TOTAL SYSTEM PERFORMANCE ASSESSMENT AND INTEGRATION (TSPAI) ISSUE RESOLUTION BLUEPRINT

Prepared for

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The coordinators wish to thank all technical staff members from the CNWRA and the NRC high-level waste program who contributed to this report by preparing comments listed in the appendix. The coordinators also wish to thank R. Benke, L. Howard, M. Smith, J. Weldy, and G. Wittmeyer for their technical reviews and B. Sagar for his programmatic review. Technical assistance provided by J.S. Paddock of Solution Consulting in developing the database is gratefully acknowledged. Thanks are also expressed to D. Moore for his editorial review and C. Weaver for her secretarial support.

QUALITY OF DATA, ANALYSES, AND CODE DEVELOPMENT

There are no original data contained in this report. Results from computer codes used in formulating some of the comments documented in this report are not explicitly stated in this report. Other calculations, such as hand calculations, meet quality assurance requirements described in the CNWRA Quality Assurance Manual.

1 INTRODUCTION

The U.S. Nuclear Regulatory Commission (NRC) together with its contractor, the Center for Nuclear Waste Regulatory Analyses (CNWRA) are involved in pre-licensing consultations with the U.S. Department of Energy (DOE). Such consultations are called for in the Nuclear Waste Policy Act of 1882 or amended and have the objective that any license application prepared by DOE will be high-quality and complete. An agreement was also reached in 1992 between the NRC and the DOE that staff-level resolution can be achieved on any potential issue during pre-licensing consultation. The purpose of staff-level issue resolution is to assure that sufficient information is available to enable the NRC to docket a license application.[1] Issue resolution at the staff level, during pre-licensing, is achieved when the staff have no further questions or comments regarding how the DOE is addressing an issue.

For issue resolution, the NRC and CNWRA staff review the DOE documents, perform independent experiment and confirmatory calculations, and document issues based on their current understanding of the site characteristics, waste form characteristics, design data, modeling approach, and analyses approaches. The results of the review efforts are then provided to the DOE periodically at technical exchanges.

The NRC and DOE already have engaged in several rounds of pre-licensing interactions on total system performance assessment, including interactions associated with the DOE Total System Performance Assessment–95 (CRWMS M&O, 1995) and Total System Performance Assessment–Viability Assessment (DOE, 1998). The NRC and the CNWRA prepared numerous written comments on these two Total System Performance Assessments, and presented the findings to the DOE. The Total System Performance Assessment–Site Recommendation (CRWMS M&O, 2000a,b), which is the latest performance assessment conducted by the DOE in support of a site suitability decision, provides the NRC and CNWRA staff with a rich resource of new information to be used in the pre-licensing interactions.

The Total System Performance Assessment issue resolution blueprint document, contained in the appendix, documents all Total System Performance Assessment and Integration Key Technical Issue comments generated by the CNWRA and NRC staff from the review of Total System Performance Assessment–Site Recommendation (CRWMS M&O, 2000a) and its supporting documents. The blueprint was developed to facilitate formal tracking of the large number of comments generated during the review. The blueprint provides material for direct interactions with the DOE; however, these comments are also expected to be used in developing sufficiency comments, preparing the integrated issue resolution status report, developing acceptance criteria, and review methods for use in the Yucca Mountain Review Plan.

The comments presented in this document were presented to the DOE at a series of technical exchanges. The first technical exchange, held on May 15–17, 2001,[2] focused on the scenario

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[1]Resolution at the staff level does not preclude an issue being raised and considered during the licensing proceedings, nor does it prejudge what the NRC staff evaluation of that issue will be after its licensing review.

[2]Reamer, C.W. "U.S. Nuclear Regulatory Commission/U.S. Department of Energy Technical Exchange and Management Meeting on Total System Performance Assessment and Integration-Features, Events, and Processes (May 15–17, 2001)." Letter (May 30) to S.J. Brocoum. Washington, DC: DOE. 2001

analysis subissue and, in particular, on the screening of features, events, and processes for performance assessment. The second technical exchange, held August 6–10, 2001,[3] focused on the remaining portions of the scenario analysis subissue and the remaining subissues within the Total System Performance Assessment and Integration Key Technical Issue.

In the following sections, the review approach and the documentation of the review findings are described. Section 2 describes the scope of the review. Section 3 describes how the review was conducted in a risk-informed manner. Section 4 describes and documents review findings. Conclusions and the path forward are presented in Section 5.

2 SCOPE OF REVIEW

The scope of the review is limited to the information available prior to the DOE release of their Science and Engineering Report (DOE, 2001). The review is not based on a complete and thorough reading of all available documents, but rather a limited, focused, risk-informed review of selected portions of DOE documents that support the Total System Performance Assessment–Site Recommendation. These documents include Analysis and Model Reports, Process Model Reports, the DOE Repository Safety Strategy (CRWMS M&O, 2000c), the Total System Performance Assessment–Site Recommendation Technical Document (CRWMS M&O, 2000a), and the Total System Performance Assessment–Site Recommendation Model Report (CRWMS M&O, 2000b).

The focus of the review is specifically guided by the objective of resolving subissues. The NRC has developed three categories to present the status of resolution. Subissues are closed if the DOE approach and available information acceptably address staff questions such that no information beyond what is currently available will likely be required for regulatory decision making at the time of any initial license application. Subissues are closed-pending if the NRC staff have confidence that the DOE proposed approach, together with the DOE agreement to provide the NRC with additional information (through specified testing, analysis, etc.), acceptably address the NRC questions such that no information beyond that provided or agreed to will likely be required at the time of the initial license application. Subissues are open if the NRC has identified questions regarding the DOE approach or information and the DOE has not yet acceptably addressed the questions or agreed to provide the necessary additional information in a potential license application. For transparency and to enable the DOE to fully understand the NRC concern, the NRC and CNWRA staff prepared specific comments (i.e., questions or concerns) under each subissue and presented them to the DOE. The DOE response by DOE is then classified as either satisfied, or not satisfied depending on whether the DOE has acceptably responded to the NRC question or concern. Staff questions may range from a transparency question (i.e., gaining clarification) to addressing a deficiency in the methodology or data preparation. If any questions or concerns under a subissue remain open, the subissue remains open.

The review findings were classified under the four Total System Performance Assessment and Integration Key Technical Issue subissues: (i) system description and demonstration of multiple barriers, (ii) scenario analysis, (iii) model abstraction, and (iv) demonstration of the overall performance objective. The review findings under each subissue were also mapped to individual

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[3]Reamer, C.W. "U.S. Nuclear Regulatory Commission/U.S. Department of Energy Technical Exchange and Management Meeting on Total System Performance Assessment and Integration (August 6 through 10, 2001)." Letter (August 23) to S.J. Brocoum. Washington, DC: DOE. 2001.

acceptance criteria. In the absence of the Yucca Mountain Review Plan, the acceptance criteria and the review methods in the Total System Performance Assessment Key Technical Issue Integrated Issue Resolution Status Report, Revision 3 (NRC, 2000) were used to provide a transparent and consistent measure for the review of data, design detail, and analyses in DOE documents. The following is a summary of the review areas.

Comments on multiple barriers addressed the system of natural and engineered barriers that would provide isolation of waste. Comments were written for three major aspects of multiple barriers: (i) identification of barriers, (ii) description of barrier capabilities to isolate waste, and (iii) the technical basis for barrier capabilities.

Comments generated from the review-of-scenario analysis included the DOE identification, classification, screening, and construction of scenarios from features, events, and processes relevant to the Yucca Mountain site. The review addressed the manner in which the DOE addressed the full range of features, events, and processes, as well as whether additional data or analyses are needed to support the scenario analysis.

Comments on model abstractions addressed the 14 Integrated Subissues, which derive their technical validity and support from those aspects of the engineered, geosphere, and biosphere subsystems shown to be most important to performance. These abstracted models are:

- Degradation of engineered barriers
- Mechanical disruption of engineered barriers
- Quantity and chemistry of water contacting waste packages and waste forms
- Radionuclide release rates and solubility limits
- Flow paths in the unsaturated zone
- Radionuclide transport in the unsaturated zone
- Flow paths in the saturated zone
- Radionuclide transport in the saturated zone
- Volcanic disruption of waste packages
- Airborne transport of radionuclides
- Climate and infiltration
- Dilution of radionuclides in groundwater due to well pumping
- Redistribution of radionuclides in soil
- Reasonably maximally exposed individual lifestyle and reference biosphere.

The review concentrated on whether the DOE has adequately addressed all five of the generic acceptance criteria specified in the Total System Performance Assessment and Integration Issue Resolution Status Report (NRC, 2000). The five generic acceptance criteria include (i) data and model justification, (ii) data uncertainties, (iii) model uncertainties, (iv) model support, and (v) integration.

Comments on the overall performance objective subissue involved evaluation of the adequacy, appropriateness, and acceptability of the (i) scenarios considered in the calculation of the expected annual dose, (ii) method the DOE will use to demonstrate that the average annual dose to the average member of the critical group in any year during the compliance period will not exceed the regulatory limit, (iii) the DOE Total System Performance Assessment is providing a credible representation of repository performance, (iv) consideration of human intrusion, and (v) comparative evaluation of alternatives to the major design features. It should be emphasized

that compliance with the proposed standards at 10 CFR Part 63 for overall performance was not considered in pre-licensing issue resolution; only the methodology for evaluating the overall performance objective was considered in this context.

A formal review of the DOE quality assurance procedure was not part of the Total System Performance Assessment review. However, comments were prepared on model validation, software verification, and technical errors or inconsistencies. References were also made to the DOE Corrective Action Reports which, had already identified deficiencies in the implementation of quality assurance procedures for validation and verification. The CNWRA and the NRC staff found technical errors and inconsistencies between the Total System Performance Assessment–Site Recommendation reports and the Analysis and Model Reports, computer codes, and hand calculations. Although these findings are documented in this report in a generic sense, a letter from the NRC to the DOE[4] covers the full scope of the findings.

3 RISK-INFORMED REVIEW

Consistent with the risk-informed approach employed in proposed 10 CFR Part 63 (NRC, 1999), the review focused on those aspects of the repository system and the DOE analyses that are most important to safety. In order to risk-inform their reviews, NRC and CNWRA staff

- Identified the major components of the DOE safety case
- Identified important scenarios
- Determined the principal barriers considered for demonstrating multiple barriers
- Considered the importance of conceptual model uncertainty within the abstraction
- Identified and evaluated the importance of major assumptions
- Identified the importance of conceptual model uncertainty
- Evaluated the importance of coupled processes
- Identified the important parameters and models controlling system behavior
- Evaluated the importance of correlations between parameters.

Staff efforts to risk-inform the review also recognized the timing of available information. Technical information on specific components of the DOE analyses was available in the form of Analysis and Model Reports before the DOE completed its Total System Performance Assessment for the current repository design and before the DOE completed its Repository Safety Strategy. Information was also available to the staff at the Appendix 7 meetings, DOE and NRC technical exchanges, and audit observation of the DOE audit of technical activities. Given the limited time available for the review of the Total System Performance Assessment–Site Recommendation, the staff reviewed technical information that addressed previous staff concerns and new risk-significant information. The staff refined their review comments as the Total System Performance Assessment–Site Recommendation (i.e., Model Report and Technical Document) and the DOE Repository Safety Strategy document, Revision 4, became available.

The staff conducted a few bounding calculations and performance assessments using the TPA code and confirmatory analyses using process-level models; however, indepth, detailed

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[4] Reamer, C.W. "U.S. Nuclear Regulatory Commission/U.S. Department of Energy Conference Call Regarding Quality Assurance and Performance Assessment Issues." Letter (May 17) to S.J. Brocoum, DOE. Washington, DC: DOE. 2001.

analyses were limited. The NRC TPA code was used to risk-inform the review. In the review, the emphasis was on the DOE performance assessment. Therefore, the staff reviewed the information provided by the DOE that led to risk insights. Independent NRC calculations using the NRC TPA code (Mohanty and McCartin, 1998) were used to complement the risk insights gained by reviewing the DOE analyses. The staff also used the risk insights already gained from the NRC and CNWRA sensitivity and uncertainty analyses (Mohanty, et al., 1999) to risk-inform the review on the relative importance of model abstractions, conceptual model uncertainty, major assumptions, coupled processes, parameters (e.g., data range and distribution type), and parameter correlations. In addition, the TPA code results were used to help understand the results of the DOE Total System Performance Assessment–Site Recommendation. The staff also used other codes, such as MULTIFLO (Lichtner, et al., 2000), to conduct analyses to verify questions raised on the DOE Total System Performance Assessment. In-depth detailed calculations, however, were limited to only a few applications.

4 DOCUMENTATION OF REVIEW FINDINGS

The blueprint document contains all staff comments presented at two consecutive subissue resolution technical exchanges. The principal outcome of these technical exchanges was the establishment of agreements between the DOE and the NRC which, if met, would result in closure of the Total System Performance Assessment and Integration subissues. Due to the large number (more than 300) and complexity of the comments and concerns to be addressed within the Total System Performance Assessment and Integration Key Technical Issue, a Microsoft® Access 97 database was developed to track the staff comments, DOE responses, and the agreements reached at the technical exchanges. The information in the appendix is a hardcopy report produced from the database.

The database has numerous functions, including a powerful search capability and stylized report printing options. However, because the database is at a developmental stage, only a limited capability was used to produce the appendix. The database fields that were used in producing the appendix include (i) tracking number, (ii) references, (iii) DOE response, (iv) agreement number, and (v) agreement. These fields are explained below.

Tracking number: The tracking number system is used to uniquely identify each comment or question. Although the alphanumeric format of the tracking numbers have evolved with the review. The original tracking numbers were left intact to avoid confusion with the agreement numbers.

Comment: The comment field contains the original NRC and CNWRA comment or question forwarded to the DOE, and can be referenced by its associated tracking number.

References: The references field contains the references that were reviewed to generate the comments.

DOE Response: The DOE response field contains the original written response the DOE provided to the NRC prior to the corresponding technical exchanges. These responses were proposed by the DOE as bases for discussion at the technical exchanges toward reaching agreements.

Agreement: The agreement field either contains the text of the agreement reached to satisfy the comment, or it contains a note explaining why no official agreement was deemed necessary. Most commonly, the comment has either been discussed elsewhere, or the DOE response was considered adequate to satisfy the NRC and CNWRA comment.

Agreement number: When the NRC and CNWRA concern was systemic, the concern was provided in general form with numerous examples. The DOE chose to respond to the NRC and CNWRA comments example-by-example. For tracking these responses, the blueprint document used the same tracking number for all these responses but, for uniqueness, it also used a new agreement number to indicate that unique agreements were reached for each of the NRC and CNWRA example. Similar to other agreements, if no official agreement was needed to satisfy the NRC comment presented in the form of examples, then the agreement number field was left blank.

5 CONCLUSIONS

Consistent with the Nuclear Waste Policy Act and the agreement reached between the NRC and the DOE, staff from the CNWRA and the NRC have been reviewing the DOE pre-license documents and consulting with the DOE to assure that sufficient information is available on an issue to enable the NRC to docket a proposed license application. The NRC and CNWRA staff have conducted limited risk-informed reviews of selected portions of recently provided DOE documents. The staff have also performed their own calculations (where feasible) before raising issues based on their current understanding of the site characteristics, waste form characteristics, design data, and the DOE analysis approach. The results were provided to the DOE at two technical exchanges.

The acceptance criteria in the Total System Performance Assessment and Integration Key Technical Issue Resolution Status Report (NRC, 2000) form the basis for the risk-informed review comments documented in this report. Because information needed to fully risk-inform, the review will continue to be made available, staff will continue to update their perspective on the areas of greatest importance, and later review efforts will reflect this evolution in the understanding of the DOE analyses. Additional technical exchanges and Appendix 7 meetings may be needed to reevaluate open or close-pending subissues. The blueprint document will be updated as new information will be available. The database will also be expanded with the goal of using it as a licensing tool.

6 REFERENCES

CRWMS M&O. "Total System Performance Assessment for the Site Recommendation." TDR–WIS–PA–000001. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000a.

———. "Total System Performance Assessment (TSPA) Model for Site Recommendation." MDL–WIS–PA–000002. Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000b.

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———. "Total System Performance Assessment—1995: An Evaluation of the Potential Yucca Mountain Repository." B00000000–01717–2200–00136. Revision 01. Las Vegas, Nevada: TRW Environmental Safety Systems, Inc. 1995.

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Lichtner, P.C., M.S. Seth, and S. Painter. "MULTIFLO Version 1.2: Two-Phase Nonisothermal Coupled Thermal-Hydrological-Chemical Flow Simulator." Revision 2. San Antonio, Texas: CNWRA. 2000.

Mohanty, S., R. Codell, R.W. Rice, J. Weldy, Y. Lu, M.R. Byrne, T.J. McCartin, M.S. Jarzemba, and G.W. Wittmeyer. "System-level Repository Sensitivity Analyses Using TPA Version 3.2 Code." CNWRA 99-002. San Antonio, Texas: CNWRA. 1999.

Mohanty, S., and T. McCartin (coordinators). "Total-system Performance Assessment Version 3.2 Code: Module Descriptions and User's Guide." San Antonio, Texas: CNWRA. 1998.

NRC. "Issue Resolution Status Report Key Technical Issues: Total-system Performance Assessment and Integration." Revision 3.0. Washington, DC: NRC. 2000.

———. "Disposal of High-Level Radioactive Wastes in a Proposed Geological Repository at Yucca Mountain, Nevada: Proposed Rule." Federal Register 64(34): 8640–8679. Washington, DC: U.S. Government Printing Office. 1999.

APPENDIX

Subissue #1 - Multiple Barriers J-MB 1.1T

Tracking # J-MB 1.1T

Comment NRC Staff find the techniques used to identify barriers as presented in the Repository Safety Strategy, Rev. 4 (CRWMS M&O, 2000b) document acceptable. However, the documentation of the process used to identify the barriers needs to be clarified to show that DOE has fully identified the barriers that are important to waste isolation. For example, it is not clear if the identification of barriers (CRWMS M&O 2000a) is based on expected barrier capability or from tracing parameters from TSPA sensitivity/importance analyses back to determine the important barriers in the system.

References CRWMS M&O. "Total System Performance Assessment for the Site Recommendation." TDR-WIS-PA-000001 Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000a.
CRWMS M&O. "Repository Safety Strategy: Plan to Prepare the Safety Case to Support Yucca Mountain Site Recommendation and Licensing Considerations." TDR-WIS-RL-000001 Revision 04 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000b.

DOE Response The barriers that are identified as important to waste isolation for any potential license application will be distinct physical elements of the repository system that are demonstrated to contribute to waste isolation. This demonstration will be made using a set of complementary analytic techniques. The capability of the barriers to prevent or substantially delay movement of water or radionuclides will be described in any potential license application. Uncertainties in characterizing and modeling the barriers in the analyses will be delineated.

Identification of the barriers important to waste isolation in Repository Safety Strategy, Rev. 4 (CRWMS M&O 2001i) was based on elements of the system that are expected to play a role in limiting the amount of water that might enter emplacement drifts, limiting contact of water with the waste, limiting release of radionuclides from the engineered barrier system, delaying radionuclide transport to the accessible environment, or diluting radionuclide concentrations.

Reference: CRWMS M&O 2001i. Repository Safety Strategy: Plan to Prepare the Safety Case to Support Yucca Mountain Site Recommendation and Licensing Considerations. TDR-WIS-RL-000001 REV 04 ICN 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20010329.0825.

Agreement Number

Agreement DOE response during Technical Exchange was considered adequate by the NRC. Total System Performance Assessment and

Subissue #1 - Multiple Barriers J-MB 2.1

Tracking # J-MB 2.1

Comment DOE needs to provide information on the capability of barriers to prevent or substantially delay movement of water or radionuclide materials. For example, Repository Safety Strategy, Rev. 4 (CRWMS M&O, 2000b; p. 2-5) describes barrier capability, but no diagrams are presented to support the discussion. Diagrams for barrier neutralization analyses and degraded barrier analysis (CRWMS M&O, 2000a) are based on dose and not on barrier capability to prevent or delay movement of water or radionuclides. Without this information, staff cannot assess the capability of the barriers to determine what is retained by each barrier, what is delayed by each barrier, and what moves through each barrier. The capabilities of individual barriers to prevent or delay movement of water or radionuclides (across the spectrum of radionuclides) should be discussed in the context of the important properties of the barrier (e.g. matrix diffusion, distribution coefficients).

References CRWMS M&O. "Total System Performance Assessment for the Site Recommendation." TDR-WIS-PA-000001 Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000a.
CRWMS M&O. "Repository Safety Strategy: Plan to Prepare the Safety Case to Support Yucca Mountain Site Recommendation and Licensing Considerations." TDR-WIS-RL-000001 Revision 04 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000b.

DOE Response The capability of the barriers important to waste isolation will be described in any potential license application. The specific characteristics of each barrier to prevent or substantially delay movement of water or radionuclides will be included.

In addition, contribution of each of these barriers to waste isolation will be evaluated quantitatively through a set of complementary analyses. These analyses may include

* Intermediate performance analysis (CRWMS M&O 2000ar, Section 4.1)

* Pinch point analysis (CRWMS M&O 2000as, Section 4.5.3)

* Barrier robustness analysis (CRWMS M&O 2000ar, Section 5.3; CRWMS M&O 2001i, Section 3.2)

* Barrier neutralization analysis (CRWMS M&O 2000as, Section 4.5.4; CRWMS M&O 2001i, Section 3.4).

These analyses provide information clarifying the specific contribution of the barrier to the estimate of mean annual dose, the

capability of the barrier to prevent or delay the movement of water or radionuclides, the accumulation of radionuclides in the barriers, and the reduction in concentration (e.g., through dispersion). The analyses show the performance of individual radionuclides, including those most important to the estimated mean annual dose. Since the analyses are conducted with the TSPA model, uncertainty in models for processes affecting the barrier are explicitly considered. Further, time evolution of barrier performance and spatial variability of barrier characteristics are accounted for. Further interdependencies of barriers and correlations among models and parameters affecting the barriers can be addressed. Masking of one barrier by another can be addressed.

References: CRWMS M&O 2000ar. Total System Performance Assessment for the Site Recommendation. TDR-WIS-PA-000001 REV 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001220.0045.

CRWMS M&O 2000as. Total System Performance Assessment-Site Recommendation Methods and Assumptions. TDR-MGR-MD-000001 REV 00 ICN 02. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20000307.0384.

CRWMS M&O 2001i. Repository Safety Strategy: Plan to Prepare the Safety Case to Support Yucca Mountain Site Recommendation and Licensing Considerations. TDR-WIS-RL-000001 REV 04 ICN 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20010329.0825.

Agreement Number TSPAI.1.01

Agreement DOE will provide enhanced descriptive treatment for presenting barrier capabilities in the final approach for demonstrating multiple barriers. DOE will also provide discussion of the capabilities of individual barriers, in light of existing parameter uncertainty (e.g., in barrier and system characteristics) and model uncertainty. The information will be documented in TSPA Methods and Assumptions document, expected to be available to NRC in FY 2002, for any potential license application.

Subissue #1 - Multiple Barriers J-MB 2.2

Tracking # J-MB 2.2

Comment The methods used to distinguish the contributions of barriers that perform similar functions need to be explained. These combinations could include components of natural and engineered systems (e.g., the combination of the natural system above the repository and the drip shield) along important boundaries. The discussion of barrier capabilities needs to discuss and differentiate between the independent and the interdependent contributions of the individual barriers.

References CRWMS M&O. "Total System Performance Assessment for the Site Recommendation." TDR-WIS-PA-000001 Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000a.
CRWMS M&O. "Repository Safety Strategy: Plan to Prepare the Safety Case to Support Yucca Mountain Site Recommendation and Licensing Considerations." TDR-WIS-RL-000001 Revision 04 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000b.

DOE Response The use of neutralization analysis in both "one-off" and "two-off" modes assist in differentiating between the independent and interdependent contributions of individual barriers.

Agreement Number TSPAI.1.01

Agreement DOE will provide enhanced descriptive treatment for presenting barrier capabilities in the final approach for demonstrating multiple barriers. DOE will also provide discussion of the capabilities of individual barriers, in light of existing parameter uncertainty (e.g., in barrier and system characteristics) and model uncertainty. The information will be documented in TSPA Methods and Assumptions document, expected to be available to NRC in FY 2002, for any potential license application.

Subissue #1 - Multiple Barriers J-MB 2.3

Tracking # J-MB 2.3

Comment The description of the barrier capability for the drift invert is not clear, because the type of material (e.g. crushed tuff or limestone) has not been selected. The type of invert material used in the repository influences aqueous and mineral chemistry as well as diffusion rates. These processes affect radionuclide transport through the invert and may have a significant effect on the capability of the barrier.

References CRWMS M&O. "Total System Performance Assessment for the Site Recommendation." TDR-WIS-PA-000001 Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000a.
CRWMS M&O. "Repository Safety Strategy: Plan to Prepare the Safety Case to Support Yucca Mountain Site Recommendation and Licensing Considerations." TDR-WIS-RL-000001 Revision 04 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000b.

DOE Response The capability of barriers important to waste isolation, including the drift invert-if it is determined to be important to waste isolation-will be described in any potential license application. The characteristics of the barrier to prevent or substantially delay movement of water or radionuclides will be included. In addition, quantitative analyses will be conducted to assess contribution the barrier makes to the estimate of mean annual dose.

Agreement Number

Agreement DOE response during Technical Exchange was considered adequate by the NRC. Total System Performance Assessment and Integration Technical Exchange, August 6-10, 2001.

Subissue #1 - Multiple Barriers J-MB 2.4

Tracking # J-MB 2.4

Comment The uncertainty associated with particular barriers needs to be described. The description needs to include model uncertainty, such as the performance of the barrier assuming alternative conceptual models, and uncertainty in the attributes of the barrier (e.g., parameter uncertainty). The performance needs to be discussed in terms of barrier capability to prevent or delay movement of water or radionuclides.

References CRWMS M&O. "Total System Performance Assessment for the Site Recommendation." TDR-WIS-PA-000001 Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000a.
CRWMS M&O. "Repository Safety Strategy: Plan to Prepare the Safety Case to Support Yucca Mountain Site Recommendation and Licensing Considerations." TDR-WIS-RL-000001 Revision 04 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000b.

DOE Response The primary analytical tool proposed for multiple barrier analysis is the probabilistic TSPA model, which includes model and parameter uncertainty. As such, uncertainty in characterizing and modeling barriers (e.g., physically distinct components of the waste disposal system) is included in the analyses.

Agreement Number TSPAI.1.02

Agreement DOE will provide a discussion of the following in documentation of barrier capabilities and the corresponding technical bases: (1) parameter uncertainty, (2) model uncertainty (i.e., the effect of viable alternative conceptual models), (3) spatial and temporal variability in the performance of the barriers, (4) independent and interdependent capabilities of the barriers (e.g., including a differentiation of the capabilities of barriers performing similar functions), and (5) barrier effectiveness with regard to individual radionuclides. DOE will also analyze and document barrier capabilities, in light of existing data and analyses of the performance of the repository system. The information will be documented in TSPA for any potential license application expected to be available in FY 2003.

Subissue #1 - Multiple Barriers J-MB 2.5

Tracking # J-MB 2.5

Comment The DOE analyses of barriers needs to be discussed in terms of the individual barriers and their interdependence with other barriers (as appropriate). Results from the degraded barrier analyses indicate that the described capabilities are consistent with the results from the total system performance assessment. However, there appears to be inconsistency in the treatment of combinations of barriers. For example, the combination of barriers treated in Repository Safety Strategy, Rev. 4 (CRWMS M&O, 2000b) for the degraded barrier analyses are different from those used in the barrier neutralization analyses. Similarly, the combination of barriers presented in the TSPA Technical Document (CRWMS M&O, 2000a) are different from the combinations presented in the Repository Safety Strategy, Rev. 4 (CRWMS M&O, 2000b) for degraded barrier analyses and barrier neutralization analyses. It is difficult to understand the basis for, and the results of, the degraded barrier analyses and barrier neutralization analyses without a discussion of the results in terms of the independent and interdependent contributions of the barriers. Example 1: The presence of the drip shield in the degraded waste package analyses (CRWMS M&O, 2000b) could mask the effect of the waste package on radionuclide transport during the early period or at least until the drip shield fails. While such analyses (i.e., in the presence of drip shield) shows the protection afforded by the drip shield even after the waste package fails, the actual protection provided by each individual barrier in 10,000 years is not clearly identified. Example 2: It is not clear why performance improved for the degraded radionuclide concentration limits case, which represents non-mechanistic juvenile failure scenario-sensitivity to radionuclide concentration limits, between 2000 and 8000 years [see figure 3-20, p. 3-18, in Repository Safety Strategy, Rev. 4 (CRWMS M&O, 2000b)].

References

CRWMS M&O. "Total System Performance Assessment for the Site Recommendation." TDR-WIS-PA-000001 Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000a.

CRWMS M&O. "Repository Safety Strategy: Plan to Prepare the Safety Case to Support Yucca Mountain Site Recommendation and Licensing Considerations." TDR-WIS-RL-000001 Revision 04 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000b.

DOE Response The capability of the barriers important to waste isolation will be described in any potential license application. The specific characteristics of each barrier to prevent or substantially delay movement of water or radionuclides will be included.

In addition, contribution of each of these barriers to waste isolation will be evaluated quantitatively through a set of complementary

analyses. These analyses may include

* Intermediate performance analysis (CRWMS M&O 2000ar, Section 4.1)

* Pinch point analysis (CRWMS M&O 2000as, Section 4.5.3)

* Barrier robustness analysis (CRWMS M&O 2000ar, Section 5.3; CRWMS M&O 2001i, Section 3.2)

* Barrier neutralization analysis (CRWMS M&O 2000as, Section 4.5.4; CRWMS M&O 2001i, Section 3.4).

These analyses will directly address issues illustrated by the examples in this comment. For example, if the drip shield and waste package are identified as barriers important to waste isolation, potential masking of the performance of the waste package by the drip shield could be addressed in analyses that neutralize performance of the drip shield. As a second example, questions about relative performance of degraded barriers and neutralized barriers could be directly addressed.

References: CRWMS M&O 2000ar. Total System Performance Assessment for the Site Recommendation. TDR-WIS-PA-000001 REV 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001220.0045.

CRWMS M&O 2000as. Total System Performance Assessment-Site Recommendation Methods and Assumptions. TDR-MGR-MD-000001 REV 00 ICN 02. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20000307.0384.

CRWMS M&O 2001i. Repository Safety Strategy: Plan to Prepare the Safety Case to Support Yucca Mountain Site Recommendation and Licensing Considerations. TDR-WIS-RL-000001 REV 04 ICN 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20010329.0825.

Agreement Number TSPAI.1.02

Agreement DOE will provide a discussion of the following in documentation of barrier capabilities and the corresponding technical bases: (1) parameter uncertainty, (2) model uncertainty (i.e., the effect of viable alternative conceptual models), (3) spatial and temporal variability in the performance of the barriers, (4) independent and interdependent capabilities of the barriers (e.g., including a differentiation of the capabilities of barriers performing similar functions), and (5) barrier effectiveness with regard to individual

radionuclides. DOE will also analyze and document barrier capabilities, in light of existing data and analyses of the performance of the repository system. The information will be documented in TSPA for any potential license application expected to be available in FY 2003.

Subissue #1 - Multiple Barriers J-MB 2.6

Tracking # J-MB 2.6

Comment TSPA-SR robustness analysis section 5.3.7 (CRWMS M&O, 2000a) states that the similarity of the degraded and base cases for saturated zone is attributed to the dominance in the base case average of the high-dose realizations. Barrier neutralization analyses reported in the Repository Safety Strategy, Rev. 4 (CRWMS M&O, 2000b), where all saturated zone performance is removed gives essentially the same curve as the robustness analysis. Further discussion is needed to explain the saturated zone neutralization analysis.Furthermore, the analysis indicates significant performance for matrix diffusion (and sorption in the matrix) in the unsaturated zone.

References CRWMS M&O. "Total System Performance Assessment for the Site Recommendation." TDR-WIS-PA-000001 Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000a.
CRWMS M&O. "Repository Safety Strategy: Plan to Prepare the Safety Case to Support Yucca Mountain Site Recommendation and Licensing Considerations." TDR-WIS-RL-000001 Revision 04 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000b.

DOE Response The summary in the TSPA-Site Recommendation document (CRWMS M&O 2000ar) examined the contribution of individual realizations to the mean annual dose estimate. The summary revealed that the mean was dominated by a few realizations. The degraded barrier analyses examined the performance of the barrier (saturated zone transport barrier in the present case) to an extreme. The extreme did not significantly change the few realizations that dominated system performance. Consequently, the mean was not significantly affected. Likewise, the neutralization analyses conducted for Repository Safety Strategy, Rev. 4 (CRWMS M&O 2001i) also showed little change to the mean because the few realizations that dominated that mean was not significantly affected. Thus, the two separate analyses had the same result for the same reason.

The degraded barrier analyses and neutralization analyses for the unsaturated zone transport barrier had the same conclusions with regard to this barrier as in the discussion above-a few realizations dominated the estimate of mean annual dose and degrading or neutralizing the barrier did not significantly affect the realizations.

However, enhancing the performance of the barrier in terms of enhanced matrix diffusion and sorption in the matrix (i.e., enhanced in the sense of taking extreme values within the probability distribution) change the realizations that dominate the mean. It is for this reason, matrix diffusion is identified as an important factor affecting the mean annual dose.

References: CRWMS M&O 2000ar. Total System Performance Assessment for the Site Recommendation. TDR-WIS-PA-000001 REV 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001220.0045.

CRWMS M&O 2001i. Repository Safety Strategy: Plan to Prepare the Safety Case to Support Yucca Mountain Site Recommendation and Licensing Considerations. TDR-WIS-RL-000001 REV 04 ICN 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20010329.0825.

Agreement Number

Agreement DOE response during Technical Exchange was considered adequate by the NRC. Total System Performance Assessment and Integration Technical Exchange, August 6-10, 2001.

Subissue #1 - Multiple Barriers J-MB 2.7

Tracking # J-MB 2.7

Comment The description of the capability for individual barriers to prevent or substantially delay movement of water or radionuclide materials needs to include a discussion of the changes in barrier capability over time (throughout the 10,000 year compliance period).

The discussion should include the extent to which the conceptual models of the barriers consider cumulative degradation processes over time, processes that may significantly affect the performance of the barrier, and temporal changes within the repository system. For example, time-dependent environmental or physical-chemical variability of the system (pressure, temperature, spatial changes before, during, and after the thermal pulse); dynamic conditions (boiling zone/ refluxation; calcite-opal mobilization and precipitation in fractures, lithophysae, matrix pores; thermal-mechanical stresses inducing rockfall & drift collapse, etc.) may need to be discussed to appropriately describe the performance of particular barriers.

References CRWMS M&O. "Total System Performance Assessment for the Site Recommendation." TDR-WIS-PA-000001 Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000a.
CRWMS M&O. "Repository Safety Strategy: Plan to Prepare the Safety Case to Support Yucca Mountain Site Recommendation and Licensing Considerations." TDR-WIS-RL-000001 Revision 04 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000b.

DOE Response The multiple barrier analysis approach utilized the probabilistic TSPA model as the primary analytical tool. As such, temporal evolution of the system and associated variations in barrier capabilities are included in the analyses.

Agreement Number TSPAI.1.02

Agreement DOE will provide a discussion of the following in documentation of barrier capabilities and the corresponding technical bases: (1) parameter uncertainty, (2) model uncertainty (i.e., the effect of viable alternative conceptual models), (3) spatial and temporal variability in the performance of the barriers, (4) independent and interdependent capabilities of the barriers (e.g., including a differentiation of the capabilities of barriers performing similar functions), and (5) barrier effectiveness with regard to individual radionuclides. DOE will also analyze and document barrier capabilities, in light of existing data and analyses of the performance of the repository system. The information will be documented in TSPA for any potential license application expected to be available in FY 2003.

Subissue #1 - Multiple Barriers J-MB 2.8

Tracking # J-MB 2.8

Comment The description of barrier capabilities needs to include a discussion of the effects of spatial variability on the ability of the barrier to prevent or substantially delay movement of water or radionuclide materials, including a discussion of the spatial resolution in the models and data used to evaluate the performance of the barriers. For example, say 50% of the CHn is strongly sorbing and 50% is not.

As another example, in the analysis of the non-mechanistic juvenile failure scenario (Repository Safety Strategy, Rev. 4 (CRWMS M&O, 2000b), Pg. 3-15), a "what-if" analysis, one waste package was artificially set to fail after 100 years. The consequences associated with the failed waste package will be influenced by the location of the failed waste package (e.g., the characteristics of radionuclide release, water flow, and radionuclide transport in the vicinity of the failed waste package, where these characteristics may be affected by spatial heterogeneity and its representation in the model used in the analysis).

References CRWMS M&O. "Total System Performance Assessment for the Site Recommendation." TDR-WIS-PA-000001 Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000a.
CRWMS M&O. "Repository Safety Strategy: Plan to Prepare the Safety Case to Support Yucca Mountain Site Recommendation and Licensing Considerations." TDR-WIS-RL-000001 Revision 04 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000b.

DOE Response The multiple barrier analysis approach utilized the probabilistic TSPA model as the primary analytical tool. As such, spatial variability in parameter values and associated barrier characteristics and capabilities are included in the analyses.

The single waste package considered in the non-mechanistic juvenile failure scenario of Repository Safety Strategy, Rev. 4 (CRWMS M&O 2001i) is not an identifiable waste package located at a single point. The location of this waste package is sampled. Consequently different realizations will have the waste package in different locations. Accordingly, spatial variability in characteristics affects the results of the complete set of realizations.

Reference: CRWMS M&O 2001i. Repository Safety Strategy: Plan to Prepare the Safety Case to Support Yucca Mountain Site Recommendation and Licensing Considerations. TDR-WIS-RL-000001 REV 04 ICN 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20010329.0825.

Subissue #1 - Multiple Barriers J-MB 2.8

Agreement Number TSPAI.1.02

Agreement DOE will provide a discussion of the following in documentation of barrier capabilities and the corresponding technical bases: (1) parameter uncertainty, (2) model uncertainty (i.e., the effect of viable alternative conceptual models), (3) spatial and temporal variability in the performance of the barriers, (4) independent and interdependent capabilities of the barriers (e.g., including a differentiation of the capabilities of barriers performing similar functions), and (5) barrier effectiveness with regard to individual radionuclides. DOE will also analyze and document barrier capabilities, in light of existing data and analyses of the performance of the repository system. The information will be documented in TSPA for any potential license application expected to be available in FY 2003.

Subissue #1 - Multiple Barriers J-MB 2.9T

Tracking # J-MB 2.9T

Comment Table 6.3-1 of the DOE's TSPA Technical Document (CRWMS M&O, 2000a) correlates barriers and process model factors. Section 5.3 of the same document identifies the barriers that are considered in the robustness analysis. Sections 3.2 and 3.4 of Repository Safety Strategy, Rev. 4 (CRWMS M&O, 2000b) also identify degraded and neutralized barrier analyses. However, the discussions of these barriers are, in several instances, mixed with process model factors such as water usage, biosphere dose conversion factors (BDCF), and backfill. Although the identification of process model factors and the associated discussions in combination with multiple barriers provide useful information, a clear distinction should be made between the discussion on process model factors and barriers.

References CRWMS M&O. "Total System Performance Assessment for the Site Recommendation." TDR-WIS-PA-000001 Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000a.
CRWMS M&O. "Repository Safety Strategy: Plan to Prepare the Safety Case to Support Yucca Mountain Site Recommendation and Licensing Considerations." TDR-WIS-RL-000001 Revision 04 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000b.

DOE Response Barriers important to waste isolation correspond to physical entities and not abstract process model factors. In addition, the role of process model factors affecting performance of these barriers will be discussed in any potential license application.

The analyses in Repository Safety Strategy, Rev. 4 (CRWMS M&O 2001i) were intended to identify areas considered for the postclosure safety case. Consequently, these analyses were not intended to assess the role of the barriers in preventing or substantially delaying movement of water or radionuclide materials. DOE's multiple barrier analysis approach involving the complementary use of 4 analytical techniques would focus on barriers, not on the role of process model factors in determining the mean annual dose.

Reference: CRWMS M&O 2001i. Repository Safety Strategy: Plan to Prepare the Safety Case to Support Yucca Mountain Site Recommendation and Licensing Considerations. TDR-WIS-RL-000001 REV 04 ICN 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20010329.0825.

Agreement Number

Agreement DOE response during Technical Exchange was considered adequate by the NRC. Total System Performance Assessment and Integration Technical Exchange, August 6-10, 2001.

Subissue #1 - Multiple Barriers J-MB 3.1

Tracking # J-MB 3.1

Comment Analyses providing the technical basis for assertions of barrier capabilities need to consider correlations between parameters in an appropriate way. The basis for correlations (or independence) in the models needs to be discussed appropriately.

References CRWMS M&O. "Total System Performance Assessment for the Site Recommendation." TDR-WIS-PA-000001 Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000a.
CRWMS M&O. "Repository Safety Strategy: Plan to Prepare the Safety Case to Support Yucca Mountain Site Recommendation and Licensing Considerations." TDR-WIS-RL-000001 Revision 04 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000b.

DOE Response The multiple barrier analysis approach utilized the probabilistic TSPA model as the primary analytical tool. As such, correlation between parameters and component models was included in the analyses.

Agreement Number

Agreement DOE response during Technical Exchange was considered adequate by the NRC. Total System Performance Assessment and Integration Technical Exchange, August 6-10, 2001.

Subissue #2 - Scenario Analysis J-1

Tracking # J-1

Comment 2.1.03.11.00 (Container form) has been excluded from consideration in the total system performance assessment code (CRWMS M&O, 2001).

The varying clearance between the drip shield and different waste package designs and the concomitant effects that this may have on the consequences of rock block impacts and/or seismic excitation have not been addressed by DOE.

References CRWMS M&O. "FEPs Screening of Processes and Issues in Drip Shield and Waste Package Degradation." ANL-EBS-PA-000002 Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001.

DOE Response Results of recently performed thermal expansion calculations indicated a need to increase the gap between the outer barrier lid and the inner barrier lid from the current 3-mm to 6-mm. DOE agreed to provide the technical basis for the screening argument in the FEPs Screening of Processes and Issues in Drip Shield and Waste Package Degradation (CRWMS M&O 2001e) which will incorporate these results (Pathforward Item 38). In addition, in the Container Life and Source Term agreement 2.8, DOE agreed to perform, prior to any potential License Application, calculations that address the effects of static loads from fallen rock on the drip shield during a seismic event for both intact and degraded conditions of the drip shield (Pathforward Item 31).

DOE believes the existing pathforward items and Container Life and Source Term agreement 2.8 identified above are sufficient to address the technical issue identified in the NRC comment.

References: CRWMS M&O 2001e. FEPs Screening of Processes and Issues in Drip Shield and Waste Package Degradation. ANL-EBS-PA-000002 REV 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20010216.0004. (future revisions)

CRWMS M&O 2000j. Design Analysis for UCF Waste Packages. ANL-UDC-MD-000001 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20000526.0336.

CRWMS M&O 2000g. Design Analysis for the Defense High-Level Waste Disposal Container. ANL-DDC-ME-000001 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20000627.0254.

CRWMS M&O 2000i. Design Analysis for the Naval SNF Waste Package. ANL-VDC-ME-000001 REV 00. Las Vegas, Nevada: CRWMS M&O . ACC: MOL.20000615.0029.

CRWMS M&O 2000h. Design Analysis for the Ex-Container Components. ANL-XCS-ME-000001 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20000525.0374.

Agreement Number TSPAI.2.02

Agreement Provide the technical basis for the screening argument, as summarized in Attachment 2. See Comment # 3, 4, 11, 12, 19 (Parts 1, 2, and 6), 25, 26, 29, 34, 35, 36, 37, 38, 39, 42, 43, 44, 48, 49, 51, 54, 55, 56, 57, 59, 60, 61, 62, 63, 64, 65, 66, 68, 69, 70, 78, 79, J-1, J-2, J-3, J-4, J-7, J-8, J-9, J-10, J-11, J-12, J-13, J-14, J-15, J-17, J-20, J-21, J-22, J-23, J-24, J-25, J-26, and J-27.

DOE will provide the technical basis for the screening argument, as summarized in Attachment 2, for the highlighted FEPs. The technical basis will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
This issue is addressed by existing agreements between DOE and NRC (CLST Subissue 2 Agreement 8). FEPs Screening of Processes and Issues in Drip Shield and Waste Package Degradation, ANL-EBS-PA-000002, will be revised upon completion of this work.

Subissue #2 - Scenario Analysis J-2

Tracking # J-2

Comment 2.1.06.05.00 (Degradation of invert and pedestal) has been screened as excluded on the basis of low consequence (CRWMS M&O, 2001).

Rock block impact orientations with the waste package will be affected by degradation of the invert. As pointed out in the comment on 2.1.07.01.00 [Rockfall (large block)], angled rock block impacts near the closure lid weld may have undesirable consequences. Furthermore, the stability of the waste package during seismic excitation will be affected by a degraded invert foundation. The corrosion of the steel pallet components should be considered when evaluating the stability of the waste package on its supporting pallet on a degraded invert foundation.

