IMPORTANT NOTICE: The current official version of this document is available via the Sandia National Laboratories WIPP Online Documents web site. A printed copy of this document may not be the version currently in effect.

SANDIA NATIONAL LABORATORIES
WASTE ISOLATION PILOT PLANT

AP-161

Analysis Plan for the 2012 WIPP Panel Closure System Performance Assessment

Task 1.4.1.2

Effective Date: July 2, 2012

Authored by:	Chris Camphouse Print Name	*Original signed by Chris Camphouse* Signature	7/2/12 Date
Reviewed by:	Bwalya Malama Print Name Technical Reviewer	*Original signed by Bwalya Malama* Signature	07/02/12 Date
Reviewed by:	Shelly Nielsen Print Name Quality Assurance Reviewer	*Original signed by Shelly R. Nielsen* Signature	7-2-12 Date
Approved by:	Janis Trone Print Name Department Manager	*Original signed by Janis Trone* Signature	7/2/12 Date

Table of Contents

List of Figures and Tables

1 Introduction and Objectives

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. Containment of TRU waste at the WIPP is regulated by the U.S. Environmental Protection Agency (EPA) according to the regulations set forth in Title 40 of the Code of Federal Regulations (CFR), Part 191. The DOE demonstrates compliance with the containment requirements according to the Certification Criteria in Title 40 CFR Part 194 by means of performance assessment (PA) calculations performed by Sandia National Laboratories (SNL). WIPP PA calculations estimate the probability and consequence of potential radionuclide releases from the repository to the accessible environment for a regulatory period of 10,000 years after facility closure. The models used in PA are maintained and updated with new information as part of an ongoing process. Improved information regarding important WIPP features, events, and processes typically results in refinements and modifications to PA models and the parameters used in them. Planned changes to the repository and/or the components therein also result in updates to WIPP PA models. WIPP PA models are used to support the repository recertification process that occurs at five-year intervals following the receipt of the first waste shipment at the site in 1999.

WIPP waste panel closures comprise a feature of the repository that has been represented in WIPP PA regulatory compliance demonstration since the Compliance Certification Application (CCA) of 1996. Panel closures are included in the repository as a safety measure during the operational period. In particular, their presence in the repository is a means to protect workers from exposure to two potential hazards: 1) volatile organic compounds that may be present in emplaced waste materials and 2) an explosion which has been hypothesized to occur from gas generation causing methane concentration in the waste panels to reach a sufficiently high level. Panel closures were not developed to isolate radionuclides in the repository after closure. The DOE stated in the CCA (DOE 1996) that *"The panel closure system was not designed or intended to support long-term repository performance."* Panel closures are included in WIPP PA models principally because they are part of the disposal system, not because they play a substantive role in inhibiting the release of radionuclides to the outside environment.

The WIPP was certified to receive TRU waste in 1998. The 1998 rulemaking had several conditions. Condition 1 involved the design of the panel closure system (PCS) implemented in the repository. The DOE presented four design options in the CCA, and

> "The EPA based its certification decision on the condition that DOE implement the most robust design [referred to in the CCA as "Option D"]. The Agency found the Option D design to be adequate, but also determined that the use of a Salado Mass Concrete - using brine rather than fresh water - would produce concrete seal permeabilities in the repository more consistent with the values used in DOE's performance assessment. Therefore, Condition 1 of the EPA's certification requires DOE to implement the Option D PCS at the WIPP, with Salado Mass Concrete" (EPA 1998).

The Option D panel closure system consists of three primary components: 1) a concrete block wall (the explosion wall), 2) open drift, and 3) a concrete monolith. The arrangement and dimensions of these components are illustrated in Figure 1.

