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Sandia National Laboratories
Waste Isolation Pilot Plant

Analysis Plan for the Modification of the Waste Shear Strength Parameter and Direct Brine Release Parameters
AP-131
Revision 1

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1 REVISION HISTORY

This is the first revision of analysis plan AP-131 (Kirkes and Herrick, 2006). This revision, AP-131, Revision 1, includes plans to utilize test results from a new set of experiments to be conducted in a vertical erosion flume to obtain a more realistic value for the lower limit of the waste shear strength parameter TAUFAIL that is used in performance assessment (PA) calculations. The test set-up and materials are described in test plan TP 09-01 (Roberts and Herrick, 2009). The new testing geometry addresses the question as to whether the data obtained from testing surrogate waste forms in a horizontal flume are applicable for the WIPP geometry, where the fluid flow is predominantly vertical upward in the borehole during a human drilling intrusion event. All tasks for the modification of the direct brine release parameters from the original version of this analysis plan have been completed (Kirkes, 2007a, 2007b; Kirkes and Clayton, 2008).

2 INTRODUCTION AND OBJECTIVES

The Waste Isolation Pilot Plant (WIPP) is a deep geologic repository developed by the U.S. Department of Energy (DOE) for the disposal of transuranic (TRU) radioactive 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 (EPA, 1993). The DOE demonstrates compliance with the containment requirements according to the Certification Criteria in Title 40 CFR Part 194 (EPA, 1996) by means of performance assessment (PA) calculations performed by Sandia National Laboratories (SNL). WIPP PA calculations estimate the probability and consequence of radionuclide releases from the repository to the accessible environment for a regulatory period of 10,000 years after facility closure.

PA calculations were included in DOE's 1996 WIPP Compliance Certification Application (CCA) (DOE, 1996), and in a subsequent Performance Assessment Verification Test (PAVT (MacKinnon and Freeze, 1997a, 1997b, 1997c). Based in part on the CCA and PAVT PA calculations, the EPA certified that the WIPP met the containment criteria in the regulations and was approved for disposal of transuranic waste in May 1998 (EPA, 1998). PA calculations were also an integral part of DOE's 2004 WIPP Compliance Recertification Applications (CRA-2004) (DOE, 2004). During their review of the CRA-2004, the EPA requested that an additional performance assessment calculations be conducted with modified assumptions and parameter values (Cotsworth, 2005). This additional PA is referred to as the WIPP 2004 Compliance Recertification Application Performance Assessment Baseline Calculations (CRA-2004 PABC) (Leigh et al., 2005).

Since the CRA-2004 PABC, additional PA calculations were completed for and documented in the 2009 Compliance Recertification Application (CRA-2009) (DOE, 2009). The CRA-2009 PA resulted from continued review of the CRA-2004 PABC, including a number of technical changes and corrections, as well as updates to parameters and improvements to the PA computer codes (Clayton et al., 2008). The EPA requested that additional information, received between the commencement of the CRA-2009 PA (December 2007) and the submittal of the CRA-2009 (March 2009), be included in an additional PA calculation, referred to as the CRA-2009

Performance Assessment Baseline Calculation (PABC-2009) (Cotsworth, 2009). The CRA-2004 PA and the CRA-2004 PABC provide the basis for EPA's most recent recertification of the WIPP issued March 29, 2006 (EPA, 2006) and represents the current PA baseline. A ruling on the CRA-2009 and PABC-2009 (Clayton et al., 2010, submitted in February 2010) is expected at anytime.

In the interim between the recertification decision and the next Compliance Recertification Application planned for submittal in 2014, SNL plans to make enhancements to certain aspects of PA. In accord with 40 CFR 194.4, changes to the PA baseline must be reported to EPA either prior to implementation or annually in the Annual Change Report, depending on the significance of the change. Therefore, the changes described in this analysis plan will be thoroughly described and submitted to the EPA as part of a planned change request.