References CRWMS M&O. "EBS FEPs/Degradation Modes Abstraction." ANL-WIS-PA-000002. Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001.

DOE Response Impact of degradation on mechanical response of waste package

Additional loading combinations are being addressed in response to Container Life and Source Term agreement 2.8. Evaluations of these loading combinations will be documented in a future revision of the Design Analysis for UCF Waste Packages (CRWMS M&O 2000j), and the Design Analysis for the Ex-Container Components (CRWMS M&O 2000h).

Seismic motion of the supporting invert Seismic motion of the supporting invert is being included in the evaluations being currently performed and will be included in the next revision of the Design Analysis for the Ex-Container Components (CRWMS M&O 2000h).

The corrosion of the steel pallet components should be considered when evaluating the stability of the waste package on its supporting pallet on a degraded invert foundation. The carbon steel members of the invert are surrounded by a ballast material, which will provide some support to the waste packages for the entire regulatory period. While the carbon steel invert may not keep the waste packages in a horizontal position for the entire regulatory period, they are designed to keep the waste packages in a horizontal position for the preclosure period. One of the repository closure activities is the installation of drip shields, which would prevent direct impact of rock blocks on the waste packages.

References: CRWMS M&O 2000j. Design Analysis for UCF Waste Packages. ANL-UDC-MD-000001 REV 00. Las Vegas, Nevada:

CRWMS M&O. ACC: MOL.20000526.0336. (future revision)

CRWMS M&O 2000h. Design Analysis for the Ex-Container Components. ANL-XCS-ME-000001 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20000525.0374. (future revision)

Agreement Number TSPAI.2.02

Agreement Provide the technical basis for the screening argument, as summarized in Attachment 2. See Comment # 3, 4, 11, 12, 19 (Parts 1, 2, and 6), 25, 26, 29, 34, 35, 36, 37, 38, 39, 42, 43, 44, 48, 49, 51, 54, 55, 56, 57, 59, 60, 61, 62, 63, 64, 65, 66, 68, 69, 70, 78, 79, J-1, J-2, J-3, J-4, J-7, J-8, J-9, J-10, J-11, J-12, J-13, J-14, J-15, J-17, J-20, J-21, J-22, J-23, J-24, J-25, J-26, and J-27.

DOE will provide the technical basis for the screening argument, as summarized in Attachment 2, for the highlighted FEPs. The technical basis will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
This issue is addressed by existing agreements between DOE and NRC (CLST Subissue 2 Agreement 8). Engineered Barrier System Features, Events, and Processes, ANL-WIS-PA-000002, will be revised upon completion of this work.

DOE agreed to provide the technical basis for the screening argument in the Engineered Barrier System Features, Events, and Processes, ANL-WIS-PA-000002, to address the NRC comment.

Subissue #2 - Scenario Analysis J-3

Tracking # J-3

Comment 2.1.06.01.00 (Degradation of cementitious materials in drift). The effects of degradation of cementitious materials on seepage chemistry are excluded on the basis of low consequence (CRWMS M&O, 2001a). Exclusion is based on arguments under 2.1.09.01.00 (Properties of the Potential Carrier Plume in the Waste and engineered barrier subsystem, CRWMS M&O 2001a), on the basis that chemical models show a negligible effect of grout associated with rock bolts. NRC has raised questions about these models, pertaining to the treatment of evaporation and the chemical divide phenomenon (Evolution of the Near-Field Environment tech exchange (Reamer, 2001)). Concerns about grout chemical effects are related to recent observations of dripping from rock bolt holes in the sealed cross-drift test. The argument for screening chemical effects of cementitious materials in the drift is considered not adequate.

Because degradation products may affect water chemistry, and therefore radionuclide sorption behavior, the effect of this Database entry on radionuclide transport in the unsaturated zone should also be evaluated. Currently, this entry is not addressed for the unsaturated zone (CRWMS M&O, 2001b).

It is necessary to the development of technical bases that degradation of cementitious materials has a negligible effect on water chemistry within and below the drift. Screening would be supported by addressing the following technical exchange agreements:

Evolution of the Near Field Environment, Subissue 2, Agreements 6 and 14: These agreements deal with model and lab results pertinent to the effects of engineered barrier subsystem materials, including cementitious, on water chemistry.

Radionuclide Transport, Subissue 1, Agreement 5, and Subissue 2, Agreement 10: These agreements concern the technical bases for transport parameter uncertainty distributions.

References

CRWMS M&O. "EBS FEPs/Degradation Modes Abstraction." ANL-WIS-PA-000002. Revision 01. Las Vegas, Nevada:CRWMS M&O. 2001a.

CRWMS M&O. "Features, Events, and Processes in UZ Flow and Transport." ANL-NBS-MD-000001 Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001b.

Reamer, C.W. "U.S. Nuclear Regulatory Commission/U.S. Department of Energy Technical Exchange and Management Meeting on Evolution of the Near-Field Environment (January 9-12,

2001)." Letter (January 26) to S. Brocoum, DOE. Washington, DC: NRC. 2001

DOE Response Although this FEP is not addressed by the Unsaturated Zone, the subject is covered by other FEPs that are addressed by the Unsaturated Zone. See FEPs 2.2.08.01.00 (Groundwater chemistry/composition in unsaturated zone and saturated zone) and 2.2.08.02.00 (Radionuclide transport occurs in a carrier plume in geosphere).

DOE will cross-reference above FEPs that address cementitious material in the next revision of the FEP Analysis/Model Reports.

An estimate of the impact on local water chemistry resulting from degradation of cementitious materials (grout) as well as the corrosion products from rockbolt degradation is being provided as part of the work being done in support of agreements Evolution of Near Field agreements 2.6, 2.10, and 2.14. The scope of these agreements takes into account evaporative concentrations and the chemical divide effect. Results of this work will be incorporated into the screening arguments for this FEP.

Agreement Number TSPAI.2.02

Agreement Provide the technical basis for the screening argument, as summarized in Attachment 2. See Comment # 3, 4, 11, 12, 19 (Parts 1, 2, and 6), 25, 26, 29, 34, 35, 36, 37, 38, 39, 42, 43, 44, 48, 49, 51, 54, 55, 56, 57, 59, 60, 61, 62, 63, 64, 65, 66, 68, 69, 70, 78, 79, J-1, J-2, J-3, J-4, J-7, J-8, J-9, J-10, J-11, J-12, J-13, J-14, J-15, J-17, J-20, J-21, J-22, J-23, J-24, J-25, J-26, and J-27.

DOE will provide the technical basis for the screening argument, as summarized in Attachment 2, for the highlighted FEPs. The technical basis will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
This issue is addressed by existing agreements between DOE and NRC (ENFE Subissue 2 Agreements 6, 10, and 14, and RT Subissue 1 Agreement 5). Engineered Barrier System Features, Events, and Processes, ANL-WIS-PA-000002, will be revised upon completion of this work.

Subissue #2 - Scenario Analysis J-4

Tracking # J-4

Comment 2.1.06.05.00 (Degradation of invert and pedestal) has been screened as excluded on the basis of low consequence (CRWMS M&O, 2001).

Invert degradation is excluded on the basis of low consequence (CRWMS M&O, 2001a). The argument that changes to diffusive properties of the invert will be negligible to dose is not supported by demonstration (by sensitivity analyses) of the significant effect of diffusive release through the invert during the first 20,000 years (CRWMS M&O, 2000, Volume II, Section 3.3). The sensitivity shown in the Repository Safety Strategy also applies to the first 10,000 years. The screening argument contradicts this information. The screening argument should directly address possible effects of degradation on invert diffusive properties.

References CRWMS M&O. "EBS FEPs/Degradation Modes Abstraction." ANL-WIS-PA-000002 Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001.
CRWMS M&O. "Repository Safety Strategy: Plan to Prepare the Safety Case to Support Yucca Mountain Site Recommendation and Licensing Considerations." TDR-WIS-RL-000001 Revision 04 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response Impact of invert and pedestal degradation on waste package.

From an engineered barrier system modeling perspective, the pedestal is assumed to fail such that the waste package is in constant contact with the invert. Thus, no credit is taken for the potentially beneficial effect of radionuclide diffusion through a water film on the pedestal surface. Since this is a conservative assumption, no further evaluation is required.

Impact of invert degradation on diffusion through the invert

Such degradation could reduce diffusion rather than enhance it. However, as part of the screening argument for this FEP, a quantification of the impact of invert degradation on relevant parameters impacting diffusion (i.e. porosity) and the impact of these parameter changes on the invert diffusion coefficient will be provided. This will demonstrate that any invert degradation will reduce diffusion (conservative to ignore it), demonstrate that any effect on the diffusion coefficient is already covered by existing sensitivity studies, or provide the basis for an expanded sensitivity range for the invert diffusion coefficient. Updates to the Repository Safety Strategy (CRWMS M&O 2001i) will be made, if necessary.

Reference: CRWMS M&O 2001i. Repository Safety Strategy: Plan

to Prepare the Safety Case to Support Yucca Mountain Site Recommendation and Licensing Considerations. TDR-WIS-RL-000001 REV 04 ICN 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20010329.0825.

Agreement Number TSPAI.2.02

Agreement Provide the technical basis for the screening argument, as summarized in Attachment 2. See Comment # 3, 4, 11, 12, 19 (Parts 1, 2, and 6), 25, 26, 29, 34, 35, 36, 37, 38, 39, 42, 43, 44, 48, 49, 51, 54, 55, 56, 57, 59, 60, 61, 62, 63, 64, 65, 66, 68, 69, 70, 78, 79, J-1, J-2, J-3, J-4, J-7, J-8, J-9, J-10, J-11, J-12, J-13, J-14, J-15, J-17, J-20, J-21, J-22, J-23, J-24, J-25, J-26, and J-27.

DOE will provide the technical basis for the screening argument, as summarized in Attachment 2, for the highlighted FEPs. The technical basis will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
This issue is addressed by existing agreements between DOE and NRC (CLST Subissue 2 Agreement 8). Engineered Barrier System Features, Events, and Processes, ANL-WIS-PA-000002, will be revised upon completion of this work.

DOE agreed to provide the technical basis for the screening argument in the Engineered Barrier System Features, Events, and Processes, ANL-WIS-PA-000002, to address the NRC comment.

Subissue #2 - Scenario Analysis J-5

Tracking # J-5

Comment 2.1.09.21.00 (Suspensions of particles larger than colloids) is screened as excluded from the engineered barrier subsystem transport and waste form release abstractions (CRWMS M&O, 2000, 2001). Exclusion is based on the assumption that although particles may be transported through fractures in the unsaturated zone, low groundwater velocities through the saturated zone would lead to particle settling (CRWMS M&O, 2000), suggesting inconsistency in the screening analysis. Without quantitative measures of particle size, pore size, groundwater velocity, and chemical variability, however, these qualitative assertions are difficult to evaluate. Since DOE includes colloid formation features, events, and processes in its screening analysis, and because of the large amounts of Fe particles that may be introduced in the engineered barrier subsystem, particle transport through the engineered barrier subsystem into the unsaturated zone is plausible. Exclusion of 2.1.09.21.00 may be acceptable, but it is necessary to have a more complete technical basis and calculations to support exclusion of this item on the basis of low consequence.

References CRWMS M&O. "Colloid-Associated Concentration Limits: Abstraction and Summary." ANL-WIS-MD-000012. Revision 00 ICN 01. Las Vegas, NV: CRWMS M&O. 2000.
CRWMS M&O. "Features, Events, and Processes in UZ Flow and Transport." ANL-NBS-MD-000001 Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001.

DOE Response DOE believes that the current exclusion of this FEP on the basis of low consequence is appropriate. However, DOE agrees to clarify the screening argument to provide additional information on the population, size and density of particles larger than colloids potentially generated within the waste form and engineered barrier systems. Also, additional information on probable pore sizes and distributions, groundwater velocities/chemical variability within the waste form and engineered barrier systems will be provided and the potential effects of these variables on the transport of suspended particles larger than colloids will be evaluated.

Agreement Number TSPAI.2.01

Agreement Provide clarification of the screening arguments, as summarized in Attachment 2. See Comment # 5, 7, 8, 9, 10, 13, 18, 19 (Part 5), 21, 32, 41, 47, 50, 53, 58, 67, J-5, J-16, and J-18

DOE will clarify the screening arguments, as summarized in Attachment 2, for the highlighted FEPs. The clarifications will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
DOE agreed to provide clarification of the screening argument in the Waste Form Colloid-Associated Concentration Limits: Abstraction and Summary ANL-WIS-MD-000012, to address the NRC comment.

Subissue #2 - Scenario Analysis J-6

Tracking # J-6

Comment 2.2.07.15.00 (Advection and dispersion). As defined, this item does not apply to the unsaturated zone, and is not discussed in (CRWMS M&O, 2001). Given that advection and dispersion are key components of the U.S. Department of Energy radionuclide transport in the unsaturated zone model abstraction, the definition of 2.2.07.15.00 (Advection and dispersion) should be extended to enclose these aspects (advection and dispersion) in the unsaturated zone.

References CRWMS M&O. "Features, Events, and Processes in UZ Flow and Transport." ANL-NBS-MD-000001 Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001.

DOE Response This FEP is currently a Saturated Zone FEP, and will be added as an Unsaturated Zone FEP.

Agreement Number TSPAI.2.03

Agreement Add the FEPs highlighted in Attachment 2 to the appropriate FEPs AMRs. See Comment 19 (Part 7 and 8), 20, and J-6.

DOE will add the FEPs highlighted in Attachment 2 to the appropriate FEPs AMRs. The FEPs will be added to the appropriate FEPs AMRs and the AMRs will be provided to the NRC in FY03.

Text in Attachment 2:
DOE will add this FEP to the Features, Events, and Processes in UZ Flow and Transport, ANL-NBS-MD-000001, and present the DOE discussion in the screening argument.

Subissue #2 - Scenario Analysis J-7

Tracking # J-7

Comment 2.2.08.01.00 (Groundwater chemistry/composition in unsaturated zone and saturated zone) is excluded. The DOE has included the current ambient groundwater conditions in the Total System Performance Assessment - Site Recommendation abstraction of radionuclide transport in the unsaturated zone, but has excluded future changes (CRWMS M&O, 2001, 2000b). The DOE asserts that the thermal effects on chemistry are minimal, but this focuses mainly on the effects of dissolution and precipitation on hydrologic properties. The screening argument refers to a model of thermo-chemical effects on seepage water chemistry at the drift wall (CRWMS M&O, 2000a). Because modeled effects fell within the range of variation included in Total System Performance Assessment, it is asserted that effects further from the drift would be smaller, based on an unverified assumption (CRWMS M&O, 2001). This argument does not address chemical changes below the repository, which are likely to be more significant than changes above, due to interactions with engineered barrier subsystem and waste materials. Even so, predicted changes in key geochemical parameters (pH and total carbon) in seepage water are large enough to have an effect on sorption coefficients. Without the details on how expert judgement was used to derive the Total System Performance Assessment - Site Recommendation sorption parameters, it is not clear how the effects of changes in the ambient chemistry system are incorporated in the transport calculations. The technical basis for this exclusion is not satisfactory.

References

CRWMS M&O. "Drift-Scale Coupled Processes (DST and THC Seepage) Models." MDL-NBS-HS-000001 Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000a.

CRWMS M&O. "Unsaturated Zone Flow and Transport Model Process Model Report." TDR-NBS-HS-000002. Revision 00 ICN02. Las Vegas, Nevada: CRWMS M&O. 2000b.

CRWMS M&O. "Features, Events, and Processes in UZ Flow and Transport." ANL-NBS-MD-000001 Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001.

DOE Response Assumption 11 is designated as needing further verification prior to any potential license application. The technical work used to resolve the Evolution of Near Field Environment agreement items 1.4, 4.3, 4.4, and Radionuclide Transport agreement 1.5 will be sufficient to provide the additional technical bases needed for the FEPs screening argument. These agreements will take into account thermal-hydrological-chemical effects on radionuclide transport out of the drift.

Agreement Number TSPAI.2.02

Subissue #2 - Scenario Analysis J-7

Agreement Provide the technical basis for the screening argument, as summarized in Attachment 2. See Comment # 3, 4, 11, 12, 19 (Parts 1, 2, and 6), 25, 26, 29, 34, 35, 36, 37, 38, 39, 42, 43, 44, 48, 49, 51, 54, 55, 56, 57, 59, 60, 61, 62, 63, 64, 65, 66, 68, 69, 70, 78, 79, J-1, J-2, J-3, J-4, J-7, J-8, J-9, J-10, J-11, J-12, J-13, J-14, J-15, J-17, J-20, J-21, J-22, J-23, J-24, J-25, J-26, and J-27.

DOE will provide the technical basis for the screening argument, as summarized in Attachment 2, for the highlighted FEPs. The technical basis will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
This issue is addressed by existing agreements between DOE and NRC (ENFE Subissue 1 Agreement 4, ENFE Subissue 4 Agreements 3 and 4, RT Subissue 1 Agreement 5, and RT Subissue 2 Agreement 10). Features, Events, and Processes in UZ Flow and Transport, ANL-NBS-MD-000001, will be revised upon completion of this work.

Subissue #2 - Scenario Analysis J-8

Tracking # J-8

Comment 2.2.08.02.00 (Radionuclide transport occurs in a carrier plume in geosphere) is excluded from the Total System Performance Assessment - Site Recommendation abstraction of radionuclide transport in the unsaturated zone on the basis of low consequence (CRWMS M&O, 2001c, 2000b). The key assumption (CRWMS M&O, 2001c) is that results from the near-field thermal-hydrological-chemical coupled processes model (CRWMS M&O, 2000a) can be used to bound the effects of similar coupled processes on far-field flow and transport. This assumption has not yet been verified. Because the screening argument for this item is focused primarily on thermal effects on the chemistry of seepage water entering the emplacement drifts, it does not appear to include other potential effects (colloids, interactions with waste forms and engineered barrier subsystem materials). Also, 2.1.09.01.00 (properties of a carrier plume in the engineered barrier subsystem) is included in the engineered barrier subsystem process model report (CRWMS M&O, 2001b, 2001a), suggesting that radionuclide transport in a carrier plume should be included in transport beyond the engineered barrier subsystem. The arguments presented for exclusion of 2.2.08.02.00 (Radionuclide transport occurs in a carrier plume in geosphere) (CRWMS M&O, 2001c) do not appear to be sufficient at this time.

References

CRWMS M&O. "Drift-Scale Coupled Processes (DST and THC Seepage) Models." MDL-NBS-HS-000001 Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000a.

CRWMS M&O. "Unsaturated Zone Flow and Transport Model Process Model Report." TDR-NBS-HS-000002. Revision 00 ICN02. Las Vegas, Nevada: CRWMS M&O. 2000b.

CRWMS M&O. "EBS FEPs/Degradation Modes Abstraction." ANL-WIS-PA-000002. Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001a.

CRWMS M&O. "Engineered Barrier System Degradation, Flow, and Transport Process Model Report." TDR-EBS-MD-000006. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2001b.

CRWMS M&O. "Features, Events, and Processes in UZ Flow and Transport." ANL-NBS-MD-000001 Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001c.

DOE Response Assumption 11 is designated as needing further verification prior to any potential license application. The technical work used to resolve Evolution of Near Field Environment agreements 1.4, 4.3, 4.4, and Radionuclide Transport agreement 1.5 will be sufficient to provide the additional technical bases needed for the FEPs screening argument. These agreements will take into account thermal-hydrologic-chemical effects on radionuclide transport out of the drift.

Subissue #2 - Scenario Analysis J-8

Agreement Number TSPAI.2.02

Agreement Provide the technical basis for the screening argument, as summarized in Attachment 2. See Comment # 3, 4, 11, 12, 19 (Parts 1, 2, and 6), 25, 26, 29, 34, 35, 36, 37, 38, 39, 42, 43, 44, 48, 49, 51, 54, 55, 56, 57, 59, 60, 61, 62, 63, 64, 65, 66, 68, 69, 70, 78, 79, J-1, J-2, J-3, J-4, J-7, J-8, J-9, J-10, J-11, J-12, J-13, J-14, J-15, J-17, J-20, J-21, J-22, J-23, J-24, J-25, J-26, and J-27.

DOE will provide the technical basis for the screening argument, as summarized in Attachment 2, for the highlighted FEPs. The technical basis will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
This issue is addressed by existing agreements between DOE and NRC (ENFE Subissue 1 Agreement 4, ENFE Subissue 4 Agreements 3 and 4, and RT Subissue 1 Agreement 5). Features, Events, and Processes in UZ Flow and Transport, ANL-NBS-MD-000001, will be revised upon completion of this work.

Subissue #2 - Scenario Analysis J-9

Tracking # J-9

Comment 2.2.08.03.00 (Geochemical interactions in geosphere [dissolution, precipitation, weathering] and effects on radionuclide transport) is excluded (CRWMS M&O, 2001, 2000b) from the Total System Performance Assessment - Site Recommendation abstraction of radionuclide transport in the unsaturated zone on the basis of low consequence. The key assumption (CRWMS M&O, 2001) is that results from the near-field thermal-hydrological-chemical coupled processes model (CRWMS M&O, 2000a) can be used to bound the effects of similar coupled processes on far-field flow and transport. This assumption has not yet been verified. Predicted mineralogical changes (CRWMS M&O, 2000a) in response to the thermal effects of the repository are small (calcite only). Predicted changes in porosity and permeability are also small. Transport through fractures is conservatively modeled in Total System Performance Assessment - Site Recommendation assuming no retardation. However, the screening argument only addresses changes in seepage water chemistry. It does not address the possibility of reduced (or enhanced) matrix diffusion through precipitation and dissolution. Diffusion into the matrix and sorption on matrix minerals can be an important retardation mechanism. The effect of small volume changes on fracture armoring and diffusion into the matrix may be important. The current screening arguments are not sufficient and will depend in part on the verification of Assumption 11 that far-field changes to radionuclide transport in the unsaturated zone will be less than calculated near-field changes (CRWMS M&O, 2001).

Effects on flow are excluded based on low consequence. Problems with modeling of drift-scale coupled processes (CRWMS M&O, 2000) used to support this screening argument have been raised by NRC. Current agreements from Evolution of the Near-Field Environment Technical Exchange (Reamer, 2001) may provide additional technical basis for the screening argument.

References

CRWMS M&O. "Drift-Scale Coupled Processes (DST and THC Seepage) Models." MDL-NBS-HS-000001 Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000a.

CRWMS M&O. "Unsaturated Zone Flow and Transport Model Process Model Report." TDR-NBS-HS-000002. Revision 00 ICN02. Las Vegas, Nevada: CRWMS M&O. 2000b.

CRWMS M&O. "Features, Events, and Processes in UZ Flow and Transport." ANL-NBS-MD-000001 Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001.

Reamer, C.W. "U.S. Nuclear Regulatory Commission/U.S. Department of Energy Technical Exchange and Management Meeting on Evolution of the Near-Field Environment (January 9-12,

2001)." Letter (January 26) to S. Brocoum, DOE. Washington, DC: NRC. 2001

DOE Response Assumption 11 is designated as needing further verification prior to any potential license application. The technical work used to resolve Evolution of Near Field Environment agreements 1.7, 2.6, and 1.4 will be sufficient to provide the additional technical bases needed for the FEPs screening argument. These agreements will address thermal-hydrological-chemical affects on mineral precipitation.

Agreement Number TSPAI.2.02

Agreement Provide the technical basis for the screening argument, as summarized in Attachment 2. See Comment # 3, 4, 11, 12, 19 (Parts 1, 2, and 6), 25, 26, 29, 34, 35, 36, 37, 38, 39, 42, 43, 44, 48, 49, 51, 54, 55, 56, 57, 59, 60, 61, 62, 63, 64, 65, 66, 68, 69, 70, 78, 79, J-1, J-2, J-3, J-4, J-7, J-8, J-9, J-10, J-11, J-12, J-13, J-14, J-15, J-17, J-20, J-21, J-22, J-23, J-24, J-25, J-26, and J-27.

DOE will provide the technical basis for the screening argument, as summarized in Attachment 2, for the highlighted FEPs. The technical basis will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
This issue is addressed by existing agreements between DOE and NRC (ENFE Subissue 1 Agreements 4 and 7 and ENFE Subissue 2 Agreement 6). Features, Events, and Processes in UZ Flow and Transport, ANL-NBS-MD-000001, will be revised upon completion of this work.

Subissue #2 - Scenario Analysis J-10

Tracking # J-10

Comment 2.2.08.06.00 (Complexation in geosphere) is excluded. The DOE has included the effects of ambient condition complexation in the Total System Performance Assessment - Site Recommendation abstraction of radionuclide transport in the unsaturated zone, but has excluded future changes (CRWMS M&O, 2001, 2000a). The effects of complexation are "...implicitly included in the radionuclide sorption coefficients", but there is no clear technical basis regarding the effects of organics or other ligands provided in establishing the Kd distributions (CRWMS M&O 2001). Experimental results reported in Triay (1997) that form much of the basis for the sorption coefficient distributions only address the effects of organics on Np and Pu sorption. The Unsaturated Zone and Saturated Zone Transport Properties Analysis and Model Report (CRWMS M&O, 2000b) does not provide any additional information on the effect of organics on other radionuclides. The current process models do not address the effects of complexation on transport parameters, and the exclusion of changes to complex formation does not have sufficient support. In addition, the screening argument refers to modeling results on repository effects on seepage chemistry, which may not be relevant to transport conditions below the repository (CRWMS M&O, 2001).

References

CRWMS M&O. "Unsaturated Zone Flow and Transport Model Process Model Report." TDR-NBS-HS-000002. Revision 00 ICN02. Las Vegas, Nevada: CRWMS M&O. 2000a.

CRWMS M&O. "Unsaturated Zone and Saturated Zone Transport Properties." ANL-NBS-HS-000019 Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000b.

CRWMS M&O. "Features, Events, and Processes in UZ Flow and Transport." ANL-NBS-MD-000001 Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001.

Triay, I.R., A. Meijer, J.L. Conca, K.S. Kung, R.S. Rundberg, E.A. Strietelmeier. "Summary and Synthesis Report on Radionuclide Retardation for the Yucca Mountain Site Characterization Project." LA-13262-MS. Los Alamos, NM: Chemical Science and Technology Division, Los Alamos National Laboratory. 1997.

DOE Response Assumption 11 is designated as needing further verification prior to any potential license application. The technical work used to resolve Evolution of Near Field Environment agreements 1.4, 4.3, 4.4, and Radionuclide Transport agreement 1.5 will be sufficient to provide the additional technical bases needed for the FEPs screening argument. These agreements will take into account thermal-hydrological-chemical effects on radionuclide transport out of the drift.

Agreement Number TSPAI.2.02

Subissue #2 - Scenario Analysis J-10

Agreement Provide the technical basis for the screening argument, as summarized in Attachment 2. See Comment # 3, 4, 11, 12, 19 (Parts 1, 2, and 6), 25, 26, 29, 34, 35, 36, 37, 38, 39, 42, 43, 44, 48, 49, 51, 54, 55, 56, 57, 59, 60, 61, 62, 63, 64, 65, 66, 68, 69, 70, 78, 79, J-1, J-2, J-3, J-4, J-7, J-8, J-9, J-10, J-11, J-12, J-13, J-14, J-15, J-17, J-20, J-21, J-22, J-23, J-24, J-25, J-26, and J-27.

DOE will provide the technical basis for the screening argument, as summarized in Attachment 2, for the highlighted FEPs. The technical basis will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
This issue is addressed by existing agreements between DOE and NRC (ENFE Subissue 1 Agreement 4, ENFE Subissue 4 Agreements 3 and 4, and RT Subissue 1 Agreement 5). Features, Events, and Processes in UZ Flow and Transport, ANL-NBS-MD-000001, will be revised upon completion of this work.

Subissue #2 - Scenario Analysis J-11

Tracking # J-11

Comment 2.2.08.07.00 (Radionuclide solubility limits in the geosphere) is excluded from the Total System Performance Assessment - Site Recommendation abstraction of radionuclide transport in the unsaturated zone on the basis of low consequence (CRWMS M&O, 2001, 2000). The DOE screening argument assumes that radionuclide solubility limits in the geosphere may be different and indicates that radionuclide solubility limits in the geosphere are conservatively ignored with respect to solubility reduction in the far-field (CRWMS M&O, 2000). This argument makes valid points, but the possibility of increasing solubility limits should also be considered. Solubility limits in the geosphere will be determined by interaction between the contaminant plume and the host rock.

References CRWMS M&O. "Unsaturated Zone Flow and Transport Model Process Model Report." TDR-NBS-HS-000002. Revision 00 ICN02. Las Vegas, Nevada: CRWMS M&O. 2000.
CRWMS M&O. "Features, Events, and Processes in UZ Flow and Transport." ANL-NBS-MD-000001 Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001.

DOE Response Changing solubility limits could affect radionuclide release from the waste form (in the waste emplacement drift) but cannot affect the unsaturated zone, given the assumptions used for unsaturated zone radionuclide transport. All radionuclides that pass from the engineered barrier system to the Unsaturated Zone are aqueous or colloidal and are assumed to remain in the dissolved or colloidal state unless sorbed to rock surfaces. There are no precipitation/ dissolution processes for radionuclides; they are either mobile (aqueous or colloidal) or sorbed. The conservative assumption is that there is no precipitate in the unsaturated zone associated with the radionuclides. Therefore, increasing solubility limits will have no effect.

Agreement Number TSPAI.2.02

Agreement Provide the technical basis for the screening argument, as summarized in Attachment 2. See Comment # 3, 4, 11, 12, 19 (Parts 1, 2, and 6), 25, 26, 29, 34, 35, 36, 37, 38, 39, 42, 43, 44, 48, 49, 51, 54, 55, 56, 57, 59, 60, 61, 62, 63, 64, 65, 66, 68, 69, 70, 78, 79, J-1, J-2, J-3, J-4, J-7, J-8, J-9, J-10, J-11, J-12, J-13, J-14, J-15, J-17, J-20, J-21, J-22, J-23, J-24, J-25, J-26, and J-27.

DOE will provide the technical basis for the screening argument, as summarized in Attachment 2, for the highlighted FEPs. The technical basis will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:

Subissue #2 - Scenario Analysis J-11

This issue is addressed by existing agreements between DOE and NRC (ENFE Subissue 4 Agreement 3). Features, Events, and Processes in UZ Flow and Transport, ANL-NBS-MD-000001, will be revised upon completion of this work.

Subissue #2 - Scenario Analysis J-12

Tracking # J-12

Comment 2.2.10.01.00 (Repository-induced thermal effects in geosphere) is excluded from the Total System Performance Assessment-Site Recommendation abstraction of radionuclide transport in the unsaturated zone on the basis of low consequence (CRWMS M&O, 2001, 2000b). The screening argument is only partially supported by near-field thermo-chemical modeling for a limited number of hydrochemical constituents and minerals (CRWMS M&O, 2000a), and is not directly related to effects on radionuclide transport. The technical basis for the screening is not sufficient at this time and future evaluation of the exclusion of 2.2.10.01.00 (Repository-induced thermal effects in geosphere) will depend in part on the verification of Assumption 11 that far-field changes to radionuclide transport in the unsaturated zone will be less than calculated near-field changes (CRWMS M&O, 2001).

References CRWMS M&O. "Drift-Scale Coupled Processes (DST and THC Seepage) Models." MDL-NBS-HS-000001 Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000a.
CRWMS M&O. "Unsaturated Zone Flow and Transport Model Process Model Report." TDR-NBS-HS-000002. Revision 00 ICN02. Las Vegas, Nevada: CRWMS M&O. 2000b.
CRWMS M&O. "Features, Events, and Processes in UZ Flow and Transport." ANL-NBS-MD-000001 Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001.

DOE Response Assumption 11 is designated as needing further verification prior to any potential license application. The technical work used to resolve Evolution of Near Field Environment agreements 1.4, 4.3, 4.4, and Radionuclide Transport agreement 1.5 will be sufficient to provide the additional technical bases needed for the FEPs screening argument. These agreements will take into account thermal-hydrological-chemical effects on radionuclide transport out of the drift.

Agreement Number TSPAI.2.02

Agreement Provide the technical basis for the screening argument, as summarized in Attachment 2. See Comment # 3, 4, 11, 12, 19 (Parts 1, 2, and 6), 25, 26, 29, 34, 35, 36, 37, 38, 39, 42, 43, 44, 48, 49, 51, 54, 55, 56, 57, 59, 60, 61, 62, 63, 64, 65, 66, 68, 69, 70, 78, 79, J-1, J-2, J-3, J-4, J-7, J-8, J-9, J-10, J-11, J-12, J-13, J-14, J-15, J-17, J-20, J-21, J-22, J-23, J-24, J-25, J-26, and J-27.

DOE will provide the technical basis for the screening argument, as summarized in Attachment 2, for the highlighted FEPs. The technical basis will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
This issue is addressed by existing agreements between DOE and NRC (ENFE Subissue 1 Agreement 4, ENFE Subissue 4 Agreements 3 and 4, and RT Subissue 1 Agreement 5). Features, Events, and Processes in UZ Flow and Transport, ANL-NBS-MD-000001, will be revised upon completion of this work.

Subissue #2 - Scenario Analysis J-13

Tracking # J-13

Comment 2.2.10.06.00 [Thermo-chemical alteration (solubility, speciation, phase changes, precipitation/dissolution)] is excluded from the Total System Performance Assessment - Site Recommendation abstraction of radionuclide transport in the unsaturated zone on the basis of low consequence (CRWMS M&O, 2001, 2000b). Thermal effects on chemistry at the mountain scale are expected to be low on the basis of near-field coupled thermal-hydrological-chemical models that indicate the thermal effects of the repository result in only small changes in major hydrochemical constituents and limited changes in mineralogy. However, the model results in the cited report (CRWMS M&O, 2000a) only consider a few components in hydrochemistry important to container life (e.g., pH, total carbon, Ca), is limited to calcite precipitation/dissolution, and addresses only seepage water chemistry. Thermo-chemical effects on transport beneath the repository, which could reflect the influence of engineered barrier subsystem and waste form materials, are not considered. In addition, although the assumption that far-field changes are likely to be less than near-field changes is reasonable, it has not been verified (CRWMS M&O, 2001). The technical basis is not sufficient at this time to demonstrate low consequence. The evaluation of this exclusion will depend in part on the verification of Assumption 11 that far-field changes to radionuclide transport in the unsaturated zone will be less than calculated near-field changes (CRWMS M&O, 2001).

References CRWMS M&O. "Drift-Scale Coupled Processes (DST and THC Seepage) Models." MDL-NBS-HS-000001 Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000a.
CRWMS M&O. "Unsaturated Zone Flow and Transport Model Process Model Report." TDR-NBS-HS-000002. Revision 00 ICN02. Las Vegas, Nevada: CRWMS M&O. 2000b.
CRWMS M&O. "Features, Events, and Processes in UZ Flow and Transport." ANL-NBS-MD-000001 Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001.

DOE Response Assumption 11 is designated as needing further verification prior to any potential license application. The technical work used to resolve Evolution of Near Field Environment agreements 1.4, 4.3, 4.4, and Radionuclide Transport 1.5 will be sufficient to provide the additional technical bases needed for the FEPs screening argument.. These agreements will take into account thermal-hydrological-chemical effects on radionuclide transport out of the drift.

Agreement Number TSPAI.2.02

Agreement Provide the technical basis for the screening argument, as summarized in Attachment 2. See Comment # 3, 4, 11, 12, 19

(Parts 1, 2, and 6), 25, 26, 29, 34, 35, 36, 37, 38, 39, 42, 43, 44, 48, 49, 51, 54, 55, 56, 57, 59, 60, 61, 62, 63, 64, 65, 66, 68, 69, 70, 78, 79, J-1, J-2, J-3, J-4, J-7, J-8, J-9, J-10, J-11, J-12, J-13, J-14, J-15, J-17, J-20, J-21, J-22, J-23, J-24, J-25, J-26, and J-27.

DOE will provide the technical basis for the screening argument, as summarized in Attachment 2, for the highlighted FEPs. The technical basis will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
This issue is addressed by existing agreements between DOE and NRC (ENFE Subissue 1 Agreement 4, ENFE Subissue 4 Agreements 3 and 4, and RT Subissue 1 Agreement 5). Features, Events, and Processes in UZ Flow and Transport, ANL-NBS-MD-000001, will be revised upon completion of this work.

Subissue #2 - Scenario Analysis J-14

Tracking # J-14

Comment 2.2.10.07.00 (Thermo-chemical alteration of the Calico Hills unit) is excluded from the Total System Performance Assessment - Site Recommendation abstraction of radionuclide transport in the unsaturated zone on the basis of low consequence (CRWMS M&O, 2001). The screening argument is based on prediction of small changes in aqueous geochemistry and mineralogy in response to coupled thermal-hydrological-chemical processes in the near-field (CRWMS M&O, 2000a). Thermo-chemical changes in the far-field, including the Calico Hills unit will be even less significant (Assumption 11, CRWMS M&O, 2001). The screening argument indicates that temperatures in the zeolite-bearing Calico Hills unit will not be high enough to cause significant zeolite alteration. Because the radionuclide transport abstraction assumes no retardation in fractures, this exclusion may be appropriate. Again, final evaluation of this exclusion will depend in part on the verification of Assumption 11 that far-field changes to radionuclide transport in the unsaturated zone will be less than calculated near-field changes (CRWMS M&O, 2001). Alteration of the uppermost nonwelded layers below the repository could significantly reduce the fraction of matrix flow below the repository. Nonwelded vitric horizons, either basal Topopah Springs vitrophyre or the uppermost Calico Hills unit, cover nearly half of the repository. In the southwestern portion of the repository footprint, the nonwelded, nonaltered tuffs lie as little as 45 m below the repository. The screening argument (CRWMS M&O, 2001) includes the assertion that temperatures in the Calico Hills unit will remain below 70°C, which is not high enough to cause significant zeolite alteration. According to the cited reference, however, it appears temperatures can exceed 70°C (up to 85°C is estimated from figures in cited section of CRWMS M&O, 2000b) where the nonwelded, nonaltered tuff is closest to the repository.

References

CRWMS M&O. "Drift-Scale Coupled Processes (DST and THC Seepage) Models." MDL-NBS-HS-000001 Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000a.

CRWMS M&O. "Mountain Scale Coupled Processes." MDL-NBS-HS-000007. Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000b.

CRWMS M&O. "Features, Events, and Processes in UZ Flow and Transport." ANL-NBS-MD-000001 Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001.

DOE Response Assumption 11 is designated as needing further verification prior to any potential license application. The technical work used to resolve Evolution of Near Field Environment agreements 1.4, 4.3, 4.4, and Radionuclide Transport 1.5 will be sufficient to provide the additional technical bases needed for the FEPs screening

argument. These agreements will take into account thermal-hydrological-chemical effects on radionuclide transport out of the drift.

Alteration temperature of 85°C for zeolite is given in the Yucca Mountain Site Description - Section 6 Geochemistry, Section 6.1.5.3.1, page 6.1-129.

Reference: Yucca Mountain Site Description, Revision 00, September 1998 - (Document Id B00000000-01717-5700-00019) Book 3, Frontmatter And Section 6 - Geochemistry

Agreement Number TSPAI.2.02

Agreement Provide the technical basis for the screening argument, as summarized in Attachment 2. See Comment # 3, 4, 11, 12, 19 (Parts 1, 2, and 6), 25, 26, 29, 34, 35, 36, 37, 38, 39, 42, 43, 44, 48, 49, 51, 54, 55, 56, 57, 59, 60, 61, 62, 63, 64, 65, 66, 68, 69, 70, 78, 79, J-1, J-2, J-3, J-4, J-7, J-8, J-9, J-10, J-11, J-12, J-13, J-14, J-15, J-17, J-20, J-21, J-22, J-23, J-24, J-25, J-26, and J-27.

DOE will provide the technical basis for the screening argument, as summarized in Attachment 2, for the highlighted FEPs. The technical basis will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
This issue is addressed by existing agreements between DOE and NRC (ENFE Subissue 1 Agreement 4, ENFE Subissue 4 Agreements 3 and 4, and RT Subissue 1 Agreement 5). Features, Events, and Processes in UZ Flow and Transport, ANL-NBS-MD-000001, will be revised upon completion of this work.

DOE also stated that alteration of vitric rock has not been addressed and will need to be included in the overall thermal-hydrological-chemical analyses.

Subissue #2 - Scenario Analysis J-15

Tracking # J-15

Comment 2.2.10.09.00 (Thermo-chemical alteration of the Topopah Spring basal vitrophyre) is excluded from the Total System Performance Assessment - Site Recommendation abstraction of radionuclide transport in the unsaturated zone on the basis of low consequence (CRWMS M&O, 2001, 2000b). The screening argument is based on prediction of small changes in aqueous geochemistry and mineralogy in response to coupled thermal-hydrological-chemical processes in the near-field (CRWMS M&O, 2000a). Thermo-chemical changes in the far-field, including the Topopah Spring basal vitrophyre, are expected to be even less significant (CRWMS M&O, 2001). Although the assumption that far-field changes are likely to be less than near-field changes (Assumption 11) is reasonable, it has not been verified (CRWMS M&O, 2001). It is important to note that the near-field analyses (CRWMS M&O, 2000a) are performed with a focus on seepage chemistry and how it might affect container life, rather than with the purpose of considering thermal effects on radionuclide transport. The technical basis is not sufficient at this time to demonstrate low consequence to radionuclide transport. Because the Total System Performance Assessment-Site Recommendation radionuclide transport abstraction assumes no retardation in fractures, this exclusion may be appropriate. Again, final evaluation of this exclusion will depend on the verification of Assumption 11 that far-field changes to radionuclide transport in the unsaturated zone will be less than calculated near-field changes (CRWMS M&O, 2001).

Alteration of the uppermost nonwelded layers below the repository could significantly reduce the fraction of matrix flow below the repository. Nonwelded vitric horizons, either basal Topopah Spring vitrophyre or the uppermost Calico Hills unit, cover nearly half of the repository. In the southwestern portion of the repository footprint, the nonwelded, nonaltered tuffs lie as little as 45 m below the repository. The screening argument for 2.2.10.07.00 (CRWMS M&O, 2001) includes the assertion that temperatures in the Calico Hills unit will remain below 70°C, which is not high enough to cause significant zeolite alteration. According to the cited reference, however, it appears temperatures can exceed 70°C (up to 85°C is estimated from figures in cited section of CRWMS M&O, 2000dd) where the nonwelded, nonaltered tuff is closest to the repository. Temperatures would be higher in the overlying Topopah Spring basal vitrophyre than in the Calico Hills.

References

CRWMS M&O. "Drift-Scale Coupled Processes (DST and THC Seepage) Models." MDL-NBS-HS-000001 Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000a.

CRWMS M&O. "Unsaturated Zone Flow and Transport Model

Process Model Report." TDR-NBS-HS-000002. Revision 00 ICN02. Las Vegas, Nevada: CRWMS M&O. 2000b.
CRWMS M&O. "Features, Events, and Processes in UZ Flow and Transport." ANL-NBS-MD-000001 Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001.

DOE Response Assumption 11 is designated as needing further verification prior to any potential license application. The technical work used to resolve Evolution of Near Field Environment agreements 1.4, 4.3, 4.4, and Radionuclide Transport 1.5 will be sufficient to provide the additional technical bases needed for the FEPs screening argument. These agreements will take into account thermal-hydrological-chemical effects on radionuclide transport out of the drift.

See response for J-14 above. Alteration of vitric rock has not been addressed and will need to be included in the overall thermal-hydrological-chemical analyses.

Regarding the maximum predicted temperatures in the CHn, the Mountain-Scale Coupled Processes Analysis/Model Report (CRWMS M&O 2000af, p. 94) states: "At the top of the CHn hydrogeologic unit, the maximum temperature rises to 75-80ºC for a period between 2000 and 7000 years."

Reference: CRWMS M&O 2000af. Mountain-Scale Coupled Processes (TH) Models. MDL-NBS-HS-000007 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19990721.0528.

Agreement Number TSPAI.2.02

Agreement Provide the technical basis for the screening argument, as summarized in Attachment 2. See Comment # 3, 4, 11, 12, 19 (Parts 1, 2, and 6), 25, 26, 29, 34, 35, 36, 37, 38, 39, 42, 43, 44, 48, 49, 51, 54, 55, 56, 57, 59, 60, 61, 62, 63, 64, 65, 66, 68, 69, 70, 78, 79, J-1, J-2, J-3, J-4, J-7, J-8, J-9, J-10, J-11, J-12, J-13, J-14, J-15, J-17, J-20, J-21, J-22, J-23, J-24, J-25, J-26, and J-27.

DOE will provide the technical basis for the screening argument, as summarized in Attachment 2, for the highlighted FEPs. The technical basis will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
This issue is addressed by existing agreements between DOE and NRC (ENFE Subissue 1 Agreement 4, ENFE Subissue 4 Agreements 3 and 4, and RT Subissue 1 Agreement 5). Features, Events, and Processes in UZ Flow and Transport, ANL-NBS-MD-000001, will be revised upon completion of this work.