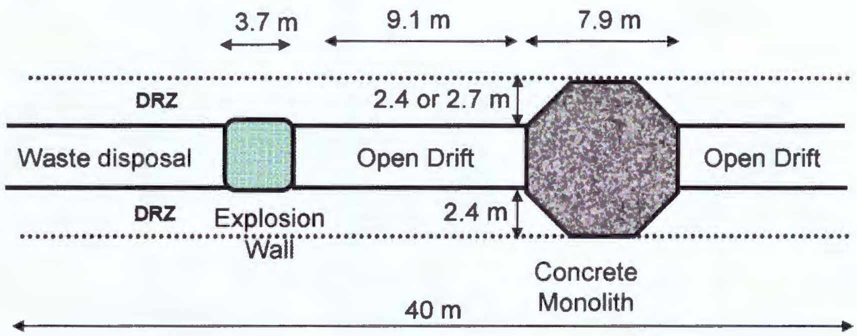
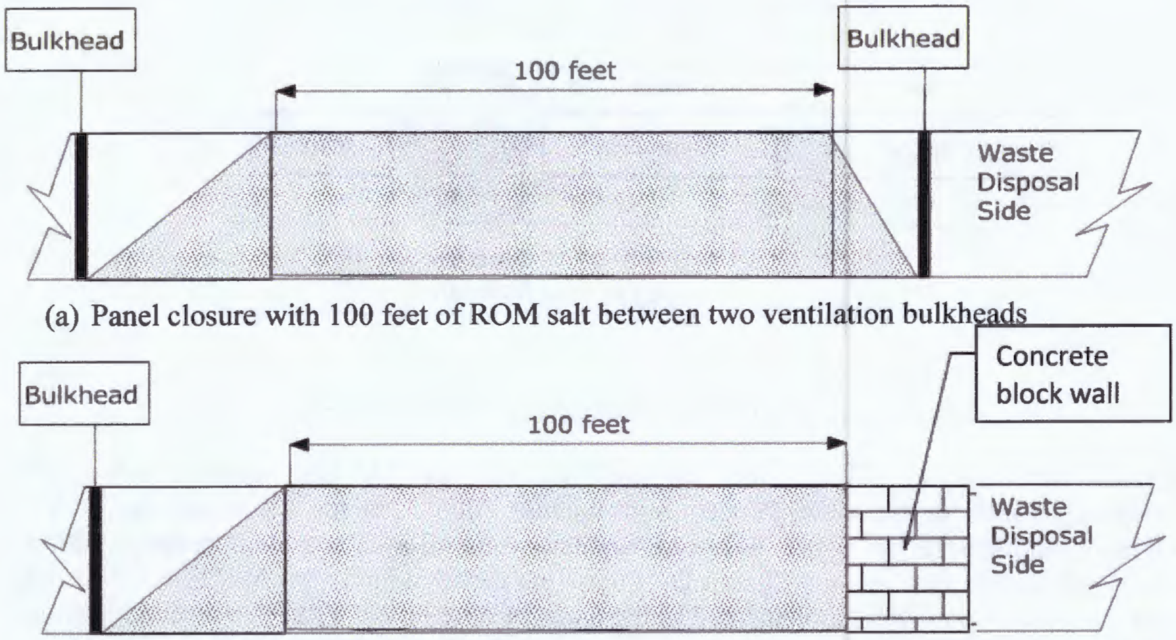


Figure 1: A Schematic of the "Option D" Panel Closure

Extensive refinement to WIPP panel closure modeling in PA has occurred since the implementation used in the CCA (Vugrin and Wagner 2006). In the CCA and the PAVT (MacKinnon and Freeze 1997) that followed, regulatory compliance was demonstrated with a generic panel closure that was not Option D. Following certification of the WIPP in 1998, and the mandate that Option D be implemented as the panel closure in WIPP, a PA was conducted in 2002 (Hansen 2002) with the aim of implementing an Option D panel closure into the repository models used in WIPP PA, and to assess the impacts of panel closure design on long-term repository performance. Two panel closure cases were considered. The first was modeled upon the mandated Option D panel closure design. The second was the generic panel closure design implemented in the CCA and PAVT. Upon completion of the analysis, it was found that total normalized releases resulting from the two panel closure cases were nearly identical. Moreover, nearly identical distributions for each release component were calculated in the two panel closure cases. A more granular representation of the Option D panel closure was developed during the 2002 – 2003 Technical Baseline Migration (TBM) PA. Upon completion of the TBM PA, it was again found that the TBM and PAVT produced releases that are nearly identical, indicating that repository performance is not significantly affected by changes in the panel closure properties (Dunagan 2003). The Option D panel closure representation developed during the TBM was used for the panel closure representation in the 2004 and 2009 Compliance Recertification Applications (CRA-2004 and CRA-2009, respectively).

The DOE has submitted a planned change request (PCR) to the EPA requesting that EPA modify Condition 1 of the Final Certification Rulemaking for 40 CFR Part 194 (EPA, 1998) for the WIPP. Following the selection of the Option D panel closure design in 1998, the DOE has reassessed the engineering of the panel closure and established a revised design which is simpler, easier to construct and equally effective at performing its operational-period isolating function. Accordingly, the PCR submitted to EPA requested that Condition 1 be changed, and that a revised design for the panel closures be approved for use in all panels (DOE, 2011). The revised design of the PCS, known as the Run-of-Mine Panel Closure System (ROMPCS), comprises 100 feet of run-of-mine (ROM) salt with barriers at each end (Figure 2). The ROM salt is generated from ongoing mining operations at the WIPP and may be compacted and/or moistened as it is emplaced in a panel entry. The ROM salt will be emplaced to all salt surfaces (back, walls, etc.)

as completely as practicable. After emplacement, creep closure of the panel entries will cause the ROM salt to consolidate to a condition approaching intact salt, with low porosity and low permeability.



(a) Panel closure with 100 feet of ROM salt between two ventilation bulkheads

(b) Panel closure with 100 feet of ROM salt between a ventilation bulkhead & explosion wall

Figure 2. Schematic diagram of the revised panel closure design

The barriers will consist of ventilation bulkheads, similar to those currently used in the panels as room closures. The ventilation bulkheads are designed to restrict air flows and prevent personnel access into waste-filled areas during the operational phase. In Panels 1, 2, and 5, where explosion walls fabricated from concrete blocks have already been emplaced in the panel entries, an explosion wall is the inner barrier and a ventilation bulkhead will be the outer barrier, as shown in Figure 2b.

