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Sandia National Laboratories
Waste Isolation Pilot Plant

Reassessment of MONPAR Analysis for Use in the 2009 Compliance Recertification Application

Revision 0

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Table of Contents

Table of Contents 1
1 Introduction 2
2 Assessment Approach 2
2.1 EPA Requirement for a MONPAR Analysis 3
2.2 Original MONPAR Approach 3
3 Assessment for CRA-2009 4
3.1 Monitoring Results 4
3.2 Experimental Activities 5
3.3 Performance Assessment Changes 7
3.4 Operational changes to activities and conditions approved by the EPA 9
4 Conclusion 9
5 References 10

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). 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 (LWA, Public Law 104-201) to demonstrate continued compliance with the EPA's disposal standards. DOE is developing the second Compliance Recertification Application (CRA-2009) to document if the WIPP continues to comply 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). Similarly, a reassessment is again needed for the second 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 report developed a list of potential elements that may impact the monitoring program and assessed them against the conclusions in the original MONPAR analysis. This assessment'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. However, if a new PA is requested by the EPA during their review of the recertification application, the current repository performance monitoring parameters will be assessed to ensure the conclusions are consistent with the latest PA baseline results (per the intent of SP 9-8 and the requirements of 40 CFR 194.42).

This analysis is performed under SP9-8, *Monitoring Parameter Assessment per 40 CFR 194.42.*

2 Assessment Approach

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 (see 40 CFR §191.14). EPA's disposal standard 40 CFR §194.42 states:

> (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. 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

Prior to the first WIPP recertification in 2004, SNL revisited the original analysis to ensure that programmatic changes had not affected any of the underlying assumptions or conclusions in the original MONPAR. The result of that assessment was documented in Kirkes and Wagner 2003. That assessment concluded that the original conclusions in MONPAR remain valid and that changes to the WIPP compliance baseline do not affect the conclusions and monitoring parameters identified in the MONPAR analysis.

3 Assessment for CRA-2009

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. The processes used for this current assessment are outlined in SP 9-8 (Wagner 2008). Specifically, the PA work performed by SNL that captures the changes introduced since the CRA-2004 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:

Wagner and Hillesheim 2008	COMPS 2007
Wagner and Hillesheim 2006	COMPS 2006
Wagner and Hillesheim 2005	COMPS 2005
Pfeifle, Beauheim and Wagner 2005	COMPS 2004

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
- Water levels in the Culebra continue to rise across the monitored region. SNL continues their investigation of these events. The investigations may lead to changes in the Groundwater Conceptual Model and new data incorporated into new T-Fields.
- Groundwater chemistry monitoring is investigating sample collection and analytical laboratory techniques to reduce uncertainties in water chemistry results

The results of the COMPs reports validate the need to monitor groundwater and demonstrate the importance of continued monitoring and incorporation of the results into PA. 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 and magnesium oxide (MgO) experiments. 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 (TP 06-01; Hillesheim 2007, TP 03-01; Chace 2006, TP 00-03; Chace 2003, AP-070; Beauheim 2004, AP-114; Beauheim 2008 & AP-125; Domski & Beauheim 2005). These investigations are ongoing and are expected to result in changes to the groundwater conceptual model(s) used in PA. 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 not concluded; it is recommended that groundwater COMPs be reevaluated after the impacts of the hydrology investigations on PA have been considered.

3.2.1.2 MgO Experiments

The SNL experimental programs continues to investigate the behavior of MgO, the WIPP engineered barrier (TP 06-03, TP 02-02 & TP 00-07; Deng, Xiong and Nemer 2007). Past programs have researched characterization of vendor samples and hydration and carbonation reactions in short and long-term experiments. These investigations continue to generate data used to validate PA assumptions and periodically characterize samples of MgO from vendors. As stated in Section 2.2 of this

