanics creep model and the flow model coupled? Seth & Cliff respond
   b. How has this modeling process been validated? No Coupled F/S/W
8. What is Sandia's estimation of the percentage of the PA that is based on assumptions versus actual field and/or laboratory data?
   >1000 parameters >50% have experimental data
   iron Corrosion is an example use assumption and Apply Assumption
   some are regulator drivers.

9. What are the major time dependent factors in the PA? Seth King
~Steady State in 1K-2000 years.

questions read into the record 07/21/20.
questions provided to SRL to respond 07/21/20

JL A. TL
07/21/20

07/21/21 Caucus Notes

Conflicts

- None identified

Issues

- None Identified

Concerns

- The lack of spacial plots has made the review more difficult. used Moric and will provide more as available.

Questions

With the focus being the 3 of the 24 WIPP conceptual models being peer reviewed:

1. The DRZ vertical thickness (13 feet?) is greater than the horizontal DRZ thickness, which appears to be less than 5 feet. How was the thickness determined? above + below versus z direction
   a. Is the value derived from experiments in the excavated rooms after caving commenced using permeability measurements at depth in the halite? z is fixed Some experimental work

2. Considering that Sandia is using an empirical equation for determining the Direct Brine Release volume, one would expect it to deviate from a fully numerical approach that calculates a volumetric flux based on real geometry and the numerical results of hydraulic gradients. See notes on #4.
   a. Can you demonstrate that your simplified approach is conservative and that it captures sufficient DBR volume?
   b. Also, how is it different from what would be obtained from a numerical approach based on a refined grid?

3. The APPA currently assumes that future drilling events will occur randomly in time, whereas the pattern of existing wells (see Todd Zeitler July 13 presentation, Slide 9) suggests that well field development takes place over a relatively short period of time (decades or less) and with regularly spaced wells.
   a. How would you expect the effects of intrusion scenarios to change if all drilling were to take place over a short time (maybe decades) with closely spaced wells?

Responded to by Seth

CRA 2014 Consideration of Drilling Events in Performance Assessments

33.3.6, 40 CFR § 194.33(b)(2) EPA Compliance Review

The EPA reviewed the DOE's implementation of drilling rate and location assumptions, and concluded that the DOE used appropriate methods to derive drilling rates and locations. The EPA determined (U.S. EPA 1998d) that the DOE adequately demonstrated that drilling events were assigned as occurring over random intervals of time and at random locations. The EPA also reviewed the DOE's implementation of

drilling assumptions and determined that the method employed by the DOE in the calculations yields random drilling rate and location results. Use of Poisson distribution to project the time period that will elapse between intrusions was determined to be an acceptable approach. Division of the projected future into three distinct time periods was determined to be appropriately justified. The EPA disallowed PA credit for PICs [Passive Institutional Controls]. Nonetheless, the CCA Performance Assessment Verification Test (PAVT) calculations demonstrated that the effects of the proposed credits for active institutional controls (AICs) and PICs are insignificant, so that the PA results remain unaffected whether or not the credits are allowed (U.S. DOE 1997a).

4. The DBR model discretizes the panel pillars and open space in the panels, but the numerical grid blocks extend from pillar to pillar. The productivity index approach for calculating fluid flow from the borehole assumes a symmetrical flow entering that grid block from four sides, which does not occur when two sides of the gridblock abut the pillars.
   a. Have you evaluated the effects of this coarse grid resolution compared to a locally refined grid around the intruding borehole?

Seth addressed # 2+4
1996 Sozel & O'Brien reference for tabulation
could be Coupled – not conservative or non conservative
numerically simplification.
function of relative permeability – Appendix PA
3 vs 2 grid block test to see pillar effect.
DBR Does not use NUTS.