Panel closures are represented in PA by way of their material properties and spatial extent. Due to the regulatory time scale of 10,000 years for which regulatory compliance must be demonstrated, there are uncertainties associated with panel closure material properties. These uncertainties in material properties are incorporated in PA. A material property with an associated uncertainty is assigned a distribution, and this distribution is randomly sampled. This sampling process allows for repository performance to be quantified over a range of material conditions, as well as an analysis of performance sensitivity to changes in material properties. As briefly described above, numerous studies have been conducted to date, often by way of full PA analyses, to quantify the impact of changes in panel closure material properties on regulatory compliance. In addition, several PA analyses have been performed (Hansen 2002, Vugrin & Dunagan 2006, Camphouse et al 2011) with the aim of determining the impact of panel closure redesigns on repository performance. Regulatory compliance has been met in all PA analyses performed to date, including those that incorporated changes to panel closure modeling. Regulatory compliance has been repeatedly shown to be primarily insensitive to panel closure material properties. An additional PA is to be executed that incorporates the ROMPC design into the current PA baseline established by the 2009 Performance Assessment Baseline Calculation (PABC-2009) (Clayton et al., 2010). The name given to this new panel closure PA is PCS-2012.

The PCS-2012 PA will quantify impacts of the ROMPCS design by comparing total normalized releases to those found in the PABC-2009 where Option D was implemented as the panel closure. The PCS-2012 PA will incorporate material parameters and timings to account for the following physical processes and rock mechanics principles:

1. Creep closure of the salt rock surrounding panel entries will cause consolidation of ROM salt emplaced in panel entries.
2. Eventually, the ROM salt comprising the closures will approach a condition similar to intact salt.
3. As ROM salt reaches higher fractional densities during consolidation, back stress will be imposed on the surrounding rock mass leading to eventual healing of the disturbed rock zone (DRZ).
4. DRZ healing above and below the ROM salt panel closures will reduce DRZ porosity and permeability in those areas.

Calculations and analyses have been performed to develop material properties to be used in the PCS-2012 PA, and are documented in Camphouse (2012), DOE (2012), and Herrick (2012). Potential regulatory compliance impacts resulting from the use of the ROMPCS design in WIPP will be determined by way of a comparison of release probabilities to those calculated in the PABC-2009. Differences seen between the PABC-2009 and the PCS-2012 PA will be a direct consequence of the revised design of the PCS. This document details how SNL will conduct the compliance decision analysis for the PCS-2012 PA.

2 Approach

The PCS-2012 PA analysis will be used to demonstrate compliance of the WIPP repository with the containment requirements according to the Certification Criteria in Title 40 CFR Part 194. A focused set of PA calculations will be executed to determine the impact of the panel closure changes being proposed. The results of PCS-2012 PA calculations will be compared to those obtained in the PABC-2009. The PCS-2012 PA will examine all aspects of repository performance that are potentially impacted by the panel closure design.

The approach used for the PCS-2012 PA will be very similar to that used for PABC-2009 (Clayton 2009). The PCS-2012 PA begins with an assessment that identifies and evaluates the features, events, and processes (FEPs) that are related to the changes introduced by the proposed panel closure design. The purpose of the FEPs evaluation is to determine if the current FEPs baseline (currently the PABC-2009 FEPs baseline) is suitable to evaluate the new closure design, or if changes to FEPs descriptions, screening arguments, or decisions are necessary. The results of this assessment concluded that no changes are needed to the FEPs baseline (Kirkes 2011) [1]. It should be pointed out that the FEPs analysis only determines that the WIPP design features are

[1] Note that Kirkes (2011) also evaluated changes associated with a proposed reconfiguration of the repository layout; the PCS changes are a subset of this FEP evaluation. Only the elements (and FEPs) relating to the PCS redesign are germane to this Analysis Plan and resulting analyses.

appropriately identified, described, and screened according to established FEPs screening methods. WIPP FEPs W109 *Panel Closure Geometry* and W110, *Panel Closure Properties*, are directly related to the changes proposed by the new PCS design and were the focus of the FEPs assessment. These two FEPs have been screened in (represented) as part of previous performance assessments in all scenarios, and continue to be so in the PCS-2012 PA. Any differences in the representation of these FEPs within the WIPP repository model is described in this analysis plan, and proper parameterization of the PCS elements that represent these FEPs is described in Camphouse et al. (2012).

The impacts of the ROMPCS design on regulatory compliance will be determined by a direct comparison of PCS-2012 PA results to those obtained in the PABC-2009. The FEPs baseline utilized in the PABC-2009 will also be applied to the PCS-2012 PA, as no changes were recommended in Kirkes (2011). As such, this will enable a "like for like" comparison between the two analyses, with any compliance impacts seen in the PCS-2012 being solely attributable to the ROMPCS closure design and its material parameters.

The following sections detail the implementation of the PCS-2012 PA with particular attention being given to the way panel closure design changes will be captured in individual PA codes and parameters.