Subissue #2 - Scenario Analysis J-16

Tracking # J-16

Comment 1.2.07.01.00 (Erosion/denudation) is screened as excluded on the basis of low consequence (CRWMS M&O, 2001). It is considered that the rationale for excluding from unsaturated zone on the basis of low consequence is incomplete. It is necessary to consider onset and extent of erosion caused by construction and characterization activity at the ground surface and its long term effect on shallow infiltration.

References CRWMS M&O. "Features, Events, and Processes in UZ Flow and Transport." ANL-NBS-MD-000001 Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001.

DOE Response DOE will include reference to the site Reclamation Implementation Plan, YMP/91-14 for post-closure to address this aspect of the FEP.

Reference: YMP 2001. Reclamation Implementation Plan. YMP/91-14, Rev. 2. Las Vegas, Nevada: Yucca Mountain Site Characterization Office. ACC: MOL.20010301.0238.

Agreement Number TSPAI.2.01

Agreement Provide clarification of the screening arguments, as summarized in Attachment 2. See Comment # 5, 7, 8, 9, 10, 13, 18, 19 (Part 5), 21, 32, 41, 47, 50, 53, 58, 67, J-5, J-16, and J-18

DOE will clarify the screening arguments, as summarized in Attachment 2, for the highlighted FEPs. The clarifications will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
DOE agreed to provide clarification of the screening argument in the Features, Events, and Processes in UZ Flow and Transport, ANL-NBS-MD-000001, to address the NRC comment.

Subissue #2 - Scenario Analysis J-17

Tracking # J-17

Comment 1.2.10.02.00 (Hydrologic response to igneous activity). Excluded based on low consequence (CRWMS M&O, 2001). Argument to exclude focuses on intrusive events. It should be noted that extrusive events could increase shallow infiltration over the repository in two ways: (1) lava flow would modify or dam a wash overlying the repository, (2) volcanic fragment and ash layer, which would be highly permeable, may act to trap infiltrating water, shield it from evaporation, and reduce transpiration all leading to increased shallow infiltration across the repository. There is no data to support or exclude the temporal extent of increased shallow infiltration, though could be bounded from decades to thousands of years.

References CRWMS M&O. "Features, Events, and Processes in UZ Flow and Transport." ANL-NBS-MD-000001 Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001.

DOE Response DOE will consider revisiting the low consequence arguments concerning extrusive volcanic events on infiltration (including effects on surface vegetation) for this FEP. Consideration will be given to including low probability arguments.

Agreement Number TSPAI.2.02

Agreement Provide the technical basis for the screening argument, as summarized in Attachment 2. See Comment # 3, 4, 11, 12, 19 (Parts 1, 2, and 6), 25, 26, 29, 34, 35, 36, 37, 38, 39, 42, 43, 44, 48, 49, 51, 54, 55, 56, 57, 59, 60, 61, 62, 63, 64, 65, 66, 68, 69, 70, 78, 79, J-1, J-2, J-3, J-4, J-7, J-8, J-9, J-10, J-11, J-12, J-13, J-14, J-15, J-17, J-20, J-21, J-22, J-23, J-24, J-25, J-26, and J-27.

DOE will provide the technical basis for the screening argument, as summarized in Attachment 2, for the highlighted FEPs. The technical basis will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
DOE agreed to provide the technical basis for the screening argument in the Features, Events, and Processes in UZ Flow and Transport, ANL-NBS-MD-000001, screening argument to address the NRC comment

Subissue #2 - Scenario Analysis J-18

Tracking # J-18

Comment 1.3.04.00.00 (Periglacial effects). Excluded by low probability (CRWMS M&O, 2001). While other periglacial processes will not likely occur at Yucca Mountain, the freeze/thaw process is currently active. Freeze/thaw mechanical erosion will likely increase as the climate cools. However, the magnitude of erosion will not likely be significant even during the cooler climate condition. The screening argument should clarified to acknowledge the current freeze/thaw process.

References CRWMS M&O. "Features, Events, and Processes in UZ Flow and Transport." ANL-NBS-MD-000001 Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001.

DOE Response DOE will clarify the screening argument in next revision of FEPs Analysis/Model Report to acknowledge the current freeze/thaw process.

Reference: BSC 2001b. Features, Events, and Processes in UZ Flow and Transport. ANL-NBS-MD-000001 REV 01. Las Vegas, Nevada: Bechtel SAIC Company. ACC: MOL.20010423.0321.

Agreement Number TSPAI.2.01

Agreement Provide clarification of the screening arguments, as summarized in Attachment 2. See Comment # 5, 7, 8, 9, 10, 13, 18, 19 (Part 5), 21, 32, 41, 47, 50, 53, 58, 67, J-5, J-16, and J-18

DOE will clarify the screening arguments, as summarized in Attachment 2, for the highlighted FEPs. The clarifications will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
DOE agreed to provide clarification of the screening argument in the Features, Events, and Processes in UZ Flow and Transport, ANL-NBS-MD-000001, to address the NRC comment.

Subissue #2 - Scenario Analysis J-19

Tracking # J-19

Comment 2.1.05.01.00 (Seal physical properties). Excluded based on low consequence (CRWMS M&O, 2001). It is difficult to assess this item solely based on the screening argument provided. The assessment can be done once the actual design (ventilation tunnel locations) is released, backfill is described, and the analysis of runoff and flooding incorporated into the screening argument 2.1.05.02.00 (Groundwater flow and radionuclide transport in seals) and 2.1.05.03.00 (Seal degradation). Excluded based on low consequence, using screening argument for 2.1.05.01.00 (Seal physical properties). The adequacy of the screening argument cannot be assessed until the actual design (ventilation tunnel locations) is released, backfill is described, and the analysis of runoff and flooding is incorporated into the screening arguments.

References CRWMS M&O. "Features, Events, and Processes in UZ Flow and Transport." ANL-NBS-MD-000001 Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001.

DOE Response As indicated in the May 2001 FEPs Technical Exchange, DOE will adopt a more rigorous configuration controls as the design advances. These controls will identify FEP screening argument that could potentially change when design changes occur.

Agreement Number

Agreement DOE response during Technical Exchange was considered adequate by the NRC. Total System Performance Assessment and Integration Technical Exchange, August 6-10, 2001.

Subissue #2 - Scenario Analysis J-20

Tracking # J-20

Comment 2.2.07.05.00 (Flow and transport in the unsaturated zone from episodic infiltration). Excluded based on low consequence (CRWMS M&O, 2001b). Screening argument asserts that episodic infiltration is expected to be attenuated by flow in the paintbrush nonwelded tuff layer such that unsaturated zone flow beneath this layer is effectively steady-state. Analyses to support this assertion, however, have only considered episodic infiltration with an average of 5 mm/yr infiltration flux. Area-average infiltration flux over the proposed repository horizon at YM is expected to exceed 20 mm/yr during future wetter climate conditions.

References CRWMS M&O. "Features, Events, and Processes in UZ Flow and Transport." ANL-NBS-MD-000001 Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001.

DOE Response The technical work used to resolve Unsaturated and Saturated Flow under Isothermal Conditions agreement 4.4 will be sufficient to provide the additional technical bases needed for the FEPs screening argument. This agreement will address episodic flow in the repository. An analysis of 36 Cl will be included with respect to fast pathways through the PTn.

Treatment of undetected features in PTn can be addressed through an analysis of 36Cl measurements in the TSw (which identifies fast pathways through the PTn). This will be added to the FEP argument.

Agreement Number TSPAI.2.02

Agreement Provide the technical basis for the screening argument, as summarized in Attachment 2. See Comment # 3, 4, 11, 12, 19 (Parts 1, 2, and 6), 25, 26, 29, 34, 35, 36, 37, 38, 39, 42, 43, 44, 48, 49, 51, 54, 55, 56, 57, 59, 60, 61, 62, 63, 64, 65, 66, 68, 69, 70, 78, 79, J-1, J-2, J-3, J-4, J-7, J-8, J-9, J-10, J-11, J-12, J-13, J-14, J-15, J-17, J-20, J-21, J-22, J-23, J-24, J-25, J-26, and J-27.

DOE will provide the technical basis for the screening argument, as summarized in Attachment 2, for the highlighted FEPs. The technical basis will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
This issue is addressed by existing agreements between DOE and NRC (USFIC Subissue 4 Agreement 4). Features, Events, and Processes in UZ Flow and Transport, ANL-NBS-MD-000001, will be revised upon completion of this work.

Subissue #2 - Scenario Analysis J-21

Tracking # J-21

Comment 2.2.11.02.00 (Gas pressure effects) is excluded based on low consequence and low probability (CRWMS M&O, 2001). Consistency is needed in the screening arguments. Buildup of water vapor pressure withing rock matrix blocks due to waste heat has not been considered. Gas pressure can build up within matrix blocks which have low permeability. This can increase the boiling point and keep water in the liquid phase at higher temperatures. Flashing to vapor as liquid water leaves the matrix block can result in mineral deposition that can later affect flow pathways.

References CRWMS M&O. "Features, Events, and Processes in UZ Flow and Transport." ANL-NBS-MD-000001 Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001.

DOE Response The technical arguments for this issue (related to repository heating) are addressed as part of the thermal-hydrological-chemical analyses. Additional technical work related to the Evolution of Near Field agreements 1.5, 1.7 and 2.16 will be sufficient to provide the additional technical bases needed for the FEPs screening argument. These agreements will address thermal-hydrological-chemical affects on mineral precipitation. DOE will cross-reference this FEP with FEPs treating thermal-hydrological-chemical effects: 2.2.08.02.00 (Geochemical interactions in geosphere (dissolution, precipitation, weathering) and effects on radionuclide transport), 2.2.10.01.00 (Repository induced thermal effects in geosphere) and 2.2.10.06.00 (Thermo-chemical alteration (solubility, speciation, phase changes, precipitation/dissolution)).

Agreement Number TSPAI.2.02

Agreement Provide the technical basis for the screening argument, as summarized in Attachment 2. See Comment # 3, 4, 11, 12, 19 (Parts 1, 2, and 6), 25, 26, 29, 34, 35, 36, 37, 38, 39, 42, 43, 44, 48, 49, 51, 54, 55, 56, 57, 59, 60, 61, 62, 63, 64, 65, 66, 68, 69, 70, 78, 79, J-1, J-2, J-3, J-4, J-7, J-8, J-9, J-10, J-11, J-12, J-13, J-14, J-15, J-17, J-20, J-21, J-22, J-23, J-24, J-25, J-26, and J-27.

DOE will provide the technical basis for the screening argument, as summarized in Attachment 2, for the highlighted FEPs. The technical basis will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
This issue is addressed by existing agreements between DOE and NRC (ENFE Subissue 1 Agreements 5 and 7, and ENFE Subissue 4 Agreement 3). Features, Events, and Processes in UZ Flow and Transport, ANL-NBS-MD-000001, will be revised upon completion

of this work.

Subissue #2 - Scenario Analysis J-22

Tracking # J-22

Comment 1.2.04.02.00 (Igneous activity causes changes to rock properties) is screened as excluded from the radionuclide transport in the unsaturated zone abstraction, on the basis of low consequence (CRWMS M&O, 2000b, 2001). Although several of the arguments presented (scale, duration) may be reasonable, natural analogs (CRWMS M&O, 2000a) suggest time scales of thousands of years (Ratcliff et al., 1984) and alteration scales of tens of meters. Furthermore, modeling studies of the effects of silica redistribution on fracture porosity and permeability (CRWMS M&O, 2000a) have yielded conflicting results (Matyskiela, 1997), suggesting additional clarification is needed. Probability may also be an aspect to use in developing an screening argument for 1.2.04.02.00, provided it is consistent with the probabilities used for the igneous disruptive scenario.

References CRWMS M&O. "Natural Analogs for the Unsaturated Zone." ANL-NBS-HS-000007. Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000a.
CRWMS M&O. "Unsaturated Zone Flow and Transport Model Process Model Report." TDR-NBS-HS-000002. Revision 00 ICN02. Las Vegas, Nevada: CRWMS M&O. 2000b.
CRWMS M&O. "Features, Events, and Processes in UZ Flow and Transport." ANL-NBS-MD-000001 Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001.
Matyskiela, W. "Silica Redistribution and Hydrologic Changes in Heated Fractured Tuff." Geology. Vol. 25. pp. 1115-1118. 1997.
Ratcliff, C.D., J.W. Geissman, F.V. Perry, B.M. Crowe, and P.K. Zeitler. "Paleomagnetic Record of a Geomagnetic Field Reversal from Late Miocene Mafic Intrusions." Science. Vol. 266. pp. 412-416. 1994.

DOE Response DOE will consider probability arguments to exclude larger intrusive events that may induce hydrothermal activity and pervasive alteration of country rock. The particular issues raised by the work of Matyskiela (1997) will be addressed through the Evolution of Near Field agreements 1.7, 1.5, and 4.3. The agreements will include a resolution of the differences in behavior predicted by Matyskiela (1997) and Hardin (1998), Near Field/Altered Zone Models MOL.19980504.0577).

References: Matyskiela, W. 1997. "Silica Redistribution and Hydrologic Changes in Heated Fractured Tuff." Geology, 25, (12), 1115-1118. Boulder, Colorado: Geological Society of America. TIC: 236809.

Hardin, E.L. 1998. Near-Field/Altered-Zone Models Report. UCRL-ID-129179 DR. Livermore, California: Lawrence Livermore

National Laboratory. ACC: MOL.19980504.0577.

Agreement Number TSPAI.2.02

Agreement Provide the technical basis for the screening argument, as summarized in Attachment 2. See Comment # 3, 4, 11, 12, 19 (Parts 1, 2, and 6), 25, 26, 29, 34, 35, 36, 37, 38, 39, 42, 43, 44, 48, 49, 51, 54, 55, 56, 57, 59, 60, 61, 62, 63, 64, 65, 66, 68, 69, 70, 78, 79, J-1, J-2, J-3, J-4, J-7, J-8, J-9, J-10, J-11, J-12, J-13, J-14, J-15, J-17, J-20, J-21, J-22, J-23, J-24, J-25, J-26, and J-27.

DOE will provide the technical basis for the screening argument, as summarized in Attachment 2, for the highlighted FEPs. The technical basis will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
This issue is addressed by existing agreements between DOE and NRC (ENFE Subissue 1 Agreement 4, ENFE Subissue 4 Agreements 3 and 4, and RT Subissue 1 Agreement 5). Features, Events, and Processes in UZ Flow and Transport, ANL-NBS-MD-000001, will be revised upon completion of this work.

Subissue #2 - Scenario Analysis J-23

Tracking # J-23

Comment 1.2.06.00.00 (Hydrothermal activity). Excluded on the basis of low consequence for basaltic magmatism, and low probability for silicic magmatism (CRWMS M&O, 2001). A consistent approach for the screening arguments is needed. Screening argument is considered incomplete as (i) past hydrothermal activity in the Yucca Mountain region is not clearly related to basaltic igneous activity, and (ii) probability screening arguments in CRWMS M&O (2001) are incomplete with respect to silicic magmatism. In addition, the DOE cites unpublished work by the U.S. Geological Survey and University of Nevada, Las Vegas that reportedly demonstrates hydrothermal activity was a site characteristic until about 2 Ma. Additional unpublished work by Dublyanski and others, however, does not support this conclusion. None of the unpublished work, however, has supported the conclusion that the likelihood of hydrothermal activity at YM during the next 10,000 yr is clearly less than 1 in 10,000. Absent a clear linkage to the consequences of basaltic igneous activity, or a demonstrated technical basis for probability values below 1 in 10,000 in 10,000 yr, the DOE has an incomplete technical basis to screen 1.2.06.00.00 from further consideration.

References CRWMS M&O. "Features, Events, and Processes in UZ Flow and Transport." ANL-NBS-MD-000001 Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001.

DOE Response The technical work used to resolve Evolution of Near Field agreement 2.3 will be sufficient to provide the additional technical bases needed for the FEPs screening argument.

Agreement Number TSPAI.2.02

Agreement Provide the technical basis for the screening argument, as summarized in Attachment 2. See Comment # 3, 4, 11, 12, 19 (Parts 1, 2, and 6), 25, 26, 29, 34, 35, 36, 37, 38, 39, 42, 43, 44, 48, 49, 51, 54, 55, 56, 57, 59, 60, 61, 62, 63, 64, 65, 66, 68, 69, 70, 78, 79, J-1, J-2, J-3, J-4, J-7, J-8, J-9, J-10, J-11, J-12, J-13, J-14, J-15, J-17, J-20, J-21, J-22, J-23, J-24, J-25, J-26, and J-27.

DOE will provide the technical basis for the screening argument, as summarized in Attachment 2, for the highlighted FEPs. The technical basis will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
This issue is addressed by existing agreements between DOE and NRC (ENFE Subissue 2 Agreement 3). Features, Events, and Processes in UZ Flow and Transport, ANL-NBS-MD-000001, will be revised upon completion of this work.

Subissue #2 - Scenario Analysis J-24

Tracking # J-24

Comment 1.2.04.07.00 (Ashfall). The screening argument in (CRWMS M&O, 2001) for ashfall impacting the saturated zone [i.e., secondary 1.2.04.07.01 (Soil Leaching Following Ashfall)] includes a three order of magnitude error in the calculation of the concentration of radionuclides in the well water. Although conservative assumptions are used in the analysis, the error found in Table 6-1 would cause the calculated dose to be 16.1 rem, instead of 16.1 mrem, and would not support a low consequence screening argument.

References CRWMS M&O. "Features, Events, and Processes in SZ Flow and Transport." ANL-NBS-MD-000002. Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001.

DOE Response The NRC comment regarding Table 6-1 and a three order of magnitude error in the calculation of the radionuclide concentrations is correct.

The present analysis conservatively assumes instantaneous transport of radionuclides through the unsaturated zone to the water table. Simplified calculations of expected transport times through the unsaturated alluvium for short-to moderately short-lived radionuclides (e.g., Sr-90, Cs-137, Pu-238) indicate a reduction in mass for these radionuclides by many orders of magnitude. Consequently, these radionuclides can be removed from consideration in the analysis presented in Table 6-1. The screening argument will be expanded to consider loss of radionuclide mass by radioactive decay during transport through the unsaturated zone. The error noted in the calculation of the radionuclide concentrations in Table 6-1 will be corrected for the more restricted list of radionuclides and the results will be used as support for the low consequence screening argument. The expanded screening argument and corrected calculations will be documented in a revised version of the Saturated Zone FEPs Analysis/Model Report (CRWMS M&O 2001c).

Reference: CRWMS M&O 2001c. Features, Events, and Processes in SZ Flow and Transport. ANL-NBS-MD-000002 REV 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20010214.0230.

Agreement Number TSPAI.2.02

Agreement Provide the technical basis for the screening argument, as summarized in Attachment 2. See Comment # 3, 4, 11, 12, 19 (Parts 1, 2, and 6), 25, 26, 29, 34, 35, 36, 37, 38, 39, 42, 43, 44, 48, 49, 51, 54, 55, 56, 57, 59, 60, 61, 62, 63, 64, 65, 66, 68, 69, 70, 78, 79, J-1, J-2, J-3, J-4, J-7, J-8, J-9, J-10, J-11, J-12, J-13, J-14,

J-15, J-17, J-20, J-21, J-22, J-23, J-24, J-25, J-26, and J-27.

DOE will provide the technical basis for the screening argument, as summarized in Attachment 2, for the highlighted FEPs. The technical basis will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
DOE agreed to provide the technical basis for the screening argument in the Features, Events, and Processes in SZ Flow and Transport, ANL-NBS-MD-000002 screening argument to address the NRC comment.

Subissue #2 - Scenario Analysis J-25

Tracking # J-25

Comment 1.2.02.02.00 (Faulting). Changes of fault characteristics has been screened as excluded on the basis of low consequence (CRWMS M&O, 2001); and formation of new faults has been excluded on the basis of low probability. 1.2.02.03.00 (Fault Movement Shears Waste Container) has been excluded on the basis of low probability.1.2.03.02.00 (Seismic Vibration Causes Container Failure) has been excluded on the basis of low consequence (CRWMS M&O, 2001). In these items, DOE's screening argument relies, in large part, upon the median values of fault displacements and ground motions for postclosure (less than 10-6/year), rather than the mean values. The screening arguments do not provide sufficient technical justification for staff review. The staff considers that the mean more reliably incorporates uncertainty and is a more reasonable and prudent statistical measure than the median. DOE has agreed to address this concern in a forthcoming Request for Additional Information.

References CRWMS M&O. "Features, Events, and Processes: Screening for Disruptive Events." ANL-WIS-MD-000005. Revision 00 ICN 01. CRWMS M&O. 2001.

DOE Response DOE will address this concern in the forthcoming Request for Additional Information.

Agreement Number TSPAI.2.02

Agreement Provide the technical basis for the screening argument, as summarized in Attachment 2. See Comment # 3, 4, 11, 12, 19 (Parts 1, 2, and 6), 25, 26, 29, 34, 35, 36, 37, 38, 39, 42, 43, 44, 48, 49, 51, 54, 55, 56, 57, 59, 60, 61, 62, 63, 64, 65, 66, 68, 69, 70, 78, 79, J-1, J-2, J-3, J-4, J-7, J-8, J-9, J-10, J-11, J-12, J-13, J-14, J-15, J-17, J-20, J-21, J-22, J-23, J-24, J-25, J-26, and J-27.

DOE will provide the technical basis for the screening argument, as summarized in Attachment 2, for the highlighted FEPs. The technical basis will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
This issue is addressed by existing agreements between DOE and NRC (SDS Subissue 1 Agreement 2) and an NRC letter dated August 3, 2001. Features, Events, and Processes: Screening for Disruptive Events, ANL-WIS-MD-000005 will be revised upon completion of this work.

Subissue #2 - Scenario Analysis J-26

Tracking # J-26

Comment The screening argument for 1.2.02.03.00 (Fault Movement Shears Waste Container) is based, in part, on specific setback distances that will be used by U.S. Department of Energy in the repository design (CRWMS M&O, 2001). The setback distances are a function of fault displacement magnitudes. Thus, the setback values used in the design may need to be reassessed after the displacement issue is resolved.

References CRWMS M&O. "Features, Events, and Processes: Screening for Disruptive Events." ANL-WIS-MD-000005. Revision 00 ICN 01. CRWMS M&O. 2001.

DOE Response DOE will address this concern in the forthcoming Request for Additional Information.

Agreement Number TSPAI.2.02

Agreement Provide the technical basis for the screening argument, as summarized in Attachment 2. See Comment # 3, 4, 11, 12, 19 (Parts 1, 2, and 6), 25, 26, 29, 34, 35, 36, 37, 38, 39, 42, 43, 44, 48, 49, 51, 54, 55, 56, 57, 59, 60, 61, 62, 63, 64, 65, 66, 68, 69, 70, 78, 79, J-1, J-2, J-3, J-4, J-7, J-8, J-9, J-10, J-11, J-12, J-13, J-14, J-15, J-17, J-20, J-21, J-22, J-23, J-24, J-25, J-26, and J-27.

DOE will provide the technical basis for the screening argument, as summarized in Attachment 2, for the highlighted FEPs. The technical basis will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
This issue is addressed by existing agreements between DOE and NRC (SDS Subissue 1 Agreement 2) and an NRC letter dated August 3, 2001. Features, Events, and Processes: Screening for Disruptive Events, ANL-WIS-MD-000005 will be revised upon completion of this work.

Subissue #2 - Scenario Analysis J-27

Tracking # J-27

Comment 1.2.03.01.00 (Seismic activity) has been screened as excluded on the basis of low consequence of effects on such components as drip shield and waste package, and included with regard to effects on cladding (CRWMS M&O, 2001). The distributions for ground-motion parameters were developed using the Probabilistic Seismic Hazard Assessment expert elicitation. There are apparent discrepancies among these input parameters from several experts. DOE has agreed to address this concern in a forthcoming Request for Additional Information.

References CRWMS M&O. "Features, Events, and Processes: Screening for Disruptive Events." ANL-WIS-MD-000005. Revision 00 ICN 01. CRWMS M&O. 2001.

DOE Response DOE will address this concern in the forthcoming Request for Additional Information.

Agreement Number TSPAI.2.02

Agreement Provide the technical basis for the screening argument, as summarized in Attachment 2. See Comment # 3, 4, 11, 12, 19 (Parts 1, 2, and 6), 25, 26, 29, 34, 35, 36, 37, 38, 39, 42, 43, 44, 48, 49, 51, 54, 55, 56, 57, 59, 60, 61, 62, 63, 64, 65, 66, 68, 69, 70, 78, 79, J-1, J-2, J-3, J-4, J-7, J-8, J-9, J-10, J-11, J-12, J-13, J-14, J-15, J-17, J-20, J-21, J-22, J-23, J-24, J-25, J-26, and J-27.

DOE will provide the technical basis for the screening argument, as summarized in Attachment 2, for the highlighted FEPs. The technical basis will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
This issue is addressed by existing agreements between DOE and NRC (SDS Subissue 2 Agreement 1) and an NRC letter dated August 3, 2001. Features, Events, and Processes: Screening for Disruptive Events, ANL-WIS-MD-000005, will be revised upon completion of this work.

Subissue #2 - Scenario Analysis SA-3

Tracking # SA-3

Comment 2.2.10.03.00 (Natural geothermal effects). It is stated that natural geothermal effects are included because the current geothermal gradient is addressed in the SZFT model (CRWMS M&O, 2001). However, this discussion does not address the potential for spatial and temporal variation in that gradient, which is part of the description of 2.2.10.03.00. Resolution of this issue is necessary to address the issue of changes in the geothermal gradient in 2.2.10.13.00 [Density-driven groundwater flow (thermal)].

References CRWMS M&O. "Features, Events, and Processes in SZ Flow and Transport." ANL-NBS-MD-000002. Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001.

DOE Response Response same as 2.2.10.13.00 - Density-driven groundwater flow from natural thermal effects due to hydrothermal activity could result in greater dilution of radionuclide concentrations due to convection, as discussed in the section on Feature, Event and Process 1.2.06.00.00 in the Saturated Zone Features, Events and Processes Analysis/Model Report (CRWMS M&O 2001f). In addition, potential impacts due to increased groundwater flow rates in the Saturated Zone are captured within the range of uncertainty in specific discharge analyzed in the Saturated Zone site-scale flow and transport model for Total System Performance Assessment-Site Recommendation (CRWMS M&O 2000aq). Specific discharge in the Saturated Zone is scaled upward by a factor of 10 for a significant number of realizations of the Saturated Zone flow and transport system (CRWMS M&O. 2000ar).

References

CRWMS M&O 2001f. Features, Events, and Processes in SZ Flow and Transport. ANL-NBS-MD-000002 REV 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20010214.0230. CRWMS M&O 2000ar. Uncertainty Distribution for Stochastic Parameters. ANL-NBS-MD-000011 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20000526.0328.

Agreement Number TSPAI.2.02

Agreement Provide the technical basis for the screening argument, as summarized in Attachment 2. See Comment # 3, 4, 11, 12, 19 (Parts 1, 2, and 6), 25, 26, 29, 34, 35, 36, 37, 38, 39, 42, 43, 44, 48, 49, 51, 54, 55, 56, 57, 59, 60, 61, 62, 63, 64, 65, 66, 68, 69, 70, 78, 79, J-1, J-2, J-3, J-4, J-7, J-8, J-9, J-10, J-11, J-12, J-13, J-14, J-15, J-17, J-20, J-21, J-22, J-23, J-24, J-25, J-26, and J-27.

DOE will provide the technical basis for the screening argument, as summarized in Attachment 2, for the highlighted FEPs. The

technical basis will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
This issue is addressed by existing DOE/NRC agreement (USFIC Subissue 5 Agreement 13). The Features, Events, and Processes in SZ Flow and Transport, ANL-NBS-MD-000002, will be updated as necessary to reflect the results of this existing agreement.

Subissue #2 - Scenario Analysis SA-4

Tracking # SA-4

Comment 1.2.06.00.00 (Hydrothermal activity). In (CRWMS M&O, 2001), this item is excluded on the basis of low consequence. For saturated zone transport, the argument is that the adopted Kd distributions account for possible lithologic changes and thermal effects, with reference to CRWMS M&O (2000). However, the latter document does not provide a clear technical basis that the Kds were derived in such a fashion. In addition, though the screening argument is based on low consequence, there is a reference at the conclusion of the Supplemental Discussion to the low probability of hydrothermal activity (CRWMS M&O, 2001). Resolution of this issue is necessary to address the issue of changes in the geothermal gradient in 2.2.10.13.00 [Density-driven groundwater flow (thermal)]. The DOE should provide a stronger technical basis for the assertion that possible hydrothermal effects on Kd values are accounted for in the total system performance assessment.

References CRWMS M&O. "Uncertainty Distribution for Stochastic Parameters". ANL-NBS-MD-000011. Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000.
CRWMS M&O. "Features, Events, and Processes in SZ Flow and Transport." ANL-NBS-MD-000002. Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001.

DOE Response The approach taken to assigning uncertainty distributions for Kd in the Saturated Zone transport model is to use the most conservative (i.e., lowest Kd values) from among the different volcanic rock types reported in CRWMS M&O (2000as). By taking the most conservative distribution of Kd for all volcanic rock types (including some that have experienced volcanic hydrothermal alteration, such as zeolitization), the Saturated Zone transport analysis implicitly incorporates the consideration of potential future hydrothermal alteration in a conservative manner. It is recognized that the analysis of Kd distributions in CRWMS M&O (2000as) does not directly discuss the issue of hydrothermal alteration, but does include analysis of Kd distributions for zeolitic volcanic units. The reference to low probability at the end of the Supplemental Discussion section is extraneous to the argument of low consequence and will be removed in the next revision of the Saturated Zone Features, Events, and Processes Analysis/Model Report. This comment is addressed in Radionuclide Transport agreement KRT0210. The agreement states in part, AConsistent with the less structured approach for informal expert judgement acknowledged in NUREG-1563 guidance and consistent with AP-3.10Q, DOE will document how it derived the transport distributions for performance assessment. The information obtained from agreement KRT0210 will respond to this comment in full and no

additional work is needed. The Saturated Zone Features, Events, and Processes Analysis/Model Report will be revised, to support any potential License Application, to include the new information obtained from agreement KRT0210.

References:

CRWMS M&O 2000as. Unsaturated Zone and Saturated Zone Transport Properties (U0100). ANL-NBS-HS-000019 REV00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL20000829.0006.

Agreement Number TSPAI.2.02

Agreement Provide the technical basis for the screening argument, as summarized in Attachment 2. See Comment # 3, 4, 11, 12, 19 (Parts 1, 2, and 6), 25, 26, 29, 34, 35, 36, 37, 38, 39, 42, 43, 44, 48, 49, 51, 54, 55, 56, 57, 59, 60, 61, 62, 63, 64, 65, 66, 68, 69, 70, 78, 79, J-1, J-2, J-3, J-4, J-7, J-8, J-9, J-10, J-11, J-12, J-13, J-14, J-15, J-17, J-20, J-21, J-22, J-23, J-24, J-25, J-26, and J-27.

DOE will provide the technical basis for the screening argument, as summarized in Attachment 2, for the highlighted FEPs. The technical basis will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
This issue is addressed by existing DOE/NRC agreements (RT Subissue 1 Agreement 5 and Subissue 2 Agreement 10). The Features, Events, and Processes in SZ Flow and Transport, ANL-NBS-MD-000002, will be updated as necessary to reflect the results of these existing agreements.

Subissue #2 - Scenario Analysis SA-5

Tracking # SA-5

Comment 2.1.09.21.00 (Suspension of particles larger than colloids). The analysis and model report on features, events, and processes in the saturated zone (CRWMS M&O, 2001a) states that these particles will be included and treated as colloids. However, 2.1.09.21.00 (Suspension of particles larger than colloids) is not addressed in the analogous analysis model report for the unsaturated zone (CRWMS M&O, 2001b) and noted as excluded under two other model components in the Yucca Mountain Project Database (CRWMS M&O, 2001c). Furthermore, it is not clear how the effects of particles are included with colloids. 2.1.09.21.00 (Suspension of particles larger than colloids) should be addressed under the scope of (CRWMS M&O, 2001b) and the integration of its disposition across the engineered barrier subsystem, unsaturated zone, and saturated zone should be clarified.

References CRWMS M&O. "Features, Events, and Processes in SZ Flow and Transport." ANL-NBS-MD-000002. Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001a.
CRWMS M&O. "Features, Events, and Processes in UZ Flow and Transport." ANL-NBS-MD-000001 Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001.
CRWMS M&O. "Yucca Mountain FEP Database." TDR-WIS-MD-000003 Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2001c.

DOE Response It should be noted that particles larger than colloids are not included in the Total System Performance Assessment-Site Recommendation (CRWMS M&O 2000aq) analysis and have been explicitly excluded by the waste form and near field environment components of the Total System Performance Assessment. This feature, event and process is identified as potentially included in the Saturated Zone to the extent that it cannot be shown to have sufficiently low consequence to the Saturated Zone component of the analysis. The point is that radionuclides associated with particulate matter (colloids or larger) are treated as colloids in the Saturated Zone analysis, if they are deposited in the Saturated Zone from other components of the Total System Performance Assessment. However, suspension of particles larger than colloids has been excluded from the analysis at the source. If particles larger than colloids are included in the Near Field Environment, Waste Form, and Unsaturated Zone models they will also be included in the Saturated Zone transport model and will be modeled conservatively using the colloid transport model. Likewise if they are excluded in the Near Field Environment, Waste Form, or Unsaturated Zone they will not be included in the Saturated Zone transport model. As indicated in the response to feature, event and

process 1.4.06.01.00 (Altered soil or surface water chemistry) above, the treatment of any feature, event and process will be consistent throughout the Total System Performance Assessment components.

Agreement Number TSPAI.2.01

Agreement Provide clarification of the screening arguments, as summarized in Attachment 2. See Comment # 5, 7, 8, 9, 10, 13, 18, 19 (Part 5), 21, 32, 41, 47, 50, 53, 58, 67, J-5, J-16, and J-18

DOE will clarify the screening arguments, as summarized in Attachment 2, for the highlighted FEPs. The clarifications will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
DOE agreed to provide clarification for the screening argument in the Features, Events, and Processes in SZ Flow and Transport, ANL-NBS-MD-000002, to address the NRC comments.

Subissue #2 - Scenario Analysis SA-6

Tracking # SA-6

Comment Assumptions labeled as To-Be-Verified were found in the following reports: CRWMS M&O (2000), CRWMS M&O (2001a), and CRWMS M&O (2001b).

It is necessary to disclose plans to verify these assumptions and identify the data and analyses that will be used in the verification.

References CRWMS M&O. "Features, Events, and Processes in UZ Flow and Transport." ANL-NBS-MD-000001 Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000.
CRWMS M&O. "FEPs in Thermal Hydrology and Coupled Processes." ANL-NBS-MD-000004 Revision 00 ICN1. Las Vegas, Nevada: CRWMS M&O. 2001a
CRWMS M&O. "Features, Events, and Processes in SZ Flow and Transport." ANL-NBS-MD-000002 Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001b

DOE Response Initiation, tracking, resolution and closure of To Be Verified's in technical products are procedurally controlled per procedure AP-3.15Q. Resolution of this issue is being addressed at DOE and NRC Management meetings.

Agreement Number

Agreement DOE response during Technical Exchange was considered adequate by the NRC. Technical Exchange on Features, Events, and Processes, May 15-17, 2001.

Subissue #2 - Scenario Analysis SA-7

Tracking # SA-7

Comment 1.4.06.01.00 (Altered soil or surface water chemistry). This item is excluded on the basis of low probability (CRWMS M&O, 2001b), but it is not addressed under the scope of document ANL-NBS-MD-000002 (CRWMS M&O, 2001a). The probability argument is not supported by a calculation or estimate. This item is possibly relevant for the Integrated Subissue Radionuclide Transport in the Saturated Zone because of possible changes in groundwater chemistry.

References CRWMS M&O. "Features, Events, and Processes in SZ Flow and Transport." ANL-NBS-MD-000002. Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001a.
CRWMS M&O. "Features, Events, and Processes in UZ Flow and Transport." ANL-NBS-MD-000001 Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001.

DOE Response The basis for excluding this Feature, Event and Process (FEP) is provided in the Unsaturated Zone (FEPs) Analysis/Model Report (BSC 2001d). This FEP is not considered in the Saturated Zone flow and transport since it has been excluded in the Unsaturated Zone flow and transport, i.e., any effect in the Saturated Zone would be less than that in the Unsaturated Zone.

Reference: BSC 2001d. Features, Events, and Processes in UZ Flow and Transport. ANL-NBS-MD-000001 REV 01. Las Vegas, Nevada: Bechtel SAIC Company. ACC: MOL.20010423.0321.

Agreement Number TSPAI.2.01

Agreement Provide clarification of the screening arguments, as summarized in Attachment 2. See Comment # 5, 7, 8, 9, 10, 13, 18, 19 (Part 5), 21, 32, 41, 47, 50, 53, 58, 67, J-5, J-16, and J-18

DOE will clarify the screening arguments, as summarized in Attachment 2, for the highlighted FEPs. The clarifications will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
DOE agreed to provide clarification of the screening argument in the Features, Events, and Processes in SZ Flow and Transport, ANL-NBS-MD-000002, to address the NRC comments. The AMR will also address the aggregate affects of 1.4.06.01.00 (Altered soil or surface water chemistry) on UZ and SZ.

Subissue #2 - Scenario Analysis SA-8

Tracking # SA-8

Comment 1.2.04.07.00 (Ashfall). DOE assumes that ashfall blankets the region between the repository and the compliance boundary (CRWMS M&O, 2001). Radionuclides associated with ashfall are then assumed to be transported instantaneously into the saturated zone. DOE presented only the case for uniform distribution. Moreover, parameter values and models used in the Ashfall analysis are not clear. Some parameters used in the model are not well documented and other parameters such as the number of waste package that fail are not viewed as conservative. DOE should provide additional bases for the choice of models and parameters used to screen this item.

References CRWMS M&O. "Features, Events, and Processes in SZ Flow and Transport." ANL-NBS-MD-000002. Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001.

DOE Response The uniform distribution of ashfall along the flow path from the repository to the receptor is a stylized, conservative representation of volcanic ash distribution on the land surface that allows a relatively simple analysis of potential impacts. It is conservative to assume that all of the volcanic ash would be concentrated on a relatively narrow band of the land surface within the capture zone of the well(s) providing groundwater to the hypothetical farming community. The range of waste packages as a result of a volcanic eruption is 3 to 39. The number of waste packages that are assumed to fail in the ashfall analysis is the median number of packages from the Total System Performance Assessment-Site Recommendation modeling (CRWMS M&O 2000aq). The expected behavior with respect to the number of waste package failures is used in the ashfall analysis.; There is no regulatory requirement that conservative parameter values be used in every aspect of the screening analysis. DOE believes no additional work is needed in this regard.

References:

CRWMS M&O 2000aq. Total System Performance Assessment for the Site Recommendation. TDR-WIS-PA-000001 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001005.0282.

Agreement Number TSPAI.2.01

Agreement Provide clarification of the screening arguments, as summarized in Attachment 2. See Comment # 5, 7, 8, 9, 10, 13, 18, 19 (Part 5), 21, 32, 41, 47, 50, 53, 58, 67, J-5, J-16, and J-18

DOE will clarify the screening arguments, as summarized in Attachment 2, for the highlighted FEPs. The clarifications will be

provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
DOE agreed to provide clarification of the screening argument in the Features, Events, and Processes in SZ Flow and Transport, ANL-NBS-MD-000002, to address the NRC comment.

Subissue #2 - Scenario Analysis SA-9

Tracking # SA-9

Comment 2.2.10.06.00 [Thermo-chemical alteration (solubility, speciation, phase changes, precipitation/dissolution)]. This item is excluded on the basis of low consequence (CRWMS M&O 2001) with reference to the screening argument for 2.2.7.10.00 in the UZ FEPs AMR (BSC 2001). The argument that repository thermal effects on Saturated Zone radionuclide transport will be minimal is based on a to-be-verified assumption (BSC 2001). There is no explicit technical basis presented that rock alteration or temperature effects on geochemical properties and processes will negligibly affect Saturated Zone transport. In addition, it is asserted in the Saturated Zone FEPs AMR (CRWMS M&O 2001) that any such effects would be within the bounds of uncertainty ranges established for transport properties such as Kd. However, the relevant AMR (CRWMS M&O 2000) does not provide a clear technical basis that this is the case. DOE's current technical justification is inadequate. The DOE should provide additional technical justification to fully exclude 2.2.10.06.00 [Thermo-chemical alteration (solubility, speciation, phase changes, precipitation/dissolution)].

Same comment applies to 2.2.10.08.00 (Thermo-chemical alteration of the saturated zone).

References

CRWMS M&O. "Features, Events, and Processes in SZ Flow and Transport." ANL-NBS-MD-000002 Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001.
BSC. "Features, Events, and Processes in UZ Flow and Transport." ANL-NBS-MD-000001 Revision 01. Las Vegas, Nevada: Bechtel SAIC Company. 2001.
CRWMS M&O. "Unsaturated Zone and Saturated Zone Transport Properties." ANL-NBS-HS-000019 Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response The rationale for excluding this Feature, Event and Process from the Saturated Zone does rest on the conclusions of the unsaturated zone features, events and processes screening analysis that it can be excluded on the basis of low consequence. This rationale is reasonable and appropriate. If the higher temperature conditions in the unsaturated zone near the repository are insufficient to have a significant consequence on radionuclide transport, then the smaller temperature rise in the saturated zone would also have no significant consequences. However, it is recognize that this conclusion is based on a To Be Verified assumption in the unsaturated zone and if the screening decision is changed for the unsaturated zone, the screening decision and justification for the saturated zone would need to be revisited. This comment is addressed in Radionuclide Transport agreement

KRT0210. The agreement states in part, "Consistent with the less structured approach for informal expert judgement acknowledged in NUREG-1563 guidance and consistent with AP-3.10Q, DOE will document how it derived the transport distributions for performance assessment ... ." The information obtained from agreement KRT0210 will respond to this comment in full and no additional work is needed. The Saturated Zone Features, Events and Processes Analysis/Model Report will be revised, to support any potential License Application, to include the new information obtained from the Radionuclide Transport agreement KRT0210.

References:
BSC 2001d. Features, Events, and Processes in UZ Flow and Transport. ANL-NBS-MD-000001 REV 01. Las Vegas, Nevada: Bechtel SAIC Company. ACC: MOL.20010423.0321.
CRWMS M&O 2000as. Unsaturated Zone and Saturated Zone Transport Properties (U0100). ANL-NBS-HS-000019 REV00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL20000829.0006.

Agreement Number TSPAI.2.01

Agreement Provide clarification of the screening arguments, as summarized in Attachment 2. See Comment # 5, 7, 8, 9, 10, 13, 18, 19 (Part 5), 21, 32, 41, 47, 50, 53, 58, 67, J-5, J-16, and J-18

DOE will clarify the screening arguments, as summarized in Attachment 2, for the highlighted FEPs. The clarifications will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
DOE agreed to provide clarification of the screening argument in the Features, Events, and Processes in SZ Flow and Transport, ANL-NBS-MD-000002, to address the NRC comment.

Subissue #2 - Scenario Analysis SA-10

Tracking # SA-10

Comment 2.3.11.04.00 (Groundwater discharge to surface) is excluded on the basis of low consequence (CRWMS M&O, 2001). Modeling shows that spring discharge within the 20-km radius is not likely, yet past discharges have occurred within the 20-km radius (e.g., paleospring deposits at 9S and 1S). See discussion of 1.3.07.02.00 (water table rise). Any screening argument that spring discharges are outside of the proposed compliance area is insufficient. Additional technical justification is required to fully exclude 2.3.11.04.00.

References CRWMS M&O. "Features, Events, and Processes in SZ Flow and Transport." ANL-NBS-MD-000002. Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001.

DOE Response No groundwater discharge at springs along the saturated zone flow path from the repository (within 20 km) is anticipated for glacial climatic conditions, as indicated by the lack of paleospring deposits in this area and by regional-scale groundwater flow modeling results (D=Agnese et al. 1999). Paleospring deposits at the southern end of Crater Flats indicate that groundwater discharge has occurred in this area under past glacial conditions and would alter the groundwater flow to some extent. However, these potential discharge points are over 10 km to the west of the present groundwater flow path and are not expected to be a source of potential radionuclide releases to the accessible environment.

References:

D=Agnese, F.A.; O=Brien, G.M.; Faunt, C.C.; and San Juan, C.A. 1999. Simulated Effects of Climate Change on the Death Valley Regional Ground-Water Flow System, Nevada and California. Water-Resources Investigations Report 98-4041. Denver, Colorado: U.S. Geological Survey. TIC: 243555.

Agreement Number TSPAI.2.01

Agreement Provide clarification of the screening arguments, as summarized in Attachment 2. See Comment # 5, 7, 8, 9, 10, 13, 18, 19 (Part 5), 21, 32, 41, 47, 50, 53, 58, 67, J-5, J-16, and J-18

DOE will clarify the screening arguments, as summarized in Attachment 2, for the highlighted FEPs. The clarifications will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
DOE agreed to provide clarification of the screening argument in the Features, Events, and Processes in SZ Flow and Transport,

ANL-NBS-MD-000002, to address the NRC comment.