An activity that prioritized and defined planned changes to the PA baseline was conducted by Nemer and Leigh (2006). This activity recommended that PA parameters for both waste shear strength and the duration of direct brine release (DBR) are beneficial changes that should be made to the PA baseline. While this prioritization activity identified other changes to be made to the PA baseline, the original version of this AP specifically addressed only the waste shear strength parameter and the duration of DBR. Kirkes (2007a) recommended changes to the duration of DBR that were incorporated in the CRA-2009 and CRA-2009 PABC. This revision describes the approach used to develop, document, and implement changes only to the parameter TAUFAIL within the PA system since the work for the DBR duration is considered complete.

2.1 Rationale for Change to the Waste Shear Strength

Hansen (2005) examined how the parameter values for waste shear strength were established and concluded that the current values are excessively conservative with no technical basis. In addition, sensitivity analyses have shown that uncertainty in waste shear strength contributes the vast majority of uncertainty observed in cavings and total normalized releases (Kirchner, 2005). Therefore, it is recommended that a more accurate representation of waste shear strength be implemented in PA.

Work in this area will involve the development of a new parameter distribution for the waste shear strength, TAUFAIL. Hansen (2005) described work that has already been done that could provide the basis for a new distribution. The argument for raising the minimum shear strength is based on observed critical shear strengths of surrogate waste material measured via horizontal flume experiments (Jepsen et al., 1998). As a first step in this change, these experimental results will be presented to the EPA. These experiments suggest that the minimum shear strength should be raised to at least 1.4 Pa, as opposed to the current value of 0.05 Pa. A peer review panel convened in part to issue a decision on this suggested modification to the lower limit of TAUFAIL acknowledged that hydrodynamic shear testing is an appropriate method of determining the shear strength of a layer of particulate material, such as might be produced in the WIPP repository after an extended period of extreme degradation of the emplaced waste (Coons et al., 2007). The panel, however, called into question whether data obtained from testing surrogate waste forms in a horizontal flume is applicable to the WIPP geometry, where the fluid flow is predominantly vertical upward in the borehole during a human drilling intrusion event. To that end, hydrodynamic shear testing of representative surrogate wastes will be conducted in

a vertical flume as described in TP 09-01 (Roberts and Herrick, 2009). Use of the experimental results will require sufficient justification of how the surrogate waste material was developed, however there is a precedent for using this type of experimental approach for developing parameter values (Hansen et al., 2003).

3 APPROACH

The approach described in this AP is to re-evaluate the parameter TAUFAIL based on any newly acquired and/or previously overlooked information. This information may be based on new technology, new or overlooked literature and studies, expert opinion, or newly available experimental results.

Each of these parameters are considered "Conceptual Model Parameters" as described in WIPP QA procedure NP 9-2, *Parameters*, because they implement a Feature, Event, or Process (FEP) within one or more of the conceptual models in the current PA system. That is, these parameters represent a FEP that has been screened-in to one or more of the PA models. Modifying the values of these parameters is downstream of FEPs that have already been screened-in and as such an assessment of their impact to the FEPs basis is not necessary.

Furthermore, it is not the intent of this activity to change or modify the conceptual models that use these parameters. Only changes to the values and/or their distributions will be made as a result of this activity.

NP 9-2, *Parameters*, provides very specific steps to be taken when developing or modifying parameters used in PA. The steps detailed in this AP do not replace or in any way diminish the requirement to strictly follow NP 9-2, *Parameters*.

3.1 Waste Shear Strength in Performance Assessment

The parameter records package for TAUFAIL will be reviewed and updated with any new information applicable to the value of the waste shear strength. Historic information on the selection of the lower and upper limits (Berglund, 1996; Hansen and Leigh, 2002) of this value have been reviewed and re-evaluated in light of subsequent investigations (Herrick et al., 2007a, 2007b). These included a literature review of seafloor and channel bed sediments. An analysis in which the effects of the repository environment, including consolidation, may have on the sediment model was also conducted. Most importantly, the experimental results for the waste shear strength (Jepsen et al., 1998) were evaluated since there is a precedence for the use of experimentally derived values and because their use will provide consistency between models (i.e., CUTTINGS_S and DR_SPALL). A revisit of the analysis using the results of the expert elicitation on the waste particle diameter distribution (Wang and Larsen, 1997; CTAC, 1997) was also performed. This revision of AP-131 includes plans to utilize test results from a new set of experiments to be conducted in a vertical erosion flume to obtain a more realistic value for the lower limit of TAUFAIL. The test set-up and materials are described in test plan TP 09-01 (Roberts and Herrick, 2009). The new testing geometry is required to give a better representation of the WIPP underground where the fluid flow is predominantly vertically upward in a borehole as a result of a human drilling intrusion event.