report, MONPAR used PA parameters and assumptions to determine important parameters to include in the compliance monitoring program. MgO is not explicitly represented in PA such that no parameters relating to MgO were included in the compliance monitoring program. However, EPA has emphasized the importance of MgO and assumptions concerning MgO in PA. During their review and approval of a planned change request to emplace compressed waste in WIPP, EPA required DOE to develop a system to track the amount of cellulose, plastic and rubber (CPR) materials in the waste and the amount of MgO emplaced in a room to demonstrate the 1.67 excess factor (now 1.2) is maintained (EPA 2004). EPA reiterated this requirement and added the requirement that DOE annually verify the reactivity of MgO and ensure that it is maintained at 96% (EPA 2008). In effect, the EPA has implemented a compliance monitoring program for MgO. DOE waste operations and Procurement specifications are in place to ensure proper MgO emplacement and ensure the quality of the material delivered by the vendor meets program requirements (an SNL MgO investigations-derived program). The impacts of MgO in PA are addressed through chemical conditions assumptions. MgO is not directly represented in PA through parameterization. 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.... 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 there are no specific MgO-related mechanical, hydrological, thermal or chemical parameters in PA and the assumption concerning MgO in PA have not changed as a result of the experimental programs, current MgO experimental activities have not impacted the original conclusions in the MONPAR analysis.

3.2.2 LANL

The LANL experimental program continues to investigate actinide solubility behavior under conditions similar to what is expected in the WIPP environment after closure (LCO-02, RO; LCO-03,RO; LCO-04,RO; LCO-05,RO; LCO-06,RO; LCO-07,RO). These programs confirm actinide solubility assumptions in PA for long-term conditions. The original MONPAR recognized actinide solubilites as important PA parameters and recent sensitivity analysis have confirmed the importance of actinide solubility uncertainties on long-term repository performance (Kirchner 2007& Kirchner 2008). 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 future results from the actinide solubility experimental program may

be used to validate PA assumptions, they are not expected to impact the original MONPAR conclusions.

3.3 Performance Assessment Changes

Since the 2004-CRA PA there have been two PAs, the 2004 CRA PABC and the 2009 CRA PA. Changes from the CRA-2004 PABC are outlined in Analysis Plan for post-CRA PA baseline calculation AP-121 (Kanney 2005). The changes from the CRA-2009 PA are found in the CRA PA Analysis Plan AP-137 (Clayton 2007).

3.3.1 CRA to PABC Changes

Changes incorporated into the 2004 CRA PABC are grouped into two areas:

1. Modifications and improvements to:
    a. inventory information
    b. actinide solubility values
    c. actinide solubility uncertainty ranges
    d. microbial gas generation model
    e. Culebra T-Field mining modifications
    f. modification of sampling of parameters for spallings calculations
2. New code versions for:
    a. LHS code error corrections
    b. CUTTING_S code maintenance changes and unnecessary functionality deletion
    c. CCDFGF and PRECCDFGF codes error corrections

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 is accounted for in 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.

With the exception of the quantity of cellulose, plastic and rubber materials (CPR) in the waste, microbial gas generation parameters are not conducive to monitoring in the repository during operations and after closure (they were determined experimentally). DOE is also required to track CPR to repository limits to meet 40 CFR 194.24 waste characterization requirements and to ensure the MgO excess factor is maintained (discussed in Section 3.4).

The Culebra T-Field mining modifications deal with the treatment of mining exemptions surrounding existing oil and gas wells. This change relates to PA implementation. The MONPAR analysis did not identify human activities associated with mining exemptions as important to performance such that changes to the implementation of mining exemptions in PA do not impact the MONPAR conclusions.

Performance assessment code versions are not considered in the original MONPAR analysis. Maintenance and code error corrections enhance functionality, reliability and accuracy of the PA however they are not directly associated with PA parameters and therefore do not impact the conclusions of the MONPAR analysis.

3.3.2 PABC to CRA-2009 PA Changes

Changes incorporated into the CRA-2009 PA are grouped into three areas:

1. Modification and improvements to:
    a. the parameter representing the maximum flow duration for DBRs;
    b. the sampling method applied to the humid and inundated cellulose, plastic and rubber (CPR) degradation rates;
    c. the BRAGFLO computer code used in the PA;
    d. include additional chemistry modeling in BRAGFLO;
    e. capillary pressure and relative permeability models; and
    f. the DBR parameter calculations for the well productivity index and material permeabilities.
2. Update of the drilling rate (GLOBAL:LAMBDAD) as required by 40 CFR § 194.15.
3. Error corrections to:
    a. account for CPR contents in emplacement materials in the inventory;
    b. halite/disturbed rock zone porosity parameters;
    c. the fraction of repository volume occupied by waste; and
    the input files for the direct brine release (DBR) calculations and the NUTS code.

The CRA-2009 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-2009 PA results showed that all of the changes listed above do not significantly impact releases and are not significantly different than the PABC results (Clayton 2008, Kirchner 2008).