Subissue #2 - Scenario Analysis SA-11

Tracking # SA-11

Comment 1.3.07.01.00 (Drought/water table decline). According to information in CRWMS M&O, 2001, this item is excluded due to low consequence. DOE states that "a lower water table could result in less travel through the alluvial aquifer and as a result, less sorption and retardation of the contaminant plume." However, no evidence is presented that precludes a watertable decline. Current flow models assume that groundwater flow through the saturated alluvium is relatively shallow. As water tables decline, how will flow through the alluvium be affected? Is it possible that a larger component of flow will be through the deep carbonate system? Will the upward gradient observed at some locations be affected? Are there distinct pathways that are dependent on the elevation of the water table? It is likely that the transport times will stay the same or increase due to water table decline, but the exclusion argument provided seems insufficient. Additional technical justification is required to fully exclude 1.3.07.01.00 (Drought/water table decline).

References CRWMS M&O. "Features, Events, and Processes in SZ Flow and Transport." ANL-NBS-MD-000002. Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001.

DOE Response The possibility of shorter flow path lengths in the alluvium (due to hydrogeologic uncertainty or potential decline in the water table) is captured in Saturated Zone site-scale model simulations for Total System Performance Asessment-Site Recommendation (CRWMS M&O 2000ar). The general pattern of groundwater flow is not expected to change with water table decline in the Saturated Zone. The regional-scale groundwater flow is controlled by the topographic distribution of recharge and discharge areas, as well as the large-scale distribution of hydrogeologic units and structural features. It is reasonable to expect that there would be relatively minor changes in the shallow groundwater flow paths with water table decline, but major features of the Saturated Zone flow system (e.g., the upward gradient from the carbonate aquifer) are expected to remain stable in the case of either water table decline or water table rise. This comment is addressed in Radionuclide Transport and Unsaturated and Saturated Flow Under Isothermal Conditions agreement KRT0208 and KUZ0504 respectively. The agreements state in part, ADOE will provide additional information to include Nye county data as available, to further justify the uncertainty distribution of flow path lengths in alluvium Y@ The information obtained from agreement KRT0208 will respond to this comment in full and no additional work is needed. The Saturated Zone Features, Events and Processes Analysis/Model Report (CRWMS M&O 2001f) will be revised, to support any potential License Application, to include the new information obtained from

agreement KRT0208.

References:

CRWMS M&O 2000ar. Uncertainty Distribution for Stochastic Parameters. ANL-NBS-MD-000011 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20000526.0328.

Agreement Number TSPAI.2.02

Agreement Provide the technical basis for the screening argument, as summarized in Attachment 2. See Comment # 3, 4, 11, 12, 19 (Parts 1, 2, and 6), 25, 26, 29, 34, 35, 36, 37, 38, 39, 42, 43, 44, 48, 49, 51, 54, 55, 56, 57, 59, 60, 61, 62, 63, 64, 65, 66, 68, 69, 70, 78, 79, J-1, J-2, J-3, J-4, J-7, J-8, J-9, J-10, J-11, J-12, J-13, J-14, J-15, J-17, J-20, J-21, J-22, J-23, J-24, J-25, J-26, and J-27.

DOE will provide the technical basis for the screening argument, as summarized in Attachment 2, for the highlighted FEPs. The technical basis will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
This issue is addressed by existing DOE/NRC agreements (RT Subissue 2 Agreement 8 and USFIC Subissue 5 Agreement 4). The Features, Events, and Processes in SZ Flow and Transport, ANL-NBS-MD-000002, will be updated as necessary to reflect the results of these existing agreements and clarify the screening argument.

Subissue #2 - Scenario Analysis SA-12

Tracking # SA-12

Comment 2.2.10.13.00 [Density-driven groundwater flow (thermal)]. The saturated zone features, events, and processes analysis and model report (CRWMS M&O, 2001) addresses this item in two parts: repository-induced effects ("excluded," low consequence) and natural geothermal effects ("included"). Exclusion of repository effects on flow based on DOE analyses is accepted. Natural effects are included only to the extent that the "natural geothermal gradient" is applied in the SZFT model. However, changes in thermal gradients are excluded on the basis of low consequence, with reference to 1.2.06.00.00 (Hydrothermal activity) and 1.2.10.02.00 (Hydrologic response to igneous activity) (CRWMS M&O, 2001). A clear technical basis is not provided under these items that all possible changes in thermal gradients will be localized. The screening argument for 1.2.06.00.00 focuses on geochemical effects (see separate entry), while 1.2.10.02.00 is focused on highly localized igneous intrusions. How these arguments apply to 2.2.10.13.00 is not entirely clear.

References CRWMS M&O. "Features, Events, and Processes in SZ Flow and Transport." ANL-NBS-MD-000002. Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001.

DOE Response Density-driven groundwater flow from natural thermal effects due to hydrothermal activity could result in greater dilution of radionuclide concentrations due to convection, as discussed in the section on Feature, Event and Process 1.2.06.00.00 in the Saturated Zone Features, Events and Processes Analysis/Model Report (CRWMS M&O 2001f). In addition, potential impacts due to increased groundwater flow rates in the saturated zone are captured within the range of uncertainty in specific discharge analyzed in the saturated zone site-scale flow and transport model for Total System Performance Assessment-Site Recommendation. Specific discharge in the saturated zone is scaled upward by a factor of 10 for a significant number of realizations of the saturated zone flow and transport system (CRWMS M&O. 2000ar).

References:

CRWMS M&O 2001f. Features, Events, and Processes in SZ Flow and Transport. ANL-NBS-MD-000002 REV 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20010214.0230. CRWMS M&O 2000ar. Uncertainty Distribution for Stochastic Parameters. ANL-NBS-MD-000011 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20000526.0328.

Agreement Number TSPAI.2.02

Agreement Provide the technical basis for the screening argument, as

summarized in Attachment 2. See Comment # 3, 4, 11, 12, 19 (Parts 1, 2, and 6), 25, 26, 29, 34, 35, 36, 37, 38, 39, 42, 43, 44, 48, 49, 51, 54, 55, 56, 57, 59, 60, 61, 62, 63, 64, 65, 66, 68, 69, 70, 78, 79, J-1, J-2, J-3, J-4, J-7, J-8, J-9, J-10, J-11, J-12, J-13, J-14, J-15, J-17, J-20, J-21, J-22, J-23, J-24, J-25, J-26, and J-27.

DOE will provide the technical basis for the screening argument, as summarized in Attachment 2, for the highlighted FEPs. The technical basis will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
This issue is addressed by an existing DOE/NRC agreement (USFIC Subissue 5 Agreement 13). The Features, Events, and Processes in SZ Flow and Transport, ANL-NBS-MD-000002, will be updated to clarify the screening argument and to reflect the results of this existing agreement.

Subissue #2 - Scenario Analysis SA-13

Tracking # SA-13

Comment 2.2.10.02.00 (Thermal convection cell develops in saturated zone) is screened as excluded on the basis of low consequence (CRWMS M&O, 2001). DOE indicates that temperatures at the water table are expected to approach 80°C. The DOE further points out that the resulting concern is that thermally driven water flow in the upper tuff aquifer could increase groundwater velocities relative to the system without heat sources. Additional justification for exclusion is necessary.

References CRWMS M&O. "Features, Events, and Processes in SZ Flow and Transport." ANL-NBS-MD-000002. Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001.

DOE Response The screening argument, for excluding this Feature, Event and Process, is that thermally driven groundwater flow in the Saturated Zone will not significantly alter the range of uncertainty in specific discharge that is already included in the Saturated Zone site-scale flow and transport model for Total System Performance Assessment-Site Recommendation and therefore will not significantly alter the expected dose. To account for uncertainties, pecific discharge in the Saturated Zone is scaled upward by a factor of 10 for a significant number of realizations of the Saturated Zone flow and transport system (CRWMS M&O. 2000ar). In addition, for nominal-case behavior in Total System Performance Assessment-Site Recommendation there is negligible transport of radionuclides through the Unsaturated Zone during the period of significant thermal perturbation.

References:

CRWMS M&O 2000ar. Uncertainty Distribution for Stochastic Parameters. ANL-NBS-MD-000011 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20000526.0328.

Agreement Number TSPAI.2.01

Agreement Provide clarification of the screening arguments, as summarized in Attachment 2. See Comment # 5, 7, 8, 9, 10, 13, 18, 19 (Part 5), 21, 32, 41, 47, 50, 53, 58, 67, J-5, J-16, and J-18

DOE will clarify the screening arguments, as summarized in Attachment 2, for the highlighted FEPs. The clarifications will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
DOE agreed to provide clarification of the screening argument in the Features, Events, and Processes in SZ Flow and Transport,

ANL-NBS-MD-000002, to address the NRC comment.

Subissue #2 - Scenario Analysis SA-18

Tracking # SA-18

Comment The Biosphere Analysis Model Report on features, events, and processes (CRWMS M&O, 2001) indicates that any future changes in 1.4.07.01.00 (Water management activities) can be excluded based on the proposed 10 CFR Part 63. This item includes well pumping from an aquifer as a water management activity. The conclusion that changes to water management activities may be excluded is not supportable by the regulation. The draft regulation indicates that the behaviors and characteristics of the farming community shall be consistent with current conditions of the region surrounding the Yucca Mountain site and that climate evolution shall be consistent with the geologic record. As the climate becomes wetter and cooler, the farming community is likely to pump less water out of the aquifer, consistent with sites analogous to the predicted future climate of Yucca Mountain. This reduction in pumping would not be considered a change in the behavior or characteristics of the critical group since the community would still be raising similar crops using similar farming methods.

References CRWMS M&O. "Evaluation of the Applicability of Biosphere-Related Features, Events, and Processes (FEP)." ANL-MGR-MD-000011. Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001.

DOE Response This Feature, Event and Process (FEP) can be excluded on the basis of the proposed regulation as this FEP deals with the use of man-made structures and not specifically with the use of groundwater. Since these features do not currently exist in the vicinity of the location of the critical group, not considering them is consistent with the current conditions. The use of groundwater, via well(s), and the changes associated with climate evolution are specifically related to FEP 1.4.07.02.00 "Wells" and is not considered to be part of this FEP. Effect of climate change, FEP 1.3.01.00.00, on water use is considered and addressed in Nominal Case Biosphere Dose Conversion Factor Analysis/Model Report.

Agreement Number TSPAI.2.01

Agreement Provide clarification of the screening arguments, as summarized in Attachment 2. See Comment # 5, 7, 8, 9, 10, 13, 18, 19 (Part 5), 21, 32, 41, 47, 50, 53, 58, 67, J-5, J-16, and J-18

DOE will clarify the screening arguments, as summarized in Attachment 2, for the highlighted FEPs. The clarifications will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:

DOE agreed to provide clarification of the screening argument in the Features, Events, and Processes in SZ Flow and Transport, ANL-NBS-MD-000002, to address the NRC comment.

Subissue #2 - Scenario Analysis SA-19

Tracking # SA-19

Comment DOE has selected a subset of the full list of features, events, and processes as applicable for biosphere screening in (CRWMS M&O, 2001). Some entries that are potentially applicable to biosphere dose conversion factor calculations (that should at least be considered for screening) have not been included in the scope of the document ANL-MGR-MD-000011 (CRWMS M&O, 2001). These include:
2.3.11.04.00 (Groundwater discharge to surface)
1.3.07.02.00 (Water table rise)
3.2.10.00.00 (Atmospheric transport of contaminants)
1.2.04.01.00 (Igneous activity)
2.2.08.01.00 (Groundwater chemistry/composition in unsaturated zone and saturated zone) (i.e., chemical species can impact dose coefficient selection)
2.2.08.11.00 (Distribution and release of nuclides from the geosphere)
3.1.01.01.00 (Radioactive decay and ingrowth) and
1.2.04.07.00 (Ashfall).

References CRWMS M&O. "Evaluation of the Applicability of Biosphere-Related Features, Events, and Processes (FEP)." ANL-MGR-MD-000011. Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001.

DOE Response Feature, Event and Process (FEP) 1.3.07.02.00 "Water table rise" and FEP 2.3.11.04.00 "Groundwater discharge to surface". The processes addressed in FEPs 1.3.07.02.00 & 2.3.11.04.00 are not directly related to the biosphere and are not evaluated by the Biosphere FEP Analysis/Model Report (CRWMS M&O 2001e). Effects of any surface discharge or water table rise in the compliance area, if any, would be addressed within FEP 3.3.05.11.00 "Radiation doses". The effects of climate change within the compliance area, if any, on the processes addressed in these FEP will be evaluated in support of any potential license application.

FEP 3.2.10.00.00 "Atmospheric transport of contaminants" - Those FEP, which deal with the mechanics of atmospheric transport of contaminants as a result of a volcanic event, are discussed, considered and evaluated within the scope of the Disruptive Event FEP Analysis/Model Report (CRWMS M&O 2000i). The effects of other atmospheric transport processes, such as wind erosion and resuspension, are currently considered in calculation of Biosphere Dose Conversion Factors. Specifically, wind erosion is considered under FEP #s 1.2.07.01.00, 1.2.07.02.00, and 2.3.02.02.00.

FEP 1.2.04.01.00 "Igneous activity" - As described in Freeze et al. 2001, the YMP Primary FEP Description, the Originator FEP

Description, and the secondary FEP descriptions, this FEP is focused on the consequences of igneous activity in the geosphere. This FEP is not directly relevant to the biosphere and, as a result, does not need to be evaluated in the Biosphere FEP Analysis/Model Report. FEP 2.2.08.02.00 "Groundwater chemistry/composition in unsaturated zone and saturated zone" - As cited Freeze et al. 2001, this FEP corresponds to a FEP titled "Radionuclide transport occurs in a carrier plume in the geosphere". The Yucca Mountain Project Primary FEP Descriptor, Originator Descriptor and associated secondary FEP descriptors all relate to transport in the geosphere. This FEP is not directly relevant to the biosphere and, as a result, it does not need to be evaluated in the Biosphere FEP Analysis/Model Report. DOE agrees that chemical species can effect the dose coefficient selection. In the analyses of radiation doses, FEP 3.3.05.01.00 ,which is considered in the Biosphere FEP Analysis/Model Report (CRWMS M&O 2001e), this effect is bounded by selecting the highest dose coefficient factor.

FEP 2.2.08.11.00 "Distribution and release of radionuclides from the geosphere" - As stated in the both the Yucca Mountain Project Primary FEP Description and the Originator Description, this FEP is focused exclusively on the transport of radionuclides in the groundwater. The release of radionuclides in groundwater, as cited in the Biosphere FEP Analysis/Model Report (CRWMS M&O 2001e), is considered via a well, FEP 1.4.07.02.00. This FEP is not directly relevant to the biosphere and, as a result, does not need to be evaluated in the Biosphere FEP Analysis/Model Report.

FEP 3.1.01.01.00 "Radioactive decay and ingrowth" - DOE is reconsidering citing this as an applicable FEP. Although this FEP is not cited as an applicable FEP in the Biosphere, the analyses of radiation dose, FEP 3.3.05.01.00, was addressed in the Biosphere FEP Analysis/Model Report (CRWMS M&O 2001e) and did include the consideration of radioactive decay and progeny ingrowth along the various pathways to man.

FEP 1.2.04.07.00 "Ashfall" - DOE is reconsidering citing this as an applicable FEP. Although this FEP is not cited as an applicable FEP in the Biosphere, the analysis of radiation dose, FEP 3.3.05.01.00, was addressed in the Biosphere FEP Analysis/Model Report (CRWMS M&O 2001e) and did include ashfall for the disruption event scenario.

Agreement Number TSPAI.2.01, TSPAI.2.02, TSPAI.2.03

Agreement Check detailed information in Attachment 2, included at the bottom, for clarification of formal agreements.

TSPAI.2.01- Provide clarification of the screening arguments, as summarized in Attachment 2. See Comment # 5, 7, 8, 9, 10, 13, 18, 19 (Part 5), 21, 32, 41, 47, 50, 53, 58, 67, J-5, J-16, and J-18

DOE will clarify the screening arguments, as summarized in Attachment 2, for the highlighted FEPs. The clarifications will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

TSPAI.2.02 - Provide the technical basis for the screening argument, as summarized in Attachment 2. See Comment # 3, 4, 11, 12, 19 (Parts 1, 2, and 6), 25, 26, 29, 34, 35, 36, 37, 38, 39, 42, 43, 44, 48, 49, 51, 54, 55, 56, 57, 59, 60, 61, 62, 63, 64, 65, 66, 68, 69, 70, 78, 79, J-1, J-2, J-3, J-4, J-7, J-8, J-9, J-10, J-11, J-12, J-13, J-14, J-15, J-17, J-20, J-21, J-22, J-23, J-24, J-25, J-26, and J-27.

DOE will provide the technical basis for the screening argument, as summarized in Attachment 2, for the highlighted FEPs. The technical basis will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

TSPAI.2.03 - Add the FEPs highlighted in Attachment 2 to the appropriate FEPs AMRs. See Comment 19 (Part 7 and 8), 20, and J-6.

DOE will add the FEPs highlighted in Attachment 2 to the appropriate FEPs AMRs. The FEPs will be added to the appropriate FEPs AMRs and the AMRs will be provided to the NRC in FY03.

Text in Attachment 2:
DOE will provide a technical basis in the Evaluation of the Applicability of Biosphere-Related Features, Events, and Processes (FEPs), ANL-MGR-MD-000011, to address the NRC comment for FEP 2.3.11.04.00 (Groundwater discharge to surface), FEP 1.3.07.02.00 (Water table rise), and FEP 2.2.08.11.00 (Distribution and release of nuclides from the geosphere).

No further action is required for FEP 3.2.10.00.00 (Atmospheric transport of contaminants) and FEP 1.2.04.01.00 (Igneous activity).

DOE agreed to provide clarification of the screening argument in the Evaluation of the Applicability of Biosphere-Related Features, Events, and Processes (FEP), ANL-MGR-MD-000011, for FEP

2.2.08.02.00 (Groundwater chemistry/composition in unsaturated zone and saturated zone).

DOE will add links to the Evaluation of the Applicability of Biosphere-Related Features, Events, and Processes (FEP), ANL-MGR-MD-000011, for FEP 3.1.01.01.00 (Radioactive decay and ingrowth), and FEP 1.2.04.07.00 (Ashfall).

Subissue #2 - Scenario Analysis SA-20

Tracking # SA-20

Comment 2.2.08.07.00 (Radionuclide solubility limits in the geosphere). The Yucca Mountain Project Database (Rev 00 ICN 01; CRWMS M&O, 2001) does not indicate that 2.2.08.07.00 (Radionuclide solubility limits in the geosphere) is relevant to the biosphere. This item is relevant for limiting the quantity of radioactive material that can leach radionuclides out of the soil or tephra deposit in the biosphere compared to the quantity of radionuclides that would be predicted to leach out of the deposit using only leach rate limits.

References CRWMS M&O. "Yucca Mountain FEP Database." TDR-WIS-MD-000003 Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2001.

DOE Response The Feature, Event and Process (FEP) as described in the FEP database is specific to "Geosphere." The Biosphere as described in the Biosphere Process Model Report excludes processes in the geosphere, therefore this FEP is not considered in the Biosphere.

The concern for limiting the quantity of radioactive material that can leach from soil or tephra deposits does have relevance to the biosphere. The process of leaching in which solubility limits apply is addressed in FEP 2.3.02.02.00, "Radionuclide Accumulation in soil."

For the nominal scenario (groundwater contamination), the process depends on the radionuclide build-up in soil, which includes leaching, and partition coefficient (ratio of concentrations in liquid and solid matter). The process would be applicable to the leaching of the contamination from volcanic ash. However for volcanic release, the Biosphere model does not consider contamination removal by leaching and is thus bounding and conservative. In this scenario the dominant pathway is inhalation from resuspended particulate matter. The inclusion of leaching (with solubility limits) as a transport mechanism from the surfacial layer of contaminated ash (where all resuspension originates) into the deeper layers (where the contamination cannot be resuspended and is thus not available for inhalation) can only reduce the dose contribution from the primary pathway.

Agreement Number TSPAI.2.03

Agreement Add the FEPs highlighted in Attachment 2 to the appropriate FEPs AMRs. See Comment 19 (Part 7 and 8), 20, and J-6.

DOE will add the FEPs highlighted in Attachment 2 to the appropriate FEPs AMRs. The FEPs will be added to the appropriate FEPs AMRs and the AMRs will be provided to the NRC in FY03.

Text in Attachment 2:
DOE will add this item to the Evaluation of the Applicability of Biosphere-Related Features, Events, and Processes (FEP), ANL-MGR-MD-000011, and present the DOE discussion in the screening argument.

Subissue #2 - Scenario Analysis SA-21

Tracking # SA-21

Comment 2.3.13.01.00 (Biosphere characteristics) screening argument indicates YM region lacks permanent surface water (CRWMS M&O, 2001). Is this statement consistent with the geologic record of past climate change in the area?

References CRWMS M&O. "Evaluation of the Applicability of Biosphere-Related Features, Events, and Processes (FEP)." ANL-MGR-MD-000011. Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001.

DOE Response As described in Section 7.1 of the Yucca Mountain Site Description (CRWMS M&O 2000aw), the region around Yucca Mountain lacks permanent surface water bodies (see Feature, Event and Process 2.3.04.01.00 Surface Water Transport and Mixing). Intermittent sources of water on the Nevada Test Site were not considered since access to the Nevada Test Site is controlled and such sources would not be available to members of the critical group. At the present time, the presence of an intermittent seep or spring at the proposed location of the critical group has not been identified and is considered unlikely given the depth to groundwater (>90 meters) at that location. DOE considers that this issue is conservatively addressed in the current analysis of the nominal scenario.

Agreement Number TSPAI.2.01

Agreement Provide clarification of the screening arguments, as summarized in Attachment 2. See Comment # 5, 7, 8, 9, 10, 13, 18, 19 (Part 5), 21, 32, 41, 47, 50, 53, 58, 67, J-5, J-16, and J-18

DOE will clarify the screening arguments, as summarized in Attachment 2, for the highlighted FEPs. The clarifications will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
DOE agreed to provide clarification of the screening argument in the Evaluation of the Applicability of Biosphere-Related Features, Events, and Processes (FEP). ANL-MGR-MD-000011 to address the NRC comment.

Subissue #2 - Scenario Analysis SA-24

Tracking # SA-24

Comment 2.3.13.02.00 (Biosphere transport) contains only two secondary entries related to surface water, gas, and biogeochemical transport processes (CRWMS M&O, 2001). The Yucca Mountain Project feature, event, and process description and the originator description are different and call into question whether the focus of this item is transport processes, alterations during transport, or both.

References CRWMS M&O. "Evaluation of the Applicability of Biosphere-Related Features, Events, and Processes (FEP)." ANL-MGR-MD-000011. Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001.

DOE Response The objective of the Features, Events and Processes (FEPs) Database, as cited in Freeze et al. 2001, is to document a manageable number of primary FEPs that encompass, through comprehensively worded Yucca Mountain Project primary FEP descriptions, all of the relevant issues. To ensure completeness, a Yucca Mountain Project primary FEP description must include those issues identified in the Originator FEP. For this particular FEP, the statement "Once in the biosphere, radionuclides may be transported through and between the different compartments of the biosphere" inherently captures the intent of the Originator FEP Description phrase "Within the biosphere ..." The treatment of the this FEP in the biosphere is both transport processes and alterations during transport.

Agreement Number TSPAI.2.04

Agreement Provide a clarification of the description of the primary FEP. See Comments 24, 31, and 33.

DOE will clarify the description of the primary FEPs, as summarized in Attachment 2, for the highlighted FEPs. The clarifications will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03

Text in Attachment 2:
DOE agreed to clarify the description of the primary FEP in the Evaluation of the Applicability of Biosphere-Related Features, Events, and Processes (FEPs), ANL-MGR-MD-000011, to address the NRC comment.

Subissue #2 - Scenario Analysis SA-25

Tracking # SA-25

Comment 2.4.07.00.00 (Dwellings) includes a secondary entry, household cooling, which has an inappropriate screening argument (CRWMS M&O, 2001). The screening argument indicates that since the use of an evaporative cooler would only increase the inhalation and direct exposure pathways, and these pathways are only minor contributors to the current dose conversion factors, the use of evaporative coolers can be screened. However, the direct exposure and inhalation doses from evaporative coolers are the result of significantly different processes than the direct exposure and inhalation doses from radionuclides deposited on soils and could have a more significant dose impact.

References CRWMS M&O. "Evaluation of the Applicability of Biosphere-Related Features, Events, and Processes (FEP)." ANL-MGR-MD-000011. Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001.

DOE Response Household (evaporative) cooling is not expected to result in a significant increase in the relative contribution of the inhalation and external pathways to the expected annual dose. For the nominal case (ANL-MGR-MD-000009, Rev 01), which considers indoor exposure as a fraction of the outdoor exposure, the external pathway and the inhalation pathway generally contribute only a small fraction of the Biosphere Dose Converaion Factor. Given the fact that household cooling is used approximately 50% of the time and that people spend less than 50% of their time indoors, any increase in the relative contribution of the external and inhalation pathways to the expected annual as a result of household cooling is expected to be negligible.

For the Disruptive Event (CRWMS M&O 2000p), groundwater is uncontaminated. Therefore, use of evaporative cooling would not present any additional source of indoor exposure in significant effect on the expected annual dose.

DOE considers effects of this secondary Feature Event and Process to be adequately covered in the current analyses of Biosphere Dose Conversion Factors for the two scenarios.

Agreement Number TSPAI.2.02

Agreement Provide the technical basis for the screening argument, as summarized in Attachment 2. See Comment # 3, 4, 11, 12, 19 (Parts 1, 2, and 6), 25, 26, 29, 34, 35, 36, 37, 38, 39, 42, 43, 44, 48, 49, 51, 54, 55, 56, 57, 59, 60, 61, 62, 63, 64, 65, 66, 68, 69, 70, 78, 79, J-1, J-2, J-3, J-4, J-7, J-8, J-9, J-10, J-11, J-12, J-13, J-14, J-15, J-17, J-20, J-21, J-22, J-23, J-24, J-25, J-26, and J-27.

DOE will provide the technical basis for the screening argument, as

summarized in Attachment 2, for the highlighted FEPs. The technical basis will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
DOE agreed to provide the technical basis for the screening argument in the Evaluation of the Applicability of Biosphere-Related Features, Events, and Processes (FEP), ANL-MGR-MD-000011, to address the NRC comment.

Subissue #2 - Scenario Analysis SA-26

Tracking # SA-26

Comment The Analysis and Model Report on Biosphere features, events, and processes (CRWMS M&O, 2001) states that 3.3.08.00.00 (Radon and daughter exposure) is screened as excluded on the basis that the parent radionuclide (Th-230) will not reach the critical group in 10,000 years in the base case scenario (CRWMS M&O, 2001, 2000). This rationale, however, does not apply to the direct release scenario where transport times are much shorter.

References CRWMS M&O. "Disruptive Event Biosphere Dose Conversion Factor Analysis." ANL-MGR-MD-000003. Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000.
CRWMS M&O. "Evaluation of the Applicability of Biosphere-Related Features, Events, and Processes (FEP)." ANL-MGR-MD-000011. Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001.

DOE Response Inventory Abstraction Analysis/Model Report (CRWMS M&O 2000aj) does not identify either Th-230 or Ra-226 as a significant radionuclide, i.e. one of the radionuclides required to account for 95% of the dose, for the inhalation or ingestion pathway within 10,000 years after repository closure. The inventory abstraction analysis has been revised and may be considered in subsequent biosphere analyses.

Agreement Number TSPAI.2.02

Agreement Provide the technical basis for the screening argument, as summarized in Attachment 2. See Comment # 3, 4, 11, 12, 19 (Parts 1, 2, and 6), 25, 26, 29, 34, 35, 36, 37, 38, 39, 42, 43, 44, 48, 49, 51, 54, 55, 56, 57, 59, 60, 61, 62, 63, 64, 65, 66, 68, 69, 70, 78, 79, J-1, J-2, J-3, J-4, J-7, J-8, J-9, J-10, J-11, J-12, J-13, J-14, J-15, J-17, J-20, J-21, J-22, J-23, J-24, J-25, J-26, and J-27.

DOE will provide the technical basis for the screening argument, as summarized in Attachment 2, for the highlighted FEPs. The technical basis will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
DOE agreed to provide the technical basis for the screening argument in the Evaluation of the Applicability of Biosphere-Related Features, Events, and Processes (FEP), ANL-MGR-MD-000011, to address the NRC comment.

Subissue #2 - Scenario Analysis SA-29

Tracking # SA-29

Comment 2.1.06.07.00 (Effects at material interfaces) is screened as excluded on the basis of low consequence (CRWMS M&O, 2001). The basic chemical processes that occur at phase boundaries (principally liquid/solid) are included in other features, events, and processes. Solid/solid contact either does occur or could occur between the drip shield and the invert and/or backfill (if included in the Yucca Mountain Project design); between the waste package and the invert and/or backfill (if included in the Yucca Mountain Project design); between the pedestal and the waste package and/or drip shield; and between the waste form and any of the other engineered barrier subsystem component materials. Since these materials are all relatively inert, no solid/solid interaction mechanisms have been identified that are significant relative to the basic seepage water induced corrosion of the engineered barrier subsystem components and hence this process is excluded on the basis of low consequence. However, interfaces between solid phases in contact with an aqueous phase can accelerate degradation processes such as crevice corrosion of waste package or galvanic coupling of drip shield to steel components [see screening arguments for 2.1.03.01.00 (Corrosion of waste containers) and 2.1.03.04.00 (Hydride cracking of waste containers and drip shields)].

References CRWMS M&O. "FEPs Screening of Processes and Issues in Drip Shield and Waste Package Degradation." ANL-EBS-PA-000002. Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001.

DOE Response Any electrochemical coupling of Alloy 22 with 316NG will result in increased corrosion degradation of 316NG and enhanced performance of Alloy 22. The similarity of the corrosion potentials of Alloy 22 and Titanium Grade 7 indicates that even if electrical contact were established, it would be of little consequence to the degradation characteristics of the waste package or the drip shield. Analyses (CRWMS M&O 2000a) indicate that crevice corrosion of the waste package outer barrier or the drip shield will not occur under repository-relevant exposure conditions. Galvanic coupling of the drip shield to steel components is discussed in Feature, Event and Process 2.1.03.04.00, Hydride Cracking of Waste Containers and Drip Shields and is determined to have no consequence to the performance of the drip shield.

Interfaces between the waste package and the pallets are not included because the same material is used for the construction.

Reference:

CRWMS M&O 2000a. Abstraction of Models for Pitting and

Crevice Corrosion of Drip Shield and Waste Package Outer Barrier. ANL-EBS-PA-000003 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20000526.0327. CRWMS M&O 2001h. FEPs Screening of Processes and Issues in Drip Shield and Waste Package Degradation. ANL-EBS-PA-000002 REV 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20010216.0004.

Agreement Number TSPAI.2.02

Agreement Provide the technical basis for the screening argument, as summarized in Attachment 2. See Comment # 3, 4, 11, 12, 19 (Parts 1, 2, and 6), 25, 26, 29, 34, 35, 36, 37, 38, 39, 42, 43, 44, 48, 49, 51, 54, 55, 56, 57, 59, 60, 61, 62, 63, 64, 65, 66, 68, 69, 70, 78, 79, J-1, J-2, J-3, J-4, J-7, J-8, J-9, J-10, J-11, J-12, J-13, J-14, J-15, J-17, J-20, J-21, J-22, J-23, J-24, J-25, J-26, and J-27.

DOE will provide the technical basis for the screening argument, as summarized in Attachment 2, for the highlighted FEPs. The technical basis will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
This issue is addressed by an existing agreement (CLST subissue 6 Agreement 1). DOE agreed to provide clarification of the screening argument in the FEPs Screening of Processes and Issues in Drip Shield and Waste Package Degradation, ANL-EBS-PA-000002, as necessary upon completion of the agreement item.

Subissue #2 - Scenario Analysis SA-30

Tracking # SA-30

Comment 2.1.03.05.00 (Microbially mediated corrosion of waste container). Screened as included for waste package, and as excluded for drip shield on the basis of low consequence (CRWMS M&O, 2001). Quantitative data on microbially influenced corrosion of drip shield materials such as Ti grades 7 and 16 are not available from the literature. If microbially influenced corrosion of the drip shield occurs it would not have an effect on dose. Accelerated corrosion rates of drip shield have been evaluated and shown not to have an effect on dose (CRWMS M&O, 2000).

References CRWMS M&O. "Total System Performance for the Site Recommendation." TDR-WIS-PA-000001. Revision 00 ICN1. Las Vegas, Nevada: CRWMS M&O. 2000.
CRWMS M&O. "FEPs Screening of Processes and Issues in Drip Shield and Waste Package Degradation." ANL-EBS-PA-000002. Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001.

DOE Response Microbial induced corrosion of Titanium Grade 7 has not been reported in the literature. Hence, the microbial induced corrosion of the drip shield was screened out. Accelerated corrosion of drip shield under the seismic event will be addressed and documented under Container Life and Source Term agreement KCL0208.

Agreement Number

Agreement DOE response during Technical Exchange was considered adequate by the NRC. Technical Exchange on Features, Events, and Processes, May 15-17, 2001.

Subissue #2 - Scenario Analysis SA-31

Tracking # SA-31

Comment There is no FEP addressing the response of the drip shield to static loads and seismic excitation. It is necessary to account for the degradation of the capability of the drip shield to avoid water infiltration due to the interaction of seismic excitation with dead loads (such as those caused by rock fall or naturally occurring backfill) on the drip shield, and it is recommended to add a new FEP.

FEP 1.2.03.02.00 (Seismic vibration causes container failure) assesses the effect of ground motion on the waste package and drip shield, without consideration of possible pre-existing static loads. The screening argument for FEP 2.1.06.06.00 (Effects and degradation of drip shield) in CRWMS M&O, 2001 states that

"... seismic activity will not induce SCC of the waste packages or drip shields, regardless of magnitude, since a sustained tensile stress is required for SCC and an earthquake is only temporary in nature (CRWMS M&O 2000, Section 5, Assumption 1)."

The above assumption does not account for the possibility of static loads affecting the drip shield and possibly, the waste package.

References CRWMS M&O. "Stress Corrosion Cracking of the Drip Shield, the Waste Package Outer Barrier, and the Stainless Steel Structural Material." ANL-EBS-MD-000005 Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.
CRWMS M&O. "FEPs Screening of Processes and Issues in Drip Shield and Waste Package Degradation." ANL-EBS-PA-000002 Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001.

DOE Response

Agreement Number TSPAI.2.04

Agreement Provide a clarification of the description of the primary FEP. See Comments 24, 31, and 33.

DOE will clarify the description of the primary FEPs, as summarized in Attachment 2, for the highlighted FEPs. The clarifications will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03

Text in Attachment 2:
DOE agreed to clarify the description of the primary FEP in the FEPs Screening of Processes and Issues in Drip Shield and Waste Package Degradation, ANL-EBS-PA-000002, to address the NRC comment.

Subissue #2 - Scenario Analysis SA-32

Tracking # SA-32

Comment 2.1.13.01.00 (Radiolysis) is excluded based on low consequence (CRWMS M&O, 2000, 2001).
[Waste Package]:Alpha, beta, gamma and neutron irradiation of air saturated water can cause changes in chemical conditions (Eh, pH, and concentration of reactive radicals) and positive shifts in corrosion potential due to the formation of hydrogen peroxide. DOE, on the bases of experimental work concluded that radiolysis will not lead to localized corrosion of Alloy 22. However, additional work by the DOE is necessary to complete the evaluation of the critical potentials related to localized corrosion of Alloy 22.
[Waste Form Miscellaneous]:Screening argument considers only radiolysis of water to produce hydrogen and oxidants. No consideration of the formation of nitric acid resulting from radiolysis in presence of air. Spent fuel is expected to have higher dissolution rates at lower pH, thus ignoring nitric acid may underestimate radionuclide release. Potential production of nitric acid from radiolysis of N2 in air should be considered. It is necessary to consider potential effect of acid environments on the corrosion of Alloy 22 and Ti.

References CRWMS M&O. "Miscellaneous Waste Form FEPs." ANL-WIS-MD-000009. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.
CRWMS M&O. "FEPs Screening of Processes and Issues in Drip Shield and Waste Package Degradation." ANL-EBS-PA-000002. Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001.

DOE Response Container Life and Source Term agreement KCL0302 states in part, AY(DOE) will address specific NRC questions regarding radiolysis, incoming water, localized corrosion, corrosion products, transient effects, and a sensitivity study on differing dissolution rate of components." And Container Life and Source Term agreement KCL0303 states in part, "(DOE to) provide a more detailed calculation on the in package chemistry effects of radiolysis ..." DOE believes that the Analysis/Model Report, In-Package Chemistry for Waste Forms (BSC 2001b) provided information on the effect on in-package chemistry of nitric acid produced by radiolysis, consistent with the Container Life and Source Term agreements KCL0302 and KCL0303. The Miscellaneous Waste Form Features, Events and Processes Analysis/Model Report (CRWMS M&O 2001i) will be revised, to support any potential License Application, to reflect this new information.

Agreement Number TSPAI.2.01

Agreement Provide clarification of the screening arguments, as summarized in Attachment 2. See Comment # 5, 7, 8, 9, 10, 13, 18, 19 (Part 5), 21, 32, 41, 47, 50, 53, 58, 67, J-5, J-16, and J-18

DOE will clarify the screening arguments, as summarized in Attachment 2, for the highlighted FEPs. The clarifications will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
DOE agreed to provide additional information on critical potentials for localized corrosion in the DOE/NRC CLST Technical Exchange (9/12-13/2000).

DOE agreed to provide clarification of the screening argument in the FEPs Screening of Processes and Issues in Drip Shield and Waste Package Degradation, ANL-EBS-PA-000002, to address the NRC comment.

Subissue #2 - Scenario Analysis SA-33

Tracking # SA-33

Comment FEP(s) related to the effect of trace metal cations on Alloy-22 and Ti corrosion and stress corrosion should be added to database, given results recently reported by Barkatt and Gorman (2000).

References A. Barkatt and J.A. Gorman, Tests to Explore Specific Aspects of the Corrosion Resistance of C-22, Nuclear Waste Technical Review Board Meeting, August 1, 2000, Carson City, NV, 2000.

DOE Response The project has reviewed the results reported in Barkatt and Gorman (2000) and has concluded that the testing conditions used were not relevant to Yucca Mountain Project.

However existing Container Life and Source Term agreements (KCL0101, KCL0110, and KCL0601) are intended to evaluate the effects of introduced materials on water chemistry and deleterious trace element concentrations on the corrosion behavior of titanium, similar to the electrochemically based studies on Alloy 22.

Consideration will be given to adding a new feature, event and process or augmenting an existing feature, event and process to account for the effects of trace elements on Alloy-22 and Titanium corrosion and stress corrosion.

DOE believes the existing Container Life and Source Term agreements identified above are sufficient to address the technical issue identified in the NRC comment without any new agreement items.

Agreement Number TSPAI.2.04

Agreement Provide a clarification of the description of the primary FEP. See Comments 24, 31, and 33.

DOE will clarify the description of the primary FEPs, as summarized in Attachment 2, for the highlighted FEPs. The clarifications will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03

Text in Attachment 2:
DOE agreed to clarify the description of the primary FEP in the FEPs Screening of Processes and Issues in Drip Shield and Waste Package Degradation, ANL-EBS-PA-000002, to address the NRC comment.

Subissue #2 - Scenario Analysis SA-34

Tracking # SA-34

Comment 2.1.03.02.00 (Stress corrosion cracking of Waste Containers). Screened as included for waste package but as excluded for drip shield on the basis of low consequence (CRWMS M&O, 2001). The screening argument states that"...Source of stress for cracks is due to cold work stress and cracks caused by rockfall. However these cracks tend to be tight (i.e., small crack opening displacement) and fill with corrosion products and carbonate minerals. These corrosion products will limit water transport through the drip shield and thus not contribute significantly to overall radionuclide release rate from the underlying failed waste packages..." The screening argument for drip shield is weak. Simplified calculations by DOE indicate cracks will take considerable time to fill with corrosion products (CRWMS M&O, 2000). Cracks that develop in the DS may propagate and/or "open up" when subjected to subsequent loads caused by rockfall/drift collapse and/or seismic excitation allowing significant ground water infiltration through the drip shield.

References CRWMS M&O. "FEPs Screening of Processes and Issues in Drip Shield and Waste Package Degradation." ANL-EBS-PA-000002. Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001.
CRWMS M&O. "Stress corrosion cracking of the Drip Shield, the Waste Package Outer Barrier and the Stainless Steel Structural Material." ANL-EBS-MD-000005 Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response It is agreed that simplified calculations by DOE indicate cracks will take considerable time to fill with corrosion products ([CRWMS M&O 2000ap), however, quantitative bounding analyses have been underway to determine whether calcite and other minerals can precipitate at a sufficiently high rate to plug cracks resulted from stress corrosion cracking. The calculation depends mainly on two parameters: the evaporation at the surface of the waste package or drip shield in particular in the vicinity of cracks and the precipitation rate of minerals (BSC 2001c) . The analyses consider calcite and amorphous silica as minerals that potentially precipitate within the stress corrosion cracks. The analyses consider two end-member scenarios for potential water flow characteristics in the cracks: film flow and water bridging across the crack opening (BSC 2001c, Section 5.3.3). The water bridging scenario employs highly conservative assumptions such as no corrosion of the crack wall, no mixing of the bridging water with the outside environment, no water transport along the crack wall, and no consideration of mineral precipitate in the presence of fine particulates of corrosion products along the crack wall.

The analysis results show that for the film flow scenario, cracks are

plugged by mineral precipitates within a decade (BSC 2001c, Tables 6-3 and 6-5). For the conservative scenario (i.e., water bridging scenario), plugging of stress corrosion cracks takes 600 to 1,000 years if the stress corrosion crack opening occurs prior to 20,000 years (BSC 2001c, Tables 6-4 and 6-6). Considering the conservatism employed in the water bridging scenario, the time to plugging the cracks would be sooner than the bounding estimates. In general the analysis results support the assumption for the stress corrosion crack plugging by precipitates in Total System Performance Assessment-Site Recommendation REV 00 (CRWMS M&O 2000aq).

The ability of the additional loading combinations to initiate and/or propagate preexisting cracks are being addressed in response to Container Life and Source Term agreement KCL0208. Evaluations of the ability of these loading combinations to initiate and/or propagate preexisting cracks will be documented in a future revision of the Design Analysis for Uncanistered Fuel Waste Packages (CRWMS M&O 2000n), and the Design Analysis for the Ex-Container Components (CRWMS M&O 2000l).

Reference: CRWMS M&O 2000ap. Stress Corrosion Cracking of the Drip Shield, the Waste Package Outer Barrier, and the Stainless Steel Structural Material. ANL-EBS-MD-000005 REV 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001102.0340.

Agreement Number TSPAI.2.02

Agreement Provide the technical basis for the screening argument, as summarized in Attachment 2. See Comment # 3, 4, 11, 12, 19 (Parts 1, 2, and 6), 25, 26, 29, 34, 35, 36, 37, 38, 39, 42, 43, 44, 48, 49, 51, 54, 55, 56, 57, 59, 60, 61, 62, 63, 64, 65, 66, 68, 69, 70, 78, 79, J-1, J-2, J-3, J-4, J-7, J-8, J-9, J-10, J-11, J-12, J-13, J-14, J-15, J-17, J-20, J-21, J-22, J-23, J-24, J-25, J-26, and J-27.

DOE will provide the technical basis for the screening argument, as summarized in Attachment 2, for the highlighted FEPs. The technical basis will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
This issue is covered by an existing DOE/NRC agreement (CLST Subissue 2 Agreement 8). DOE will update the FEPs Screening of Processes and Issues in Drip Shield and Waste Package Degradation, ANL-EBS-PA-000002, screening argument upon completion of the agreement.

Subissue #2 - Scenario Analysis SA-35

Tracking # SA-35

Comment 2.1.03.08.00 (Juvenile and early failure of waste containers). Screened as included for manufacturing and welding defects in waste container degradation analysis, and as excluded for manufacturing defects in drip shield degradation analysis, early failure of waste package and drip shield from improper quality control during the emplacement (CRWMS M&O, 2001). The screening argument states that the "Major effect of pre-existing manufacturing defects is to provide sites for crack growth by stress corrosion cracking. Tensile stress is required to have stress corrosion cracking. Because all fabrication welds of DS are fully annealed prior to emplacement, drip shields are not subject to stress corrosion cracking earthquakes are insignificant to cause stress corrosion cracking (stresses are temporary in nature)." Manufacturing defects in the drip shield and early failures of the Waste package and drip shield from improper quality control during emplacement can be excluded based on negligible consequence to dose." The bases for this assessment is that slap down analysis of a 21-PWR waste package resulted in stresses in the waste package material that were less than 90 percent of the ultimate tensile strength. The impact energy associated with emplacement error is substantially less than that expected in a vertical tip over, emplacement errors are "not expected to result in any damage." The results of the Slap-down analysis are cited as the screening analyses of several features, events, and processes. The damage reported in the Slap down analyses is concerning. While the impact energy of emplacement errors may be substantially less than those experienced in the slap-down analyses, a proper assessment of the extent of Waste package damage as a result of emplacement errors should be performed.