2.1 ROMPCS Model

The PCS-2012 PA will replace the PABC-2009 representation of the Option D panel closure with a representation of the ROMPCS within the WIPP repository model. As discussed in relation to Figure 2, concrete block explosion walls have already been emplaced in waste panels 1, 2, and 5. The ventilation bulkheads used in the ROMPCS are designed to provide isolation only during the operational period. These bulkheads are not expected to remain intact 100 years after repository closure because of creep closure of the panel entries. The explosion wall is also designed for the operational period. These walls are inspected on a regular basis, and their anticipated condition is also assessed through numerical modeling (e.g. RockSol, 2006). Installed explosion walls show surface spalling or slabbing of the concrete blocks as a result of the loading caused by inward creep of the salt. Numerical stress analysis of the concrete explosion wall has demonstrated that the free faces and the rib contacts will be in a condition of plastic yield with an unyielded core by 7 years after emplacement (Rocksol, 2006, Figures 7 and 10). No long term stress analyses have been carried out; however, it is expected that the spalling and yield will be progressive, and that the walls will not be significant structures after the initial 100 year time period, due to the brittle, non-plastic behavior of concrete. The ventilation bulkheads and explosion walls will therefore have no significant impact on long-term performance of the panel closures and are therefore not included in the PCS-2012 PA representation of the ROMPCS. Consequently, the ROMPCS will be modeled as consisting of 100 feet of ROM salt.

The ROMPCS properties will be based on three time periods: from 0 to 100 years, from 100 years to 200 years, and from 200 years to 10,000 years. This is a refinement to the granularity of panel closure modeling undertaken in the 2006 PCS PA (Vugrin and Dunagan 2006) and the 2011 PC3R PA (Camphouse et al 2011). Three time periods are appropriate because the process to consolidate the ROM salt occurs over a primary time scale of approximately 100 years, while the process to heal fractures in the DRZ surrounding the PCS occurs over a longer time scale of approximately 200 years. The ROM salt will therefore be represented by three materials, denoted as PCS_T1 for the first 100 years, PCS_T2 for 100 to 200 years, and PCS_T3 for 200 to 10,000 years. Analyses and calculations have shown (Camphouse et al 2012) that the time-dependent back stress imposed on the DRZ by the re-consolidated ROM salt panel closure does not become appreciable until roughly 200 years after emplacement of the ROM salt in the drift. As a result, it is reasonable and appropriate to maintain the same properties for the DRZ above and below the ROMPCS for the first 200 years after closure as are specified to the DRZ surrounding the disposal rooms. After 200 years, the DRZ above and below the ROMPCS will be modeled as having healed, and this sub-region of the DRZ will be represented by material DRZ_PCS. Material DRZ_PCS was developed during the TBM PA to represent healed DRZ above Option D panel closures (Stein 2002). Material DRZ_PCS has been used since the TBM PA to represent healed DRZ regions above and below panel closures, and will be used in the PCS-2012 to maintain consistency in material names with prior analyses.

The effective permeability and porosity of the ROMPCS are the two parameters expected to have the greatest impact on calculations of pressure and brine saturation in repository waste areas. Consequently, materials PCS_T1, PCS_T2, and PCS_T3 will be assigned porosities and permeabilities appropriate for representation of the ROMPCS. Properties specified for material DRZ_PCS will be identical to those used in the PABC-2009 PA. BRAGFLO calculations require that two-phase flow properties be specified for all materials. A brief discussion of the two-phase flow parameters used for PCS_T1, PCS_T2, and PCS_T3, particularly their implementation in regard to BRAGFLO capillary pressure modeling, is given in Camphouse (2012). A full list of properties to be established for materials PCS_T1, PCS_T2, and PCS_T3 is given in Table 1. In addition to the properties listed in Table 1, the initial brine saturation of the ROMPCS will be specified. This parameter corresponds to property SAT_IBRN for material PCS_T1. With the exception of these parameters, the PCS-2012 PA will use the same parameters and parameter values that were used for the PABC-2009 (Clayton 2009).

Table 1: PCS_T1, PCS_T2, and PCS_T3 Properties to be used in the PCS-2012 PA

Property	Description
CAP_MOD	Capillary Pressure Model Number (CAP_MOD = 1 or 2 has been used in every PA to date for all materials in BRAGFLO)
COMP_RCK	Bulk Compressibility
KPT	Flag to Enable Dynamic Updating of Threshold Capillary Pressure as a Function of Permeability (KPT = 0 has been used in every PA to date for all materials in BRAGFLO)
PC_MAX	Maximum Allowable Capillary Pressure (PC_MAX = 1×10^8 Pa has been used for all BRAGFLO materials since the CCA)
PCT_A	Threshold Capillary Pressure Linear Parameter
PCT_EXP	Threshold Capillary Pressure Exponential Parameter
PO_MIN	Minimum Brine Pressure for Capillary Model 3 (CAP_MOD = 3 has never been used in PA)

Property	Description
PORE_DIS	Brooks-Corey Pore Distribution Parameter
POROSITY	Effective Porosity
PRMX_LOG	Log of Intrinsic Permeability, X-Direction
PRMY_LOG	Log of Intrinsic Permeability, Y-Direction
PRMZ_LOG	Log of Intrinsic Permeability, Z-Direction
RELP_MOD	Relative Permeability Model Number
SAT_RBRN	Residual Brine Saturation
SAT_RGAS	Residual Gas Saturation

2.2 Calculation Methodology

2.2.1 Rationale

The aim of the PCS-2012 PA is to quantify regulatory compliance impacts associated with the ROMPCS design. Impacts will be determined by direct comparison of PCS-2012 PA results to the current compliance baseline established by the PABC-2009. To enable the direct comparison of results obtained in the two analyses, the PCS-2012 PA is constructed so that the structure of calculations performed are as similar as possible to that used in the PABC-2009. To that end, the PCS-2012 PA will utilize the same waste inventory information, intrusion scenarios, drilling rate and plugging pattern parameters, radionuclide solubility parameters, and hydrologic transmissivity fields as were used in the PABC-2009. The PCS-2012 PA will consist of a full set of PA compliance calculations. That is, three replicates of PA calculations, each replicate consisting of 100 vectors, will be performed. The random seeds from the PABC-2009 will be preserved so that results from the PCS-2012 PA analysis can be compared to those from the PABC-2009 on a vector-by-vector basis.

