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Sandia National Laboratories
Waste Isolation Pilot Plant

Reassessment of MONPAR Analysis for Use in the 2014 Compliance Recertification Application

Revision 0

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WIPP:1.3.1:PA:QA-L:557522

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1 Introduction

This report documents a reassessment of the 40 CFR 194.42 compliance certification analysis used to determine repository performance monitoring parameters. The Compliance Certification Application (CCA) contains an analysis which was used to fulfill the regulatory requirement at 40 CFR §194.42. This analysis was documented in CCA Appendix MON, Attachment MONPAR (termed the MONPAR analysis; U.S. DOE 1996). Information from the MONPAR analysis was used to determine what monitoring parameters should be included in a monitoring program to address Environmental Protection Agency (EPA) requirements. The Department of Energy (DOE) is required by the Land Withdrawal Act (U.S. Congress 1996) to demonstrate continued compliance with the EPA's disposal standards. DOE is developing the third Compliance Recertification Application (CRA-2014) to document WIPP's continue compliance with the EPA standards. A reassessment was made of MONPAR at the time of the first CRA (Kirkes and Wagner 2003) and was performed under AP-109 (Wagner 2003). A reassessment was also made for the CRA-2009 (Wagner 2009) under SP- 9-8 (Wagner 2011a). Similarly, a reassessment is again needed for the third recertification application.

Reassessments of MONPAR are necessary to demonstrate continued compliance with the EPA's monitoring requirements at 40 CFR §194.42. Since the CCA, many changes in activities and conditions have occurred within the WIPP project that could potentially impact the conclusions in the original MONPAR analysis. This reassessment report developed a list of potential elements that may impact the monitoring program and assesses them against the conclusions in the original MONPAR analysis (DOE 1996). This reassessment's objective is to determine one of three conclusions;

1. If the conclusions of the MONPAR Analysis remain valid and its conclusions continue to be adequate for inclusion in CRA;
2. If the conclusions of the MONPAR Analysis remain valid with minor modification; or
3. If the conclusions of the MONPAR Analysis are invalid and a new analysis is needed.

The results of this reassessment determined that the original conclusions in MONPAR remain valid and its conclusions continue to be adequate for inclusion in the CRA. A similar assessment was made during the CRA-2014 five-year cycle that recommended a new MONPAR analysis be performed. That analysis had a different intent and used a different approach. The other report did not determine if the original conclusions of the MONPAR analysis were valid for compliance with 40 CFR 194.42, it analyzed the compliance monitoring program from a programmatic standpoint. As noted in Wagner 2011b:

> "Since the original monitoring parameters were developed through an EPA approved process documented in the CCA as attachment MONPAR to Appendix MON, the monitoring program meets the basic EPA monitoring requirements."

Both analyses support the conclusion that the MONPAR Analysis remains valid and adequate for inclusion in the CRA-2014.

2 Assessment Approach

This analysis is performed under SP 9-8, *Monitoring Parameter Assessment per 40 CFR 194.42* (Wagner 2011a). The objective of this reassessment is to determine the adequacy of continuing to use the CCA MONPAR analysis to meet the regulatory requirements of 40 CFR §194.42. The reassessment does this by assessing the impacts of changes that have occurred since the last recertification on the original MONPAR conclusions. The regulatory requirement for a monitoring analysis and the original MONPAR was reviewed to determine the processes and assumptions used to derive the MONPAR conclusions.

2.1 EPA Requirement for a MONPAR Analysis

The EPA requires the DOE to monitor repository performance as an assurance requirement. EPA's disposal standard 40 CFR §194.42 states (U.S. EPA 1996):

> (a) The Department shall conduct an analysis of the effects of disposal system parameters on the containment of waste in the disposal system and shall include the results of such analysis in any compliance application. The results of the analysis shall be used in developing plans for pre-closure and post-closure monitoring required pursuant to paragraphs (c) and (d) of this section. The disposal system parameters analyzed shall include, at a minimum:
>
> (1) Properties of backfilled material, including porosity, permeability, and degree of compaction and reconsolidation;
> (2) Stresses and extent of deformation of the surrounding roof, walls, and floor of the waste disposal room;
> (3) Initiation or displacement of major brittle deformation features in the roof or surrounding rock;
> (4) Ground water flow and other effects of human intrusion in the vicinity of the disposal system;
> (5) Brine quantity, flux, composition, and spatial distribution;
> (6) Gas quantity and composition; and
> (7) Temperature distribution.