References CRWMS M&O. "FEPs Screening of Processes and Issues in Drip Shield and Waste Package Degradation." ANL-EBS-PA-000002. Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001.

DOE Response The potential early failure mechanisms discussed in CRWMS M&O 2000d indicates that improper heat treatment of waste packages should be included in the waste package degradation and Total System Performance Assessment analysis. Manufacturing defects in the waste package outer barrier closure welds are also considered as in past analyses.

Exclusion of the drip shield failures due to manufacturing flaws is not based on slap down analysis but o the fact that they will be annealed to eliminated fabrication stresses. The slap down analyses pertain to waste package failures and the early failure Analysis/Model Report addresses the probabilities and effects of handling damages. Reference: CRWMS M&O 2000d. Analysis of

Mechanisms for Early Waste Package Failure. ANL-EBS-MD-000023 REV 02. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001011.0196.

Agreement Number TSPAI.2.02

Agreement Provide the technical basis for the screening argument, as summarized in Attachment 2. See Comment # 3, 4, 11, 12, 19 (Parts 1, 2, and 6), 25, 26, 29, 34, 35, 36, 37, 38, 39, 42, 43, 44, 48, 49, 51, 54, 55, 56, 57, 59, 60, 61, 62, 63, 64, 65, 66, 68, 69, 70, 78, 79, J-1, J-2, J-3, J-4, J-7, J-8, J-9, J-10, J-11, J-12, J-13, J-14, J-15, J-17, J-20, J-21, J-22, J-23, J-24, J-25, J-26, and J-27.

DOE will provide the technical basis for the screening argument, as summarized in Attachment 2, for the highlighted FEPs. The technical basis will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
Manufacturing defects associated with the drip shield will be addressed during the resolution of an existing agreement item for the waste package (CLST Subissue 2, Agreement 7). The FEPs Screening of Processes and Issues in Drip Shield and Waste Package Degradation, ANL-EBS-PA-000002, will be updated to reflect the results of this agreement.

Mechanical integrity of the drip shield will be addressed during the resolution of an existing agreement item for the waste package (CLST Subissue 2, Agreement 6). The FEPs Screening of Processes and Issues in Drip Shield and Waste Package Degradation, ANL-EBS-PA-000002, will be updated to reflect the results of this agreement.

Rockfall effects on the drip shield will be addressed during the resolution of an existing agreement item for the waste package (CLST Subissue 2, Agreement 8). The FEPs Screening of Processes and Issues in Drip Shield and Waste Package Degradation, ANL-EBS-PA-000002, will be updated to reflect the results of this agreement.

The FEPs Screening of Processes and Issues in Drip Shield and Waste Package Degradation, ANL-EBS-PA-000002, will be revised to address damage from improper quality control and emplacement of the drip shield. The criteria for damage to waste package during emplacement will be addressed by administrative procedures for emplacement operations that will be developed prior to operation of the facility.

Subissue #2 - Scenario Analysis SA-36

Tracking # SA-36

Comment 2.1.09.03.00 (Volume increase of corrosion products) is screened as excluded on the basis of low consequence (CRWMS M&O, 2001). The presence of waste package corrosion products with higher molar volume than the uncorroded material that may change the stress state in the material being corroded is excluded in the case of waste package based on low consequence. However, it may have an effect on corrosion processes such as SCC of outer container after its initial breaching that may affect radionuclide release [see 2.1.03.07.00 (Mechanical Impact on the Waste Container and Drip Shield)]. The possibility of additional sources of stress arising from the formation of corrosion products should be evaluated in regard to stress corrosion cracking. See comment for 2.1.11.05.00 (Differing thermal expansion of repository components).

References CRWMS M&O. "FEPs Screening of Processes and Issues in Drip Shield and Waste Package Degradation." ANL-EBS-PA-000002. Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001.

DOE Response Analyses cited in Degradation of Stainless Steel Structural Material (CRWMS M&O 2000j, Section 6.1), indicate that even under very conservative assumptions, the growth of this corrosion product will not exceed 93 ?m after 10,000 years. This oxide layer is not thick enough to produce enough pressure to cause mechanical damage to the Alloy 22 container.

Reference: CRWMS M&O 2000j. Degradation of Stainless Steel Structural Material. ANL-EBS-MD-000007 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20000329.1188.

Agreement Number TSPAI.2.02

Agreement Provide the technical basis for the screening argument, as summarized in Attachment 2. See Comment # 3, 4, 11, 12, 19 (Parts 1, 2, and 6), 25, 26, 29, 34, 35, 36, 37, 38, 39, 42, 43, 44, 48, 49, 51, 54, 55, 56, 57, 59, 60, 61, 62, 63, 64, 65, 66, 68, 69, 70, 78, 79, J-1, J-2, J-3, J-4, J-7, J-8, J-9, J-10, J-11, J-12, J-13, J-14, J-15, J-17, J-20, J-21, J-22, J-23, J-24, J-25, J-26, and J-27.

DOE will provide the technical basis for the screening argument, as summarized in Attachment 2, for the highlighted FEPs. The technical basis will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
DOE agreed to provide the technical basis for the screening argument in the FEPs Screening of Processes and Issues in Drip Shield and Waste Package Degradation, ANL-EBS-PA-000002, to

address the NRC comment.

Subissue #2 - Scenario Analysis SA-37

Tracking # SA-37

Comment 2.1.07.05.00 (Creeping of metallic materials in the engineered barrier subsystem) has been excluded from consideration in the total system performance assessment code (CRWMS M&O, 2001a, 2001b). Although DOE correctly points out in the screening argument (CRWMS M&O, 2001b) that ". . .the deformation of many titanium alloys loaded to yield point does not increase with time," (American Society for Metals International, 1990), it still does not specifically address the potential for creeping of titanium grades 7 and 24. For example, some titanium alloys have been shown to creep at room temperatures (Ankem, S., et al., 1994). Creeping of the titanium drip shield subjected to dead loads caused by fallen rock blocks and/or drift collapse could significantly reduce the clearance between the drip shield and waste package over time. As a result, the drip shield may cause substantial damage to the waste package during its dynamic response to subsequent seismic loads. In addition, creeping could potentially cause separation of the individual drip shield units.

References

American Society for Metals International. 1990. Properties and Selection: Nonferrous Alloys and Special-Purpose Materials, Specific Metals and Alloys. Volume 2 of Metals Handbook. 10th Edition. Metals Park, Ohio: American Society for MetalsAnkem, S., C.A. Greene, and S. Singh. "Time Dependent Twinning During Ambient Temperature Creep of a Ti-Mn Alloy." Scripta Metallurgica et Materialia. Vol. 30. No. 6. pp. 803-808. 1994.
CRWMS M&O. "EBS FEPs/Degradation Modes Abstraction." ANL-WIS-PA-000002. Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001aP.
CRWMS M&O. "FEPs Screening of Processes and Issues in Drip Shield and Waste Package Degradation." ANL-EBS-PA-000002. Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001b.

DOE Response Treatment of creep of the drip shield is appropriate for the static loads and temperatures expected. Prior calculations assuming the presence of backfill and rockfall on top of the backfill showed the static loads on the drip shield to be low (<25% of yield strength). However, this calculation will be revised to eliminate the backfill effects. In addition, the potential for creep of Titanium drip shield under the static load will be explicitly addressed in the future revision of the Design Analysis for the Ex-Container Components, (CRWMS M&O 2000l) as part of the Container Life and Source Term agreement KCL0208.

Additional loading combinations are being addressed in response to Container Life and Source Term agreement KCL0208. Evaluations of these loading combinations will be documented in a future revision of the Design Analysis for UCF Waste Packages

(CRWMS M&O 2000n), and the Design Analysis for the Ex-Container Components, (CRWMS M&O 2000l)

Agreement Number TSPAI.2.02

Agreement Provide the technical basis for the screening argument, as summarized in Attachment 2. See Comment # 3, 4, 11, 12, 19 (Parts 1, 2, and 6), 25, 26, 29, 34, 35, 36, 37, 38, 39, 42, 43, 44, 48, 49, 51, 54, 55, 56, 57, 59, 60, 61, 62, 63, 64, 65, 66, 68, 69, 70, 78, 79, J-1, J-2, J-3, J-4, J-7, J-8, J-9, J-10, J-11, J-12, J-13, J-14, J-15, J-17, J-20, J-21, J-22, J-23, J-24, J-25, J-26, and J-27.

DOE will provide the technical basis for the screening argument, as summarized in Attachment 2, for the highlighted FEPs. The technical basis will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
Treatment of creep of the drip shield will be addressed as part of an existing agreement related to drip shield rockfall analyses (CLST Subissue 2 Agreement 8). DOE agreed to provide the technical basis for the screening argument in the FEPs Screening of Processes and Issues in Drip Shield and Waste Package Degradation, ANL-EBS-PA-000002.

Tracking # SA-38

Comment 2.1.11.05.00 (Differing thermal expansion of repository components) has been excluded from consideration in the total system performance assessment code (CRWMS M&O, 2001a, 2001c). The technical basis for excluding differing thermal expansion effects on repository performance is not comprehensive nor adequate. For example, according to the screening arguments (CRWMS M&O, 2001b),

"... the difference in temperature between the inside of the waste package inner barrier (316NG) and the outside of the waste package outer barrier (Alloy 22) never exceeds 2°C. As an illustrative example, using the coefficients of thermal expansion for the two materials discussed above [i.e., Alloy 22 and 316NG] and a bounding 5°C (or 5 K) temperature difference between them, the calculated strain is 2.15x10-5 m/m. This strain is so small that thermal expansion of waste package barriers will result in a negligible effect on expected mean dose rate.

A ~1 mm gap will prevent the resultant stress due to the differing thermal expansion coefficients of the waste package materials from reaching a critical level that could lead to stresses in the waste package barriers. The Waste Package Operation Fabrication Process Report (CRWMS M&O, 2000b, Section 8.1.8) requires a loose fit between the outer barrier (Alloy 22) and the inner shell (316NG stainless steel) to accommodate the differing thermal expansion coefficients, and so 2.1.11.05.00 (Differing thermal expansion of repository components) can be excluded for the waste packages based on low consequence to the expected annual dose."

The quoted rationale is not technically correct and does not address the limited clearance between the inner and outer barriers of the waste package in the axial direction, which may be as small as 2-mm according to design drawings (CRWMS M&O, 2000a). In addition, the differential thermal expansion between various invert components and the drift wall (which they are attached to) has not been addressed.

2.1.11.05.00 (Differing thermal expansion of repository components) is excluded on the basis of low consequence (CRWMS M&O. 2001a, 2001c). Peak temperature of waste package 278°C with backfill and 176°C without backfill with 0.5 meter spacing and 50-yr ventilation. Screening argument is that the temperature differential between inner type 316NG barrier and outer Alloy 22 barrier is 5°C and the corresponding strain of 2.15x10-5 m/m. This calculation is performed using the difference

between thermal expansion coefficients for 316NG and Alloy 22 using the maximum expected temperature difference between the waste package barriers. There will be at least a 1 mm gap between the barriers so no thermal stresses are predicted.

The calculation should use a temperature of the waste package rather than the difference between waste package barriers. The clearance between the inner type 316NG and the outer Alloy 22 is specified in the waste package design and fabrication process report to be 0 to 4 mm (CRWMS M&O. 2000b). It is implicit that this clearance is specified at ambient temperature (i.e., 25°C) because (i) no temperature is specified and (ii) the outer Alloy 22 waste package outer barrier will be heated to 700 F (371°C) for inner 316NG cylinder installation. Using a temperature of 186°C the calculated strain is 7.99x10-4 m/m. For waste package with clearance gaps of 1 mm or less at 25°C, thermal stresses will occur as a result of the difference in thermal expansion.

References

CRWMS M&O. "Design Analysis for the Ex-Container Components." ANL-XCS-ME-000001. Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000a.
CRWMS M&O. "Waste Package Operations Fabrication Process Report." TDR-EBS-ND-000003. Revision 01. Las Vegas, Nevada: CRWMS M&O. 2000b.
CRWMS M&O. "EBS FEPs/Degradation Modes Abstraction." ANL-WIS-PA-000002. Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001a.
CRWMS M&O. "Evaluation of the Applicability of Biosphere-Related Features, Events, and Processes (FEP)". ANL-MGR-MD-000011. Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001b.
CRWMS M&O. "FEPs Screening of Processes and Issues in Drip Shield and Waste Package Degradation." ANL-EBS-PA-000002. Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001c.

DOE Response

Tensile stresses due to differential thermal expansion between waste package barriers are eliminated by the introduction of a gap between the barriers. This is done to eliminate tensile stresses due to differential thermal expansion from contributing to stress corrosion cracking of the waste package barriers. With this source of stress eliminated, it does not contribute to calculated dose rates due to waste package failure.

Thermal expansion calculations already performed and in the process of documentation have indicated a need to increase the gap between the outer barrier lid and the inner barrier lid from the current 3-mm to 6-mm in the next revision to the waste package design concepts. These modifications are underway and will be

included in next revisions to the Design Analysis for the UCF Waste Packages (CRWMS M&O 2000n), Design Analysis for the Defense High Level Waste Disposal Containers (CRWMS M&O 2000k), and Design Analysis for the Naval SNF Waste Package (CRWMS M&O 2000m).

A more comprehensive listing of interfaces where differing thermal expansion may be of relevance in the Engineered Barrier System will be developed. For each such location, the amount of differential expansion will be estimated relative to the potential impact of such expansion on Engineered Barrier System component performance. This will provide a quantified basis for the Exclude B Low Consequence screening.

Agreement Number TSPAI.2.02

Agreement Provide the technical basis for the screening argument, as summarized in Attachment 2. See Comment # 3, 4, 11, 12, 19 (Parts 1, 2, and 6), 25, 26, 29, 34, 35, 36, 37, 38, 39, 42, 43, 44, 48, 49, 51, 54, 55, 56, 57, 59, 60, 61, 62, 63, 64, 65, 66, 68, 69, 70, 78, 79, J-1, J-2, J-3, J-4, J-7, J-8, J-9, J-10, J-11, J-12, J-13, J-14, J-15, J-17, J-20, J-21, J-22, J-23, J-24, J-25, J-26, and J-27.

DOE will provide the technical basis for the screening argument, as summarized in Attachment 2, for the highlighted FEPs. The technical basis will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
DOE agreed to provide the technical basis for the screening argument in the FEPs Screening of Processes and Issues in Drip Shield and Waste Package Degradation, ANL-EBS-PA-000002, screening argument to address the NRC comment.

Subissue #2 - Scenario Analysis SA-39

Tracking # SA-39

Comment 2.1.06.06.00 (Effects and Degradation of Drip Shield). Excluded based on low consequence (CRWMS M&O, 2001b). The drip shield is an important component of the engineered barrier subsystem and its function and degradation is explicitly considered in the total system performance assessment. The degradation of the drip shield due to corrosion processes is considered directly in the model abstraction for waste package degradation, whereas remaining aspects of drip shield behavior are considered as part of the engineered barrier subsystem analysis. For the secondary feature-event-process 2.1.06.06.01 (Oxygen embrittlement of Ti drip shield), DOE argues that it is explicitly considered in the screening argument, but no discussion is presented. It is noted that this issue is most relevant to mechanical failure of the drip shield, which is discussed under 2.1.07.01.00 (rockfall) and 2.1.07.02.00 (mechanical degradation or drift collapse).Although physical and chemical degradation processes have been included into the Total System Performance Assessment, their effects on the ability of the drip shield to withstand dead loads (caused by drift collapse and/or fallen rock blocks), rock block impacts, and seismic excitation is not accounted for in the screening arguments (CRWMS M&O, 2001a, 2001b). In (CRWMS M&O, 2000) it is stated that the impact of rockfall on the degraded drip shield has been screened as excluded until more detailed structural response calculations for the drip shield under various rock loads are available. No references are provided in this document as to when and where these analyses will be available.

References

CRWMS M&O. "AMR EBS Radionuclide Transport Abstraction." ANL-WIS-PA-000001. Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000.

CRWMS M&O. "EBS FEPs/Degradation Modes Abstraction." ANL-WIS-PA-000002. Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001a.

CRWMS M&O. "FEPs Screening of Processes and Issues in Drip Shield and Waste Package Degradation." ANL-EBS-PA-000002. Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001b.

DOE Response In the current revision of the FEPs Screening of Process and Issues in Drip Shield and Waste Package Degradation (CRWMS M&O 2001h), oxygen embrittlement of titanium results from diffusion of interstitial oxygen into the metal at higher temperatures (>340?C) (ASM International 1987, p. 681). The time to failure depends on the alloy composition, material thickness, and stress state. For the thermal hydrologic time history files used in the Total System Performance Assessment analyses, the waste package surface temperatures never exceed 186°C (CRWMS M&O 2000b, Section 6.3.1), which is less than the threshold temperature of

340°C. Therefore, oxygen embrittlement of the titanium drip shields is excluded on the basis of low consequence to the expected annual dose.

Reference

ASM International 1987. Corrosion. Volume 13 of Metals Handbook. 9th Edition. Metals Park, Ohio: ASM International. TIC: 209807.

CRWMS M&O 2000b. Abstraction of NFE Drift Thermodynamic Environment and Percolation Flux. ANL-EBS-HS-000003 REV 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001206.0143.

Agreement Number TSPAI.2.02

Agreement Provide the technical basis for the screening argument, as summarized in Attachment 2. See Comment # 3, 4, 11, 12, 19 (Parts 1, 2, and 6), 25, 26, 29, 34, 35, 36, 37, 38, 39, 42, 43, 44, 48, 49, 51, 54, 55, 56, 57, 59, 60, 61, 62, 63, 64, 65, 66, 68, 69, 70, 78, 79, J-1, J-2, J-3, J-4, J-7, J-8, J-9, J-10, J-11, J-12, J-13, J-14, J-15, J-17, J-20, J-21, J-22, J-23, J-24, J-25, J-26, and J-27.

DOE will provide the technical basis for the screening argument, as summarized in Attachment 2, for the highlighted FEPs. The technical basis will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
The ability of the additional loading combinations to initiate and/or propagate preexisting cracks are being addressed in existing agreements (CLST Subissue 2 Agreements 8 and 9). DOE agreed to provide the technical basis for the screening argument in the FEPs Screening of Processes and Issues in Drip Shield and Waste Package Degradation, ANL-EBS-PA-000002.

Subissue #2 - Scenario Analysis SA-40

Tracking # SA-40

Comment FEP 2.1.02.21.00 (Stress corrosion cracking [SCC] of cladding). Included but only the SCC caused by fission products that operates from the inside out of the cladding (FEP 2.1.02.21.01). The occurrence of SCC caused by the action of chemical or salts present inside the WP and acting from the outside in, even that is considered in another secondary FEP (FEP 2.1.02.21.02), it is not discussed in the screening arguments. Therefore, no justification is offered in the database for the exclusion of SCC occurring from the outside in. In the Table 2 of the Clad Degradation - FEPs Screening Arguments (CRWMS M&O, 2000) this secondary FEP is listed as included.

References CRWMS M&O. "Clad Degradation - FEPs Screening Arguments." ANL-WIS-MD-000008 Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response At the May 15-17, 2001 Technical Exchange, NRC stated that the FEP is appropriately addressed under CLST Agreement 3.7.

Agreement Number

Agreement DOE response during Technical Exchange was considered adequate by the NRC. Technical Exchange on Features, Events, and Processes, May 15-17, 2001.

Subissue #2 - Scenario Analysis SA-41

Tracking # SA-41

Comment 2.1.02.20.00 (Pressurization from helium production causes cladding failure). Included as a process of internal gas pressure buildup that increases the cladding stress contributing to delayed hydride cracking and strain (creep?) failures (CRWMS M&O, 2000). The wording could be more precise in the text where it is clarified that helium production from alpha decay is the main source of pressure buildup.

References CRWMS M&O. "Clad Degradation - FEPs Screening Arguments." ANL-WIS-MD-000008 Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response At 100,000 years, the pressure, stresses, and stress intensities are a factor of 2.38 higher than at 100 years (values reported in the Clad Degradation B Summary and Abstraction Analysis/Model Report, CRWMS M&O 2001a). These values are still less than the threshold stress intensity values for stress corrosion cracking from Chlorine, Iodine, and Bromine at room temperature. Hence, the conclusions in the original Analysis/Model Report remain unchanged; stress corrosion cracking is not expected even with alpha decay, the main source of Helium production and pressure buildup, for 100,000 years.

The role of helium buildup in cladding degradation will be included in the next revision of the Clad Degradation Summary and Abstraction Analysis/Model Report (CRWMS M&O 2001a).

Agreement Number TSPAI.2.01

Agreement Provide clarification of the screening arguments, as summarized in Attachment 2. See Comment # 5, 7, 8, 9, 10, 13, 18, 19 (Part 5), 21, 32, 41, 47, 50, 53, 58, 67, J-5, J-16, and J-18

DOE will clarify the screening arguments, as summarized in Attachment 2, for the highlighted FEPs. The clarifications will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
DOE agreed to provide clarification of the screening argument in the Clad Degradation - FEPs Screening Arguments, ANL-WIS-MD-000008 to address the NRC comment.

Subissue #2 - Scenario Analysis SA-42

Tracking # SA-42

Comment 2.1.08.07.00 (Pathways for unsaturated flow and transport in the waste and engineered barrier system) evaluates unsaturated flow and radionuclide transport that may occur along preferential pathways in the waste and engineered barrier subsystem (CRWMS M&O, 2000). The DOE indicates that preferential pathways are already "included" via "a series of linked one dimensional flowpaths and mixing cells through the engineered barrier subsystem, drip shield, waste package and into the invert (CRWMS M&O, 2000)." Staff are concerned that preferred pathways in the engineered barrier subsystem are not being evaluated at the appropriate scale. Water has been observed to drip preferentially along grouted rock bolts in the enhanced characterization of repository block, for example, demonstrating that the introduced materials themselves can influence the location of preferred flow pathways. Interactions with engineered materials, such as cementitious and metallic components, can have a significant effect on evolved water and gas compositions. Because the description of 2.1.08.07.00 states that "Physical and chemical properties of the engineered barrier subsystem and waste form, in both intact and degraded states, should be considered in evaluating [preferential] pathways", staff expect the screening arguments to be based on an evaluation of these topics (NRC, 2000).

References

CRWMS M&O. "Miscellaneous Waste Form FEPs." ANL-WIS-MD-000009. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

NRC. "Issue Resolution Status Report. Key Technical Issue: Evolution of the Near Field Environment" Revision 3. Washington, DC: Nuclear Regulatory Commission. 2000.

DOE Response

Agreement Number TSPAI.2.02

Agreement Provide the technical basis for the screening argument, as summarized in Attachment 2. See Comment # 3, 4, 11, 12, 19 (Parts 1, 2, and 6), 25, 26, 29, 34, 35, 36, 37, 38, 39, 42, 43, 44, 48, 49, 51, 54, 55, 56, 57, 59, 60, 61, 62, 63, 64, 65, 66, 68, 69, 70, 78, 79, J-1, J-2, J-3, J-4, J-7, J-8, J-9, J-10, J-11, J-12, J-13, J-14, J-15, J-17, J-20, J-21, J-22, J-23, J-24, J-25, J-26, and J-27.

DOE will provide the technical basis for the screening argument, as summarized in Attachment 2, for the highlighted FEPs. The technical basis will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:

This issue is addressed by an existing DOE/NRC agreement (ENFE Subissue 2 Agreement 6, 10, and 14). The Engineered Barrier System Features, Events, and Processes. ANL-WIS-PA-000002, will be updated upon completion of these agreement items.

Subissue #2 - Scenario Analysis SA-43

Tracking # SA-43

Comment 2.1.02.27.00 (Localized corrosion perforation from fluoride). Included because fluoride is present in YM waters and zirconium corrodes in environments containing fluoride (CRWMS M&O, 2000). It is argued that localized corrosion caused by fluoride is included in the model abstraction for cladding degradation to account for modeling uncertainty of the in-package chemistry since conditions for corrosion induced by fluoride were considered more likely to occur relative to other processes examined.

References CRWMS M&O. "Clad Degradation - FEPs Screening Arguments." ANL-WIS-MD-000008 Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response

Agreement Number TSPAI.2.02

Agreement Provide the technical basis for the screening argument, as summarized in Attachment 2. See Comment # 3, 4, 11, 12, 19 (Parts 1, 2, and 6), 25, 26, 29, 34, 35, 36, 37, 38, 39, 42, 43, 44, 48, 49, 51, 54, 55, 56, 57, 59, 60, 61, 62, 63, 64, 65, 66, 68, 69, 70, 78, 79, J-1, J-2, J-3, J-4, J-7, J-8, J-9, J-10, J-11, J-12, J-13, J-14, J-15, J-17, J-20, J-21, J-22, J-23, J-24, J-25, J-26, and J-27.

DOE will provide the technical basis for the screening argument, as summarized in Attachment 2, for the highlighted FEPs. The technical basis will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
This issue is addressed by an existing DOE/NRC agreement (CLST Subissue 3 Agreement 7). DOE agreed to provide clarification of the screening argument in the Clad Degradation - FEPs Screening Arguments, ANL-WIS-MD-000008 to address the NRC comment.

Subissue #2 - Scenario Analysis SA-44

Tracking # SA-44

Comment 2.1.02.16.00 (Localized corrosion [pitting] of cladding). Included because localized corrosion by pits could produce penetration of cladding (CRWMS M&O, 2000). Even though localized corrosion is included in the commercial spent nuclear fuel cladding degradation model abstraction, the effect of chloride ions as pitting promoters is not considered in the analysis of localized corrosion done by the DOE. It is stated that pitting corrosion is promoted by concentrated chloride and fluoride solutions at very low pHs and very high oxidation potentials, but these conditions are not predicted to occur in the bulk solution inside waste packages. However, it accepted that certain processes such as microbial induced corrosion, galvanic coupling, radiolysis in a humid environment, and evaporation may generate locally concentrated solutions of aggressive species or pH decreases such that a model for localized corrosion is necessary.

References CRWMS M&O. "Clad Degradation - FEPs Screening Arguments." ANL-WIS-MD-000008 Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response The localized corrosion model will be modified to include pitting by chlorides. This model will be used in future cladding abstractions for Total System Performance Assessment-License Application. Probability distributions for pH will also be included in the analysis. This comment is addressed in agreements KCL0306 and KCL0307. Container Life and Source Term agreement KCL0306 states in part, A(DOE) to provide additional technical basis for the (cladding) failure rate and how the rate is affected by localized corrosion." And Container Life and Source Term agreement KCL0307 states in part, "(DOE) to provide data to address chloride induced localized corrosion and stress corrosion cracking under the environment predicted by in-package chemistry modeling." The Analysis/Model Reports: Clad Degradation B Summary and Abstraction, ANL-WIS-MD-000007 (CRWMS M&O 2001a) and Clad Degradation B FEPs Screening Arguments, ANL-WIS-MD-000008 (CRWMS M&O 2000h) will also be revised, incorporating the results from agreement KCL0307 to support any potential License Application, to reflect this new information.

Agreement Number TSPAI.2.02

Agreement Provide the technical basis for the screening argument, as summarized in Attachment 2. See Comment # 3, 4, 11, 12, 19 (Parts 1, 2, and 6), 25, 26, 29, 34, 35, 36, 37, 38, 39, 42, 43, 44, 48, 49, 51, 54, 55, 56, 57, 59, 60, 61, 62, 63, 64, 65, 66, 68, 69, 70, 78, 79, J-1, J-2, J-3, J-4, J-7, J-8, J-9, J-10, J-11, J-12, J-13, J-14, J-15, J-17, J-20, J-21, J-22, J-23, J-24, J-25, J-26, and J-27.

DOE will provide the technical basis for the screening argument, as summarized in Attachment 2, for the highlighted FEPs. The technical basis will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
This issue is addressed by an existing DOE/NRC agreement (CLST Subissue 3 Agreement 7). DOE agreed to provide clarification of the screening argument in the Clad Degradation - FEPs Screening Arguments, ANL-WIS-MD-000008 to address the NRC comment.

Subissue #2 - Scenario Analysis SA-45

Tracking # SA-45

Comment FEP 2.1.02.19.00 (Creep rupture of cladding). Included as perforation mechanism for the CSNF cladding degradation component (CRWMS M&O, 2000). Distribution of cladding temperatures and hoop stresses used to evaluate the propensity to hydride reorientation and embrittlement (see FEP 2.1.02.22.00) should be consistent with those for creep and SCC calculations.

References CRWMS M&O. "Clad Degradation - FEPs Screening Arguments." ANL-WIS-MD-000008 Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response

Agreement Number

Agreement At the May 15-17, 2001 Technical Exchange, the NRC stated that it is currently reviewing information pertaining to this FEP and that, if necessary, NRC would formally request additional information from DOE.

Subissue #2 - Scenario Analysis SA-46

Tracking # SA-46

Comment FEP 2.1.02.24.00 (Mechanical failure [of cladding]). Included as a failure process resulting from external stresses such as ground motion during earthquakes assuming a frequency of 1.1×10-6 events/year that cause failure of all cladding that is available for unzipping (CRWMS M&O, 2000). On the contrary, cladding failure arising from rock fall is not included in the model abstraction assuming integrity of the WP for 10,000 years (See FEP 2.1.07.01.00).

References CRWMS M&O. "Clad Degradation - FEPs Screening Arguments." ANL-WIS-MD-000008 Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response

Agreement Number

Agreement At the May 15-17, 2001 Technical Exchange, the NRC stated that the FEP was discussed in an NRC letter dated August 3, 2000, related to Structural Deformation and Seismicity KTI and did not need to be addressed at this meeting

Subissue #2 - Scenario Analysis SA-47

Tracking # SA-47

Comment 2.1.02.17.00 (Localized corrosion [crevice corrosion] of cladding). Excluded based on low probability of occurrence (CRWMS M&O, 2000a). Experimental evidence is cited to indicate that crevice corrosion has not been observed in zirconium alloys exposed to chloride solutions, including NRC and CNWRA results. There is a need to develop a better understanding of localized corrosion of zirconium alloys before confirming this conclusion because the data are limited. In the report on Clad Degradation- Local Corrosion of Zirconium and Its Alloys Under Repository Conditions (CRWMS M&O, 2000b) it is noted that crevice corrosion may occur in the presence of fluoride ions.

References CRWMS M&O. "Clad Degradation - FEPs Screening Arguments." ANL-WIS-MD-000008 Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000a.
CRWMS M&O. "Clad Degradation - Local Corrosion of Zirconium and its Alloys under Repository ConditionsJuly 17, 2001." ANL-EBS-BMD-000012. Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000b.

DOE Response DOE will continue to review new crevice corrosion literature as part of the execution of Container Life and Source Term agreement KCL0307. Agreement KCL0307 states in part, "(DOE) to provide data to address chloride induced localized corrosion and stress corrosion cracking under the environment predicted by in-package chemistry modeling." The Analysis/Model Reports: Clad Degradation B Summary and Abstraction, ANL-WIS-MD-000007 and Clad Degradation B FEPs Screening Arguments, ANL-WIS-MD-000008 will be revised, incorporating information from agreement KCL0307, including a summary of any significant new crevice corrosion literature, in time to support any potential License Application

Agreement Number TSPAI.2.01

Agreement Provide clarification of the screening arguments, as summarized in Attachment 2. See Comment # 5, 7, 8, 9, 10, 13, 18, 19 (Part 5), 21, 32, 41, 47, 50, 53, 58, 67, J-5, J-16, and J-18

DOE will clarify the screening arguments, as summarized in Attachment 2, for the highlighted FEPs. The clarifications will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
DOE agreed to provide clarification of the screening argument in the Clad Degradation – FEPs Screening Arguments, ANL-WIS-MD-000008 to address the NRC comment using data relevant to the

proposed repository.

Subissue #2 - Scenario Analysis SA-48

Tracking # SA-48

Comment 2.1.01.04.00 (Spatial Heterogeneity of Emplaced Waste) is screened as excluded on the basis of low consequence (CRWMS M&O, 2000). Waste placed in Yucca Mountain will have physical, chemical, and radiological properties that will vary. The effect of spatial heterogeneity of the waste on repository-scale response is excluded based on low consequence but the heterogeneity within a waste package is implicitly included in the evaluation of in-package temperature used to determine perforation of the commercial spent nuclear fuel cladding. However, spatial variability that may affect degradation of engineering barrier, such as conditions leading to crevice corrosion vs passive corrosion of outer container, is not considered in this feature-event-process.

References CRWMS M&O. "Miscellaneous Waste Form FEPs." ANL-WIS-MD-000009. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response Spatial heterogeneity of the waste is addresses below. Spatial variability that may affect degradation of the waste package will be addressed as part of the resolution of the Container Life and Source Term agreement KCL0101. The scope of the agreement includes the evaluation of the range of chemical environments on the waste package.

Agreement Number TSPAI.2.02

Agreement Provide the technical basis for the screening argument, as summarized in Attachment 2. See Comment # 3, 4, 11, 12, 19 (Parts 1, 2, and 6), 25, 26, 29, 34, 35, 36, 37, 38, 39, 42, 43, 44, 48, 49, 51, 54, 55, 56, 57, 59, 60, 61, 62, 63, 64, 65, 66, 68, 69, 70, 78, 79, J-1, J-2, J-3, J-4, J-7, J-8, J-9, J-10, J-11, J-12, J-13, J-14, J-15, J-17, J-20, J-21, J-22, J-23, J-24, J-25, J-26, and J-27.

DOE will provide the technical basis for the screening argument, as summarized in Attachment 2, for the highlighted FEPs. The technical basis will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
Spatial variability that may affect degradation of the waste package will be addressed as part of the resolution of an existing agreement (CLST Subissue 1 Agreement 1). The scope of the agreement includes the evaluation of the range of chemical environments on the waste package.

Subissue #2 - Scenario Analysis SA-49

Tracking # SA-49

Comment 2.1.02.15.00 (Acid corrosion of cladding from radiolysis). Included as part of localized corrosion model on the basis that the formation of HNO3 and H2O2 ions(sic) by radiolysis can enhance corrosion of cladding (CRWMS M&O, 2000). It is stated, however, that zirconium has excellent corrosion resistance to HNO3 and concentrated H2O2. The arguments are poorly worded stating that radiolysis is not expected to occur until waste package failure and then the gamma dose will be very low to produce sufficient HNO3 and H2O2 to promote general corrosion but localized corrosion could be possible. The argument of local acidic pH causing localized corrosion of cladding is in contradiction with experimental evidence showing that zirconium alloys are resistant to corrosion in reducing and oxidizing acids. In addition, it is in contradiction with arguments to screen out pitting corrosion by chloride anions {see 2.1.02.16.00 [Localized corrosion (pitting) of cladding]}. In the Basis for Screening undue consideration is given to alkaline conditions arising from concrete liner whereas the possibility of very acidic conditions (pH< 2) are not discussed.

References CRWMS M&O. "Clad Degradation - FEPs Screening Arguments." ANL-WIS-MD-000008 Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response Radiolysis by itself is not expected to damage the cladding. Radiolysis as a possible cause of pH reduction and coupled with FeCl3 pitting is a possible mechanism for cladding failure. A new cladding localized corrosion model addressing radiolysis and low pH (pH < 2) will be developed in time to support any potential License Application. This comment is addressed in Container Life and Source Term agreement KCL0307. Agreement KCL0307 states in part, A(DOE) to provide data to address chloride induced localized corrosion and stress corrosion cracking under the environment predicted by in-package chemistry modeling.@ The Analysis/Model Reports: Clad Degradation B Summary and Abstraction, ANL-WIS-MD-000007 (CRWMS M&O 2001a) and Clad Degradation B FEPs Screening Arguments, ANL-WIS-MD-000008 (CRWMS M&O 2000h) will be revised, incorporating information from agreement KCL0307, in time to support any potential License Application.

Agreement Number TSPAI.2.02

Agreement Provide the technical basis for the screening argument, as summarized in Attachment 2. See Comment # 3, 4, 11, 12, 19 (Parts 1, 2, and 6), 25, 26, 29, 34, 35, 36, 37, 38, 39, 42, 43, 44, 48, 49, 51, 54, 55, 56, 57, 59, 60, 61, 62, 63, 64, 65, 66, 68, 69, 70, 78, 79, J-1, J-2, J-3, J-4, J-7, J-8, J-9, J-10, J-11, J-12, J-13, J-14, J-15, J-17, J-20, J-21, J-22, J-23, J-24, J-25, J-26, and J-27.

DOE will provide the technical basis for the screening argument, as summarized in Attachment 2, for the highlighted FEPs. The technical basis will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
This issue is addressed by an existing DOE/NRC agreement (CLST Subissue 3 Agreement 7). DOE agreed to provide clarification of the screening argument in the Clad Degradation - FEPs Screening Arguments, ANL-WIS-MD-000008 to address the NRC comment.

Subissue #2 - Scenario Analysis SA-50

Tracking # SA-50

Comment 2.1.02.13.00 (General corrosion of cladding). Excluded based on low probability of occurrence (CRWMS M&O, 2000). Although general corrosion of cladding could expose large areas of irradiated fuel matrix and produce hydrides it is argued that it is a very slow process. The arguments are based on extrapolation to low temperatures at test data obtained at temperatures above 250°C and in measurements of oxide thickness from specific fuel rods after reactor operation and exposure to water in reactor pool storage.

References CRWMS M&O. "Clad Degradation - FEPs Screening Arguments." ANL-WIS-MD-000008 Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response The distributions of fuel characteristics developed in the Analysis/Model Report: Initial Cladding Condition (CRWMS M&O 2000ah) addresses fuel burnup to 75 MWd/kgU and oxide thickness to 120 μm, 20 μm above the NRC allowable limit of 100 μm. The distribution developed has 10.1% of the rods exceeding the NRC limit and 2.55% at 120 μm. These projections adequately address the general corrosion of the higher burnup fuels. In all calculations involving stress, the oxide thickness is subtracted off of the wall thickness (no structural credit for oxides). The Clad Degradation Features, Events and Processes Analysis/Model Report (CRWMS M&O 2000h) will be revised to reflect this information.

Agreement Number TSPAI.2.01

Agreement Provide clarification of the screening arguments, as summarized in Attachment 2. See Comment # 5, 7, 8, 9, 10, 13, 18, 19 (Part 5), 21, 32, 41, 47, 50, 53, 58, 67, J-5, J-16, and J-18

DOE will clarify the screening arguments, as summarized in Attachment 2, for the highlighted FEPs. The clarifications will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
DOE agreed to provide clarification of the screening argument in the Clad Degradation Features, Events and Processes Analysis/Model Report, ANL-WIS-MD-000008, to address the NRC comment.

Subissue #2 - Scenario Analysis SA-51

Tracking # SA-51

Comment 2.1.02.14.00 (Microbially induced corrosion of cladding). Included as part of localized corrosion model on the basis that microbial activity may induce local pH decreases and the local acidic environment may produce multiple penetrations of the cladding (CRWMS M&O, 2000). It is stated, however, that microbially induced corrosion resulting from sulfide produced by sulfate reducing bacteria and organic acid producing bacteria is not expected to occur due to resistance of zirconium to these species. The arguments are poorly worded stating that microbially induced corrosion is not expected to occur (not probable or credible) because microbial activity is screened out at the scale of the repository model as a significant bulk process.The argument of local acidic pH causing localized corrosion of cladding is in contradiction with experimental evidence showing that zirconium alloys are resistant to corrosion in reducing and oxidizing acids. In addition, it is in contradiction with arguments to screen out pitting corrosion by chloride anions {see 2.1.02.16.00 [Localized corrosion (pitting) of cladding]}. Screening arguments for inclusion or exclusion should be consistent with screening decisions for related entries [see 2.1.02.15.00 (Acid corrosion of cladding from radiolysis). A third group of bacteria iron oxidizers should be considered in the analysis also (NRC, 2001).

References CRWMS M&O. "Clad Degradation - FEPs Screening Arguments." ANL-WIS-MD-000008 Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.
NRC. "Issue Resolution Status Report. Key Technical Issue: Container Life and Source Term." Revision 3. Washington, DC: NRC. 2001.

DOE Response The impact of microbial induced corrosion on the cladding environment and corrosion will be re-evaluated and documented during the execution of the Container Life and Source Term agreement KCL0307. Agreement KCL0307 states in part, "(DOE) to provide data to address chloride induced localized corrosion and stress corrosion cracking under the environment predicted by in-package chemistry modeling." The Analysis/Model Reports: Clad Degradation B Summary and Abstraction, ANL-WIS-MD-000007 (CRWMS M&O 2001a) and Clad Degradation B FEPs Screening Arguments, ANL-WIS-MD-000008 (CRWMS M&O 2000h) will be revised, incorporating information from agreement KCL0307, in time to support any potential License Application.

Agreement Number TSPAI.2.02

Agreement Provide the technical basis for the screening argument, as summarized in Attachment 2. See Comment # 3, 4, 11, 12, 19 (Parts 1, 2, and 6), 25, 26, 29, 34, 35, 36, 37, 38, 39, 42, 43, 44,

48, 49, 51, 54, 55, 56, 57, 59, 60, 61, 62, 63, 64, 65, 66, 68, 69, 70, 78, 79, J-1, J-2, J-3, J-4, J-7, J-8, J-9, J-10, J-11, J-12, J-13, J-14, J-15, J-17, J-20, J-21, J-22, J-23, J-24, J-25, J-26, and J-27.

DOE will provide the technical basis for the screening argument, as summarized in Attachment 2, for the highlighted FEPs. The technical basis will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
This issue is addressed by an existing DOE/NRC agreement (CLST Subissue 3 Agreement 7). DOE agreed to provide clarification of the screening argument in the Clad Degradation - FEPs Screening Arguments, ANL-WIS-MD-000008 to address the NRC comment.

The new cladding local corrosion model will reference the In-Drift Microbial Communities AMR, ANL-EBS-MD-000038, which includes discussion of iron oxidizing bacteria. The Clad Degradation - FEPs Screening Arguments, ANL-WIS-MD-000008 AMR will be revised to be consistent with the updated Summary-Abstraction AMR.

Tracking # SA-53

Comment 2.1.02.22.00 (Hydride embrittlement of cladding). Excluded based on low probability of occurrence (CRWMS M&O, 2000). DOE screening argument states that the in-package environment and cladding stresses are not conductive to hydride cracking. The NRC staff believes that reorientation of pre-existing hydride and embrittlement depend on temperature in addition to the required stresses. Clarification is needed on the cladding temperature and stress distributions used in the analysis. Several secondary features, events, and processes related to various processes leading to hydrogen entry into the cladding are listed below:

2.1.02.22.01 (Hydride embrittlement from zirconium corrosion [of cladding]). Excluded due to low probability of occurrence because the hydrogen pickup as a result of cladding corrosion is very low due to the low corrosion rate and the relatively small pickup fraction. The experimental hydrogen pickup fraction is given and it is argued that the corrosion rate is very low. The conclusion attained by the DOE regarding failure of cladding as a result of hydrogen pickup due to general corrosion is acceptable. However, the screening arguments can be better justified using quantitative arguments for the corrosion rate under disposal conditions.

2.1.02.22.02 (Hydride embrittlement from waste package corrosion and hydrogen absorption [of cladding]). Excluded due to low probability of occurrence because the hydrogen generated by corrosion of waste package and waste package internals and present as a molecule in gas or dissolved in water is not directly absorbed by the cladding. It is argued on the basis of experimental data that hydrogen absorption occurred through the reaction with water and not from the dissolved molecular hydrogen. The conclusion attained by the DOE regarding failure of cladding as a result of absorption of hydrogen gas generated by corrosion of waste package materials is acceptable. However, the screening arguments can be better organized.

2.1.02.22.03 (Hydride embrittlement from galvanic corrosion of waste package contacting cladding). Excluded due to low probability of occurrence because corrosion of waste package internals will not result in hydriding of cladding. It is argued using some experimental data as basis that galvanic coupling to carbon steel will not be conducive to hydrogen charging because corrosion products will interrupt the electrical contact. It is claimed also that the Ni content both in Zircaloy 2- and -4 is not sufficient to induce the necessary hydrogen charging. The conclusion attained by the DOE regarding failure of cladding as a result of

hydrogen entry due to galvanic coupling with internal components of the waste package is in general acceptable. However, the screening arguments could be better supported by more relevant experimental data.

2.1.02.22.04 (Delayed hydride cracking [of cladding]) Excluded due to low probability of occurrence. The analysis is based on the use of calculated values for the distribution of the stress intensity factor which are compared with the threshold stress intensity for irradiated Zircaloy-2. The conclusion attained by the DOE regarding failure of cladding as a result of DHC is acceptable. However, the DOE analysis of DHC is based on material properties of cladding containing mostly circumferential hydrides. DOE needs to provide cladding temperatures and stress distributions and demonstrate that they are insufficient to cause hydride reorientation.