The design of the ROMPCS potentially alters pressure profiles in repository waste regions as compared to Option D design implemented in the PABC-2009. Pressure changes in the waste panels translate directly to changes in spallings releases as pressure changes yield changes in spallings volumes. Moreover, pressure changes in waste areas potentially alter the influx of brine into these regions, corresponding to changes in brine saturation. Direct brine releases are a function of pressure and brine saturation at the time of intrusion. Two conditions must be met for a DBR to occur. First, the brine saturation in the intruded panel must exceed the residual brine saturation of the waste, a sampled parameter in PA. Second, the repository pressure near the drilling location must exceed the hydrostatic pressure of the drilling fluid, which is specified in PA to be 8 MPa. The combined impact of pressure and brine saturation changes resulting from implementation of the ROMPCS potentially alters the released brine volume associated with a particular intrusion event as compared to the PABC-2009. The potential for changes to released brine volumes translates directly to changes in DBRs. For these reasons, spallings and DBRs are the primary release mechanisms of interest in the PCS-2012 PA. Changes to the panel closure design have no impact on releases due to cuttings and cavings. Transport releases through the Culebra had virtually no impact on total normalized releases in the PABC-2009 (Clayton et al 2010). Implementation of the ROMPCS will not change this result. In addition, hydrologic transmissivity fields are not being updated as part of the PCS-2012 PA. Consequently, Culebra transport results obtained in the PABC-2009 will also be used in the PCS-2012 PA.

The calculations to be conducted for the PCS-2012 PA are listed below. Results generated from the PABC-2009 will be used for codes not discussed below.

2.2.2 Parameter Sampling: LHS

Three replicates of 100 vectors will be created using the computer code LHS. LHS version 2.42 will be used for the PCS-2012 PA, which is the same code used for the PABC-2009. The random seed and parameter ordering from the PABC-2009 will be used for the PCS-2012 PA. Use of the PABC-2009 random seeds and ordering will result in identical sampled parameter values for parameters that are common to both the PCS-2012 PA and the PABC-2009. This approach enables comparison of the PCS-2012 PA and the PABC-2009 on a vector-by-vector basis.

PA material CONC_PCS was used in the PABC-2009 to represent the concrete monolith component of the Option D panel closure. In the PCS-2012 PA, material CONC_PCS will be replaced by materials PCS_T1, PCS_T2, and PCS_T3 and their corresponding properties. Distributions prescribed to these three materials are listed in Camphouse et al (2012).

2.2.3 Salado Flow: BRAGFLO

The two-phase flow code BRAGFLO simulates the brine and gas flow in and around the WIPP repository and incorporates the effects of disposal room closure, gas generation, brine consumption, and inter-bed fracturing in response to gas pressure. The results of BRAGFLO scenarios S1-BF to S5-BF are used as input for the subsequent calculation of Salado radionuclide transport, DBRs, and spallings releases. BRAGFLO scenario S6-BF is used in the calculation of radionuclide transport to the Culebra. The scenarios modeled in BRAGFLO are listed in Table 2.

Table 2: WIPP PA BRAGFLO Scenarios

Scenario	# of Drilling Intrusions	Time of Intrusion (Years)	Castile Brine Pocket encountered
S1-BF	0 (Undisturbed)	NA	NA
S2-BF	1	350	Yes
S3-BF	1	1,000	Yes
S4-BF	1	350	No
S5-BF	1	1,000	No
S6-BF	2	1,000 and 2,000	Only at 2,000

Implementation of the ROMPCS will slightly alter the BRAGFLO computational grid and material map that were used in the PABC-2009. In particular, Option D panel closures represented in the PABC-2009 BRAGFLO grid will be replaced by panel closures consisting of ROM salt for the PCS-2012 PA. Healing of the DRZ directly above and below redesigned panel closures as discussed in Section 1 will also be captured in PCS-2012 PA calculations. Finally, the Option D panel closure implemented in the PABC-2009 is 40 meters long (Figure 1) while the ROMPCS modeled in the PCS-2012 is 100 feet (30.48 meters) long. The PABC-2009

BRAGFLO grid will be modified slightly to account for the reduction in length of the ROMPCS as compared to Option D.

A complete suite of BRAGFLO calculations will be executed for the PCS-2012 PA. These calculations will consist of 3 replicates, 100 vectors per replicate, and 6 scenarios (see Table 2) per vector. The codes PREBRAG version 8.0, BRAGFLO version 6.0 and POSTBRAG version 4.00A will be used for the PCS-2012 PA, which are the same codes used for PABC-2009.