3.1.1 Impact Analysis of Changes to TAUFAIL

If changes to the TAUFAIL parameter values are deemed necessary, an impact analysis will be conducted to determine the degree of impact that such changes make on the release volumes in the cuttings scenario. This impact analysis will consist of CUTTING_S and CCDFGF runs using the new value(s), and possibly the new distribution, for TAUFAIL. These volumes will then be compared to the most recent analogous CUTTINGS and CCDFGF runs, presumably from the CRA-2009 PABC. The results of this comparison will be documented in an analysis report following NP 9-1, *Analyses*.

4 TASKS

Table 1 below identifies the specific tasks and anticipated completion dates for changes to the waste shear strength parameter TAUFAIL.

Table 1. Task list and estimated schedule for changes to the waste shear strength parameter TAUFAIL

Task	Description	Responsible Personnel [if complete (date, ERMS #)]	Approximate Completion Date
1	Re-evaluate conclusions reached that were based on expert elicitation on the waste particle diameter distribution	Herrick et al. (2007a, 546033)	Complete
2	Re-evaluate channel bed sediment materials including effects of the repository environment	Herrick et al. (2007a, 546033)	Complete
3a	Re-evaluate waste shear strength experimental test results from Jepsen et al. (1998)	Herrick et al. (2007b, 546343)	Complete
3b	Evaluate waste shear strength experimental test results from vertical flume	Herrick and Roberts	3-DEC-2010
4	Re-evaluate stuck pipe and gas spall (erosion) 2	Herrick et al (2007a, 546033)	Complete
5	Document results of information review for waste shear strength in TAUFAIL Parameter Justification Report	Herrick	7-JAN-2011
6	Implement NP 9-2 for TAUFAIL	Herrick	21-JAN-2011
7	Perform an impact analysis using CUTTING_S and CCDFGF	Camphouse and others	4-MAR-2011
8	Document results for Waste Shear Strength in a final analysis report	Herrick, Roberts, and others	29-APR-2011

[2] Tasks 5-7 are dependent upon the results and outcome of Tasks 1-4.

5 SOFTWARE

The major WIPP PA codes expected to be used for this analysis are listed in Table 2. These codes will be executed on the WIPP PA Alpha Cluster, which is described in Table 3. Additionally, commercial off-the-shelf (COTS) software, such as MATHCAD® and Excel®,

running on MS Windows XP or 7®-based PC workstations may be utilized. The use of any COTS application will be verified per NP 9-1 Appendix C "Routine Calculations" as appropriate.

Table 2. Codes to be used for AP-131, Rev. 1 analyses

Code	Version	Build Date	Executable
CCDFGF	5.02	13-DEC-2004	CCDFGF_QB0502.EXE
CUTTINGS_S	6.02	9-JUN-2005	CUTTINGS_S_QA0602.EXE
LHS	2.42	18-JAN-2005	LHS_QA0242.EXE
POSTLHS	4.07A	25-APR-2005	POSTLHS_QA0407A.EXE
PRECCDFGF	1.01	7-JUL-2005	PRECCDFGF_QA0101.EXE
PRELHS	2.30	27-NOV-2001	PRELHS_QA0230.EXE

Table 3. WIPP PA Alpha Cluster

Node	Hardware Type	CPU	Operating System
CCR	HP AlphaServer ES45 Model 2	Alpha EV68	Open VMS 8.2
TDN	HP AlphaServer ES45 Model 2	Alpha EV68	Open VMS 8.2
BTO	HP AlphaServer ES45 Model 2	Alpha EV68	Open VMS 8.2
CSN	HP AlphaServer ES45 Model 2	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

6 SPECIAL CONSIDERATIONS

None.

7 APPLICABLE PROCEDURES

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

- 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*.
- Parameter values will be established according to NP 9-2, *Parameters*.
- 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*.

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