2.1.02.22.05 (Hydride reorientation [of cladding]). Excluded due to low probability of occurrence because tested fuel rods did not exhibit hydride reorientation at stresses higher than those expected at the repository temperatures. It is argued, in addition, that any hydride reorientation stresses will be insufficient for hydride embrittlement and clad failure. Therefore hydride reorientation has not been included in the model abstraction for cladding degradation. DOE agreed to provide updated documentation on the distribution of cladding temperatures and hoop stresses, critical parameters needed to evaluate the propensity to hydride reorientation and embrittlement. See the primary 2.1.02.22.00 (Hydride Embrittlement of Cladding).

2.1.02.22.06 (Hydride axial migration [of cladding]). Excluded based on low probability since it is unlikely that sufficient hydrogen can be moved to the cooler ends of the fuel rods because of a lack of large temperature gradients in the waste packages. Based on studies for storage up to 90 years, it is concluded that the temperature gradients are not sufficient to induce redistribution of hydrides. The conclusion attained by the DOE regarding redistribution of hydrides caused by temperature gradients is acceptable. The screening arguments, however, should include the combined effects of stress and temperature.

2.1.02.22.07 (Hydride embrittlement from fuel reaction [causes failure if cladding]). Excluded based on low probability of occurrence because hydride embrittlement from fuel reaction is only observed in boiling water reactors and a high temperature steam environment is required for failure propagation, conditions which are unlikely even after waste package failure. The

conclusion is acceptable because it is not a credible failure mechanism. However, the screening arguments are, to say the least, confusing.

References CRWMS M&O. "Clad Degradation - FEPs Screening Arguments." ANL-WIS-MD-000008 Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response This response is applicable to Features, Events and Processes 2.1.02.22.00 through 2.1.02.22.07.

The next revision to the Clad Degradation Features, Events and Processes Analysis/Model Report (ANL-WIS-MD-000008 will update the discussion of each component of hydride embrittlement in the 8 Features, Events and Processes (2.1.02.22.00 through 2.1.02.22.07) with emphasis on providing better organized, more quantitative discussion and the combined effects of both stress and temperature. .2.1.02.22.07 will be changed from exclude to include based on recent experimental evidence.

Agreement Number TSPAI.2.01

Agreement Provide clarification of the screening arguments, as summarized in Attachment 2. See Comment # 5, 7, 8, 9, 10, 13, 18, 19 (Part 5), 21, 32, 41, 47, 50, 53, 58, 67, J-5, J-16, and J-18

DOE will clarify the screening arguments, as summarized in Attachment 2, for the highlighted FEPs. The clarifications will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
DOE agreed to provide clarification of the screening argument in the Clad Degradation - FEPs Screening Arguments, ANL-WIS-MD-000008 to address the NRC comment.

Subissue #2 - Scenario Analysis SA-54

Tracking # SA-54

Comment 2.1.09.02.00 (Interaction with corrosion products) was excluded in the engineered barrier subsystem (except for colloid-related effects) on the basis of low consequence (CRWMS M&O, 2001). As noted in the NRC and U.S. Department of Energy technical exchange on Evolution of the Near-Field Environment, changes in seepage water chemistry resulting from interactions with engineered materials and their corrosion products were not adequately addressed in (CRWMS M&O, 2000). Water has been observed to drip preferentially along grouted rock bolts in the enhanced characterization of repository block, for example, demonstrating that the introduced materials themselves can influence the location of preferred flow pathways. Seepage waters that have interacted with engineered materials and their corrosion products, can have a significant effect on evolved water and gas compositions.

References CRWMS M&O. "EBS Physical and Chemical Environmental Model AMR." ANL-EBS-MD-000033. Revision 01. Las Vegas, Nevada: CRWMS M&O. 2000.
CRWMS M&O. "EBS FEPs/Degradation Modes Abstraction." ANL-WIS-PA-000002. Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001.

DOE Response An estimate of potential heterogeneity in seepage water chemistry due to localized interactions with Engineered Barrier System components and their corrosion products in addition to the potential for such seepage interacting with Engineered Barrier System components and accelerating Engineered Barrier System degradation processes will be addressed as part of agreement KEN0206. An evaluation of the impact of the range of local chemistry (e.g., dripping of equilibrated evaporated cement leachate and corrosion products) conditions at the drip shield and waste package considering the chemical divide phenomena that may propagate small uncertainties into large effects. The DOE will evaluate the range of local chemical conditions at the drip shield and waste package (e.g. local variations in water composition associated with cement leaching or the presence of corrosion products), considering potential evaporative concentration and the chemical divide effect whereby small differences in initial composition could cause large differences in brine characteristics.

Agreement Number TSPAI.2.02

Agreement Provide the technical basis for the screening argument, as summarized in Attachment 2. See Comment # 3, 4, 11, 12, 19 (Parts 1, 2, and 6), 25, 26, 29, 34, 35, 36, 37, 38, 39, 42, 43, 44, 48, 49, 51, 54, 55, 56, 57, 59, 60, 61, 62, 63, 64, 65, 66, 68, 69, 70, 78, 79, J-1, J-2, J-3, J-4, J-7, J-8, J-9, J-10, J-11, J-12, J-13, J-14,

J-15, J-17, J-20, J-21, J-22, J-23, J-24, J-25, J-26, and J-27.

DOE will provide the technical basis for the screening argument, as summarized in Attachment 2, for the highlighted FEPs. The technical basis will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
This issue is addressed by an existing DOE/NRC agreements (ENFE Subissue 2 Agreement 6, 10, and 14). The Engineered Barrier System Features, Events, and Processes, ANL-WIS-PA-000002, will be updated upon completion of these agreement items.

Subissue #2 - Scenario Analysis SA-55

Tracking # SA-55

Comment 2.1.09.07.00 (Reaction kinetics in waste and engineered barrier subsystem).
[Engineered Barrier Subsystem]: Item screened as excluded on the basis of low consequence (CRWMS M&O, 2001). Consideration of chemical reactions, such as radionuclide dissolution/ precipitation reactions and reactions controlling the reduction-oxidation state is included by considering reaction kinetics in the in-package equilibrium model but excluded based on low consequence for the engineered barrier subsystem. However, these processes may affect the composition of the near field environment, particularly for trace elements, and the effect on corrosion of container materials could be indirect and should be considered.

[Waste Form Misc]: Item screened as excluded on the basis of low consequence (CRWMS M&O, 2000). Adequate technical bases have not been provided to demonstrate that the combination of transport processes and reaction kinetics in the engineered barrier subsystem will not adversely impact performance by altering the composition of water contacting the drip shield and waste package.

References CRWMS M&O. "Miscellaneous Waste Form FEPs." ANL-WIS-MD-000009. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.
CRWMS M&O. "EBS FEPs/Degradation Modes Abstraction." ANL-WIS-PA-000002. Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001.

DOE Response In the Near Field agreement KEN0211, the DOE will provide additional technical basis for the treatment of precipitation-dissolution kinetics by the in-drift geochemical models, in a revision to the Engineered Barrier System: Physical and Chemical Environment Model Analysis/Model Report (CRWMS M&O 2000w). The technical basis will include reaction progress simulation for laboratory evaporative concentration tests, and will include appropriate treatment of time as related to the residence times associated with the abstractions used to represent in-drift processes in Total System Performance Assessment.

In addition, agreement KEN0208 indicates that DOE will provide additional technical basis for the suppression of individual minerals predicted by equilibrium models, in a revision to the Engineered Barrier System: Physical and Chemical Environment Model Analysis/Model Report (CRWMS M&O 2000w)

Agreement Number TSPAI.2.02

Agreement Provide the technical basis for the screening argument, as

summarized in Attachment 2. See Comment # 3, 4, 11, 12, 19 (Parts 1, 2, and 6), 25, 26, 29, 34, 35, 36, 37, 38, 39, 42, 43, 44, 48, 49, 51, 54, 55, 56, 57, 59, 60, 61, 62, 63, 64, 65, 66, 68, 69, 70, 78, 79, J-1, J-2, J-3, J-4, J-7, J-8, J-9, J-10, J-11, J-12, J-13, J-14, J-15, J-17, J-20, J-21, J-22, J-23, J-24, J-25, J-26, and J-27.

DOE will provide the technical basis for the screening argument, as summarized in Attachment 2, for the highlighted FEPs. The technical basis will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
This issue is addressed by an existing DOE/NRC agreements (ENFE Subissue 2 Agreement 5, 8, 11, and 12). The Engineered Barrier System Features, Events, and Processes, ANL-WIS-PA-000002, will be updated upon completion of these agreement items.

Subissue #2 - Scenario Analysis SA-56

Tracking # SA-56

Comment 2.1.07.06.00 (Floor Buckling) has been screened as excluded in (CRWMS M&O, 2001) and EBS Radionuclide Transport Abstraction (CRWMS M&O, 2000) based on analyses documented in Repository Ground Support Analysis for Viability Assessment (CRWMS M&O, 1998), which indicate that floor heave from thermal-mechanical effects would not exceed about 10 mm. However, to address concerns raised by U.S. Nuclear Regulatory Commission staff about the appropriateness of the thermal-mechanical properties used in DOE calculations (such as the analyses cited above), the DOE has agreed to revise its assessment of floor buckling [repository design and thermal-mechanical effects Agreement 3.9 (DOE and U.S. Nuclear Regulatory Commission Technical Exchange on repository design and thermal-mechanical effects, February 6-8, 2001, Las Vegas, Nevada)]. Note that the screening argument relies on analyses that DOE has agreed to revise to address outstanding NRC concerns in repository design and thermal-mechanical effects Agreements 3.2-3.13 (repository design and thermal-mechanical effects Technical Exchange, February 6-8, 2001, Las Vegas, Nevada).

References

CRWMS M&O. "Repository Ground Support Analysis for Viability Assessment." BCAA00000B01717B0200B0004. Revision 01. Las Vegas, Nevada: CRWMS M&O. 1998.

CRWMS M&O. "AMR EBS Radionuclide Transport Abstraction." ANL-WIS-PA-000001. Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000.

CRWMS M&O. "EBS FEPs/Degradation Modes Abstraction." ANL-WIS-PA-000002. Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001.

DOE Response The information on the buckling or heave of the floor of an emplacement drift can be inferred from computer output files generated for ground control analyses, such as Ground Control for Emplacement Drifts for Site Recommendation (CRWMS M&O 2000ae). The topic was not addressed in ground control analyses in an explicit manner because it has no direct implications on ground control. An ICN is currently being issued to Ground Control for Emplacement Drifts for Site Recommendation, and the preliminary results using latest thermal properties indicate that the maximum differential movement of the invert area is well within 10 mm.

The Repository Design and Thermal Mechanical Effects agreement on floor heave, KRD0309: "DOE will provide appropriate analysis that shows rock movements in the floor of the emplacement drift are within the range acceptable for preclosure

operations. The analysis results will be provided in a revision to the Ground Control for Emplacement Drifts for Site Recommendation (CRWMS M&O 2000ae) (or other document) supporting any potential license application," will be addressed in detail in additional ground control analyses necessary for Key Techncial Resolution resolution.

Agreement Number TSPAI.2.02

Agreement Provide the technical basis for the screening argument, as summarized in Attachment 2. See Comment # 3, 4, 11, 12, 19 (Parts 1, 2, and 6), 25, 26, 29, 34, 35, 36, 37, 38, 39, 42, 43, 44, 48, 49, 51, 54, 55, 56, 57, 59, 60, 61, 62, 63, 64, 65, 66, 68, 69, 70, 78, 79, J-1, J-2, J-3, J-4, J-7, J-8, J-9, J-10, J-11, J-12, J-13, J-14, J-15, J-17, J-20, J-21, J-22, J-23, J-24, J-25, J-26, and J-27.

DOE will provide the technical basis for the screening argument, as summarized in Attachment 2, for the highlighted FEPs. The technical basis will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
This issue is addressed by existing DOE/NRC agreements (RDTME Subissue 3 Agreements 2 - 13). DOE agreed to include the analysis of floor buckling for post-closure conditions, consistent with the site-specific parameters and loading conditions used to satisfy RDTME Subissue 3, Agreements 2-13. The Engineered Barrier System Features, Events, and Processes, ANL-WIS-PA-000002, will be revised to include this information.

Subissue #2 - Scenario Analysis SA-57

Tracking # SA-57

Comment 1.1.02.03.00 (Undesirable materials left) is screened out on the basis of low consequences (CRWMS M&O, 2001). Although a report cited by the DOE (CRWMS M&O, 1995) provides an analysis of acceptable upper bounds on materials introduced into the repository, no analysis has been conducted to determine if the current design will meet these limits. An assumption that the limits will be adhered to during the preclosure period is considered inadequate to exclude 1.1.02.03.00. DOE should provide adequate technical basis for the effect of introduced materials on water chemistry.

References CRWMS M&O. " Waste Isolation Evaluation: Tracers, Fluids, and Materials, and Excavation Methods for Use in the Package 2C Exploratory Studies Facility Construction." BABE00000B01717B2200B00007. Revision 04. Las Vegas, Nevada: CRWMS M&O. 1995.
CRWMS M&O. "EBS FEPs/Degradation Modes Abstraction." ANL-WIS-PA-000002. Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001.

DOE Response An inherent assumption in the licensing and construction process, as stated in the features, events and processes (FEPs) Analysis/Model Report, is that the repository will be built as designed, and that the quality control requirements will be adhered to, monitored, and enforced per the NRC=s regulations. A review of the current repository design will be conducted to provide estimates of the quantities of Aundesirable materials@ (organics, cementitious materials, etc.) to be used in the current design pre-closure phase relative to the limits discussed in the referenced document. This review will also consider the assessment of trace material impact on Engineered Barrier System groundwater chemistry (both within the drift as well as the plume leaving the drift) being conducted as part of the Engineered Barrier System Thermo-hydrologic chemical modeling.

Operational process controls, such as, (1) providing procedural assurance that future operational actions will be done according to a plan, and (2) including in FEPs analysis a reasonable estimate of the uncertainty associated with our ability to implement the plan exactly, is sufficient to account for the potential of undesirable conditions.

Agreement Number TSPAI.2.02

Agreement Provide the technical basis for the screening argument, as summarized in Attachment 2. See Comment # 3, 4, 11, 12, 19 (Parts 1, 2, and 6), 25, 26, 29, 34, 35, 36, 37, 38, 39, 42, 43, 44, 48, 49, 51, 54, 55, 56, 57, 59, 60, 61, 62, 63, 64, 65, 66, 68, 69, 70,

78, 79, J-1, J-2, J-3, J-4, J-7, J-8, J-9, J-10, J-11, J-12, J-13, J-14, J-15, J-17, J-20, J-21, J-22, J-23, J-24, J-25, J-26, and J-27.

DOE will provide the technical basis for the screening argument, as summarized in Attachment 2, for the highlighted FEPs. The technical basis will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
DOE agreed to provide the technical basis for the screening argument in the Engineered Barrier System Features, Events, and Processes, ANL-WIS-PA-000002, to address the NRC comment. This will include a technical basis for the use of the Waste Isolation Evaluation: Tracers, Fluids, and Materials, and Excavation Methods for Use in the Package 2C Exploratory Studies Facility Construction. BABE00000-01717-2200-00007 Rev 04.

Subissue #2 - Scenario Analysis SA-58

Tracking # SA-58

Comment Screening arguments were labeled with the word Preliminary in (CRWMS M&0, 2001a) {FEPs 2.1.07.01.00 [Rockfall (Large Block)]; 1.2.02.01.00 (Fractures); 1.2.02.02.00 (Faulting); 1.2.03.01.00 (Seismic activity); etc}, and in (CRWMS M&0, 2001b). Attachment I of this latter document includes 61 FEPs arguments that are considered preliminary. It is stated that "future modeling and analysis efforts may enhance these considerations, and in this sense they are preliminary."

It is necessary to disclose plans to release screening arguments with improved technical bases.

References CRWMS M&O. "Features, Events, and Processes: Screening for Disruptive Events." ANL-WIS-MD-000005 Revision 00 ICN1. Las Vegas, Nevada: CRWMS M&O. 2001a.
CRWMS M&O. "EBS FEPs/Degradation Modes Abstraction. ANL-WIS-PA-000002 Revision 01." Las Vegas, Nevada: CRWMS M&O. 2001b.

DOE Response

Agreement Number TSPAI.2.01

Agreement Provide clarification of the screening arguments, as summarized in Attachment 2. See Comment # 5, 7, 8, 9, 10, 13, 18, 19 (Part 5), 21, 32, 41, 47, 50, 53, 58, 67, J-5, J-16, and J-18

DOE will clarify the screening arguments, as summarized in Attachment 2, for the highlighted FEPs. The clarifications will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
DOE agreed to provide clarification of the screening argument in the Engineered Barrier System Features, Events, and Processes, ANL-WIS-PA-000002, to address the NRC comment.

Subissue #2 - Scenario Analysis SA-59

Tracking # SA-59

Comment 2.1.08.04.00 (Cold Traps) screened as excluded on the basis of low consequence (CRWMS M&O, 2001). Emplacement of waste in the drifts creates thermal gradients within the repository that may result in condensation forming on the roof of the drifts or elsewhere in the engineered barrier subsystem, leading to enhanced dripping on the drip shields, waste packages, or exposed waste material. Cold traps are excluded on the basis of low consequence (CRWMS M&O, 2001). The DOE's Multiscale Thermohydrologic Model does not account for mass transport along the length of drifts. The only Multiscale Thermohydrologic Model submodel that includes thermal hydrology (i.e., mass transport) is a cross-section of a drift so it accounts for potential condensation only along the radial axis.

References CRWMS M&O. "EBS FEPs/Degradation Modes Abstraction." ANL-WIS-PA-000002. Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001.

DOE Response Thermal Effects on Flow agreement KTE0205 states that technical support for the inclusion or exclusion of the cold trap effect in the various scale models will be documented in the Multi-scale Thermal Hydrological Model. The analysis will consider repository edge effects and in-drift geochemical environment abstraction. The magnitude of such enhancement relative to the seepage flux will be considered relative to its impact on drip shield and waste package failure and on waste form dissolution and radionuclide transport. This will provide a quantified basis for the Exclude B Low Consequence screening.

Agreement Number TSPAI.2.02

Agreement Provide the technical basis for the screening argument, as summarized in Attachment 2. See Comment # 3, 4, 11, 12, 19 (Parts 1, 2, and 6), 25, 26, 29, 34, 35, 36, 37, 38, 39, 42, 43, 44, 48, 49, 51, 54, 55, 56, 57, 59, 60, 61, 62, 63, 64, 65, 66, 68, 69, 70, 78, 79, J-1, J-2, J-3, J-4, J-7, J-8, J-9, J-10, J-11, J-12, J-13, J-14, J-15, J-17, J-20, J-21, J-22, J-23, J-24, J-25, J-26, and J-27.

DOE will provide the technical basis for the screening argument, as summarized in Attachment 2, for the highlighted FEPs. The technical basis will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
This issue is addressed by an existing DOE/NRC agreement (TEF Agreement Subissue 2 Agreement 5). The Engineered Barrier System Features, Events, and Processes, ANL-WIS-PA-000002, will be revised upon completion of this agreement.

Subissue #2 - Scenario Analysis SA-60

Tracking # SA-60

Comment The exclusion of 2.1.12.01.00 (Gas generation) and 2.1.12.05.00 (Gas generation from concrete) in (CRWMS M&O, 2001, 2000) is unacceptable, because adequate technical bases have not been provided to justify the characterization of chemical environments in the engineered barrier subsystem in terms of bulk water and gas compositions. The possibility of existence of local heterogeneity in gas composition in the drift, altering the chemistry of the DS/waste package environment and adversely impacting repository performance should be explored. Local variations in the efficiency of advection/diffusion processes, relative to reaction rates, should be evaluated.

References CRWMS M&O. "Miscellaneous Waste Form FEPs." ANL-WIS-MD-000009. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.
CRWMS M&O. "EBS FEPs/Degradation Modes Abstraction." ANL-WIS-PA-000002. Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001.

DOE Response Engineered Barrier System will estimate the potential heterogeneity in local gas composition within the drift, due to gas generation from corrosion, microbial action, and concrete degradation. Based on such bounding estimates of compositional heterogeneity, the impact on local chemistry and key reaction rates will also be estimated.

Agreement Number TSPAI.2.02

Agreement Provide the technical basis for the screening argument, as summarized in Attachment 2. See Comment # 3, 4, 11, 12, 19 (Parts 1, 2, and 6), 25, 26, 29, 34, 35, 36, 37, 38, 39, 42, 43, 44, 48, 49, 51, 54, 55, 56, 57, 59, 60, 61, 62, 63, 64, 65, 66, 68, 69, 70, 78, 79, J-1, J-2, J-3, J-4, J-7, J-8, J-9, J-10, J-11, J-12, J-13, J-14, J-15, J-17, J-20, J-21, J-22, J-23, J-24, J-25, J-26, and J-27.

DOE will provide the technical basis for the screening argument, as summarized in Attachment 2, for the highlighted FEPs. The technical basis will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
This issue is partially addressed by an existing DOE/NRC agreement (ENFE Subissue 2 Agreement 6). DOE agreed to provide the technical basis for the screening argument in the Engineered Barrier System Features, Events, and Processes, ANL-WIS-PA-000002, to address the NRC comment.

Subissue #2 - Scenario Analysis SA-61

Tracking # SA-61

Comment 2.2.10.12.00 (Geosphere dry-out due to waste heat). Necessary to develop screening argument for this item under scope of unsaturated zone Flow and Transport FEP AMR (CRWMS M&O, 2001b). Elevated thermal effects on shallow infiltration due to changes in soil water content were not addressed for 2.2.10.12.00 (Geosphere dry-out due to waste heat). U.S. Department of Energy study of a natural thermal gradient on YM addresses this item (CRWMS M&O, 1998). 2.2.10.12.00 (Geosphere dry-out due to waste heat) is screened as included in (CRWMS M&O, 2001a) for issues related to Near Field Environment, but does not address its effects on infiltration.

References CRWMS M&O. "Final Report: Plant and Soil Related Processes along a Natural Thermal Gradient at Yucca Mountain, Nevada." B00000000B01717B5705B00109. Revision 00. Las Vegas, Nevada: CRWMS M&O. 1998.
CRWMS M&O. "Features, Events, and Processes in Thermal Hydrology and Coupled Processes." ANL-NBS-MD-000004. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2001a.
CRWMS M&O. "Features, Events, and Processes in UZ Flow and Transport." ANL-NBS-MD-000001 Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001.

DOE Response DOE will cite the suggested reference for this question and include this feature, event and process in the next revision of the Features, Events, and Processes in Unsaturated Zone Flow and Transport Analysis/Model Report (ANL-NBS-MD-000001, BSC 2001d)

Agreement Number TSPAI.2.02

Agreement Provide the technical basis for the screening argument, as summarized in Attachment 2. See Comment # 3, 4, 11, 12, 19 (Parts 1, 2, and 6), 25, 26, 29, 34, 35, 36, 37, 38, 39, 42, 43, 44, 48, 49, 51, 54, 55, 56, 57, 59, 60, 61, 62, 63, 64, 65, 66, 68, 69, 70, 78, 79, J-1, J-2, J-3, J-4, J-7, J-8, J-9, J-10, J-11, J-12, J-13, J-14, J-15, J-17, J-20, J-21, J-22, J-23, J-24, J-25, J-26, and J-27.

DOE will provide the technical basis for the screening argument, as summarized in Attachment 2, for the highlighted FEPs. The technical basis will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
DOE agreed to provide the technical basis for the screening argument in the Features, Events, and Processes in the Features, Events, and Processes in UZ Flow and Transport, ANL-NBS-MD-000001, to address the NRC comment.

Subissue #2 - Scenario Analysis SA-62

Tracking # SA-62

Comment 2.2.01.02.00 (Thermal and other waste and engineered barrier subsystem-related changes in the adjacent host rock) is screened as excluded on the basis of low consequence (thermal-mechanical effects) and low probability (thermal-hydrological-chemical and backfill effects) (CRWMS M&O, 2001). Changes in host rock properties result from thermal effects or other factors related to emplacement of the waste and engineered barrier subsystem, such as mechanical or chemical effects of backfill. Properties that may be affected include rock strength, fracture spacing and block size, and hydrologic properties such as permeability. The screening argument did not consider mechanical degradation of the rock mass, such as fracture-wall rock alteration owing to long-term exposure to heat, moisture, and atmospheric conditions. Such degradation would increase the severity of mechanical failure, (Ofoegbu G.I., 2000). However, DOE is expected to reevaluate its assessment of long-term mechanical degradation to satisfy outstanding DOE and NRC agreements (repository design and thermal-mechanical effects Agreements 3.11 and 3.19). In the analyses, it is necessary to account for long-term mechanical degradation of the host rock mass in its assessment of drift degradation, rockfall, and changes in hydrological properties; and their effects on repository performance.

References CRWMS M&O. "Features, Events, and Processes in Thermal Hydrology and Coupled Processes." ANL-NBS-MD-000004. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2001.
Ofoegbu G.I. "Thermal-Mechanical Effects on Long-Term Hydrological Properties at the Proposed Yucca Mountain Nuclear Waste Repository." CNWRA 2000-03. San Antonio, TX: CNWRA. 2000.

DOE Response The current Total System Performance Assessment increases the quantity of seepage that enters an intact drift by 50% to account for the degradation of the drift. This value was based on a sensitivity study performed in the seepage model. Although the drift is not expected to degrade everywhere, this 50% increase in seepage flow is used at all locations.

In addition, the subject matter introduced by this question is the basis for two Repository Design and Thermal Mechanical Effects agreements between DOE and NRC (KRD0311 and KRD0319).

In the Repository Design and Thermal Mechanical Effects agreement KRD0311, the DOE will justify the preclosure ground support system design (including the effects of long term degradation of rock mass and joint strength properties) in a revision to the Ground Control for Emplacement Drifts for Site-

Recommendation (CRWMS M&O 2000ae) (or other document) supporting any potential license application.

In the Repository Design and Thermal Mechanical Effects agreement KRD0319, the DOE states its belief that the Drift Degradation Analysis is consistent with current understanding of the Yucca Mountain site and the level of detail of the design to date. As understanding of the site and the design evolve, DOE will: (1) provide revised Discrete Region Key-Block Analysis (DRKBA) analyses using appropriate range of strength properties for rock joints from a design parameters analysis report (or other document), accounting for their long-term degradation; (2) provide an analysis of block sizes based on the full distribution of joint trace length data from the Fracture Geometry Analysis for the Stratigraphic Units of the Repository Host Horizon(CRWMS M&O 2000ad), supplemented by available small joint trace length data; (3) verify the results of the revised DRKBA analyses using: (a) appropriate boundary conditions for thermal and seismic loading; (b) critical fracture patterns from the DRKBA Monte Carlo simulations (at least two patterns for each rock unit); (c) thermal and mechanical properties for rock blocks and joints from a design parameters analysis report (or other document); (d) long-term degradation of joint strength parameters; and (e) site-specific ground motion time histories appropriate for post-closure period. This will be documented in a revision to the Drift Degradation Analysis (CRWMS M&O 2000t). Based on the results of the analyses above and subsequent drip shield calculation revisions, DOE will reconsider the screening decision for inclusion or exclusion of rockfall in performance assessment analysis. Any changes to screening decisions will be documented in analyses prior to any potential License Application.

Agreement Number TSPAI.2.02

Agreement Provide the technical basis for the screening argument, as summarized in Attachment 2. See Comment # 3, 4, 11, 12, 19 (Parts 1, 2, and 6), 25, 26, 29, 34, 35, 36, 37, 38, 39, 42, 43, 44, 48, 49, 51, 54, 55, 56, 57, 59, 60, 61, 62, 63, 64, 65, 66, 68, 69, 70, 78, 79, J-1, J-2, J-3, J-4, J-7, J-8, J-9, J-10, J-11, J-12, J-13, J-14, J-15, J-17, J-20, J-21, J-22, J-23, J-24, J-25, J-26, and J-27.

DOE will provide the technical basis for the screening argument, as summarized in Attachment 2, for the highlighted FEPs. The technical basis will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
TM effects on fractures will be addressed by existing agreements

between DOE and NRC (RDTME Subissue 3 Agreement 20 and 21). The FEPs in Thermal Hydrology and Coupled Processes, ANL-NBS-MD-000004, will be revised upon completion of this work.

Long term degradation of the host rock is addressed by existing agreements between DOE and NRC (RDTME Subissue 3 Agreement 11 and 19).

DOE will provide an improved technical basis for 2.2.01.02.00 (Thermal and other waste and EBS-related changes in the adjacent host rock) by performing a postclosure drift deformation analysis that incorporates postclosure loads and rock properties using relevant information from existing agreements (RDTME Subissue 3 Agreements 2 - 13). The Engineered Barrier System Features, Events, and Processes, ANL-WIS-PA-000002, will be revised to include this information.

Subissue #2 - Scenario Analysis SA-63

Tracking # SA-63

Comment 2.1.09.12.00 (Rind (altered zone) formation in waste, engineered barrier subsystem, and adjacent rock). Included (thermal-hydrological-chemical model), and screened as excluded (thermal-hydrological model, effects on transport) on the basis of low consequence (CRWMS M&O, 2001). Thermo-chemical processes alter the rock forming the drift walls mineralogically. These alterations have hydrologic, thermal and mineralogic properties different from the current country rock.

References CRWMS M&O. "Features, Events, and Processes in Thermal Hydrology and Coupled Processes." ANL-NBS-MD-000004. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2001.

DOE Response This technical issue introduced by this comment is the subject of an existing near field agreement KEN0103. KEN0103 commits to gathering information on the quantity of unreacted solute mass that is trapped in dry-out zone in TOUGHREACT simulations, as well as how this would affect precipitation and the resulting change in hydrologic properties. The DOE provided to NRC documentation of model validation, consistent with the DOE quality assurance requirements, in the Drift-Scale Coupled Processes (Drift-Scale Test and Thermal-hydrological-chemical Seepage) Analysis/Model Report (CRWMS M&O 2001c) in March 2001. In accordance with agreement KEN0103, DOE will provide information on the quantity of unreacted solute mass that is trapped in the dryout zone in TOUGHREACT simulations in the Drift-Scale Coupled Processes (Drift-Scale Test and Thermal-hydrological-chemical Seepage) Models Analysis/Model Report Rev 02. This information will be used to provide the basis for inclusion or exclusion of the subject scenario.

Agreement Number TSPAI.2.02

Agreement Provide the technical basis for the screening argument, as summarized in Attachment 2. See Comment # 3, 4, 11, 12, 19 (Parts 1, 2, and 6), 25, 26, 29, 34, 35, 36, 37, 38, 39, 42, 43, 44, 48, 49, 51, 54, 55, 56, 57, 59, 60, 61, 62, 63, 64, 65, 66, 68, 69, 70, 78, 79, J-1, J-2, J-3, J-4, J-7, J-8, J-9, J-10, J-11, J-12, J-13, J-14, J-15, J-17, J-20, J-21, J-22, J-23, J-24, J-25, J-26, and J-27.

DOE will provide the technical basis for the screening argument, as summarized in Attachment 2, for the highlighted FEPs. The technical basis will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
This issue is addressed by existing agreements between DOE and NRC (ENFE Subissue 1 Agreement 3). FEPs in Thermal Hydrology

and Coupled Processes, ANL-NBS-MD-000004 will be revised upon completion of this work.

Subissue #2 - Scenario Analysis SA-64

Tracking # SA-64

Comment FEP 2.2.10.06.00 (Thermo-chemical alteration (solubility speciation, phase changes, precipitation/dissolution)). Item excluded on the basis of low consequence (CRWMS M&O, 2001). Changes in the groundwater temperature in the far-field, if significant, may change the solubility and speciation of certain radionuclides. This would have the effect of altering radionuclide transport processes. Relevant processes include volume effects associated with silica phase changes, precipitation and dissolution of fracture-filling minerals (including silica and calcite), and alteration of zeolites and other minerals to clays.

References CRWMS M&O. "Thermal hydrology and coupled processes features, events, and processes." ANL-NBS-MD-000004 Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2001.

DOE Response

Agreement Number TSPAI2.02

Agreement Provide the technical basis for the screening argument, as summarized in Attachment 2. See Comment # 3, 4, 11, 12, 19 (Parts 1, 2, and 6), 25, 26, 29, 34, 35, 36, 37, 38, 39, 42, 43, 44, 48, 49, 51, 54, 55, 56, 57, 59, 60, 61, 62, 63, 64, 65, 66, 68, 69, 70, 78, 79, J-1, J-2, J-3, J-4, J-7, J-8, J-9, J-10, J-11, J-12, J-13, J-14, J-15, J-17, J-20, J-21, J-22, J-23, J-24, J-25, J-26, and J-27.

DOE will provide the technical basis for the screening argument, as summarized in Attachment 2, for the highlighted FEPs. The technical basis will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
This issue is addressed by existing agreements between DOE and NRC (ENFE Subissue 1 Agreement 3). The FEPs in Thermal Hydrology and Coupled Processes, ANL-NBS-MD-000004 will be revised upon completion of this work.

Subissue #2 - Scenario Analysis SA-65

Tracking # SA-65

Comment 2.1.11.02.00 (Nonuniform heat distribution/edge effects in repository). Included (thermal-hydrological and thermal-hydrological-chemical aspects) is screened as excluded (thermal-mechanical effects) on the basis of low consequence (CRWMS M&O, 2001). Temperature inhomogeneities in the repository lead to localized accumulation of moisture. Uneven heating and cooling at repository edges lead to non-uniform thermal effects during both the thermal peak and the cool-down period.

References CRWMS M&O. "Features, Events, and Processes in Thermal Hydrology and Coupled Processes." ANL-NBS-MD-000004. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2001.

DOE Response Repository wide non-uniform heating effects are the subject of Thermal Effects on Flow agreement KTE0205 this work will represent the cold-trap effect in the appropriate models or provide the technical basis for exclusion of it in the various scale models.

Agreement Number TSPAI.2.02

Agreement Provide the technical basis for the screening argument, as summarized in Attachment 2. See Comment # 3, 4, 11, 12, 19 (Parts 1, 2, and 6), 25, 26, 29, 34, 35, 36, 37, 38, 39, 42, 43, 44, 48, 49, 51, 54, 55, 56, 57, 59, 60, 61, 62, 63, 64, 65, 66, 68, 69, 70, 78, 79, J-1, J-2, J-3, J-4, J-7, J-8, J-9, J-10, J-11, J-12, J-13, J-14, J-15, J-17, J-20, J-21, J-22, J-23, J-24, J-25, J-26, and J-27.

DOE will provide the technical basis for the screening argument, as summarized in Attachment 2, for the highlighted FEPs. The technical basis will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
Repository wide non-uniform heating effects are the subject of existing DOE/NRC agreements (TEF Subissue 2 Agreement 5, RDTME Subissue 3 Agreement 20 and 21). The FEPs in Thermal Hydrology and Coupled Processes, ANL-NBS-MD-000004 will be revised upon completion of this work.

THM continuum modeling will address non-uniform effects at a mountain scale. This information will be provided in the Coupled Thermal-Hydrologic-Mechanical Effects on Permeability Analysis and Model Report AMR, ANL-NBS-HS-000037.

Subissue #2 - Scenario Analysis SA-66

Tracking # SA-66

Comment 2.2.06.01.00 [Changes in stress (due to thermal, seismic, or tectonic effects) change porosity and permeability of rock] is screened as excluded on the basis of low consequence and low probability (for one secondary entry) (CRWMS M&O, 2001b). Even small changes in the fracture openings cause large changes in permeability. The rock deforms according to the rock stress field. Changes in the groundwater flow and in the temperature field will change the stress acting on the rock which will in turn change the groundwater flow. 2.2.06.01.00 [Change in stress (due to thermal, seismic, or tectonic effects) change porosity and permeability of rock] is excluded as having low consequence to dose (CRWMS M&O, 2001a). However, the DOE analyses used to support the screening argument (CRWMS M&O, 2000) did not consider water-flux diversion toward a drift from the adjacent pillar caused by increased aperture of subhorizontal fractures in the pillar from thermal-mechanical response. Such flux diversion would cause increased water flow to the drifts.

References CRWMS M&O. "AMR Fault Displacement Effects on Transport in the Unsaturated Zone." ANL-NBS-HS-000020. Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000.
CRWMS M&O. "Features, Events, and Processes in Thermal Hydrology and Coupled Processes." ANL-NBS-MD-000004. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2001a.
CRWMS M&O. "Features, Events, and Processes: Screening for Disruptive Events." ANL-WIS-MD-000005. Revision 00 ICN 01. CRWMS M&O. 2001b.

DOE Response Thermal-mechanical effects may result in changes in fracture apertures in support pillars between drifts. If the horizontal fractures open up more than the vertical fractures, it may be possible that flow could divert towards the drifts. DOE is presently performing process-model simulations using both continuum and discrete fracture models to analyze the effects of thermal-hydrologic-mechanical coupled processes with regard to drainage in the pillars and flow in the vicinity of the drifts. Furthermore, DOE is performing thermal-hydrological/ thermal-hydrological-chemical/ thermal-hydrological-mechanical analyses to quantify uncertainties in the thermal seepage model. Based on the results, DOE will revisit the Feature, Event and Process screening arguments. Interim results are reported in the Supplemental Science and Performance Analysis.

Agreement Number TSPAI.2.02

Agreement Provide the technical basis for the screening argument, as summarized in Attachment 2. See Comment # 3, 4, 11, 12, 19 (Parts 1, 2, and 6), 25, 26, 29, 34, 35, 36, 37, 38, 39, 42, 43, 44,

48, 49, 51, 54, 55, 56, 57, 59, 60, 61, 62, 63, 64, 65, 66, 68, 69, 70, 78, 79, J-1, J-2, J-3, J-4, J-7, J-8, J-9, J-10, J-11, J-12, J-13, J-14, J-15, J-17, J-20, J-21, J-22, J-23, J-24, J-25, J-26, and J-27.

DOE will provide the technical basis for the screening argument, as summarized in Attachment 2, for the highlighted FEPs. The technical basis will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
The thermal mechanical effects on rock properties are addressed by an existing DOE/NRC agreement (RDTME Subissue 3 Agreement 20 and 21). The FEPs in Thermal Hydrology and Coupled Processes, ANL-NBS-MD-000004 and the Features, Events, and Processes: Screening for Disruptive Events. ANL-WIS-MD-000005 will be revised upon completion of this work.

Subissue #2 - Scenario Analysis SA-67

Tracking # SA-67

Comment 2.2.10.05.00 (Thermo-mechanical alteration of rocks above and below the repository) is screened as excluded on the basis of low consequence (CRWMS M&O, 2001). Thermal-mechanical compression at the repository produces tension-fracturing in the paintbrush nonwelded tuff and other units above the repository. These fractures alter unsaturated zone flow between the surface and the repository. Extreme fracturing may propagate to the surface, affecting infiltration. Thermal fracturing in rocks below the repository affects flow and radionuclide transport to the saturated zone.

References CRWMS M&O. "Features, Events, and Processes in Thermal Hydrology and Coupled Processes." ANL-NBS-MD-000004. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2001.

DOE Response See response to Feature, Event and Process 2.2.01.01.00

Agreement Number TSPAI.2.01

Agreement Provide clarification of the screening arguments, as summarized in Attachment 2. See Comment # 5, 7, 8, 9, 10, 13, 18, 19 (Part 5), 21, 32, 41, 47, 50, 53, 58, 67, J-5, J-16, and J-18

DOE will clarify the screening arguments, as summarized in Attachment 2, for the highlighted FEPs. The clarifications will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
DOE has planned work to analyze the effects of thermal-hydrologic-mechanical coupled processes with regard to drainage in the pillars and flow in the vicinity of the drifts, and thermal-hydrological/ thermal-hydrological -chemical/ thermal-hydrological-mechanical analyses to quantify uncertainties in the thermal seepage model. In addition, THM continuum modeling will address thermal mechanical effects in rocks above and below the repository at a mountain scale in an update to the Coupled Thermal-Hydrologic-Mechanical Effects on Permeability Analysis and Model Report AMR, ANL-NBS-HS-000037. DOE will clarify the screening arguments in the FEPs in Thermal Hydrology and Coupled Processes, ANL-NBS-MD-000004 upon completion of this work.

Subissue #2 - Scenario Analysis SA-68

Tracking # SA-68

Comment 1.2.02.01.00 (Fractures). Included (seepage). Excluded on the basis of low consequence (permanent effects) (CRWMS M&O, 2001). Generation of new fractures and re-activation of preexisting fractures may significantly change the flow and transport paths. Newly formed and reactivated fractures typically result from thermal, seismic, or tectonic events. Thermally induced changes in stress may result in permeability changes between drifts that could act to divert flow toward drifts. Also see comment on 2.2.06.01.00 [Changes in stress (due to thermal, seismic, or tectonic effects) change porosity and permeability of rock].

References CRWMS M&O. "Features, Events, and Processes in Thermal Hydrology and Coupled Processes." ANL-NBS-MD-000004. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2001.

DOE Response Thermal-mechanical effects may result in changes in fracture apertures in support pillars between drifts. If the horizontal fractures open up more than the vertical fractures, it may be possible that flow could divert towards the drifts.

DOE is presently performing process-model simulations using both continuum and discrete fracture models to analyze the effects of thermal-hydrologic-mechanical coupled processes with regard to drainage in the pillars and flow in the vicinity of the drifts. Furthermore, DOE is performing thermal-hydrological/ thermal-hydrological -chemical/ thermal-hydrological-mechanical analyses to quantify uncertainties in the thermal seepage model. Based on the results, DOE will revisit the Feature, Event and Process screening arguments. Interim results are reported in the Supplemental Science and Performance Analysis.

Agreement Number TSPAI.2.02

Agreement Provide the technical basis for the screening argument, as summarized in Attachment 2. See Comment # 3, 4, 11, 12, 19 (Parts 1, 2, and 6), 25, 26, 29, 34, 35, 36, 37, 38, 39, 42, 43, 44, 48, 49, 51, 54, 55, 56, 57, 59, 60, 61, 62, 63, 64, 65, 66, 68, 69, 70, 78, 79, J-1, J-2, J-3, J-4, J-7, J-8, J-9, J-10, J-11, J-12, J-13, J-14, J-15, J-17, J-20, J-21, J-22, J-23, J-24, J-25, J-26, and J-27.

DOE will provide the technical basis for the screening argument, as summarized in Attachment 2, for the highlighted FEPs. The technical basis will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
The thermal mechanical effects on rock properties are addressed

by an existing DOE/NRC agreement (RDTME Subissue 3 Agreement 20 and 21). The FEPs in Thermal Hydrology and Coupled Processes, ANL-NBS-MD-000004 will be revised upon completion of this work.

Subissue #2 - Scenario Analysis SA-69

Tracking # SA-69

Comment 2.2.01.01.00 (Excavation and construction-related changes in the adjacent host rock). Included (initial effects on seepage) and screened as excluded (permanent thermal-hydrological-chemical and thermal-mechanical effects) on the basis of low consequence (CRWMS M&O, 2001). Stress relief, leading to dilation of joints and fractures, is expected in an axial zone of up to one diameter width surrounding the tunnels.

References CRWMS M&O. "Features, Events, and Processes in Thermal Hydrology and Coupled Processes." ANL-NBS-MD-000004. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2001.

DOE Response Thermal-mechanical effects may result in changes in fracture apertures in support pillars between drifts. If the horizontal fractures open up more than the vertical fractures, it may be possible that flow could divert towards the drifts. DOE is presently performing process-model simulations using both continuum and discrete fracture models to analyze the effects of thermal-hydrologic-mechanical coupled processes with regard to drainage in the pillars and flow in the vicinity of the drifts. Furthermore, DOE is performing thermal-hydrological/ thermal-hydrological-chemical/ thermal-hydrological-mechanical analyses to quantify uncertainties in the thermal seepage model. Based on the results, DOE will revisit the Feature, Event and Process screening arguments. Interim results are reported in the Supplemental Science and Performance Analysis.

Agreement Number TSPAI.2.02

Agreement Provide the technical basis for the screening argument, as summarized in Attachment 2. See Comment # 3, 4, 11, 12, 19 (Parts 1, 2, and 6), 25, 26, 29, 34, 35, 36, 37, 38, 39, 42, 43, 44, 48, 49, 51, 54, 55, 56, 57, 59, 60, 61, 62, 63, 64, 65, 66, 68, 69, 70, 78, 79, J-1, J-2, J-3, J-4, J-7, J-8, J-9, J-10, J-11, J-12, J-13, J-14, J-15, J-17, J-20, J-21, J-22, J-23, J-24, J-25, J-26, and J-27.

DOE will provide the technical basis for the screening argument, as summarized in Attachment 2, for the highlighted FEPs. The technical basis will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
The thermal mechanical effects on rock properties are addressed by an existing DOE/NRC agreement (RDTME Subissue 3 Agreement 20 and 21). The FEPs in Thermal Hydrology and Coupled Processes, ANL-NBS-MD-000004 will be revised upon completion of this work.

Subissue #2 - Scenario Analysis SA-70

Tracking # SA-70

Comment 2.2.10.04.00 (Thermo-Mechanical alteration of fractures near repository) is screened excluded on the basis of low consequence (CRWMS M&O, 2001a, 2001b). See discussion under 2.2.06.01.00 [Changes in stress (due to thermal, seismic, or tectonic effects) change porosity and permeability of rock].Heat from the waste causes thermal expansion of the surrounding rock, generating compressive stresses near the drifts and extensional stresses away from them. The zone of compression migrates with time.