2.2 Original MONPAR Approach

The original MONPAR analysis is documented in CCA Appendix MON (U.S. DOE 1996). The MONPAR analysis looked for potentially significant parameters used in PA that could be used in pre-closure and post-closure monitoring programs. Significant parameters are defined in 40 CFR § 194.42(c) as those that "affect the system's ability to contain waste or the ability to verify predictions about the future performance of the disposal system." The term parameter is used in 40 CFR Part 194 to describe properties and processes in the disposal system. While this use is somewhat inconsistent with the DOE's use of parameters in the mathematical modeling system, the

DOE has considered PA parameters, properties, and processes in the MONPAR analysis to satisfy the criteria of 40 CFR § 194.42. The original MONPAR analysis looked at PA parameters, modeling assumptions and current monitoring programs at WIPP for possible inputs. These inputs were qualitatively assessed against EPA's definition of significance. The analysis also considered the possibility of monitoring the parameter at WIPP. The results of the analysis were used in the CCA to propose an operational monitoring program using 10 parameters (CCA Chapter 7; Appendix MON)(Compliance Monitoring Parameters – COMPs). As a result of the MONPAR analysis, the following parameters have been monitored in the COMPs program and included in an annual report since 1999.

1. Drilling Rate
2. Probability of Encountering a Brine Reservoir
3. Waste Activity
4. Subsidence
5. Changes in Groundwater Flow
6. Change in Groundwater Composition
7. Creep Closure
8. Extent of Deformation
9. Initiation of Brittle Deformation
10. Displacement of Deformation Features

3 Assessment for CRA-2014

The objective of this current assessment is to determine if elements of the WIPP program that have changed since the last certification affect the "parameters" used in the MONPAR analysis. Specifically, the PA work performed by SNL that captures the changes introduced since the CRA-2009 PABC was reviewed to determine the impact on the original MONPAR analysis. The process first determines which changes could be considered in this reassessment, and then determines the impact of these changes on the conclusions drawn in the CCA MONPAR Analysis. Changes from the following disposal system elements were evaluated for any impacts to the CCA MONPAR analysis:

1. Monitoring Results
2. Experimental Activities
3. Performance Assessment Changes – Methodology/Parameters/Implementation
4. WIPP Operational Changes
5. Proposed changes to activities and conditions approved by the EPA

3.1 Monitoring Results

There have been four annual COMPs reports since the last reassessment. These include:

- 2008 COMPs Report – (Wagner and Hillesheim 2009)
- 2009 COMPs Report, Revision 1 – (Wagner 2010)
- 2010 COMPs Report – (Wagner and Kuhlman 2010a)

- 2011 COMPs Report – (Wagner, Kuhlman and Johnson 2011)
- 2012 COMPs Report – (Wagner, Kuhlman and Johnson 2012)

A review of the conclusions in these annual COMPs reports show:

- Results of the COMPs assessments concluded that there were no reportable conditions or events during their reporting periods.
- The Groundwater monitoring COMPs were modified. The groundwater composition COMP sampling frequency changed from biannually to annually while the Change in Culebra Groundwater Flow COMP derivation technique and trigger value were modified to address change made to the PA groundwater model T-field generation process.

The COMPs reports did not recommend changes to the monitoring parameters. As a result of the review, no issues were identified that effect the conclusion of the original MONPAR analysis.

3.2 Experimental Activities

3.2.1 SNL

WIPP-relevant experimental activities performed by Sandia National Laboratories (SNL) include hydrology investigations, Iron (Fe) and Lead (Pb) chemistry experiments and waste erodibility analyses. The following sections describe these activities and their impacts on MONPAR conclusions.

3.2.1.1 Hydrology Investigations

The SNL hydrology program continues to investigate regional groundwater conditions to support flow and transport modeling in CRA performance assessments. These activities are described in the following Analysis Plans:

AP-111	Analysis Plan for Optimization and Minimization of the Culebra Monitoring Network for the WIPP
AP-147	Analysis Plan for the Evaluation of WIPP Groundwater Compositions
AP-149	Analysis Plan for the Interpretation of Culebra Tracer Tests
AP-150	Analysis Plan for the Analysis of Observed Water Level Fluctuations

These investigations are ongoing. The current COMPs include assessment of groundwater flow and composition. Data from groundwater well monitoring is used in these assessments and also in the ongoing hydrology investigations. Because the original COMPs assessments identified issues that initiated the current hydrology investigations, the original conclusion to monitor groundwater flow and composition have been validated. The hydrology studies have resulted in changes to the groundwater flow and transport conceptual models used in the CRA-2009 PABC. Changes were made to the derivation and trigger value for the Change in Culebra Groundwater Flow COMP (Wagner and Kuhlman 2010b). These changes refined the COMP but did not change the monitoring parameter.

