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Regulatory Issues for Waste Isolation Pilot Plant Long-Term Compliance with U.S. Environmental Protection Agency 40 CFR 191B and 268

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ABSTRACT

Before disposing of transuranic radioactive waste at the Waste Isolation Pilot Plant (WIPP), the United States Department of Energy (DOE) must evaluate compliance with long-term regulations of the United States Environmental Protection Agency (EPA), specifically the *Environmental Standards for the Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Radioactive Wastes* (40 CFR 191), and the *Land Disposal Restrictions* (40 CFR 268) of the *Hazardous and Solid Waste Amendments* to the *Resource Conservation and Recovery Act* (RCRA). Sandia National Laboratories (SNL) is conducting iterative performance assessments (PAs) of the WIPP for the DOE to provide interim guidance while preparing for final compliance evaluations. This paper provides background information on the regulations, describes the SNL WIPP PA Department's approach to developing a defensible technical basis for consistent compliance evaluations, and summarizes the major observations and conclusions drawn from the 1991 and 1992 PAs.

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PREFACE

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REGULATORY ISSUES FOR WIPP LONG-TERM COMPLIANCE
WITH EPA 40 CFR 191B AND 268

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ABSTRACT

Before disposing of transuranic radioactive waste at the Waste Isolation Pilot Plant (WIPP), the United States Department of Energy (DOE) must evaluate compliance with long-term regulations of the United States Environmental Protection Agency (EPA), specifically the *Environmental Standards for the Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Radioactive Wastes* (40 CFR 191), and the *Land Disposal Restrictions* (40 CFR 268) of the *Hazardous and Solid Waste Amendments* to the *Resource Conservation and Recovery Act* (RCRA). Sandia National Laboratories (SNL) is conducting iterative performance assessments (PAs) of the WIPP for the DOE to provide interim guidance while preparing for final compliance evaluations. This paper provides background information on the regulations, describes the SNL WIPP PA Department's approach to developing a defensible technical basis for consistent compliance evaluations, and summarizes the major observations and conclusions drawn from the 1991 and 1992 PAs.

INTRODUCTION

The United States Department of Energy (DOE) is developing the Waste Isolation Pilot Plant (WIPP), located in 255-million-year-old bedded salt in southeastern New Mexico, for disposal of transuranic wastes generated by defense programs. The DOE must first evaluate compliance with the Environmental Protection Agency's (EPA) *Environmental Standards for the Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Radioactive Wastes* (40 CFR 191),¹ and with the *Land Disposal Restrictions* (40 CFR 268)² of the *Hazardous and Solid Waste Amendments* to the *Resource Conservation and Recovery Act* (RCRA). The *National Environmental Policy Act* (NEPA)³

requires all agencies of the federal government to prepare a detailed statement on the environmental impacts of "proposed major federal actions affecting the quality of the human environment." In compliance with the NEPA, an additional supplemental environmental impact statement (SEIS) is planned prior to permanent disposal.⁴ Sandia National Laboratories (SNL) is conducting iterative performance assessments (PAs) of the WIPP for the DOE to provide interim guidance while preparing for final compliance evaluations. This paper addresses issues related to developing a defensible and consistent technical basis for evaluating compliance with both 40 CFR 191, Subpart B, and 40 CFR 268.6.

REGULATORY BACKGROUND

Subpart B of 40 CFR 191 regulates releases of radioactive material to the accessible environment for 10,000 years. As discussed in more detail elsewhere,^{5,6,7} the Containment Requirements of 40 CFR 191B set limits on the probability that cumulative radionuclide releases to the accessible environment will exceed certain limits. The accessible environment is defined to be "(1) the atmosphere; (2) land surfaces; (3) surface waters; (4) oceans; and (5) all of the lithosphere that is beyond the controlled area (§ 191.12[k]).¹ The controlled area for the 1992 WIPP PA is the 41 km² (16 mi²) land-withdrawal area.

