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Recent Progress in Scenario Development for the WIPP

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RECENT PROGRESS IN SCENARIO DEVELOPMENT FOR THE WIPP

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I. INTRODUCTION

The U.S. Department of Energy (DOE) is preparing to request the U.S. Environmental Protection Agency to certify compliance with the radioactive waste disposal standards found in 40 CFR Part 191 for the Waste Isolation Pilot Plant (WIPP). The DOE will also need to demonstrate compliance with a number of other State and Federal standards and, in particular, the Land Disposal Restrictions of the Resource Conservation and Recovery Act (RCRA), 40 CFR Part 268. Demonstrating compliance with these regulations requires an assessment of the long-term performance of the WIPP disposal system. Re-evaluation and extension of past scenario development for the WIPP forms an integral part of the ongoing performance assessment (PA) process.

II. METHODOLOGY

Scenario development is one starting point of a system assessment, and generates inquiry, in the broadest sense, about the present state and future evolution of the disposal system. This inquiry aims to ensure that a comprehensive set of features, events and processes (FEPs) is considered in the assessment. The internationally accepted definitions of "scenario development" and "scenario" are adopted here.[1]

Scenario development is "*...the identification, broad description and selection of alternative futures relevant to a reliable assessment of the safety of a disposal system.*"

A scenario "*...specifies one possible set of events and processes, and provides a broad-brush description of their characteristics and sequencing.*"

Scenario development involves four steps:[2]

(i) Identification and classification of FEPs potentially relevant to the performance of the repository and site.

(ii) Elimination of FEPs according to well-defined screening criteria.

(iii) Identification or formation of scenarios relevant to the performance of the repository and site.

(iv) Specification of scenarios for consequence analysis.

Scenario development for the WIPP has involved a structured approach to screening to establish those FEPs currently included in postclosure PA modeling, those FEPs which can be defensibly excluded, and those FEPs for which defensible screening arguments cannot currently be presented, but which are not included in the PA modeling.

The current work builds upon previous scenario development for the WIPP,[3] but differs in several ways:

- The initial list of FEPs is as comprehensive as possible, and is intended to apply to both the present state of the system and its possible future evolution.
- Screening of the FEP list has led to suggestions for alternative treatment of several FEPs compared to earlier WIPP PAs.
- FEPs have been identified for which screening decisions can not yet be made because of incomplete analyses.

Screening arguments include (i) lack of relevancy to an evaluation of WIPP disposal system performance, (ii) regulatory guidance[4] concerning future human actions provided in Appendix C of 40 CFR Part 191, (iii)

insignificant consequence, and (iv) low probability. FEPs were assessed against each criterion in the order presented above. The first, if any, criterion was used for classification, although many FEPs could be excluded on the basis of more than one criterion.

III. THE MULTIBARRIER CONCEPT FOR THE WIPP

Scenario development for a particular disposal concept depends on the purpose of the assessment and the barrier system that isolates the radioactive waste after disposal. Recent PAs for the WIPP indicate that long-term containment of wastes will be provided by a multibarrier system that comprises three principal components:[3]

(i) *Engineered barriers (shaft, drift, and panel seal systems).* Although the waste canisters are assumed to be crushed by salt creep relatively soon after the repository is decommissioned, other components of the repository system are considered to evolve gradually and to provide a barrier function over the regulatory period. In particular, under undisturbed conditions (defined below), long-term performance of the shaft seal systems is important in limiting releases. Engineering modifications that could serve to improve the long-term performance of the repository are under consideration.

(ii) *The 600-m thick halite host rock (Salado Formation).* This unit has extremely low permeability, when undisturbed, and is not expected to provide a pathway for significant contaminant transport to the accessible environment in the next 10,000 years, unless it is breached by future human actions, such as exploration for natural resources. Possible gas-phase transport, within the Salado, of hazardous constituents regulated under 40 CFR §268.6 is currently under investigation. The possibility of the positive physical characteristics of the Salado changing with time is being considered.

(iii) *The geologic units underlying and overlying the Salado.* Given a breach of the Salado by a future borehole, it is possible that significant delay and retardation of radionuclides will occur in units overlying or underlying this Formation. The historical focus of the project has been strongly on the Culebra Dolomite Member of the Rustler Formation, thought to be the most transmissive water-saturated unit overlying the repository. However, additional hydrological units above and below the repository are now being considered in more detail.