A monitoring well optimization was performed during this recertification cycle (Kuhlman 2008, 2010a & 2010b). The results were intended to identify possible locations for new

wells and the locations of important existing steel-cased wells (for possible replacement with new fiberglass cased wells). This information was used in well maintenance and replacement. Since the Kuhlman (2010a) report was prepared, WIPP-25 has been plugged and abandoned (without replacement), and wells H-9c, H-4b, and H-11b4 have been plugged and replaced with fiberglass-cased monitoring wells. No new well locations were added during this recertification cycle. Since these activities enhance the monitoring of groundwater flow, they do not negatively impact the COMPs program.

Monitoring Culebra groundwater levels continues. Data since 2006 show stable to declining water levels in the context of the end of the long-term rises observed in most wells (which approximately ended in 2008). No new hydrological data was used in the CRA-2014, the same T-field information from the CRA-2009 PABC was used again. As such, recent groundwater investigations have not impacted the groundwater COMPs and no recommendations have been made to change the compliance monitoring program.

3.2.1.2 Fe and Pb Experiments

The SNL experimental programs continue to investigate the long-term chemical conditions expected after repository closure. These activities are described in the following analysis plans.

AP-154	Analysis Plan for Derivation of Thermodynamic Properties Including Pitzer Parameters for Solubility Studies of Iron, Lead and EDTA
AP-159	Analysis Plan for Determination of Gas Generation Rates from Iron/Lead Corrosion Experiments
AP-163	Analysis Plan to Evaluate Waste Material Degradation Incorporating Recent Corrosion Experimental Data

The impacts of Fe in PA are addressed through chemical condition assumptions and specific corrosion parameters. The impacts of Pb corrosion are not included in PA. With respect to chemical conditions in the repository, the original MONPAR stated,

> *"The closed repository will not achieve the long-term chemical conditions (brine composition, dissolved actinide concentrations, or colloidal actinide concentrations) used in performance assessment during the operational or active control periods. Therefore, monitoring the [repository] chemical conditions will not provide relevant information or verify assumptions used in performance assessment. Chemical conditions in the repository cannot be monitored after decommissioning without jeopardizing repository integrity. Thus these parameters will not be monitored during the operational period nor during the post-closure periods…. ".*

There are Fe-related parameters and assumptions in PA. Iron corrosion parameters were changed in the CRA-2014 as a result of the experimental programs. However, these changes are refinements to the parameters and have not impacted the original conclusions in the MONPAR analysis because these experimentally derived conditions cannot be explicitly monitored in the repository.

3.2.1.3 Waste Erodibility Studies

The SNL experimental programs also investigated waste erodibility to develop new waste strength related parameters for the CRA-2014 PA. These activities are described in the test plan:

TP 09-01 Waste Erodibility with Vertical and Horizontal Erosion Flumes

These studies use surrogate waste intended to represent degraded waste in the repository hundreds to thousands of years after closure. These studies do not impact the MONPAR conclusions for the same reasons discussed in Section 3.2.1.2 in that these experimentally derived conditions cannot be monitored in the repository.

3.2.2 LANL

The LANL experimental program continues to investigate actinide solubility behavior and microbial interactions under conditions similar to what is expected in the WIPP environment after closure. The implementing documents for these activities are listed below.