References CRWMS M&O. "Features, Events, and Processes in Thermal Hydrology and Coupled Processes." ANL-NBS-MD-000004. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2001a. CCRWMS M&O. "Features, Events, and Processes in UZ Flow and Transport." ANL-NBS-MD-000001 Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001.

DOE Response See response to Feature, Event and Process 2.2.01.01.00

Agreement Number TSPAI.2.02

Agreement Provide the technical basis for the screening argument, as summarized in Attachment 2. See Comment # 3, 4, 11, 12, 19 (Parts 1, 2, and 6), 25, 26, 29, 34, 35, 36, 37, 38, 39, 42, 43, 44, 48, 49, 51, 54, 55, 56, 57, 59, 60, 61, 62, 63, 64, 65, 66, 68, 69, 70, 78, 79, J-1, J-2, J-3, J-4, J-7, J-8, J-9, J-10, J-11, J-12, J-13, J-14, J-15, J-17, J-20, J-21, J-22, J-23, J-24, J-25, J-26, and J-27.

DOE will provide the technical basis for the screening argument, as summarized in Attachment 2, for the highlighted FEPs. The technical basis will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
The thermal mechanical effects on rock properties are addressed by an existing DOE/NRC agreement (RDTME Subissue 3 Agreement 20 and 21). The FEPs in Thermal Hydrology and Coupled Processes, ANL-NBS-MD-000004, will be revised upon completion of this work.

Subissue #2 - Scenario Analysis SA-74

Tracking # SA-74

Comment 2.1.14.01.00 (Criticality in waste and engineered barrier subsystem) was preliminarily excluded in the document (CRWMS M&O, 2001a, 2000b) based on low probability. A preliminary screening status was assigned because the criticality calculations were not complete for (i) DSNF following igneous intrusion and (ii) near-field and far-field criticality of all waste types following igneous disruption. The excluded screening status will be regarded unacceptable until concerns on the calculation of the probability for criticality are addressed. Since the probability of criticality depends on the presence of a breach of the waste package barriers, most of the discussion of criticality probability is focused on the probability of waste package failure. U.S. Department of Energy has referenced the document, Probability of Criticality in 10,000 Years (CRWMS M&O, 2000d) for addressing the criticality probability due to early failure by stress corrosion cracking, waste package damage following igneous intrusion, and seismic events. DOE has referenced the screening argument for rockfall (2.1.07.01.00) for screening the damage to the waste package and drip shield from seismically-induced rockfall. In general, DOE needs to address the concerns raised on the waste package and mechanical disruption related features, events, and processes, and the issues raised at the container life and source term technical exchange before it can conclude that there is no waste package breach before 10,000 years.The concerns on the probability calculation in the document, Probability of Criticality in 10,000 Years (CRWMS M&O, 2000d) are:
(i) the conclusion of waste package failure probability of 2.7 x 10 - 11 due to stress corrosion cracking, based on the equation in Section 6.1.1, is contrary to the total system performance assessment results which indicate the first waste package failure, using the upper-bound curve, due to SCC at approximately 10,000 years.
(ii) the screening argument for 1.2.03.02.00 (Seismic Vibration Causes Container Failure), fails to consider the appropriate combinations of dead loads (caused by drift collapse and/or fallen rock blocks), rock block impact, and seismic excitation or the ability of these loads to initiate cracks and/or propagate preexisting cracks.
(iii) the screening argument for seismic events does not consider the indirect effects, such as causing dents which could aid in the collection and channeling of water or tilting the waste packages, which would result in the greater height of the water within the waste package. Seismic shaking, combined with a sloped waste package, may also allow materials to accumulate at one end of a waste package and form a more reactive geometry.
(iv) the screening argument for seismically-induced rockfall

damaging the drip shield and waste package includes several deficiencies as documented in the staff review of the Drift Degradation Analysis (CRWMS M&O 2000à) Analysis and Model Report and 2.1.07.01.00 [Rockfall (large block)] Other concerns related to the impact of rockfall on the waste package are reflected in the comments on the related features, events, and processes.

(v) the calculation of the criticality probability does not fully consider mechanisms that could result in accelerated degradation of the fuel during an igneous event, such as burning of Zircaloy or creep of the fuel at high temperatures.

(vi) the analysis of damage to Zone 2 waste packages (CRWMS M&O, 2000d) fails to consider long term exposure to high temperatures changing the microstructure of Alloy 22 and reducing the mechanical strength of the material (e.g., Rebak et al., 1999) or the differences in thermal expansion between the inner alloy 316 NG SS and Alloy 22 causing significant hoop-stress on waste package walls, in addition to the internal pressurization effects analyzed in CRWMS M&O (2000c). Analyses in CRWMS M&O (2000d) also do not consider potentially adverse chemical reactions, such as sulfidation reactions, in response to magmatic degassing or contact with basaltic magma. These processes could cause a more significant breach than the 10 cm2 hole currently assumed for waste packages located in DOE Zone 2 during basaltic igneous events.

(vii) the calculation does not consider any changes to drift by the magma, such as magma solidifying in the lower part of the drift, causing ponding above and around the waste package or fractures forming in the cooled magma that may provide preferential pathways to the waste package. Finally, the unsaturated flow may be modified by the presence of 1170°C magma so current parameters may no longer be valid.

(viii) the Criticality Probability document is inconsistent when discussing the water content of the magma in Section 5.3.2. The text indicates that the magma would consist of a very conservative 5 weight percent water content, but Table 5-1 lists the water content as only 0.05 weight percent. The computer files provided with the document that contained the actual calculations used a more realistic water content of 1.6%. A water content of 5 weight percent would clearly be very conservative, but justification needs to be provided if a lower water content is utilized in the calculations.

References

CRWMS M&O. "Drift Degradation Analysis AMR." ANL-EBS-MD-000027. Revision 01. Las Vegas, Nevada: CRWMS M&O. 2000a.

CRWMS M&O. "Features, Events, and Processes: System-Level and Criticality." ANL-WIS-MD-000019 Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000b.

CRWMS M&O. "Natural Analogs for the Unsaturated Zone." ANL-NBS-HS-000007. Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000c.
CRWMS M&O. Probability of Criticality in 10,000 Years. CAL-EBS-NU-000014. Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000d.
CRWMS M&O. "Features, Events, and Processes: Screening for Disruptive Events." ANL-WIS-MD-000005. Revision 00 ICN 01. CRWMS M&O. 2001a.
Rebak, R.B., T.S.E. Summers, and R.M. Carranza. "Mechanical properties, microstructure, and corrosion performance of C-22 alloy aged at 260C to 800C." Materials Research Society, Boston Meeting, Paper QQ 14.4. 1999.

DOE Response DOE's process for evaluating criticality is stated in the Disposal Criticality Analysis Methodology Topical Report, (YMP 2000). The process includes calculating the probability and consequences of potential criticality events, based on mechanisms at the site, and evaluating them using the Total System Performance Assessment processes, including Features, Events and Processes (FEPs) screenings. DOE will finish the criticality calculations following an igneous event or develop an argument as to why the consequences to the source from such an igneous event can be ignored. Furthermore, DOE will re-evaluate the criticality FEPs, should the reevaluation (as agreed to in the Container Life and Source Term agreement K0106) of the waste package FEPs, related to seismicity and rock fall, show that waste packages will fail prior to 10,000 years.

Specifically, agreement KCR0106 indicates that DOE will perform a "what if" (non-risk-informed) evaluation that determines the consequences of criticality for a non-mechanistic, waste package failure during the 10,000 year regulatory period. The results of this evaluation are not part of the normal Total System Performance Assessment process, and thus will not be included as part of the FEPs process. The results will be used as a sensitivity evaluation.

The probability of 2.7 x 10 -11 is per waste package. The probability of a waste package failure in the first 10,000 years with ~11,000 packages is 3.2 x 10-7. The probability results for stress corrosion cracking based failure shown in Probability of Criticality before 10,000 Years (CRWMS 2000am, Section 6.1.1, page 19) are based on the information from Analysis of Mechanisms for Early Waste Package Failure (CRWMS 2000d, page 43) with inputs from Abstraction of Models of Stress Corrosion Cracking of Drip Shield and Waste Package Outer Barrier and Hydrogen Induced Corrosion of Drip Shield (CRWMS 2000aaa, page 28).

DOE will examine the apparent discrepancy of waste package failure at 10,000 yearsr in the Total System Performance Assessment at the 95th percentile with the calculational mean probability of 3.2 x 10-7 and if necessary, supercede this waste package failure probability

The criticality FEPs screening is based on the current inputs for waste package failure. When the inputs are revised to address additional concerns (e.g., dead loads, indirect effects of rock block impacts, tilting of breached waste packages) then the criticality FEPs screening will be reassessed. The NRC concerns will be addressed when the seismic vibration Feature, Event and Process is modified (Container Life and Source Term agreement KCL0114). In addition, DOE will evaluate the rockfall effect and dead weight effects on the waste package. Other pertinent rockfall agreements are KCL0201, KCL0202, KCL0208, KCL0301, KRD0317, and KRD03019.

The criticality FEPs screening is based on the current inputs for waste form degradation. When the inputs are revised to address additional concerns, then the criticality FEPs screening will be reassessed.

With respect to cladding degradation, DOE notes that within zone 2 all of the cladding is perforated and all the drip shields are removed, thus cladding damage is already accounted for. In addition, DOE may argue that the combination of criticality and igneous intrusion on the source-term can be neglected based on low consequence in a future revision of this Feature, Event and Process.

The effect of temperature with respect to damage to Zone 2 waste packages was addressed in the Analysis/Model Report Dike Propagation Near Drifts; (CRWMS &O 2000o). Reference to this Analysis/Model Report will be made in the future. As explained in 3.10.2.3.2 of the Total System Performance Assessment-Site Recommendation (CRWMS M&O 2000aq), the failure size of the lid weld varies between 1 cm2 and 1 x 104 cm2 (cross section of a lid) with a mean of 10 cm2. This failure is applied to all containers in zone 2.

DOE notes that in zone 2 the shields have been removed and so a direct path to the waste package is possible. Furthermore, in Total System Performance Assessment-Viability Assessment (DOE 1998), the effect of dikes on fluid flow in the saturated zone was evaluated. The influence was negligible. DOE will cite this work in a future revision as indirect evidence that the secondary effects of

igneous intrusion have only a secondary effect on dose. In addition, DOE may argue that the combination of criticality and igneous intrusion can be neglected based on low consequence in a future revision of this Feature, Event and Process.

DOE has examine the inconsistency and determined the value listed in Table 5-1 for water content in magma is a typo (water fraction was listed instead of water wt%). The 5-wt% value listed in the rest of the document is correct. It is based on a conservative number from Characterize Eruptive Processes at Yucca Mountain, Nevada ANL-MGR-GS-000002 REV 00 (CRWMS 2000e, Section 6.2.2, pg. 28). DOE has reviewed its computer files and the value used was 5 wt%. DOE needs to look at the computer files supplied to the NRC to be able to identify the source of the 1.6-wt% number

Agreement Number

Agreement At the May 15-17, 2001 Technical Exchange, the NRC stated that current agreements related to criticality cover concern and no additional action by the DOE is necessary.

Subissue #2 - Scenario Analysis SA-75

Tracking # SA-75

Comment A number of features, events, and processes that could potentially influence the evolution of an igneous event intersecting the repository have not been identified as being relevant for disruptive events. These include:

1.1.02.00.00 (Excavation/Construction) - changes to the rock around the repository due to excavation and construction could affect dike/repository interactions and influence how a dike behaves near the surface. Additionally, repository features such as ventilation shafts could provide a path to the surface that would bypass the repository.

1.1.04.01.00 (Incomplete Closure) - if the design of the repository includes a seal at the end of the drifts strong enough to contain magma which is relied upon for performance calculations, failure to complete these seals could significantly affect repository performance.

2.1.03.12.00 (Canister Failure (Long-Term)) - for intrusive volcanism, credit is taken for the waste packages remaining mostly intact other than an end cap breach following magma interactions. The only waste package failure mechanism that is investigated to take this credit is internal gas pressure buildup. Other waste package failure mechanisms such as differential expansion of the inner and outer waste packages and phase changes in the Alloy 22 due to the long term exposure to elevated temperatures are not considered.

2.1.07.02.00 (Mechanical Degradation or Collapse of Drift) - could affect magma-repository interactions and affect the dose as a result of an igneous event.

2.3.01.00.00 (Topography and Morphology) - the topography may affect dike propagation near the surface and dike propagation probably should be discussed under this features, events, and processes.

References CRWMS M&O. "Features, Events, and Processes: Screening for Disruptive Events." ANL-WIS-MD-000005. Revision 00 ICN 01. CRWMS M&O. 2001a.
CRWMS M&O. "Yucca Mountain FEP Database." TDR-WIS-MD-000003 Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2001b.

DOE Response The following Features, Events and Processes (FEPs) will be discussed at the May 18, 2001, Igneous Activity Appendix 7 Meeting.

FEP 1.1.02.00.00 (Excavation/Construction). It is not clear which specific rock changes due to excavation and construction with which the NRC is concerned. Changes in stress due to excavation and their possible effects on dike interactions with the drift are addressed in the Dike Propagation Near Drifts Analysis/Model Report (CRWMS M&O 2000o, Section 6.3.1). This effect is considered in the evaluation of FEP 1.2.04.03.00, Igneous Intrusion into the Repository, and thus consideration under FEP 1.1.02.00.00 is not needed. Magma flow through drifts to a ventilation shaft and then to the surface is not considered in the current DOE analysis.

FEP 1.1.04.01.00 (Incomplete Closure) B The DOE analysis documented in the Dike Propagation Near Drifts Analysis/Model Report (CRWMS M&O 2000o) does not assume or rely upon drift seals to contain magma. Rather, the high energy nature of the system causes the drifts to become plugged or clogged with debris and materials from pyroclastic flows, cooling magma, and repository components. Therefore, consideration of FEP 1.1.04.01.00 with respect to igneous intrusion is not needed.

FEP 2.1.03.12.00 (Canister Failure (Long-Term). The effect of magma on waste packages is considered under FEP 1.2.04.04.00, "Magma Interacts with Waste." Therefore, consideration of FEP 1.1.04.01.00 with respect to igneous intrusion is not needed.

The end-cap breach is used because it is the locus for the largest stress and deformation resulting from increased heat and pressure. The end cap weld damage is used as a "surrogate" as a means to estimate the extent of damage. As stated in the igneous consequence modeling Analysis/Model Report in Section 6.2

"Although the mean value can be thought of conceptually as corresponding to a 1-mm-wide crack that propagates for 1 m along a weld, or a 2-mm-wide crack that extends 50 cm, it was not chosen to represent any specific dimensions of a weld failure. Rather, it was chosen as an approximation of the size of opening necessary to permit rapid gas flow and pressure equilibration. Sampling the area of the breach from a distribution that includes much larger hole sizes is intended to account for both uncertainty regarding the nature of the magmatic fluids and the package response and spatial variability in the extent of damage within the drifts."

DOE has evaluated this issue under the FEPs "Igneous Intrusion Into the Repository" or "Magma Interacts with Waste.

Consideration under FEP 2.1.03.12.00 is not needed.

FEP 2.1.07.02.00 (Mechanical Degradation or Collapse of Drift) -

To address this comment, DOE needs to know by what process the NRC believes collapse of the drift will increase dose determined for igneous disruption of a repository. Any effects of drift collapse can be covered in the screening evaluation for FEP 1.2.04.03.00, "Igneous Intrusion into the Repository."

FEP 2.3.01.00.00 (Topography and Morphology) - To address this comment, the DOE needs to know in what manner the NRC believes topography will affect dike propagation. Any effects can be covered in the screening evaluation for the FEP 1.0.04.06.00, "Basaltic Cinder Cone Erupts Through the Repository."

Agreement Number

Agreement None yet available.

Subissue #2 - Scenario Analysis SA-76

Tracking # SA-76

Comment Detailed processes related to the interaction of the ascending dike with the repository drift are not described as FEPs. Instead, the FEP database includes only general categories like "Magma interacts with waste" and "Igneous Activity". This very high level treatment of the igneous FEPs likely has caused the DOE to miss many of the FEPs that are relevant to repository/dike interactions and interactions between magma and waste packages and fuel, particularly for Type 2 waste package failures (waste packages that fail, but whose contents are not removed by the event) and the determination of the number of waste packages affected. FEPs related to magma/repository interactions that are not included in the FEP database include: mechanical and fluid dynamics at the dike tip; fragmentation; vesiculation; plume dynamics; effect of drip shield on magma/repository interactions; geologic factors; threshold flow characteristics; gas segregation; alternate models of vent formation; effects of air shafts and drifts; consideration of flow segregation; localization of magma; recirculation of magma; and evolution of flow conditions. Canister/magma interactions that appear to have been missed include hoop stress due to differential expansion of the inner and outer waste packages; melting of materials; thermal shock; and phase changes in the Alloy 22 due to the long-term exposure to elevated temperatures. Fuel/magma interactions that may have been missed could include: cladding burning at high temperatures in the presence of air; cladding/fuel chemical reactions causing damage to the fuel form (no credit is taken for cladding); dissolution of fuel in magma; mechanical shear; oxidation (during and post-eruption); reworking of spent fuel in conduit; and evolution of flow conditions.

References CRWMS M&O. "Yucca Mountain FEP Database." TDR-WIS-MD-000003 Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2001.

DOE Response

Agreement Number

Agreement None yet available.

Subissue #2 - Scenario Analysis SA-77

Tracking # SA-77

Comment 2.1.07.02.00 (Mechanical degradation or collapse of drift) has been screened as excluded (CRWMS M&O, 2001a, 2001b) based on (CRWMS M&O, 2000), which indicates that the emplacement drifts would essentially maintain their integrity through the period of regulatory concern. DOE is expected to revise the Drift Degradation Analysis to satisfy Repository design and thermal-mechanical effects Agreements 3.17 and 3.19 (DOE and NRC Technical Exchange on repository design and thermal-mechanical effects, February 6-8, 2001, Las Vegas, Nevada).At this stage, the screening argument is considered closed-pending given the existence of the repository design and thermal-mechanical effects Agreements 3.17 and 3.19.It should be noted, however, that the current state of knowledge on unsupported openings in fractured rock indicates that majority of drifts are likely to collapse soon after cessation of maintenance. This opinion is consistent with the conclusion of the DOE expert panel on drift stability (Brekke, T.L., et al, 1999) and to recent analyses of the behavior of unsupported drifts in fractured rock during seismic loading from an earthquake (Hsiung, S.M., et al., 2001). Drift collapse could have implications on temperature, chemistry, seepage into drifts, and drip shield performance.

References

Brekke T.L., E.J. Cording, J. Daemen, R.D. Hart, J.A. Hudson, P.K. Kaiser, and S. Pelizza. Panel Report on the Drift Stability Workshop, Las Vegas, Nevada, 9-11 December, 1998. Yucca Mountain Site Characterization Project 1999.

CRWMS M&O. "Drift Degradation Analysis AMR." ANL-EBS-MD-000027. Revision 01. Las Vegas, Nevada: CRWMS M&O. 2000.

CRWMS M&O. "EBS FEPs/Degradation Modes Abstraction." ANL-WIS-PA-000002. Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001a.

CRWMS M&O. "Features, Events, and Processes: Screening for Disruptive Events." ANL-WIS-MD-000005. Revision 00 ICN 01. CRWMS M&O. 2001b.

Hsiung S.M. and G.-H. Shi. 2001. Simulation of earthquake effects on underground excavations using discontinuous deformation analysis (DDA). To appear in Proceedings 38th U.S. Rock Mechanics Symposium, Washington, DC: 7-10 July, 2001.

DOE Response The screening decisions were based solely on the results of the Drift Degradation Analysis and will be revisited once the analysis to resolve the Repository Design Thermal Mechanical Effects agreement KRD0319 has been completed. NRC should consider providing an advanced copy of the cited paper (Hsuing and Shi 2001) since it is not currently available.

The referenced expert panel report on drift stability also clearly states on page 2-3 that "Fracture propagation during cooling and tectonic events appears to have been arrested by the lithophysae so that continuous joints, which could form large rock blocks and overbreak, are largely absent. Overbreak or rock loosening in the form of slabs or block was almost nonexistent in the lithophysal zones in both the 7.6-meter diameter North Ramp and the 5-meter diameter Cross Drift." This would suggest that NRC's concerns about fracture length and the possible formation of extensive slabs of rock expressed during multiple Key Technical Issues is at conflict with the findings of this panel as well.

DOE requests that the NRC provide a specific citation (section/conclusionary statement) from the expert panel report that they feel is in conflict with the Drift Degradation Analysis.

Agreement Number

Agreement The point is intended as a comment. No additional DOE action is required. RDTME Subissue 3, Agreements 17 and 19, address concern on drift collapse.

Subissue #2 - Scenario Analysis SA-78

Tracking # SA-78

Comment 1.2.03.02.00 (Seismic Vibration Causes Container Failure). The Seismic Vibration Causes Container Failure features, events, and processes has been excluded from consideration in the total system performance assessment code (CRWMS M&O, 2001a, 2001b). The screening argument cites preliminary seismic analyses of the drip shield and waste package as the basis for this screening decision (CRWMS M&O, 2000a). Because these analyses were not available at the time of this review, it is not clear as to whether the appropriate combinations of dead loads (caused by drift collapse and/or fallen rock blocks), rock block impacts, and seismic excitation were considered. Moreover, the ability of these loads to initiate cracks and/or propagate preexisting cracks may not have been adequately addressed. In addition, DOE has not demonstrated that the drip shield, pallet, and/or waste package will respond in a purely elastic manner when subjected to the aforementioned loading conditions.The screening argument for 1.2.03.02.00 also states that "... it does not appear credible that the drip shield would be breached, because the drip shield has been designed to withstand up to a 6-MT rockfall." based on the rockfall on drip shield analyses performed by the DOE (CRWMS M&O, 2000b). DOE, however, has not adequately demonstrated that the drip shield has in fact been designed to withstand 6-MT rock blocks {see the comments on 2.1.07.01.00 [Rockfall (large block)], 2.1.07.02.00 (Mechanical Degradation or Collapse of Drift), and 2.1.07.05.00 (Creeping of metallic materials in the engineered barrier subsystem) for additional discussion relevant to rockfall and seismic analyses}. Also see comment on 1.2.02.02.00 (Faulting)

References

CRWMS M&O. "Input Request for Seismic Evaluations of Waste Packages and Emplacement Pallets." Input Transmittal 00230.T. Las Vegas, Nevada: CRWMS M&O. 2000a.

CRWMS M&O. "Rock Fall on Drip Shield." CAL-EDS-ME-000001. Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000b.

CRWMS M&O. "Features, Events, and Processes: Screening for Disruptive Events." ANL-WIS-MD-000005. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2001a.

CRWMS M&O. "FEPs Screening of Processes and Issues in Drip Shield and Waste Package Degradation." ANL-EBS-PA-000002. Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001b.

DOE Response The screening argument is based on 1) The design criteria to address preclosure seismic events (it is assumed that these criteria will be met) and 2) The net effect of damage to the waste package (i.e. stated in terms of equivalent drop height) that would occur from median 10-8 accelerations of 3.2 g, is met by the preclosure

drop height requirement for the initial conditions of the waste package. As NRC has noted, multiple combinations and degradation of material properties have not yet been considered. Pending the results of additional analysis to address agreements from the Container Life and Source Term, Repository Design and Thermal Mechanical Effects and Structural Deformation and Seismicity Key Technical Issue technical exchanges, the screening decision is subject to review. DOE will document its approach to post-closure seismic issues in response to Structural Deformation and Seismicity agreements KSD0102 and KSD0203.

With regard to specific issues raised:

Additional loading combinations are being addressed in response to Container Life and Source Term agreement KCL0208. Evaluations of these loading combinations will be documented in a future revision of the Design Analysis for UCF Waste Packages (CRWMS M&O 2000n), and the Design Analysis for the Ex-Container Components (CRWMS M&O 2000l).

The ability of the additional loading combinations to initiate and/or propagate preexisting cracks are being addressed in response to Container Life and Source Term agreement KCL0208. Evaluations of the ability of these loading combinations to initiate and/or propagate preexisting cracks will be documented in a future revision of the Design Analysis for UCF Waste Packages (CRWMS M&O 2000n), and the Design Analysis for the Ex-Container Components (CRWMS M&O 2000l). DOE believes that only tensile stresses contribute to the initiation and propagation of the stress corrosion cracks.

A purely elastic response of the drip shield, pallet, and/or waste package under the aforementioned loading conditions is not a design requirement. Therefore, there has been no attempt to demonstrate that these components respond in an elastic manner. Plastic deformation is reported when the evaluations indicate such. The potential for stress corrosion cracking will be addressed.

The drip shield, in new condition, has been shown to withstand the impact of a 6-metric ton rock block without rupture. Additional loading conditions are being evaluated in response to Container Life and Source Term agreements including point load rockfall (KCL0202), potential embrittlement of the drip shield (KCL0208), wall thinning due to corrosion (KCL0208), and multiple rock blocks (KCL0208). These evaluations will be documented in a future revision of the Design Analysis for the Ex-Container Components (CRWMS M&O 2000l).

Subissue #2 - Scenario Analysis SA-78

Agreement Number TSPAI.2.02

Agreement Provide the technical basis for the screening argument, as summarized in Attachment 2. See Comment # 3, 4, 11, 12, 19 (Parts 1, 2, and 6), 25, 26, 29, 34, 35, 36, 37, 38, 39, 42, 43, 44, 48, 49, 51, 54, 55, 56, 57, 59, 60, 61, 62, 63, 64, 65, 66, 68, 69, 70, 78, 79, J-1, J-2, J-3, J-4, J-7, J-8, J-9, J-10, J-11, J-12, J-13, J-14, J-15, J-17, J-20, J-21, J-22, J-23, J-24, J-25, J-26, and J-27.

DOE will provide the technical basis for the screening argument, as summarized in Attachment 2, for the highlighted FEPs. The technical basis will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
Existing agreements from the Container Life and Source Term (Subissue 2 agreements 2 and 8), Repository Design and Thermal Mechanical Effects (Subissue 3 agreements 17 and 19) and Structural Deformation and Seismicity (Subissue 1 agreement 2 and Subissue 2 agreement 3) address related work. DOE agreed to provide clarification of the screening argument in the FEPs Screening of Processes and Issues in Drip Shield and Waste Package Degradation, ANL-EBS-PA-000002, and Features, Events, and Processes: Screening for Disruptive Events, ANL-WIS-MD-000005.

Subissue #2 - Scenario Analysis SA-79

Tracking # SA-79

Comment 2.1.07.01.00 [Rockfall (Large Block)]. [Disruptive event & waste package]: The effects of Rockfall (Large Block) on the drip shield and waste package has been screened as excluded (CRWMS M&O, 2001a, 2001b, 2001c). The Drift Degradation Analysis (CRWMS M&O, 2000b) Analysis Model Report (analysis and model report) indicates that thermal loading, seismicity, and time-dependent mechanical degradation of the host rock would have minor effect on the integrity of the drifts through the entire period of regulatory concern. However, several deficiencies associated with this analysis were identified by the NRC staff at the NRC and DOE repository design and thermal-mechanical effects technical exchange [see the comments on 2.1.07.02.00 (Mechanical Degradation or Collapse of Drift) for additional discussion pertaining to the DOE rockfall analyses]. As was pointed out at the container life and source term and repository design and thermal-mechanical effects technical exchanges, the rockfall on drip shield analyses (CRWMS M&O, 2000c) did not consider (i) the temperature effects on mechanical material behavior, (ii) seismic motion of the supporting invert, (iii) point load impacts, (iv) appropriate material failure criteria, (v) material degradation processes, (vi) multiple rock block impacts, and (vii) boundary conditions that account for the potential interactions between the drip shield and gantry rails. Consequently, U.S. Department of Energy has not adequately demonstrated that the drip shield has been designed to withstand 6, 10, or 13-MT rock block impacts.Because the framework for the invert is constructed from carbon steel, their potential degradation may affect the orientation of the waste packages over time. In other words, the invert floor cannot be expected to keep the waste packages in a horizontal position for the entire regulatory period. As a result, rock block impacts on the waste package may occur at angles that are not perpendicular to the waste package longitudinal axis. Angled rock block impacts near the closure lid welds may have significantly different results than non-angled impacts. This is a new scenario that has not been presented to DOE. [Cladding]: Mechanical failure of cladding due to rockfall is excluded based on low probability because rockfall on intact waste package will not cause rod failure (CRWMS M&O, 2000a). Main screening argument is based on intact waste package. However, the discussion is confusing because arguments based on the presence of backfill are also used in quantitative estimates. Although the conclusion can be acceptable due to presence of intact waste package, the screening arguments should be improved on the bases of appropriate calculations.

References CRWMS M&O. "Clad Degradation - FEPs Screening

Arguments." ANL-WIS-MD-000008 Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000a.
CRWMS M&O. "Drift Degradation Analysis AMR." ANL-EBS-MD-000027. Revision 01. Las Vegas, Nevada: CRWMS M&O. 2000b.
CRWMS M&O. "Rock Fall on Drip Shield." CAL-EDS-ME-000001. Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000c.
CRWMS M&O. "EBS FEPs/Degradation Modes Abstraction." ANL-WIS-PA-000002. Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001a.
CRWMS M&O. "FEPs Screening of Processes and Issues in Drip Shield and Waste Package Degradation." ANL-EBS-PA-000002. Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001b.
CRWMS M&O. "Features, Events, and Processes: Screening for Disruptive Events." ANL-WIS-MD-000005. Revision 00 ICN 01. CRWMS M&O. 2001c.

DOE Response The revised Clad Degradation: Summary and Abstraction Analysis/Model Report (ANL-WIS-MD-000007 REV 00, ICN 01, CRWMS M&O 2001a) was forwarded to the NRC as part of the Container Life and Source Term Agreement KCL0306. The revised Analysis/Model Report expanded the mechanical failure model to include cladding failure from rock overburden as the waste package deteriorates. The issue of rockfall is addressed in Container Life and Source Term agreement KCL0310. The Analysis/Model Report will be further revised as necessary to incorporate new information on rockfall, in time to support any potential License Application.

Agreement Number TSPAI.2.02

Agreement Provide the technical basis for the screening argument, as summarized in Attachment 2. See Comment # 3, 4, 11, 12, 19 (Parts 1, 2, and 6), 25, 26, 29, 34, 35, 36, 37, 38, 39, 42, 43, 44, 48, 49, 51, 54, 55, 56, 57, 59, 60, 61, 62, 63, 64, 65, 66, 68, 69, 70, 78, 79, J-1, J-2, J-3, J-4, J-7, J-8, J-9, J-10, J-11, J-12, J-13, J-14, J-15, J-17, J-20, J-21, J-22, J-23, J-24, J-25, J-26, and J-27.

DOE will provide the technical basis for the screening argument, as summarized in Attachment 2, for the highlighted FEPs. The technical basis will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
Existing agreements from Repository Design and Thermal Mechanical Effects agreements (Subissue 3 agreements 17 and 19) and Container Life and Source Term (subissue 2 agreements 2, 3 and 8) address related work. DOE agreed to provide

clarification of the screening argument in the FEPs Screening of Processes and Issues in Drip Shield and Waste Package Degradation, ANL-EBS-PA-000002, and Features, Events, and Processes: Screening for Disruptive Events, ANL-WIS-MD-000005.

Subissue #2 - Scenario Analysis SA-IA-1

Tracking # SA-IA-1

Comment 2.3.02.02.00 (Radionuclide Accumulation in Soil) is included for irrigation deposition only, however, this screening argument is too limited since it excludes transport of volcanic ash from other areas to the critical group location (CRWMS M&O, 2001). DOE has indicated that redistribution will be accounted for by conservatively assuming that the wind is blowing towards the critical group and maintaining a high mass load in years following the event. DOE has not provided a demonstration that these conservatisms actually bound the effects of redistribution. Similar comment applies to 2.3.02.03.00 (Soil and Sediment Transport). In the screening argument it is claimed that 100% south-blowing wind direction assumption accounts for aeolian and fluvial transport processes. Additional technical basis for this statement is needed. 2.3.13.02.00 (Biosphere Transport) excludes transport in surface water. 2.3.11.02.00 (Surface Runoff and Flooding) and 2.3.01.00.00 (Topography and Morphology) require consideration of effects on redistribution of radionuclides following an igneous event.

References CRWMS M&O. "Evaluation of the Applicability of Biosphere-Related Features, Events, and Processes (FEP)". ANL-MGR-MD-000011. Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001.

DOE Response DOE has agreed to revisit the issue of surface-redistribution of contaminated ash and soil as part of the resolution of agreement item for Igneous Activity Agreement KIA0206. Specifically, DOE has agreed to develop a linkage between soil removal rate and surface remobilization processes characteristics of the Yucca Mountain region and to document its approach to include uncertainty related to surface-redistribution processes in Total System Performance Assessment-Site Recommendation (CRWMS M&O 2000aq). Section 14.3.6.7 of Supplemental Science and Performance Analyses (DOE 2001, in progress), will provide an overview of the work that may be conducted to address this issue. (Response applicable to each listed feature, event and process) No additional work is required beyond the existing agreement.

Agreement Number

Agreement None yet available.

Subissue #2 - Scenario Analysis SA-ENFE-1

Tracking # SA-ENFE-1

Comment 2.2.10.06.00 [Thermo-chemical alteration (solubility speciation, phase changes, precipitation/dissolution)]. DOE has not provided the technical basis for excluding entrained colloids in the analysis of 2.2.10.06.00 [Thermo-chemical alteration (solubility speciation, phase changes, precipitation/dissolution)] or an alternative database entry (CRWMS M&O, 2001). DOE has not considered possible entrainment of colloids and particulates in convecting/advecting boiling fluids or by otherwise vigorous water movement in the drift.

References CRWMS M&O. "Features, Events, and Processes in UZ Flow and Transport." ANL-NBS-MD-000001 Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001.

DOE Response

Agreement Number ENFE.1.06

Agreement Provide the technical basis for excluding entrained colloids in the analysis of FEP 2.2.10.06.00 (Thermo-Chemical Alteration) or an alternative FEP. The DOE will provide the technical basis for screening entrained colloids in the analysis of FEP 2.2.10.06.00 in a future revision of the Features, Events, and Processes in UZ Flow qnd Transport AMR (ANL-NBS-MD-000001), expected to be available in FY 02.

Subissue #2 - Scenario Analysis SA-USFIC-1

Tracking # SA-USFIC-1

Comment 2.2.07.18.00 (Film flow into drifts) is screened as included on the basis of low consequence (low film flow rates). Higher film flow rates into drifts are considered included (CRWMS M&O, 2001). Technical bases for the screening argument for 2.2.07.18.00 will derive from work needed to satisfy the Unsaturated and Saturated Flow Under Isothermal Conditions Subissue 4 Agreement 2.

References CRWMS M&O. "Features, Events, and Processes in UZ Flow and Transport." ANL-NBS-MD-000001 Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001.

DOE Response

Agreement Number USFIC.4.02

Agreement Include the effect of the low-flow regime processes (e.g., film flow) in DOE's seepage fraction and seepage flow, or justify that it is not needed. DOE will include the effect of the low-flow regime processes (e.g., film flow) in the seepage fraction and seepage flow, or justify that it is not needed. These studies will be documented in Seepage Models for PA Including Drift Collapse AMR, MDL-NBS-HS-000002, expected to be available to NRC in FY 2003.

Subissue #2 - Scenario Analysis SA-ENFE-2

Tracking # SA-ENFE-2

Comment 1.2.06.00.00 (Hydrothermal Activity). This item is excluded in the unsaturated zone on the basis of low consequence and low probability (CRWMS M&O, 2001). The DOE has not yet provided sufficient technical bases for models explaining elevated temperatures in the unsaturated zone from about 12 Ma to 2 Ma, or adequately addressed the timing and mode of formation of the Type B faults which record elevated temperatures.

References CRWMS M&O. "Features, Events, and Processes in UZ Flow and Transport." ANL-NBS-MD-000001 Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001.

DOE Response

Agreement Number ENFE.2.03

Agreement Provide the technical basis for FEP 1.2.06.00 (Hydrothermal Activity), addressing points (a) through (e) of NRC Subissue 2 slide handed out at the January 2001 ENFE technical exchange. The DOE will provide additional technical bases for the screening of FEP 1.2.06.00 (Hydrothermal Activity), in a future revision of the Features, Events, and Processes in UZ Flow and Transport AMR, ANL-NBS-MD-000001, expected to be available in FY 02. Within these technical bases, the DOE will address NRC comments [points (a) through (e)] presented on the NRC Subissue 2 slide handed out at the January 2001 ENFE technical exchange or provide justification that it is not needed.

Subissue #3 - Model Abstraction ENG 1.1.1

Tracking # ENG 1.1.1

Comment The general corrosion of a waste package is resampled part way through the degradation calculation. Technical basis is needed that the resampling of corrosion rates part way through the degradation calculation appropriately represents the physical processes occurring and that the results obtained when applying such a technique are in agreement with the original data (e.g. failure distribution and surface area failed over time).

References NRC. "Issue Resolution Status Report. Key Technical Issue: Total System Performance Assessment and Integration." Revision 3. Page 194. Washington, DC: NRC. 2000.

DOE Response The "resampling" is used to account for the dual closure lid waste package design used in TSPA-Site Recommendation (CRWMS M&O 2000ar). The closure lids are properly modeled as two separate entities (i.e., the model parameters are sampled for each closure lid). The remainder of the waste package outer barrier is indeed modeled as being composed of two "pseudo-barriers." Since failure of the closure lid weld regions determines the waste package failure time, the pseudo-barrier modeling approach used for the remainder of the waste package outer barrier is of little consequence to the expected mean annual DOSE rate. It is also expected that the current modeling approach does not affect significantly the waste package degradation analysis results and the peak DOSEs. It should be noted that in reality, general corrosion rates of the patches are likely to switch over time (i.e., rather than corroding at the same rate) throughout such a long exposure time period, and the current approach with the re-sampling of the rates a half way through is considered still highly conservative in light of the first breach time. Details of the justification for the insignificant consequence of the re-sampling of the general corrosion rate a half way through to the waste package degradation analyses will be documented in a future revision of the Waste Package Degradation Analysis/Model Report (CRWMS M&O 2000az).

Reference: CRWMS M&O 2000ar. Total System Performance Assessment for the Site Recommendation. TDR-WIS-PA-000001 REV 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001220.0045.

CRWMS M&O 2000az. WAPDEG Analysis of Waste Package and Drip Shield Degradation. ANL-EBS-PA-000001 REV 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001208.0063.

Agreement Number TSPAI.3.02

Agreement DOE will provide the technical basis for resampling the general

corrosion rates and the quantification of the impact of resampling of general corrosion rates in an update to the WAPDEG Analysis of Waste Package and Drip Shield Degradation AMR (ANL-EBS-PA-000001). This AMR is expected to be available to NRC in FY 2003.

Subissue #3 - Model Abstraction ENG 1.1.2

Tracking # ENG 1.1.2

Comment The model abstraction for the transport of water through stress corrosion cracks in the drip shield and diffusive transport of radionuclides through the stress corrosion cracks in the waste packages are also based on a beneficial FEP (2.1.03.10.00 Container Healing) that was included for the EBS in the TSPA- SR (Table B-12 p. B-37) and the Engineered Barrier System Process Model Report even though it has been excluded on the basis of low consequence in the Drip shield and Waste Package FEPs AMR as well as the Engineered Barrier System FEPs AMR

The screening argument in the FEPs Screening of Processes and Issues in Drip Shield and Waste Package Degradation, ANL-EBS-PA-000002 Rev 01, (February, 2001), specifically addresses transport of both water and radionuclides and states in FEP 2.1.03.10.00 "Plugging (or healing) of corrosion holes or pits in the waste container by corrosion products and mineral precipitates is a possible process in the repository. However there are large uncertainties associated with the quantification of the effect of the processes on water flow and radionuclide transport through the openings. Because of this, potential performance credit from the plugging (or healing) of the corrosion penetration openings are not taken into account in the TSPA analysis. Therefore this FEP is excluded based on low consequence to the expected annual dose."

The model abstraction for transport through stress corrosion cracks in the drip shield and waste packages should be consistent with the FEP screening arguments. The technical basis for the tight crack geometries that prevent advective transport through stress corrosion cracks in the waste package should be provided.

References CRWMS M&O. "Engineered Barrier System Degradation, Flow and Transport Process Model Report." TDR-EBS-MD-000006. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.
CRWMS M&O. "FEPs Screening of Processes and Issues in Drip Shield and Waste Package Degradation." ANL-EBS-PA-000002. Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001.
CRWMS M&O. "Engineered Barrier System Features, Events, and Processes." ANL-WIS-PA-000002. Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001.

DOE Response The arguments of the tightness of stress corrosion cracks and plugging of the cracks by corrosion products and mineral precipitates were used to screen out the drip shield stress corrosion cracking. Recent analysis has shown that these cracks are expected to be plugged by mineral precipitates (e.g., calcite) within a few decades (BSC 2001d, Tables 6-3 and 6-5). The very limited flow of water through the plugged cracks would not

compromise the intended function of the drip shield (i.e., diversion of dripping water). Moisture would still be available from the humid air in the emplacement drift, and condensation of water occur on the waste package surface provided the humidity of the surrounding air in the emplacement drift is high enough. The water condensation would be greatly enhanced if the waste package surface were contaminated with dust and/or hygroscopic salts. Therefore, the plugged stress corrosion cracks in the drip shield would not affect the intended function of the drip shield, and the drip shield stress corrosion cracking has been screened out (CRWMS M&O 2001e).

The TSPA-Site Recommendation assumes (CRWMS M&O 2000ar) diffusion is the dominant transport process for radionuclide release through the plugged stress corrosion cracks in the waste package. It is acknowledged that the screening arguments for FEP 2.1.03.10.00 (Container Healing) need to be updated to incorporate the latest analysis for the SCC crack plugging and to be consistent with the TSPA analysis. The waste package FEPs Analysis/Model Report (CRWMS M&O 2001e) will be revised to update the screening argument.

References: BSC 2001d. Plugging of Stress Corrosion Cracks by Precipitates. CAL-EBS-MD-000017 REV 00A. Las Vegas, Nevada: Bechtel SAIC Company. Submit to RPC.

CRWMS M&O 2001e. FEPs Screening of Processes and Issues in Drip Shield and Waste Package Degradation. ANL-EBS-PA-000002 REV 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL20010216.0004.

CRWMS M&O 2000ar. Total System Performance Assessment for the Site Recommendation. TDR-WIS-PA-000001 REV 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001220.0045

Agreement Number TSPAI.3.03

Agreement DOE will provide the technical basis for crack arrest and plugging of crack openings (including the impact of oxide wedging and stress redistribution) in assessing the stress corrosion cracking of the drip shield and waste package in an update to the Stress Corrosion Cracking of the Drip Shield, Waste Package Outer Barrier, and the Stainless Steel Structural Material AMR, ANL-EBS-MD-000005, in accordance with the scope and schedule for existing agreement item CLST 1.12.

Subissue #3 - Model abstraction ENG 1.3.1

Tracking # ENG 1.3.1

Comment DOE should explain why crevice samples yield higher corrosion rates than non-crevice samples in the Long Term Corrosion Testing experiments. Is it possible that enhanced corrosion rates as a result of a less protective film are occurring in the crevice area? Is the equation to compute corrosion rates (CRWMS M&O, 2000, Equation 3-15) adequate if there are small regions of enhanced dissolution? Equation 3-15 in (CRWMS M&O, 2000) is

$r = w/(d*A*t)$

r = corrosion rate (m/yr)
w = weigh loss (kg)
d = Alloy 22 density (kg/m3)
A = surface area of coupon sample (m2, 30.65 and 57.08 cm2 for weight loss and crevice samples, respectively, CRWMS M&O, 2000, p 3-41)
t = duration of weight loss test (yr)

A corrosion rate derived using Equation 3-15 can be interpreted as an average rate on the surface of the sample. It is not clear that this average is a valid corrosion rate in case of existence of small regions with high dissolution rates.

References CRWMS M&O. "Waste Package Degradation PMR." TDR-WIS-MD-000002. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response Container Life and Source Term agreement 1.4 will address the higher corrosion rates in crevice samples versus non-crevice (weight loss) samples. Overall, the crevice specimens do not systematically indicate higher general corrosion rates than the weight loss coupons, but there are some data sets where the average rate and range of rates from crevice specimens do appear higher. DOE is in the process of performing a more detailed analysis of the data sets to determine whether there is bias in the results and if so, what factors may be responsible.

When the 5 year corrosion data become available in February 2002, additional physical measurements will be performed and the difference between the corrosion rates for crevice and non-crevice samples will be reassessed.

Agreement Number TSPAI.3.01

Agreement The technical basis for sources of uncertainty will be established upon completion of existing agreement items CLST 1.4, 1.5, 1.6, and 1.7. DOE will then propagate significant sources of uncertainty into projections of waste package and drip shield

performance included in future performance assessments. This technical basis will be documented in a future revision of the General and Localized Corrosion of Waste Package Outer Barrier AMR, ANL-EBS-MD-000003, expected to be available consistent with the scope and schedules for the specified CLST agreements. The results of the AMR analyses will be propagated into future TSPA analyses for any potential license application.