Changes in parameters in the CRA-2009 PA identified above relate to CPR, drilling rate and DBR. The Drilling Rate parameter is a current COMP and this parameter is derived from the COMPs related program. The waste material parameters relating to CPR are tracked as part of the 40 CFR 194.24(c) requirements (see CRA Chapter 4, Section 4.2.2; DOE 2004). These parameters are also tracked to ensure the MgO safety factor is maintained in the repository. Although CPR was not identified in the original MONPAR analysis as a sensitive parameter, it is monitored to meet other similar EPA requirements. Since changes in CPR are addressed by a limit tracking program, are accounted for in each recertification PA and have not been recognized as a sensitive parameter in MONPAR, changes in this parameter do not change the MONPAR conclusions. The change to the DBR parameter was shown not to be a sensitive parameter in PA (Kirchner 2008). MONPAR did not recognize the parameter as significant or as a potential monitoring parameter.

The changes introduced since the 2004 PABC listed above 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 first CRA and the 2009-CRA, the most significant operational change at WIPP involves the engineered barrier, MgO. The EPA has recently approved a DOE planned change to reduce the MgO excess factor from 1.67 to 1.2 times the amount conservatively determined to account for the possible microbial consumption of CPR in the repository (EPA 2008). The impacts of these changes were discussed in Section 3.2.1.2. The impact of these changes and the requirements imposed by EPA ensure a more uniform distribution of MgO in the repository and ensures that excess MgO is always emplaced in WIPP beyond the amount that would be necessary to maintain the chemical conditions of the repository assumed in PA. As stated earlier, the 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. Since the PA continues to represent MgO in the same way as was done in the CRA-2004, 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-2004, this reassessment concludes that: the conclusions of the MONPAR Analysis remain valid and its conclusions continue to be adequate for inclusion in the CRA-2009.

5 References

Beauheim, R.L. 2008. Analysis Plan for Evaluation and Recalibration of Culebra Transmissivity Fields, AP-114, Revision 1, ERMS 548162, Sandia National Laboratories, Carlsbad, NM.

Beauheim, R.L. 2004. Analysis Plan for Non-Salado Hydraulic-Test Interpretations, AP-070, Revision 1, ERMS 537479, Sandia National Laboratories, Carlsbad, NM.

Borkowski M. 2006. Americium Solubility/Stability in WIPP Brine, LCO-ACP-06, RO, Los Alamos National Laboratory, Carlsbad, NM.

Borkowski M. 2007. Effects of Acetate, Citrate, EDTA, Oxalate and Borate Ions on Neodymium Solubility in WIPP Brine, LCO-ACP-07,RO, Los Alamos National Laboratory, Carlsbad, NM.

Borkowski M. 2004. Solubility of Neodymium (III) in WIPP Brines, LCO-ACP-03,RO, Los Alamos National Laboratory, Carlsbad, NM.

Chace, D.A. 2006, Test Plan TP 03-01, Revision 2, Test Plan for Testing of Wells at the WIPP Site, ERMS 542261, Sandia National Laboratories, Carlsbad, NM.

Chace, D.A. 2003. Test Plan TP 00-03, Revision 1, Compliance Monitoring Program: Recompletion and Testing of Wells for Evaluation of Monitoring Data for the Magenta Member of the Rustler Formation at the WIPP Site, ERMS 525860, Sandia National Laboratories, Carlsbad, NM.

Clayton, D.J., S. Dunagan, J.W. Garner, A.E. Ismail, T.B. Kirchner, G.R. Kirkes, M.B. Nemer. 2008. Summary Report of the 2009 Compliance Recertification Application Performance Assessment, ERMS 548862, Sandia National Laboratories, Carlsbad, NM.

Clayton, D.J. 2007. Analysis Plan for the Performance Assessment for the 2009 Compliance Recertification Application, AP-137, ERMS 547905. Sandia National Laboratories, Carlsbad, NM.

Deng, H. Y. Xiong and M. Nemer. 2007. Experimental Work Conducted on MgO Characterization and Hydration, Milestone Report, ERMS 546570, Sandia National Laboratories, Carlsbad, NM.

Deng, H. M. Nemer and Y. Xiong. 2007. Test Plan TP 06-03, Experimental Study of MgO Reaction Pathways and Kinetics, Revision 1, ERMS 545182, Sandia National Laboratories, Carlsbad, NM.