The Land Disposal Restrictions of the RCRA regulate releases of specified nonradioactive hazardous materials from the repository. For the WIPP, these hazardous materials include heavy metals (HMs) and semivolatile and volatile organic compounds (VOCs). In general, 40 CFR 268 prohibits the disposal of hazardous wastes unless the owner or operator of the facility petitions for a variance and successfully demonstrates, "to a reasonable degree of certainty, that there will be no migration of

hazardous constituents from the disposal unit or injection zone for as long as the wastes remain hazardous" or the waste is treated in accordance with applicable treatment standards (40 CFR 268.6).² Guidance provided by the EPA on the interpretation of this wording indicates that "no migration" will be defined to be concentrations of hazardous constituents below health-based or environmentally based levels at the disposal-unit boundary.⁸ The length of the regulatory period will be "a waste- and site-specific determination," according to EPA guidance,⁸ and is assumed by the SNL WIPP PA Department for the purpose of interim analyses to be 10,000 years.

In response to a no-migration variance petition from the DOE,⁹ the EPA has issued a conditional no-migration determination¹⁰ allowing the emplacement of a limited amount of hazardous waste in the WIPP for experimental purposes during the WIPP Test Phase. The EPA states that "[b]efore DOE may move from the test phase to full-scale operations, it must petition EPA again and demonstrate no migration over the long term—that is, it must successfully address current uncertainties about long-term WIPP performance" (Ref. 10, p. 47704). Long-term uncertainties specifically identified by the EPA include "the extent and effects of gas generation, the effects of brine inflow into the repository, and the influence of a "disturbed rock zone" surrounding the repository" (ibid.). The Test Phase no-migration determination defines the disposal unit for the WIPP to be the entire volume of the Salado Formation within the WIPP land-withdrawal area.¹⁰

THE ROLE OF PERFORMANCE ASSESSMENT IN COMPLIANCE EVALUATION

The role of PA in evaluating compliance with 40 CFR 191B is described in detail elsewhere.^{5,6} Briefly, 40 CFR 191B states that PA shall be used to provide probabilistic estimates of cumulative radionuclide releases, considering uncertainties from "all significant processes and events."¹ The WIPP PA Department uses a Monte Carlo technique and a system of linked computational models to calculate estimates of releases assuming realistic behavior of the disposal system and to display uncertainty in those estimates.^{5,6,11}

The scope of the performance assessment needed to evaluate compliance of the WIPP (or any transuranic or high-level radioactive waste disposal system) with the long-term requirements of 40 CFR 268.6 has not been established. Requirements of 40 CFR 268.6 are not in all cases consistent with those of 40 CFR 191B, and the SNL WIPP PA Department's approach to resolving potential inconsistencies would be to (1) assume the same lateral spatial scale for the RCRA disposal-unit boundary as accessible

environment defined for 40 CFR 191B, (2) assume the same temporal scale for 40 CFR 268.6 as that specified by 40 CFR 191B, (3) perform a full PA for the chosen RCRA performance measure using the same modeling system applied to undisturbed conditions (no human intrusion) as used for the PA to assess compliance with 40 CFR 191B, and (4) to use these PAs to develop a defensible technical basis for the preparation of a no-migration determination for 40 CFR 268.6 that is consistent with the compliance assessment for 40 CFR 191B.

To date, the WIPP PA Department has used the modeling system and methodology developed for evaluations with respect to 40 CFR 191B to conduct preliminary analyses of long-term gas and brine migration from the repository.^{12,13} These analyses do not include transport of RCRA contaminants (HMs or VOCs), and are based on preliminary models and data. Results are not suitable for evaluation of compliance with the no-migration requirement of 40 CFR 268.6.² Conclusions and observations about the potential for RCRA-contaminant migration based on these results are valid only to the extent that (1) brine migration provides a good diagnostic measure of the potential for migration of HMs and VOCs dissolved in a liquid phase, and (2) gas migration provides a good diagnostic measure of the potential for migration of gas-phase VOCs. Given these assumptions, demonstration that there is a low likelihood that gas or brine will migrate across the disposal-unit boundary in 10,000 years implies a high level of confidence in compliance with the long-term requirements of 40 CFR 268.6. The WIPP PA Department has therefore selected cumulative 10,000-year gas and brine flow across the disposal-unit boundary as a performance measure for preliminary RCRA-related uncertainty and sensitivity analyses to identify important processes and parameters potentially affecting compliance with 40 CFR 268.6.