For the WIPP, the undisturbed performance scenario represents expected behavior of the natural and engineered systems, including consideration of variability in these systems and uncertainties in characterizing them. This scenario does not take into account disruptions caused by future human actions or the occurrence of unlikely natural events.

IV. RESULTS OF FEP SCREENING

Current FEP screening for the WIPP is related to the engineered barrier system used as a basis for the 1992 WIPP PA.[3] However, system-level analyses underway within the project will include an evaluation of the need for enhanced engineering of the near-field environment. Modifications to the engineered barriers would need consideration if PA analyses indicated that unacceptable releases of contaminants to either the "accessible environment" (40 CFR Part 191)[4] or the "disposal-unit boundary" (40 CFR §268.6)[5] could occur as a result of naturally occurring events and processes, and/or human intrusion conditions, under the existing engineered design. Engineering modifications might also be made to provide additional assurance of safety. FEP screening for the WIPP would require reconsideration in the event of modifications to the engineered barriers.

A. Undisturbed Conditions for 40 CFR Parts 191 and 268

The potential for releases outside the Salado under undisturbed conditions is of concern for evaluation of long-term system performance for both 40 CFR Part 191 and 40 CFR §268.6. In the 1992 WIPP PA, no FEPs other than future human actions were identified that could result in liquid-phase releases of contaminants.[3] Furthermore, no naturally occurring far-field or external geological or climatological FEPs were identified that could enhance or create transport pathways from the Salado in the next 10,000 years. Gas-phase releases may be possible under undisturbed conditions, but transport modeling for gaseous contaminants (VOCs) has not been undertaken in previous WIPP PAs.

For undisturbed conditions, future model improvements, if required, should focus on building confidence in the containment capacity of the Salado. Work is underway to improve the modeling of gas generation rates, pressure-induced fracturing, repository and shaft disturbed zones, and seal degradation. There are also a number of FEPs that have not been modeled in the undisturbed case, but for which there are not yet defensible screening arguments (for example, nuclear criticality). Work is underway within the project to develop defensible screening arguments, or to understand the potential impact on system assessment modeling for many of these FEPs.

B. Future Human Actions for 40 CFR §191.13

Future human actions could result in breaches of the Salado, and the current study is in agreement with event and process screening work in previous WIPP PAs suggesting that human actions are the only credible means for short circuiting the barrier function of the host rock. The most important such FEP is deep drilling that intersects the waste panels. In addition, under undisturbed conditions, it is possible that some radionuclides could move gradually into the near field and through interbeds in the Salado, effectively increasing the area that needs to be considered in evaluating deep drilling events.

Deep boreholes could provide interconnections between the repository horizon and the surface, and hydraulically conductive layers above (Rustler and Dewey Lake Formations) and below (Bell Canyon and deeper formations) the Salado. It is uncertain whether such boreholes would intersect pressurized zones in the Castile Formation (brine reservoirs) or deeper units that may contain pressurized brine or hydrocarbons, and whether the flow in boreholes interconnecting the formations above and below the Salado would be upward or downward. Upward flow could be directly to the surface, or to hydraulically conductive zones in the Rustler and Dewey Lake Formations and thence laterally to the accessible environment or via pathways that serve to short circuit the barrier effect of these formations. Downward flow could be to hydraulically conductive pathways in the Bell Canyon Formation and thence laterally to the accessible environment.

Other future human actions of concern relate to activities that would potentially affect the hydrogeology of the non-Salado Formations. Such effects include:

- Extraction of fluid from near-surface aquifers (such as the Culebra Dolomite).
- Fracturing of the Salado and overlying formations resulting from potash mining.
- Leakage from fluid injection wells into hydraulically conductive zones.
- Surface activities that could affect recharge conditions.

C. Far-Field Modeling for 40 CFR §191.13

There are a number of FEPs not included in far-field flow and transport modeling, but for which there are not currently defensible screening arguments. Examples include colloid-facilitated transport, and the effects of salinity and other groundwater chemistry changes on radionuclide transport properties.

V. FUTURE WORK

The scenario development work in support of WIPP PA efforts has received review within the project, by the EPA, and by project stakeholders. Additional calculations and documentation are underway to support screening arguments for a number of FEPs that have not yet been included in PA modeling. In addition, the screening work will need to be re-evaluated in response to changes in regulation (e.g., 40 CFR Part 194, still in draft form), changes in system design, and future comments from the EPA and project stakeholders.

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