LCO-ACP-02 - Solubility/Stability of Uranium (VI) in WIPP Brines
LCO-ACP-03 - Solubility of Neodymium (III) in WIPP Brines
LCO-ACP-04 - Plutonium (VI) Reduction by Iron: Limited-Scope Confirmatory Study,
LCO-ACP-05 - Plutonium Speciation and Solubility in the WIPP
LCO-ACP-06 - Americium Solubility/Stability in WIPP Brine
LCO-ACP-07 - Effect of Acetate, Citrate, EDTA, Oxalate and Borate Ions on Neodymium Solubility in WIPP Brine
LCO-ACP-11 - WIPP Actinide-Relevant Brine Chemistry
LCO-ACP-12 - Microbial Interactions in the Waste Isolation Pilot Plant (WIPP)
ACP-TIP-003 - Redox Stability of U(VI) in WIPP Brines
ACP-TIP-005 - Technical Assessment of the Current WIPP PA Database on Pu
ACP-TIP-006 - Solubility of An(IV) in WIPP Brine, Studies Using Thorium Analog
ACP-TIP-012-3 - Sorption of An(III) and An(IV) Actinides or Analogues to Halophilic Microorganisms Under WIPP-Relevant Conditions

These program documents confirm actinide solubility assumptions in PA for long-term conditions. The original MONPAR recognized actinide solubilites as important PA parameters and past sensitivity analysis have confirmed the importance of actinide solubility uncertainties on long-term repository performance (Kirchner 2007 & Kirchner 2008). Additionally microbial degradation of cellulose, plastics and rubber waste materials is also an important element in PA. Because the experimental program addresses the long-term conditions in the repository after closure, operational monitoring programs cannot be used to directly confirm PA solubility parameters. As stated in the original MONPAR and quoted in Section 3.2.1, the closed repository will not achieve the long-term chemical conditions modeled in performance assessment during the monitoring time period such that these conditions cannot be monitored. Although the results from these studies are used to validate PA assumptions, they are not expected to impact the original MONPAR conclusions.

3.3 Performance Assessment Changes

The CRA-2009 PABC is the current compliance PA baseline. However, the last MONPAR reassessment was made against the CRA-2009 PA. The changes from the CRA-2009 PA to the CRA-2009 PABC are found in the Analysis Plan AP-145 (Clayton 2009). Changes from the CRA-2009 PABC to the CRA-2014 PA are outlined in the *Analysis Plan for the 2014 WIPP Compliance Recertification Application*, AP-164 (Camphouse 2013).

3.3.1 CRA-2009 to CRA-2009 PABC Changes

Changes incorporated into the CRA-2009 include the following:

a. Updated Inventory (Crawford et al., 2009)
b. New actinide solubility calculations
c. New Culebra T-Fields
d. New drilling rate and plugging pattern parameters

Inventory information, specifically actinide activity, was identified as important in the MONPAR analysis and was later identified in the CCA as a COMP. The inventory information has been accounted for in the CRA-2009 PA through the waste unit factor, actinide activities and waste material parameters. Since waste activity is currently a COMP, inventory parameter changes do not impact the original MONPAR conclusions. Actinide solubility values, and their uncertainty ranges are directly related to the inventory information. Although actinide solubility related parameters were determined to be significant to PA results in the MONPAR analysis, they could not be directly monitored during operations and the post-closure period and were not identified as potential COMPs.

The Culebra T-Field change relates to the process that PA uses to determine fluid flow and contaminant transport to the accessible boundary. The changes were made in response to observed water-level rises in the Culebra formation that were outside the expected ranges used in the CCA PA. The new T-fields used additional field data and geologic interpretations. The original MONPAR analysis identified groundwater monitoring as an important parameter and is used for two COMPs. The new groundwater modeling approach does impact the derivation and trigger value derivation for the Change in Culebra Groundwater Flow COMP however it did not impact the decision to include the COMP in the monitoring program (Wagner and Kuhlman 2010b). As stated earlier, these changes enhance the monitoring program and do not impact the original conclusion in the MONPAR analyses.

The Drilling Rate parameter was recognized in the MONPAR analysis as a significant parameter and is a current COMP. This rate is also a requirement under 40 CFR 194.33 such that it must be included as a monitored parameter. The current well plugging pattern is represented in PA and is monitored outside of the COMPs program. The MONPAR analysis did recognize this parameter as a potential COMP however it was not directly identified within the program. As it is an updated parameter in each recertification PA, no changes are necessary to the monitoring program.