2.2.4 *Spallings: DRSPALL and CUTTINGS_S*

Repository pressures may be affected by the implementation of the ROMPCS design. Changes in repository pressures have the potential to impact spallings results. Consequently, spallings releases for the PCS-2012 PA may differ from those found in the PABC-2009 due to differences in repository pressures calculated by BRAGFLO. Spallings volumes from a single borehole intrusion are calculated by code DRSPALL at initial repository pressures of 10, 12, 14, and 14.8 MPa. DRSPALL calculations that were utilized to generate spallings volumes at these pressures in the PABC-2009 will also be used in the PCS-2012 PA. The PCS-2012 PA will use the same procedure as was used for the PABC-2009 to interpolate between these DRSPALL volumes to calculate spallings volumes corresponding to a particular drilling intrusion. The initial repository pressure for a given scenario, time, location, and vector will be retrieved from the BRAGFLO results, and CUTTINGS_S will use this initial pressure to calculate a spallings volume for each scenario, time, location, and vector combination by interpolating between DRSPALL results. The code CUTTINGS_S version 6.02 will be used for the PCS-2012 PA, which is the same code used for the PABC-2009.

2.2.5 *Direct Brine Releases: BRAGFLO*

In addition to its role as a tool used to simulate brine and gas flow in and around the WIPP repository, BRAGFLO is also used in PA to calculate DBR volumes. As the implementation of the ROMPCS design potentially impacts pressures and brine saturations in waste-containing repository regions, DBR calculations will be performed as part of the PCS-2012 PA. The numerical grid and material map used to calculate DBRs will be updated to reflect the ROMPCS design. Conditions required for the initiation of a DBR release will remain unchanged from the PABC-2009, and the DBR volumes will be calculated for the same scenarios and times (Table 3) used in that analysis. The codes PREBRAG version 8.0, BRAGFLO version 6.0 and POSTBRAG version 4.00A will be used for the PCS-2012 PA, which are the same codes used for the PABC-2009.

Table 3: PA Intrusion Scenarios Used in Calculating Direct Brine Releases

Scenario	Conditioning (or 1st) Intrusion Time (year) and Type	Intrusion Times – Subsequent (year)
S1-DBR	None	100, 350, 1000, 3000, 5000, 10000
S2-DBR	350, E1	550, 750, 2000, 4000, 10000
S3-DBR	1000, E1	1200, 1400, 3000, 5000, 10000
S4-DBR	350, E2	550, 750, 2000, 4000, 10000
S5-DBR	1000, E2	1200, 1400, 3000, 5000, 10000

2.2.6 CCDF Construction: CCDFGF

Implementation of the ROMPCS design will have a negligible impact on potential releases from the Culebra. As a result, the PCS-2012 PA will calculate CCDFs of individual vectors for total normalized releases using Culebra release results calculated in the PABC-2009. The PCS-2012 PA will calculate CCDFs of individual vectors for total normalized releases, cuttings and cavings releases, spallings releases, and DBRs. (The use of the ROMPCS design will have no impact on cuttings and cavings releases. Nonetheless, new cuttings and cavings release volumes will be calculated in the PCS-2012 PA as a by-product of the spallings calculation.) Mean CCDFs for each release pathway will be calculated by replicate and across all replicates. The 95% confidence limit on the mean across all replicates will also be calculated. The codes PRECCDFGF version 1.01 and CCDFGF version 5.02 will be used for the PCS-2012 PA, which are the same codes used for the PABC-2009.

2.2.7 Sensitivity Analysis: STEPWISE

The PCS-2012 PA will implement sensitivity analyses for results from the major codes in a manner consistent with those employed for the PABC-2009. Specifically, global sensitivity analyses will be conducted on the results from CCDFGF using the linear regression code STEPWISE version 2.21. Since the Salado flow results from the BRAGFLO calculations are used as input to many other codes, additional sensitivity analyses may be performed using BRAGFLO results. WIPP PA codes such as PCCSRC, as well as Commercial Off-The Shelf (COTS) statistical software, may be used to assess the sensitivity of BRAGFLO results to input parameters.

2.3 Reports and Documentation

Several reports will be generated as a result of this analysis plan. Each set of calculations discussed in Section 2.2 and its subsections will be documented in an analysis report. These reports will include:

1) discussion of any implementation changes (parameters, modeling assumptions, etc.) relative to the corresponding PABC-2009 calculations; and
2) analysis of results relevant to the long term performance of the repository. The analysis will include comparisons of PCS-2012 PA results with PABC-2009 results.

A summary report describing the major results of the PA will also be written. The summary report will include the run control record as an appendix. This appendix will contain:

1. A description of the hardware platform and operating system used to perform the calculations.
2. A listing of the codes and versions used to perform the calculations.
3. A listing of the scripts used to run each calculation.
4. A listing of the input and output files for each calculation.
5. A listing of the library and class where each file is stored.
6. File naming conventions.

The analyses performed under this analysis plan are in support of a rulemaking decision to replace the current WIPP Option D panel closure design with the ROMPCS design. As such, it is likely that additional analyses and calculations will be performed as part of the regulatory review and approval process. These additional tasks and documentation, if they become necessary, will also fall under AP-161.