Domski, P. & R.L. Beauheim 2005. Analysis Plan for the Evaluation of Culebra Brine Compositions, AP-125, ERMS 540680, Sandia National Laboratories, Carlsbad, NM.

Kanney, J. F. 2005. Analysis Plan for Culebra Transport Calculations: Post CRA Baseline Calculation, AP-121, ERMS 539540. Sandia National Laboratories, Carlsbad, NM.

Kirchner, T.B. 2008 Sensitivity of the CRA-2009 Performance Assessment Calculation Releases to Parameters, ERMS 548788, Sandia National Laboratories, Carlsbad, NM.

Kirchner, T.B. 2005. Sensitivity of Performance Assessment Baseline Calculation Releases to Parameters, ERMS 540767, Sandia National Laboratories, Carlsbad, NM.

Kirkes, G.R. and S.W. Wagner. 2003. MONPAR Reassessment. ERMS 533098. Sandia National Laboratories, Carlsbad, NM.

Hillesheim, M.B. 2007. Test Plan TP 06-01, Revision 1, Monitoring Water Levels in WIPP Wells, ERMS 545770, Sandia National Laboratories, Carlsbad, NM.

Pfeifle T.W., R.L. Beauheim & S.W. Wagner 2004. Sandia National Laboratories Compliance Monitoring Parameter Assessment for 2007, ERMS 538645, Sandia National Laboratories, Carlsbad, NM.

Reed, D.T. 2005. Plutonium Speciation and Solubility in WIPP, LCO-ACP-05, RO, Los Alamos National Laboratory, Carlsbad, NM.

Reed, D.T. 2004. Plutonium (VI) Reduction by Iron:: Limited-Scope Confirmatory Study, LCO-ACP-04,RO, Los Alamos National Laboratory, Carlsbad, NM.

Reed, D.T. 2003. Solubility/Stability of Uranium (VI) in WIPP Brines, LCO-ACP-02,RO, Los Alamos National Laboratory, Carlsbad, NM.

Snider, A, Y Xiong and A.N. Wall 2004. Test Plan TP 00-07, Experimental Study of WIPP Engineered Barrier MgO at Sandia National Laboratories Carlsbad Facility, Revision 3, ERMS 538613, Sandia National Laboratories, Carlsbad, NM.

U.S. DOE 2004. Title 40 Part 191 Compliance Recertification Application for the Waste Isolation Pilot Plant, DOE/WIPP 2004-3231. Carlsbad, NM.

U.S. DOE 1996. Title 40 Part 191 Compliance Certification Application for the Waste Isolation Pilot Plant, DOE/CAO-1996-2184. Carlsbad, NM.

U.S. EPA 2008. Letter from J. Reyes, Director EPA RPD to D.C. Moody, DOE CBFO Manager, Approving MgO Safety Factor Reduction from 1.67 to 1.2, February 11, 2008.

U.S. EPA 2004. Letter from F. Marcinowski, Director EPA RPD to R.P. Detwiler, DOE CBFO Acting Manager, Approving Disposal of Compressed Waste, March 26, 2004.

Wagner, S.W. 2008. Specific Procedure SP 9-8, Monitoring Parameter Assessment per 40 CFR 194.42, ERMS 548697, Sandia National Laboratories, Carlsbad, NM.

Wagner, S.W. 2003. Analysis Plan for CRA MONPAR Investigation, AP-109, ERMS 531338, Sandia National Laboratories. Carlsbad, NM.

Wagner S.W. & M.B. Hillesheim 2008. Sandia National Laboratories Compliance Monitoring Parameter Assessment for 2007, ERMS 548041, Sandia National Laboratories, Carlsbad, NM.

Wagner S.W. & M.B. Hillesheim 2006. Sandia National Laboratories Compliance Monitoring Parameter Assessment for 2006, ERMS 544616, Sandia National Laboratories, Carlsbad, NM.

Wagner S.W. & M.B. Hillesheim 2005. Sandia National Laboratories Compliance Monitoring Parameter Assessment for 2005, ERMS 541795, Sandia National Laboratories, Carlsbad, NM

Wall, A.N. 2002, Test Plan TP 02-02, Effects of the MgO Engineered Barrier on the Possible Presences of Mg-Bearing Collides and Humic Acids in WIPP, Revision 1, ERMS 524422, Sandia National Laboratories, Carlsbad, NM.