3.3.2 CRA-2009 PABC to CRA-2014 PA Changes

Changes included in the CRA-2014 are described in AP-164 (Camphouse 2013). These changes are as follows:

- Represent Run-of-Mine salt panel closures in PA
- Inclusion of additional mined region in the northern experimental area
- An update to the probability of encountering pressurized brine parameter
- Refinement to the steel corrosion rate parameter
- Refinement to the effective waste shear strength parameter
- Updated drilling rate and plugging pattern parameter
- Implementation of a more detailed repository water balance that includes MgO hydration
- Update to actinide solubility uncertainty multipliers
- New inventory
- Other parameter error corrections

The CRA-2014 changes can be grouped into two basic types, changes to PA implementation (including error corrections) and changes to parameters. Changes to PA implementation generally do not impact MONPAR conclusions because they do not affect parameters directly. However, results from revised PAs may indicate different sensitive parameters because of the implementation changes. The CRA-2014 PA results showed that all of the changes reduced overall releases however they are not significantly different than the CRA-2009 PABC results (Kirchner 2013).

Changes in parameters in the CRA-2014 PA identified above relate to the human intrusion scenarios and chemical conditions in the closure repository, two PA elements that occur after closure. With the exception of the drilling rate, plugging pattern and pressurized brine encounter parameters, these elements are experimentally derived and are not conducive to monitoring and do not impact the original MONPAR conclusions (see discussion in Section 3.2.1.2). The drilling rate and probability of encountering pressurized brine parameters are current COMPs, and are derived from the COMPs-related monitoring program. The plugging pattern is discussed in detail in MONPAR (Section MONPAR.4.3) and is included in PA. The MONPAR analysis identified this parameter as potentially significant. This parameter is updated every CRA such that it is monitored however it was not selected as a COMP.

The latest waste inventory information was included in the CRA-2014 PA. Waste parameters were identified in MONPAR however none were identified for monitoring. Additional important waste parameters were identified in an analysis to address the 40 CFR 194.23 requirements. This analysis was documented in Appendix WCA and WCL in the CCA (DOE 1996). The important waste material parameters identified in this analysis are tracked and included in CRA PA's such that they are monitored outside of the COMPs program.

Kirchner 2013 determined that none of the water balance or panel closure parameters that were changed or added since the PABC-2009 had any substantial impact on releases. The waste shear strength, steel corrosion rate and actinide solubility

multipliers were identified as being sensitive to the release scenarios. These parameters are derived experimentally.

Overall, the changes made since the last recertification refine parameters used in PA and represent a new panel closure design. The changes introduced since the CRA-2009 PABC discussed within this section are either captured in the current monitoring programs or do not impact the MONPAR analysis and its conclusions.

3.4 Operational changes to activities and conditions approved by the EPA

For the period between the CRA-2009 and the CRA-2014, the most significant operational change at WIPP involves the engineered barrier, magnesium oxide (MgO). The WIPP emplaces MgO as an engineered barrier to sequester carbon dioxide (CO_2) and reduce the potential for actinides to be soluble in WIPP brines. The CO_2 is produced by microbial consumption of cellulose, plastic and rubber (CPR) in the waste. A minimum excess of 1.2 times the amount of MgO need to sequester all the CO_2 that could be produced is emplaced along with the waste. Originally, MgO was emplaced in super-sacks on top of every stack of waste regardless of how much CPR was in the waste. This method resulted in MgO excess factors much higher than 1.2. A change was made to track the amount of CPR emplaced in each room and emplace MgO on the waste stacks if they were needed to maintain the 1.2 excess factor (not to be less than on every other row). This change resulted in a more efficient use of MgO in the repository.

The WIPP PA does not include any backfill related parameter (mechanical, hydrological or chemical). PA assumes MgO will sequester essentially all CO_2 in the disposal system and this condition is used in actinide solubility calculations. The original MONPAR concluded that there were no important backfill properties that could be monitored during the operational period and stated that backfill properties should not be monitored, specifically,

> *"Chemical conditions in the repository cannot be monitored after decommissioning without jeopardizing repository integrity. Thus these parameters will not be monitored during the operational period nor during the post-closure periods…. The mechanical and hydrologic properties of the backfill are not significant to the performance assessment. Therefore, they will not be monitored during the operational or post-closure periods".*

Since the operational change to MgO emplacement does not change the way it is accounted for in PA and PA continues to represent MgO in the same way as was done in the CCA, the original MONPAR conclusions remain valid.

4 Conclusion

A review of the original MONPAR results was made using SP 9-8. Based on the review of activities, conditions and experimental programs that occurred since the CRA-2009,

this reassessment concludes that: the conclusions of the MONPAR Analysis remain valid and its conclusions continue to be adequate for inclusion in the CRA-2014.

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