3 Tasks

The tasks, responsible personnel and estimated task schedule are summarized below in Table 4.

Table 4: Task List and Estimated Schedule for the PCS-2012 PA.

Task	Description	Guiding Document	Approximate Completion Date	Responsible Individual(s)
1	Parameters			
1a	Development of ROMPCS parameters	SP 9-5	7/11/12	Camphouse Gross Herrick Kicker Thompson
1b	Entry of ROMPCS parameters into PAPDB	SP 9-5	7/12/12	Long
2	Preparation Tasks			
2a	Input files prepared	AP-161	7/25/12	Camphouse Clayton Kicker Kirchner Malama
2b	Input file review	AP-161	8/1/12	Camphouse
3	Code Run Environment Preparation			
3a	Libraries Update	AP-161	8/1/12	Long
3b	Run Control Script Update	AP-161	9/14/12	Long
4	Calculations			
4a	Parameter Sampling: LHS	AP-161	8/2/12	Long
4b	BRAGFLO Testing with new parameters and por/perm relationship	AP-161	8/10/12	Camphouse Malama
4c	Salado Flow: BRAGFLO	AP-161	8/17/12	Long
4d	Cuttings & Cavings, Spallings: CUTTINGS_S	AP-161	8/24/12	Long
4e	Direct Brine Releases: BRAGFLO	AP-161	8/31/12	Long
4f	CCDF Construction: CCDFGF	AP-161	9/7/12	Long
4g	Sensitivity Analysis: STEPWISE	AP-161	9/14/12	Kirchner
5	Analysis & Documentation			
5a	Parameter Sampling: LHS	AP-161	9/6/12	Kirchner
5b	Salado Flow: BRAGFLO	AP-161	9/21/12	Camphouse Malama
5d	Spallings: CUTTINGS_S	AP-161	9/28/12	Kicker
5c	Direct Brine Releases: BRAGFLO	AP-161	10/5/12	Malama Camphouse
5d	CCDF Construction: CCDFGF	AP-161	10/12/12	Kicker
5e	Sensitivity Analysis: STEPWISE	AP-161	10/19/12	Kirchner
5f	Summary Report with Run Control as Appendix	AP-161	11/9/12	Camphouse Long

4 Software

The major WIPP PA codes to be used for this analysis are listed in Table 5. These codes will be executed on the WIPP PA Alpha Cluster, which is listed in Table 6. Additionally, COTS software, such as MATHEMATICA®, MATLAB®, MATHCAD®, Excel®, Access®, Grapher®, or Kaleidagraph® may be utilized. The use of any COTS application will be verified per NP 9-1 Appendix C as appropriate.

Table 5: Codes to be used for the PCS-2012 PA.

Code	Version	Build Date	Executable
ALGEBRACDB	2.35	31-JAN-1996	ALGEBRACDB_PA96.EXE
BRAGFLO	6.0	12-FEB-2007	BRAGFLO_QB0600.EXE
CCDFGF	5.02	13-DEC-2004	CCDFGF_QB0502.EXE
CUTTINGS_S	6.02	9-JUN-2005	CUTTINGS_S_QA0602.EXE
GENMESH	6.08	31-JAN-1996	GM_PA96.EXE
ICSET	2.22	1-FEB-1996	ICSET_PA96.EXE
LHS	2.42	18-JAN-2005	LHS_QA0242.EXE
MATSET	9.10	29-NOV-2001	MATSET_QA0910.EXE
PCCSRC	2.21	23-MAY-1996	PCCSRC_PA96.EXE
POSTBRAG	4.00A	28-MAR-2007	POSTBRAG_QA0400A.EXE
POSTLHS	4.07A	25-APR-2005	POSTLHS_QA0407A.EXE
PREBRAG	8.00	8-MAR-2007	PREBRAG_QA0800.EXE
PRECCDFGF	1.01	7-JUL-2005	PRECCDFGF_QA0101.EXE
PRELHS	2.30	27-NOV-2001	PRELHS_QA0230.EXE
RELATE	1.43	6-MAR-1996	RELATE_PA96.EXE
STEPWISE	2.21	2-DEC-1996	STEPWISE_PA96_2.EXE
SUMMARIZE	3.01	21-DEC-2005	SUMMARIZE_QB0301.EXE

Table 6: WIPP PA Alpha Cluster

Node	Hardware Type	CPU	Operating System
CCR	HP AlphaServer ES45	Alpha EV68	Open VMS 8.2
TDN	HP AlphaServer ES45	Alpha EV68	Open VMS 8.2
BTO	HP AlphaServer ES45	Alpha EV68	Open VMS 8.2
CSN	HP AlphaServer ES45	Alpha EV68	Open VMS 8.2
GNR	HP AlphaServer ES47	Alpha EV7	Open VMS 8.2
MC5	HP AlphaServer ES47	Alpha EV7	Open VMS 8.2
TRS	HP AlphaServer ES47	Alpha EV7	Open VMS 8.2
TBB	HP AlphaServer ES47	Alpha EV7	Open VMS 8.2

5 Special Considerations

None

6 Applicable Procedures

All applicable WIPP QA procedures will be followed when conducting these analyses.