Guidance provided by the EPA for determining compliance with 40 CFR 268.6 indicates that "[m]odel assumptions and input data should be conservative and tend toward overestimating rather than underestimating migration."⁸ Given present understanding of the physical processes and material properties affecting gas and brine migration, realistic and conservative deterministic calculations cannot be designed at this time. Two-phase fluid flow in the three-dimensional repository environment is a complex process that involves nonlinear interactions between multiple, competing processes including humidity-dependent gas-generation reactions, pressure-dependent brine inflow and outflow, pressure-dependent halite creep, and pressure-dependent changes in porosity and permeability of the solid phases, including effects of possible fracturing of anhydrite interbeds above and below the waste. Present modeling

capability and process understanding does not permit including all processes in these calculations, and the complexity of the system is such that it is not possible to identify in advance combinations of parameter values and assumptions that will result in the largest realistic fluid migrations. The Monte Carlo uncertainty analyses performed to date by the WIPP PA Department,¹² and reported elsewhere in this volume,¹³ provide estimates of brine and gas migration based on a range of possible conditions, and therefore provide information about the appropriate level of confidence that should be assigned to performance predictions. Ultimately, this probabilistic methodology can be used to design appropriate conservative calculations using realistic modeling assumptions and combinations of less favorable values selected from realistic ranges for important parameters.

OBSERVATIONS AND CONCLUSIONS FROM THE 1991 AND 1992 WIPP PERFORMANCE ASSESSMENT

All performance assessments for the WIPP to date are preliminary, and results are not suitable for final compliance evaluations. Portions of the modeling system and the data base remain incomplete, and the level of confidence in the performance estimates is not sufficient for defensible compliance evaluations. Results are, however, suitable for providing interim guidance to the WIPP Project as it prepares for final compliance evaluations.

Observations relevant to 40 CFR 191B are based on the third iteration of preliminary WIPP PA,^{5,6} completed in 1992. Observations relevant to 40 CFR 268.6 are based on calculations performed in 1992 using the 1991 PA modeling system.^{12,13} Additional RCRA-related calculations using the 1992 PA modeling system will be performed during 1993 as part of the 1992 iteration of WIPP PA.

Specific observations and conclusions that can be drawn from the 1991 and 1992 WIPP PAs are as follows:

1. PA analysts have high confidence that compliance with Subpart B of 40 CFR 191 can be demonstrated. Additional work remains before the modeling system and data base can be judged defensible.
2. Based on preliminary analyses, PA analysts have high confidence of demonstrating that HM or VOC tracer concentrations at the disposal-unit boundary will not exceed RCRA limits during the 10,000-year regulatory period. Present preliminary analyses indicate that gas is unlikely to migrate laterally to the disposal-unit boundary. Brine, and possible RCRA contaminants contained within it, is

unlikely to migrate more than a small fraction of the distance to the lateral boundary or the top of the Salado Formation. If future analyses indicate a higher likelihood of gas or brine from the disposal panels reaching the disposal-unit boundary, engineered modifications to the waste form or repository design may be used to reduce fluid migration. Long-term compliance with 40 CFR 268.6, therefore, may not require detailed source-term characterization for calculating concentrations of specific hazardous materials. Heavy metals and other RCRA contaminants transported only by a liquid phase are particularly unlikely to reach the unit boundary.

With regard to long-term compliance with 40 CFR 268, sensitivity analyses indicate that better characterization of certain physical processes and material properties within the repository and the surrounding Salado Formation is essential to a defensible evaluation of RCRA long-term fluid-migration issues. Specifically, additional information is needed on the parameters affecting gas generation within the waste (gas generation rates for corrosion and microbial reactions under humid and inundated conditions, microbial reaction stoichiometry, and the initial liquid saturation of the waste), and on possible fracturing of anhydrite interbeds above and below the waste in response to elevated gas pressures. Gas generation data will be provided by ongoing and planned laboratory and field experiments with real waste.¹⁴ Pressure-dependent fracturing of anhydrite interbeds will be included in future PA analyses.

PA analyses to date indicate that there is apparently a shaft-seal permeability threshold which can assure that no gas reaches the disposal-unit boundary by flowing up the shafts.¹² The predicted threshold is based on a specific set of model assumptions and should not be interpreted as a design criterion. The predicted existence of such a threshold does, however, provide confidence that a sealing system will prevent vertical gas migration if it can be designed and constructed to achieve that threshold value.

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