- Training of personnel will be conducted in accordance with the requirements of NP 2-1, *Qualification and Training.*
- Analyses will be conducted and documented in accordance with the requirements of NP 9-1, *Analyses.*
- All software used will meet the requirements laid out in NP 19-1, *Software Requirements* and NP 9-1, as applicable.
- The analyses will be reviewed following NP 6-1, *Document Review Process.*
- All required records will be submitted to the WIPP Records Center in accordance with NP 17-1, *Records.*
- New and revised parameters will be created as discussed in NP 9-2, *Parameters.*

7 References

Camphouse, R.C. 2012. An overview of the BRAGFLO two-phase flow parameters used to model the run-of-mine salt panel closures implemented in the PCS-2012 PA. Memo to Paul Shoemaker dated June 7, 2012. Sandia National Laboratories, Carlsbad, NM. ERMS 557653.

Camphouse, R.C., Gross, M., Herrick, C.G., Kicker, D.C., and Thompson, B. 2012. Recommendations and Justifications of Parameter Values for the Run-of-Mine Salt Panel Closure System Design Modeled in the PCS-2012 PA. Memo to WIPP Records Center dated May 3, 2012. Sandia National Laboratories, Carlsbad, NM. ERMS 557396.

Camphouse, R.C., Clayton, D.J., Kicker, D.C., and Pasch, J.J. 2011. Summary Report for the AP-151 (PC3R) Performance Assessment, Revision 1. Sandia National Laboratories, Carlsbad, NM. ERMS 555489.

Clayton, D.C., Camphouse, R. C., Garner, J. W., Ismail, A. E., Kirchner, T. B., Kuhlman, K. L., and Nemer, M. B.. 2010. Summary Report of the CRA-2009 Performance Assessment Baseline Calculation, Revision 1. Sandia National Laboratories. Carlsbad, New Mexico, ERMS 553039.

DOE (U.S. Department of Energy). 1996. Title 40 CFR Part 191 Compliance Certification Application for the Waste Isolation Pilot Plant. DOE/CAO-1996-2184. U.S. Department of Energy, Waste Isolation Pilot Plant, Carlsbad Area Office. Carlsbad, NM.

DOE (U.S. Department of Energy), 2011. Panel Closure System Design, Planned Change Request to the EPA 40 CFR Part 194 Certification of the Waste Isolation Pilot Plant. U.S. Department of Energy, Carlsbad Field Office. Carlsbad, New Mexico.

DOE (U.S. Department of Energy), 2012. Response to First Set of EPA Questions to DOE, December 22, 2011. Letter from Mr. Juan Franco, Manager, Carlsbad Area Field Office, U.S. Department of Energy, to Mr. Jonathan Edwards, Director, Radiation Protection Division, U.S. Environmental Protection Agency, dated April 17, 2012.

Dunagan, S. C. 2003. Complementary Cumulative Distribution Functions (CCDFs) for the Technical Baseline Migration (TBM), Revision 0. Sandia National Laboratories, Carlsbad, NM. ERMS 525707.

EPA (U.S. Environmental Protection Agency). 1998. Criteria for the Certification and Re-Certification of the Waste Isolation Pilot Plants Compliance with the 40 CFR Part 191 Disposal Regulations: Certification Decision; Final Rule, *Federal Register*, Vol. 63, No. 95, pp. 27353-27406. U.S. Environmental Protection Agency, Office of Air and Radiation, Washington, D.C.

Hansen, C. W. 2002. Analysis Report for the Panel Closure Impact Assessment. Sandia National Laboratories, Carlsbad, NM. ERMS 523935.

Herrick, C.G. 2012. JAS3D Calculations Performed in Support of the PCS-2012 PA Parameter Selections. Sandia National Laboratories, Carlsbad, NM.

Kirkes, G. R. 2011. Features, Events, and Processes Assesssment for Changes Described in Analysis Plan – 151, Revision 0. March 2011. Sandia National Laboratories, Carlsbad, NM. ERMS 555237.

MacKinnon R. and G. Freeze, 1997. Supplemental Summary of EPA-Mandated Performance Assessment Verification Test (All Replicates) and Comparison with the Compliance Certification Application Calculations, Sandia National Laboratories, Carlsbad, NM. ERMS 414880. (EPA Docket A-93-02, II-G-28.)

RockSol Consulting Group, Inc. 2006. Further Assessment of the Short-term Stability of the 12 Foot Explosion Isolation Wall. Report prepared for Washington TRU Solutions, LLC.

Stein, J.S. 2002. Parameter values for new materials CONC_PCS and DRZ_PCS. Memo to Kathryn Knowles dated February 13, 2002. Sandia National Laboratories, Carlsbad, NM. ERMS 520524.

Vugrin, E.D. and S.C. Dunagan. 2006. Analysis Package for the Impact Assessment of the Redesigned Panel Closure System, Rev. 0. Sandia National Laboratories. Carlsbad, NM. ERMS 543865.

Vugrin, E., and S. Wagner. 2006. Panel Closure Summary Report. Sandia National Laboratories. Carlsbad, NM. ERMS 544802.