Subissue #3 - Model abstraction ENG 1.3.2

Tracking # ENG 1.3.2

Comment DOE should explain why corrosion rates tend to decrease with test duration in the Long Term Corrosion Testing experiments.

It has been explained that decreasing corrosion rates are the result of a passive film that thickens with time (CRWMS M&O, 2000, p 3-42). Is there any evidence that the passive film on 2-year samples is thicker than the 0.5 and 1-year samples? The inner chromium-rich oxide film, which is responsible for passivity, is likely to achieve steady-state in a short time (few weeks), at which time the inner film may maintain a constant thickness. The outer layer(s) in the film are not necessarily responsible for passivity.

References CRWMS M&O. "Waste Package Degradation PMR." TDR-WIS-MD-000002. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response The observed decrease in corrosion rate with time for long term corrosion test samples exposed for 0.5, 1.0 and 2-2.3 years is attributed to a combination of factors as indicated below:

The actual Alloy 22 corrosion rates measured on the currently used small surface area specimens in the various Long Term Corrosion Test Facility environments at 60 and 90oC are too low to allow accurate measurement by descaled weight loss. Whereas the measured corrosion rates indicate a decrease with time (mean rate decreases from 0.05 microns/year at six month to 0.01 microns/years), the calculated weight loss uncertainty due to various measurement errors is equivalent to ~0.04 microns metal loss at one standard deviation (CRWMS M&O 2000be, p. 74). Thus, any corrosion rate trend at shorter test times is partially masked by the measurement uncertainty.

For the most passive materials, and the types of expected environments, the passive film thickness and resulting corrosion rate rapidly reach an essentially constant value. Thus, as the test time increases, the measured corrosion rate would be expected to approach the true value since the weight loss uncertainty becomes a smaller fraction of the actual weight loss.

The Container Life and Source Term agreement 1.6 indicates that DOE will resolve the corrosion rate uncertainty by using higher sensitivity corrosion rate measurement techniques and by directly measuring the passive film growth kinetics using techniques such as the Tunneling Atomic Force Microscope.

Reference: CRWMS M&O 2000be. General Corrosion and

Localized Corrosion of Waste Package Outer Barrier. ANL-EBS-MD-000003 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20000202.0172.

Agreement Number TSPAI.3.01

Agreement The technical basis for sources of uncertainty will be established upon completion of existing agreement items CLST 1.4, 1.5, 1.6, and 1.7. DOE will then propagate significant sources of uncertainty into projections of waste package and drip shield performance included in future performance assessments. This technical basis will be documented in a future revision of the General and Localized Corrosion of Waste Package Outer Barrier AMR, ANL-EBS-MD-000003, expected to be available consistent with the scope and schedules for the specified CLST agreements. The results of the AMR analyses will be propagated into future TSPA analyses for any potential license application.

Subissue #3 - Model abstraction ENG 1.3.3

Tracking # ENG 1.3.3

Comment DOE should provide additional technical basis in support of the interpretation of the experimental data from the Long Term Corrosion Test Facility.

For example,
(A)
Deposition of corrosion products producing "weight gain" may compete with dissolution through the film causing "weight loss," thus weight loss measurements may underestimate corrosion rates. Precipitates have been observed on Alloy 22 under transpassive conditions (Dunn et al., 2001).

(B)
It has been explained that the observed weight gain is due to the formation of silica precipitates. Do silica precipitates form an insulating coating? Is it possible that the apparent decrease in the corrosion rate with time is due to a decrease in the extent of the reactive surface area? Note that longer term testing tended to yield more samples with weight gain (up to 40% of the total number of samples).

(C)
It has been estimated that correcting apparent corrosion rates by 63 nm/yr is sufficient to provide an estimate of intrinsic corrosion rates. Note the following computations:

Simulated Dilute Water conditions (SDW), Weight Loss Specimens - 6 month
Average corrosion rate = 27 nm/yr
Penetration of corrosion front = 27×0.5 = 13.5 nm SDW,
Weight Loss Specimens B 1 year
Average corrosion rate = -22 nm/yr
Penetration of corrosion front = -22×1 = -22 nm
Penetration of the corrosion front from 0.5 yr to 1 yr = -22 nm - 13.5 nm = -35.5 nm

If the "outward" motion of the surface is due to silica deposits, the rate of deposition would be 35.5/0.5 = 71 nm/yr. This number of 71 nm/yr is greater than the correction of 63 nm/yr used in the abstraction.

(D)
Caution must be taken when defining corrosion rates with PDFs having wide variances so as to avoid risk dilution.

References CRWMS M&O. "Waste Package Degradation PMR." TDR-WIS-

MD-000002. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response (A, B & C)
The current DOE analysis includes a correction to the general corrosion rates from the weight loss measurements for potential incomplete de-scaling of silica deposit on the sample coupons. Observations of limited number of sample coupons with atomic force microscope showed varying degrees of coverage of the sample coupon surface by the silica scale. The maximum correction of 63 nm/yr is for the complete coverage of the coupon surface by silica scale. In the DOE analysis, the correction for potential incomplete de-scaling of the silica deposit from sample coupons is accomplished by sampling the correction factor from uniform distribution between 0 and 63 nm/yr and adding the sampled factor to the general corrosion rate distribution. The maximum corrosion rate adjustment of 63 nm/yr is consistent with current experimental data. If ongoing experiments show a higher corrosion rate adjustment is appropriate, then a higher rate adjustment will be incorporated into the corrosion models.

It should be noted that the presence of silica scale on the Alloy 22 coupons would provide a certain level of protection against corrosion attack. With silica scale forming on the waste package (and drip shield) surface, which is very likely under expected repository exposure conditions, the current analysis is a realistic measure for the general corrosion rate of the waste package.

The Container Life and Source Term agreement 1.6 identifies specific activities to resolve the ambiguity regarding silica deposition and calculation of a factor to account for its influence in the general corrosion rate of Alloy 22 specimens. Corrosion data for silica-free environment will provide additional valuable information to resolve the issues associated with potential effect of silica deposit on the general corrosion rate.
(D)
Sensitivity analyses were conducted for effect of varying number of waste packages and patches on a waste package (CRWMS M&O 2000az, Section 6.4.3), which provides good indications on the stability of the analysis results from the perspective of the sampling of the tails of the stochastic input parameters (e.g., general corrosion rate distribution). The analysis results show that a larger number of waste packages and patches per waste package than the current analysis (i.e., 400 waste packages per simulation and 1,000 patches per waste package) do not have impact on the waste package degradation results (CRWMS M&O 2000az, Section 6.4.3). This demonstrates that the tails of the current general corrosion rate distribution are represented appropriately in

the current analysis.

Reference: CRWMS M&O 2000az. WAPDEG Analysis of Waste Package and Drip Shield Degradation. ANL-EBS-PA-000001 REV 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001208.0063.

Agreement Number TSPAI.3.01

Agreement The technical basis for sources of uncertainty will be established upon completion of existing agreement items CLST 1.4, 1.5, 1.6, and 1.7. DOE will then propagate significant sources of uncertainty into projections of waste package and drip shield performance included in future performance assessments. This technical basis will be documented in a future revision of the General and Localized Corrosion of Waste Package Outer Barrier AMR, ANL-EBS-MD-000003, expected to be available consistent with the scope and schedules for the specified CLST agreements. The results of the AMR analyses will be propagated into future TSPA analyses for any potential license application.

TSPAI.3.04 - DOE will provide the technical basis that the representation of the variation of general corrosion rates results in reasonably conservative projected dose rates. The technical basis will be documented in an update to the WAPDEG Analysis of Waste Package and Drip Shield Degradation AMR, ANL-EBS-PA-000001. This AMR is expected to be available to NRC in FY 2003. These results will be incorporated into future TSPA documentation for any potential license application.

Subissue #3 - Model abstraction ENG 1.3.4

Tracking # ENG 1.3.4

Comment Corrosion rates and TSPA computations.

(A) Including a factor for MIC uniformly sampled in the range (1,2) and a factor for thermal aging and phase instability uniformly sampled in the range (1,2.5) empirical PDF for corrosion rates (including 0.5-yr, 1-yr, and 2-yr test data) may produce general corrosion failure times as early as 5,000 yr. Similar independent computations by the NRC with only 2-yr test data produce much later failure times. Thus, it is very important to provide appropriate technical basis to disregard the 0.5-yr and 1-yr test data in the model abstraction.

(B) The independent computations by the NRC followed a simple approach. Corrosion rates were sampled from empirical PDFs, enhanced by the MIC and thermal aging factors. Failure times were computed as 2 cm/r, where r is the corrosion rate in cm/yr. This approach disregards the delay in the onset of aqueous environments (<<1,000 yr); however, these simple computations are expected to yield results comparable to those derived from complex models.

In particular, Figure 3.4-20 in TSPA-SR is directly comparable to results of the independent NRC computations. DOE should explain why only at most 1% of the waste package surface is degraded by general corrosion at 100,000 yr, while simple computations indicate an expected value of ~30% at 100,000 yr.

References CRWMS M&O. "Total System Performance for the Site Recommendation." TDR-WIS-PA-000001. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response A.
The Alloy 22 2-year exposure corrosion rates were used to develop the general corrosion rate distribution used in Performance Assessment. The corrosion rate distributions obtained from the Long Term Corrosion Test Facility show that as the exposure time increases, the median and variance of the corrosion rates decrease. This indicates that longer-term measurements would result in lower corrosion rate distributions. Furthermore, it has been shown that as exposure time increases the error in the Long Term Corrosion Test Facility measurements decreases (CRWMS M&O 2000ar, Table 16). These observations provide appropriate technical basis to disregard the 0.5-yr and 1-yr test data in the model abstraction.

Analyses of corrosion rates appropriate for use over long time periods are part of existing Container Life and Source Term

agreements (1.4, 1.7, 1.8).

B.
(CRWMS M&O 2000ar) shows the percentage of waste package patch breaches per failed waste package. In the DOE model, waste packages may breach by cracks or patches. In Figure 2, only general corrosion processes are considered (no cracks were considered). Therefore, Figure 2 is not directly comparable to Figure 3.4-20 in the TSPA-Site Recommendation. The results of the cases in Figure 2 were reproduced in Waste Package Degradation Model and the results are in general agreement with those shown in Figure 2. In a telecon (7/11/2001) between DOE and NRC, it was confirmed that with the discrepancies in the approach resolved, the NRC results are sufficiently close to the current DOE analysis results.

The basis for not excluding microbial induced corrosion from a microbial communities standpoint is documented in the In-Drift Microbial Communities Analysis/Model Report (CRWMS M&O 2000ac).

References: CRWMS M&O 2000ar. Total System Performance Assessment for the Site Recommendation. TDR-WIS-PA-000001 REV 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001220.0045.

CRWMS M&O 2000ac. In-Drift Microbial Communities. ANL-EBS-MD-000038 REV 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001213.0066.

Agreement Number TSPAI.3.01

Agreement The technical basis for sources of uncertainty will be established upon completion of existing agreement items CLST 1.4, 1.5, 1.6, and 1.7. DOE will then propagate significant sources of uncertainty into projections of waste package and drip shield performance included in future performance assessments. This technical basis will be documented in a future revision of the General and Localized Corrosion of Waste Package Outer Barrier AMR, ANL-EBS-MD-000003, expected to be available consistent with the scope and schedules for the specified CLST agreements. The results of the AMR analyses will be propagated into future TSPA analyses for any potential license application.

Subissue #3 - Model abstraction ENG 1.3.5

Tracking # ENG 1.3.5

Comment High corrosion rates, upper tails of PDFs.

(A) It is assumed that corrosion rates are normally distributed (CRWMS M&O, 2000, p 3-36, 3-113), an assumption that seems adequate for the 2-yr testing data. However, this assumption is not valid if all the testing data (0.5, 1, and 2 yr) is considered in the statistical population. Furthermore, for the extended population set (0.5, 1, and 2 yr), the normal distribution underestimates the high corrosion rates. Using the Gauss-Variance partitioning scheme is not enough to define confidence intervals for the high corrosion rates. Independent NRC computations indicate that much earlier failure times are predicted on the basis of an empirical PDF (i.e., defined using experimental corrosion rates) than those derived using normal PDFs of the Gauss-Variance Partitioning approach.

The intention of this comment is suggesting that if all data available is used to define normal PDFs, there is some risk of predicting larger than expected early failure times, because normal PDFs do not capture the high corrosion rates.

(B) High corrosion rates are most relevant to model abstraction. The size of the statistical population should be large enough to define the upper tail of the PDF for the corrosion rate with confidence.

References CRWMS M&O. "Waste Package Degradation PMR." TDR-WIS-MD-000002. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response The corrosion rates are not assumed to be normally distributed. They are given by an empirical Cumulative Distribution Function derived from the two-year experimental data and corrected for silica deposition. Gaussian-Variance Partitioning (GVP) preserves the span of the general corrosion rate distribution. The highest and lowest values are present in every GVP output. The Cumulative Distribution Function probabilities are mapped to normal probabilities; the variance is partitioned; and the probabilities are mapped back to real space. The net effect is that variance is partitioned between uncertainty and variability. The resulting distribution is not normally distributed.

The Alloy 22 2-year exposure corrosion rates were used to develop the general corrosion rate distribution used in Performance Assessment. The corrosion rate distributions obtained from the Long Term Corrosion Test Facility show that as the exposure time increases, the median and variance of the corrosion rates decrease. This indicates that longer-term measurements would

result in lower corrosion rate distributions. Furthermore, it has been shown that as exposure time increases the error in the Long Term Corrosion Test Facility measurements decreases (CRWMS M&O 2000be, Table 16). These observations provide appropriate technical basis to disregard the 0.5-yr and 1-yr test data in the model abstraction.

Analyses of corrosion rates appropriate for use over long time periods are part of existing Container Life and Source Term agreements (1.4, 1.7, 1.8).

(B)
TSPA simulations use 100 (sometimes 300) realizations with 400 waste package/drip shield pairs per realization. Each drip shield has 500 patches and each waste package has 1000 patches. In all some 40,000,000 patches are simulated to determine the mean annual DOSE.

Reference: CRWMS M&O 2000be. General Corrosion and Localized Corrosion of Waste Package Outer Barrier. ANL-EBS-MD-000003 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20000202.0172.

Agreement Number

Agreement DOE response during Technical Exchange was considered adequate by the NRC. Total System Performance Assessment and Integration Technical Exchange, August 6-10, 2001.

Subissue #3 - Model Abstraction ENG 1.3.6

Tracking # ENG 1.3.6

Comment Staff believes that the interpretation of the corrosion-rate data could make a significant difference in the regulatory dose, and therefore disagrees with the DOE conclusion in section 5.2.3.3 of the TSPA results that there is little effect from Gaussian Variance Partitioning (GVP).

NRC staff has developed a highly abstracted model of the relationship between failed WP area and peak mean dose, and believes there are circumstances where assuming that the corrosion rate data represent mostly spatial variability will lead to a higher peak mean dose than if the same data represented mostly experimental uncertainty.

References CRWMS M&O. "Total-System Performance Assessment for the Site Recommendation." TDR-WIS-PA-000001. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2001.

DOE Response Assuming enough samples are considered, one would expect little effect of a sampling scheme on the mean DOSE. This is shown in Section 5.2.3.3 of the TSPA in Figures 5.2-7 and 5.2-8.

In a given realization, increased spatial variability should lead to the potential for earlier failure and decrease the peak DOSEs. It is agreed that increased spatial variability could lead to higher peak DOSEs for the mean DOSE.

Review of the NRC analysis results provided to DOE and subsequent discussion of the results during a recent DOE and NRC telecon (7/11/2001 teleconference) confirmed that the NRC results of the relationship between failed waste package area and peak mean DOSE are driven mostly by the modeling assumptions made for the radionuclide transport from the failed waste packages and through the failed area. In the NRC analysis, the effect of the waste package failed area and its subsequent degradation (i.e., additional failed areas) with time on the peak mean DOSE that result from the two end-member cases assuming 100% variability and 100% uncertainty in the Alloy 22 general corrosion rate is secondary to the effect of the transport modeling assumptions. The discrepancies of the peak mean DOSE to the conceptual understanding for the two end-member cases (i.e., higher peak mean DOSEs with the 100% variability case) become greater when more conservative assumptions are employed for the transport modeling. In comparison, the DOE analysis results for the two end-member cases show no significant difference in the peak mean DOSEs.

Reference: CRWMS M&O 2000ar. Total System Performance

Assessment for the Site Recommendation. TDR-WIS-PA-000001 REV 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001220.0045.

Agreement Number TSPAI.3.05

Agreement DOE will provide the technical basis for the representation of uncertainty/variability in the general corrosion rates. This technical basis will include the results of 100% uncertainty, 100% variability, and selected intermediate representations used in the DOE model. These results will be documented in an update to the WAPDEG Analysis of Waste Package and Drip Shield Degradation AMR, ANL-EBS-PA-000001, or other document. This AMR is expected to be available to NRC in FY 2003.

Subissue #3 - Model Abstraction ENG 1.4.1

Tracking # ENG 1.4.1

Comment The DOE model abstraction assumes diffusive transport of radionuclides through stagnant water that fills stress corrosion cracks in the waste packages and lack of water transport through cracks in the drip shield. This assumption has a direct effect on dose because it is assumed that advective transport of radionuclides by flowing water through stress corrosion cracks in the waste package does not occur. In addition, the DOE model assumes that the quantity of water that is transported through cracks in the titanium alloy drip shield is limited by diffusion. Stress corrosion cracking of the drip shield has been excluded as a FEP on the basis of low consequence because water transport through cracks in the drip shield will not significantly increase the quantity of water contacting the waste packages and waste forms.

The assumption of diffusive transport of radionuclides with the exclusion of advective transport relies on stress corrosion crack geometries that will remain tight for thousands of years. The tight geometry of stress corrosion cracks are in turn based on unsupported assumptions. For the waste packages, it is assumed that the stress corrosion cracks will cease to propagate when the lid is penetrated. Secondary cracks and crack branching, which may contribute to crack opening displacement and subsequently allow advective transport of radionuclides by slow flowing water, are not considered in the DOE model.

References CRWMS M&O. "Total System Performance Assessment Model for Site Recommendation." MDL-WIS-PA-000002. Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000.
CRWMS M&O. "WAPDEG Analysis of Waste Package and Drip Shield Degradation." ANL-EBS-PA-000001. Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response The previous analyses using the fundamental relation of fracture mechanics have shown that the stress corrosion crack openings in drip shield and waste package are very "tight" (CRWMS M&O 2000ao, Section 6.5.5). The cracks in the drip shield due to rockfall (CRWMS M&O 2000am, Section 6; CRWMS M&O 2000ao, Section 6.5.5) and hydrogen induced cracking (CRWMS M&O 2000x, Section 6.3.4) are self-limited and remain tight. These tight cracks will be plugged by corrosion products and mineral precipitates. Recent analyses have shown that stress corrosion cracks are expected to be plugged by calcite within a few decades (BSC 2001d, Tables 6-3 and 6-5). Very limited water flow is expected through the plugged stress corrosion cracks. Because such plugged stress corrosion cracks would not affect the intended function of the drip shield (i.e., diversion of dripping water), the drip shield stress corrosion cracking was screened out and not modeled

in the waste package degradation analysis and TSPA-Site Recommendation.

Secondary cracks and crack branching are not modeled explicitly in the TSPA-Site Recommendation waste package degradation analysis. Because, when a crack propagates through the wall thickness, the tensile stress that has driven the crack propagation is relieved, no additional crack growth is assumed in the "immediate" vicinity of the through-wall crack. In the TSPA-Site Recommendation waste package degradation analysis, multiple cracks are allowed to grow in a single patch, and when that patch is breached by a stress corrosion crack, all remaining cracks in that patch cease to grow because of the stress relief in the immediate vicinity of the through-wall crack.

The waste package closure-lid weld region is represented with a total of 32 patches. Because one through-wall stress corrosion crack per patch is assumed in the waste package degradation analysis, the modeled maximum number of through-wall stress corrosion cracks per waste package is 32. In the TSPA-Site Recommendation analysis, the number of through-wall stress corrosion cracks estimated from the waste package degradation analysis is increased conservatively by a factor of 10 for the actual number of through-wall stress corrosion cracks used for transport calculations. The factor of 10 increase in the number of through-wall stress corrosion cracks is based on the "2T" rule, where T is the thickness of material subject to stress corrosion. The area represented by the "2T" rule is referred to a unit area in this discussion. The rule indicates that within an area that is represented by approximately two times the thickness of the material, a stress corrosion crack can grow without interfering with the neighboring stress corrosion cracks. For the weld region of the outer closure-lid (25-mm thick) of the waste package outer barrier, the "unit" area represented by the 2T rule is approximately 25 cm2 [(2x2.5 cm) x (2x2.5 cm)]. The unit area for the weld region of the inner closure-lid (10-mm thick) of the outer barrier is approximately 4 cm2 [(2x1.0 cm) - (2x1.0 cm)]. With the area of a single patch of approximately 234 cm2 (CRWMS M&O 2000az, Section 5.1), there are approximately 9.4 unit areas for the outer closure-lid weld region. This is the technical basis to increase conservatively the number of through-wall stress corrosion cracks from the waste package degradation analysis by a factor of 10 for the TSPA analysis. This is a highly conservative approach because it assumes that when a patch is breached by a through-wall stress corrosion crack, there are nine additional through-wall stress corrosion cracks penetrating that patch at the same time.

For the inner closure-lid weld region, the number of the unit areas per patch is much higher (approximately 59 unit areas) than the outer closure-lid weld region. However, the same number of the unit areas per patch as the outer closure-lid weld region is assumed for the inner closure-lid weld region. Because the approach used for the outer closure-lid weld region is already highly conservative, use of the same number of the unit areas per patch for the inner closure-lid weld region is considered reasonably conservative. Accordingly, the maximum possible number of through-wall stress corrosion cracks per waste package used in the TSPA-Site Recommendation analysis is 320. Details of the technical basis and accompanying assumptions will be documented in a future revision of the Waste Package Analysis/Model Report (CRWMS M&O 2000az).

As discussed above, the through-wall crack and secondary cracks (although not modeled explicitly) would be plugged by corrosion products and mineral precipitates in a relatively short time period (BSC 2001d, Tables 6-3 and 6-5), and exclusion of explicit representation of secondary cracks should not underestimate the transport rates of radionuclides through the plugged stress corrosion cracks. In a more realistic scenario, secondary cracks would increase tortuosity of the transport pathway, and non-inclusion of secondary cracks may be more conservative for the transport rate of radionuclides.

However, potential effects of static loads and/or rockfall on degraded drip shield and waste package by stress corrosion cracking and general corrosion have not been considered. This issue will be addressed under the Container Life and Source Term Agreement Item 2.8 prior to any potential License Application.

References: BSC 2001d. Plugging of Stress Corrosion Cracks by Precipitates. CAL-EBS-MD-000017 REV 00A. Las Vegas, Nevada: Bechtel SAIC Company. Submit to RPC.

CRWMS M&O 2000ao. Stress Corrosion Cracking of the Drip Shield, the Waste Package Outer Barrier, and the Stainless Steel Structural Material. ANL-EBS-MD-000005 REV 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001102.0340.

CRWMS M&O 2000am. Rock Fall on Drip Shield. CAL-EDS-ME-000001 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20000509.0276.

CRWMS M&O 2000x. Hydrogen Induced Cracking of Drip Shield. ANL-EBS-MD-000006 REV 00 ICN 01. Las Vegas, Nevada:

CRWMS M&O. ACC: MOL.20001025.0100.

CRWMS M&O 2000az. WAPDEG Analysis of Waste Package and Drip Shield Degradation. ANL-EBS-PA-000001 REV 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001208.0063.

Agreement Number TSPAI.3.03

Agreement DOE will provide the technical basis for crack arrest and plugging of crack openings (including the impact of oxide wedging and stress redistribution) in assessing the stress corrosion cracking of the drip shield and waste package in an update to the Stress Corrosion Cracking of the Drip Shield, Waste Package Outer Barrier, and the Stainless Steel Structural Material AMR, ANL-EBS-MD-000005, in accordance with the scope and schedule for existing agreement item CLST 1.12.

Subissue #3 - Model Abstraction ENG 1.5.1

Tracking # ENG 1.5.1

Comment Validation of WAPDEG is still pending by DOE's own account, particularly validation of the Gauss Variance Partitioning methodology.

References CRWMS M&O. "Waste Package Degradation PMR." TDR-WIS-MD-000002. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response The Waste Package Degradation software was unqualified and has since been qualified. The qualification efforts included execution of approximately 100 test cases (CRWMS M&O 2000ax) verifying the operation of various segments of the Waste Package Degradation code. The Waste Package Degradation Model has also been validated in accordance with applicable DOE procedures. The WAPDEG Analysis of Waste Package and Drip Shield Degradation (CRWMS M&O 2000az) was reviewed in accordance with applicable DOE procedures. The review included reviewers from quality assurance, waste package materials, and regulatory and licensing organizations. An International/National Waste Package Materials Peer Review is underway to review and improve corrosion testing and modeling approaches. Also, studies are underway of relevant natural analogues.

References: CRWMS M&O 2000ax. Validation Test Report (VTR) for WAPDEG V4.0. STN: 1000-4.0-00, SDN: 10000-VTR-4.0-00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001205.0014.

CRWMS M&O 2000az. WAPDEG Analysis of Waste Package and Drip Shield Degradation. ANL-EBS-PA-000001 REV 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001208.0063.

Agreement Number

Agreement DOE response during Technical Exchange was considered adequate by the NRC. Total System Performance Assessment and Integration Technical Exchange, August 6-10, 2001.

Subissue #3 - Model Abstraction ENG 1.5.2

Tracking # ENG 1.5.2

Comment Model validation is argued to be done implicitly through sub-model validation. It is unclear that this approach satisfies DOE QA requirements for model validation.

The above comment was accurate for Rev 00 of the referenced document. In ICN 01, all references to "conceptual model" have been removed and replaced with "conceptualization" in most cases. First and foremost it is unclear what the difference is between a "conceptual model" and a "conceptualization". Second, this document discusses appropriate connections and integration of in-drift models. These connections and integration are developed via analysts determining what an appropriate framework may be. It is unclear why this part of performance assessment model development would not be subject to the same degree of model support required of individual process models.

References CRWMS M&O. "Physical and Chemical Environmental Abstraction Model AMR." ANL-EBS-MD-000046. Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response REV 01 of the Physical and Chemical Environmental Abstraction Model AMR (CRWMS M&O 2001l) describes more clearly the nature and purpose of the document. It presents an overall conceptualization of the physical and chemical environment in the emplacement drift, as stated in Sections 1 and 6 of REV 01. Use of this conceptualization is limited to assistance for the Performance Assessment Department in modeling the physical and chemical environment within a repository drift and in answering key technical issues, as stated in Section 7.5 of ICN 01 (CRWMS M&O 2000bf).

However, the Physical and Chemical Environmental Abstraction Model Analysis/Model Report, along with the remainder of the project Analysis/Model Reports that support TSPA-Site Recommendation are being re-evaluated as part of Corrective Action Report-BSC-01-C-001. The scope of the Corrective Action Report includes identifying deficiencies in model validation and identifying the subset of the TSPA-Site Recommendation Analysis/Model Reports that need to be carried forward to any potential License Application.

References: CRWMS M&O 2000bf. Physical and Chemical Environmental Abstraction Model. ANL-EBS-MD-000046 REV 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001204.0023.

CRWMS M&O 2001l. Physical and Chemical Environmental Abstraction Model. ANL-EBS-MD-000046 REV 01. Las Vegas,

Nevada: CRWMS M&O. Submit to RPC.

Letter from S.J. Brocoum to W. Reamer, Total System Performance Assessment Quality Issues, dated July 6, 2001

Agreement Number

Agreement DOE response during Technical Exchange was considered adequate by the NRC. Total System Performance Assessment and Integration Technical Exchange, August 6-10, 2001.

Subissue #3 - Model Abstraction ENG 1.TT.1

Tracking # ENG 1.TT.1

Comment The abstraction for degradation of engineered barriers does not use consistent and appropriate assumptions throughout the abstraction process. The stated assumption that the drip shield is not subject to SCC is inconsistent with the discussions for FEP 2.1.03.02.00 (stress corrosion cracking of waste containers and drip shield), which indicate the potential for SCC of the drip shield and the expected attributes of the cracks that would develop (i.e small crack opening that will fill with corrosion products and carbonate minerals).

The discussion of the abstraction in the TSPA should be consistent with the discussions in the supporting Analysis and Model Reports.

References CRWMS M&O. "FEPs Screening of Processes and Issues in Drip Shield and Waste Package Degradation." ANL-EBS-PA-000002. Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001.
CRWMS M&O. "Total-System Performance Assessment for the Site Recommendation." TDR-WIS-PA-000001. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000a.
CRWMS M&O. "Total System Performance Assessment Model for Site Recommendation." MDL-WIS-PA-000002. Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000b.

DOE Response The assumption that the drip shield is not subject to stress corrosion cracking in the absence of rockfall is valid. However, the potential for rockfall induced stress corrosion cracking is acknowledged in the Waste Package FEP Analysis/Model Report (CRWMS M&O 2001e). It was concluded that the consequences of the cracking were very low because the cracks are expected to be plugged by corrosion products and deposits.

DOE will update the FEPs Analysis/Model Report to clarify the FEPs screening argument and to make it consistent with TSPA-Site Recommendation (CRWMS M&O 2000ar, p. 3-91).

References: CRWMS M&O 2001e. FEPs Screening of Processes and Issues in Drip Shield and Waste Package Degradation. ANL-EBS-PA-000002 REV 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20010216.0004.

CRWMS M&O 2000ar. Total System Performance Assessment for the Site Recommendation. TDR-WIS-PA-000001 REV 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001220.0045.

Agreement Number

Agreement DOE response during Technical Exchange was considered

adequate by the NRC. Total System Performance Assessment and Integration Technical Exchange, August 6-10, 2001.

Subissue #3 - Model Abstraction ENG 2.1.1

Tracking # ENG 2.1.1

Comment The DOE has implemented seismic effects on cladding via random sampling for the occurrence of a seismic event of sufficient magnitude (1.1E-6/yr). Unless thousands of realizations are completed, it is unlikely that the approach adopted results in a stable dose estimate. It is also unclear that risks are not underestimated utilizing this method of abstraction. The DOE should consider alternative methods for abstracting seismic cladding failure events.

References NRC. "Issue Resolution Status Report. Key Technical Issue: Total System Performance Assessment and Integration." Revision 3. Page 197. Washington, DC: NRC. 2000.

DOE Response Emphasis in the TSPA-Site Recommendation was on the first 10,000 years of performance, with simulations extended to 100,000 years to evaluate the behavior of the system after the containment of the engineered barriers is significantly degraded and to show that doses remain below the proposed limits well past 10,000 years (CRWMS M&O 2000ar, Section 4.1.1). Because of the robust waste package performance in TSPA-Site Recommendation, seismic cladding failures occurring prior to 10,000 years would not have an affect on releases from the Engineered Barrier System, and therefore do not affect the stability of the expected annual dose during the regulatory period.

As discussed at the Structural Deformation & Seismicity technical exchange in October 2000 (P. Swift presentation), the DOE recognizes that the approach taken for including seismic cladding failure in the TSPA-Site Recommendation does not provide full statistical coverage of the uncertainty associated with consequences of low-probability seismic events. However, the approach is considered appropriate for the TSPA-Site Recommendation for the following reasons:

1)
There is no impact on the expected annual dose from nominal performance during the first 10,000 years. (Cladding damage is already included in the dose calculated for igneous scenario analyses).

2)
During the first 100,000 years, consequences of seismic cladding failure were effectively bounded by the cladding neutralization analysis published in Repository Safety Strategy Rev. 4 (CRWMS M&O 2001i, Figure 3-29) and presented by Swift at the October 2000 Structural Deformation & Seismicity technical exchange. This analysis showed an increase in mean annual dose of

approximately a factor of ten.

3)
The approach provides insight into possible effects of seismic cladding damage on peak dose occurring after 10,000 years, because approximately 60% of million-year simulations include a seismic cladding failure event.

As discussed at the Structural Deformation & Seismicity technical exchange in October 2000, if future analyses show the potential for a significant impact of seismic cladding failure on expected annual dose during the regulatory period (such as might occur if ground motion were also to breach waste packages), DOE will revise the approach to ensure that risks are not underestimated.

References: CRWMS M&O 2000ar. Total System Performance Assessment for the Site Recommendation. TDR-WIS-PA-000001 REV 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001220.0045.

CRWMS M&O 2001i. Repository Safety Strategy: Plan to Prepare the Safety Case to Support Yucca Mountain Site Recommendation and Licensing Considerations. TDR-WIS-RL-000001 REV 04 ICN 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20010329.0825

Agreement Number TSPAI.3.06

Agreement DOE will provide the technical basis for the methodology used to implement the effects of seismic effects on cladding in revised documentation. DOE will demonstrate that the methodology used to represent the seismic effects of cladding does not result in an underestimation of risk in the regulatory timeframe in TSPA-LA. The documentation is expected to be available to NRC in FY 2003.

Subissue #3 - Model Abstraction ENG 2.1.2

Tracking # ENG 2.1.2

Comment Insufficient information is available to evaluate the extent of damage to proposed waste packages during potential intrusive igneous events. The analyses for limited waste-package damage in Zone 2 do not consider physical conditions representative of likely igneous events and do not evaluate the range of physical processes likely to affect waste package response during potential igneous events.

References CRWMS M&O. "Igneous Consequence Modeling for the TSPA-SR." ANL-WIS-MD-000017. Revision 00. Las Vegas, Nevada: U.S. Department of Energy, Yucca Mountain Site Characterization Office. 2000a.
CRWMS M&O, "Waste Package Behavior in Magma." CAL-EBS-ME-000002. Revision 00. Las Vegas, Nevada: U.S. Department of Energy, Yucca Mountain Site Characterization Office. 2000b.

DOE Response Addressed during the Igneous Activity KTI Technical Exchange meeting June 21-22, 2001.

Agreement Number

Agreement Igneous Activity KTI Technical Exchange, June 21-22, 2001. DOE response to this comment is unsatisfactory and will require further discussion.

Subissue #3 - Model Abstraction ENG 2.2.1

Tracking # ENG 2.2.1

Comment Juvenile and Early Failure of Waste Containers uses the software program entitled RR-PRODIGAL (NRC, 1998) to estimate waste package closure lid weld flaws and defects. RR-PRODIGAL is not an appropriate method for estimating nickel alloy or titanium welding flaws or defects because it was developed for ferretic steel nuclear reactor pressure vessels only.

References NRC. "RR-PRODIGAL - A Model for Estimating the Probabilities of Defects in Reactor Pressure Vessel Welds." NUREG/CR-5505, PNNL-11898. Rockville, Maryland: NRC. 1998.

DOE Response In the TSPA-Site Recommendation waste package degradation analysis, the probability, frequency and size of manufacturing flaws in the waste package outer barrier closure-lid welds are used as input to the stress corrosion cracking analysis of the closure-lid weld region (CRWMS M&O 2000az, Sections 4.1.7 and 5.5). The analyses for the parameters were based on the published Rolls Royce -PRODIGAL simulation results for the welds of stainless steel piping of nuclear power reactor (Khaleel et al. 1999). It is acknowledged that the results used in the waste package stress corrosion cracking analysis are not for the candidate material (Alloy 22) for the waste package outer barrier and the fabrication techniques proposed for the outer barrier closure-lids. However these are the most relevant information that was available for the TSPA-Site Recommendation. The weld flaw data specific to the waste package design and fabrication techniques will be developed from the on-going testing and measurement with a set of simulated mockups and a planned full-scale mockup. The current weld flaw model will be validated against the waste package design specific data and improved as necessary. The use of Rolls Royce - PRODIGAL will be phased out as applicable data become available.

References: CRWMS M&O 2000az. WAPDEG Analysis of Waste Package and Drip Shield Degradation. ANL-EBS-PA-000001 REV 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001208.0063.

Khaleel, M.A.; Chapman, O.J.V.; Harris, D.O.; and Simonen, F.A. 1999. "Flaw Size Distribution and Flaw Existence Frequencies in Nuclear Piping." Probabilistic and Environmental Aspects of Fracture and Fatigue: The 1999 ASME Pressure Vessels and Piping Conference. PVP-386, 127-144. New York, New York: American Society of Mechanical Engineers. TIC: 245621.

Agreement Number

Agreement DOE response during Technical Exchange was considered adequate by the NRC. Total System Performance Assessment and

Integration Technical Exchange, August 6-10, 2001. Also see Preclosure technical exchange, July 24-26, 2001.

Subissue #3 - Model Abstraction ENG 2.2.2

Tracking # ENG 2.2.2

Comment Insufficient data are available to evaluate the extent of damage to proposed waste packages during potential igneous events.

References CRWMS M&O. "Igneous Consequence Modeling for the TSPA-SR." ANL-WIS-MD-000017. Revision 00. Las Vegas, Nevada: U.S. Department of Energy, Yucca Mountain Site Characterization Office. 2000a.
CRWMS M&O. "Waste Package Behavior in Magma." CAL-EBS-ME-000002. Revision 00. Las Vegas, Nevada: U.S. Department of Energy, Yucca Mountain Site Characterization Office. 2000b.

DOE Response Addressed during the Igneous Activity KTI Technical Exchange meeting in June 21-22, 2001.

Agreement Number

Agreement Igneous Activity KTI Technical Exchange, June 21-22, 2001.
DOE response to this comment is unsatisfactory, and will require further discussion.

Subissue #3 - Model Abstraction ENG 3.1.1

Tracking # ENG 3.1.1

Comment Dripping has been observed (e.g., fist- to plate-sized puddles, wet drip cloth, corroded metal) in the sealed portion of the ECRB. This dripping may result from vapor-phase mobilization of water and condensation on surfaces such as rock bolts, ventilation ducts, and utility conduits under small thermal gradients. In an unventilated near-field environment where waste-canister heat causes spatial temperature variability, this process could result in significant dripping. Condensate could react with metal and grout at elevated but below-boiling temperatures. Dripping in the ECRB may also have resulted from seepage into the drift. Data at present are insufficient to distinguish what processes are primarily responsible for the observed dripping.

These comments were generated based on observations made in the sealed portion of the ECRB.

References

DOE Response DOE is investigating the dripping from condensation within the Enhanced Characterization of the Repository Block. New instrumentation will be installed in late fall 2001. The results of the new measurements could be used to refine the Unsaturated Zone drift-scale seepage model and the Engineered Barrier System Thermal Hydrology Model prior to the any potential License Application.

Agreement Number TSPAI.3.07

Agreement DOE will provide technical basis for determination of future sources of water in the ECRB, will evaluate the possibility of preferential dripping from engineered materials, and will give appropriate consideration to the uncertainties of the water sources, as well as their potential impact on other models. The work done to date as well as the additional work will be documented in the AMR on In-Situ Field Testing Processes (ANL-NBS-HS-000005) or other documents. This AMR will be available to NRC in FY 2003. DOE will evaluate the role of condensation as a source of water and any impacts of this on hydrologic and chemical conditions in the drift, and DOE will document this work. The effects of condensation will be included in TSPA if found to be potentially important to performance.

Subissue #3 - Model Abstraction ENG 3.1.2

Tracking # ENG 3.1.2

Comment "Flux splitting" is performed for the waste package but not for the drip shield (see page 214). No technical basis is provided for the perceived inconsistency.

References CRWMS M&O. "Total-System Performance Assessment Model for the Site Recommendation." TDR-WIS-PA-000002. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response Parts of the wording on p. 214 (CRWMS M&O 2000aq) implies that the flux splitting at the drip shield is based on patch area whereas the flux splitting at the waste package is based on axial length of patches. The Engineered Barrier System-Transport Analysis/Model Report (CRWMS M&O 2000bg) indicates that both should be based on axial length. DOE will correct the discrepancy between the TSPA-Site Recommendation and the Analysis/Model Report.

References: CRWMS M&O 2000aq. Total System Performance Assessment (TSPA) Model for Site Recommendation. MDL-WIS-PA-000002 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001226.0003.

CRWMS M&O 2000bg. EBS Radionuclide Transport Abstraction. ANL-WIS-PA-000001 REV 00 ICN 02. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001204.0029.

Agreement Number TSPAI.3.40

Agreement DOE will implement program improvements to ensure that the abstractions defined in the AMRs are consistently propagated into the TSPA, or ensure that the TSPA documentation describes any differences. Program improvements may include, for example, upgrades to work plans, procedural upgrades, preparation of desktop guides, worker training, increased review and oversight. The program improvements will be implemented and be made available to the NRC during FY 2002.

Subissue #3 - Model Abstraction ENG 3.1.3

Tracking # ENG 3.1.3

Comment The method used to abstract the in-package environments appears to be inappropriate and likely results in an underestimation of risk. For a given thermohydrological bin, a certain number of packages are assigned. An average package failure time is calculated for the packages in that bin. If the average package failure time is less than 1000 years, then "early" chemistry conditions are applied. Because waste package failure is distributed in time in the DOE model, only the first few packages that fail in a bin experience the "early" chemistry. All waste packages that fail should experience 1000 years of early chemistry if the process model was abstracted properly into the TSPA.

References CRWMS M&O. "Total-System Performance Assessment Model for the Site Recommendation." TDR-WIS-PA-000002. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response As noted on pages 259-260 of the TSPA model for SR (CRWMS M&O 2000aq), a weighted-moving-average of in-package chemistry was selected to assure the in-package chemistry for the different waste package types modeled (co-disposal waste package and commercial spent nuclear fuel), different hydrologic environments (always drip, intermittent drip, never drip), and different infiltration rate bins was representative and reasonable. DOE believes this approximation is appropriate at times when a small number of waste packages have been degraded and the rate of waste package failure is increasing. DOE believes these chemistries are most appropriate during the 10,000-year regulatory period.

At times approaching 100,000 years, the calculated weighted-moving average pH will be affected by the average chemistry of all packages that would have degraded prior to that time. Although it is possible that the unzipping rate of the cladding may be increased with a different conceptual representation, this is not expected to have a significant effect on the peak mean dose.

The extent of potential non conservatism is expected to be insignificant for the following reasons which relate to the solubility of key radionuclides and the dissolution rate of the commercial spent nuclear fuel and unzipping rate of the Zircaloy cladding on the commercial spent nuclear fuel. While the lower pH of the packages that fail at any particular time would increase the Np (and other actinide) solubilities in the waste package, the invert pH would remain essentially unchanged. The invert would then be the controlling chemistry as far as actinide releases are concerned. In addition, at lower pH, the dissolution rate may be about a factor of 10 greater, which would have a corresponding change on the rate

of unzipping of the cladding (CRWMS M&O 2000aq, Table 6-49). Such changes in dissolution rate and cladding degradation are insignificant to peak dose, because the peak is dominated by solubility-limited releases rather than the dissolution rate limited release radionuclides.

The conceptual model for in-package chemistry will be reviewed and revised for TSPA-License Application, at which time this issue will be revisited.

Reference: CRWMS M&O 2000aq. Total System Performance Assessment (TSPA) Model for Site Recommendation. MDL-WIS-PA-000002 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001226.0003.

Agreement Number TSPAI.3.08

Agreement DOE will provide the technical basis (quantification) for the abstraction of in-package chemistry and its implementation into the TSPA, which will demonstrate that the implementation methodology will not result in an underestimation of risk. The technical basis will be documented in TSPA-LA and is expected to be available in FY 2003.

Subissue #3 - Model Abstraction ENG 3.1.4

Tracking # ENG 3.1.4

Comment Near-field geochemical variables are discussed as being abstracted to "representative constant values". (Page 3-70) More information/technical basis is needed for the simplifications used in the near-field environment abstraction process.

References CRWMS M&O. "Total-System Performance Assessment Model for the Site Recommendation." TDR-WIS-PA-000002. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response The current abstraction is found in the Abstraction of Drift-Scale Coupled Processes Analysis/Model Report (CRWMS M&O 2000b). The abstraction is being updated to reflect updates to the process model. The values selected for use in the abstraction will be tied to direct results from the process model; thus the validation of the abstraction will hang on the validation of the process model. The location (i.e., the specific Analysis/Model Report) of the documentation has not been determined yet.

Reference: CRWMS M&O 2000b. Abstraction of Drift-Scale Coupled Processes. ANL-NBS-HS-000029 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20000525.0371.

Agreement Number TSPAI.3.09

Agreement DOE will present the representation of uncertainty and variability in water and gas chemistry entering the drift in the near-field environment abstractions for the TSPA. This will be documented in the Abstraction of Drift-Scale Coupled Processes, ANL-NBS-HS-000029, or other document expected to be available in FY 2003.

Subissue #3 - Model Abstraction ENG 3.1.5

Tracking # ENG 3.1.5

Comment The referenced AMR provides a global framework defining connections and interactions of other models. The framework presented appears to be consistent with the expected physical processes that may occur. Other AMRs appear to have followed a different framework for water pathways and related water chemistry calculations, even though their general inputs and outputs were to be defined by the Physical and Chemical Environmental Abstraction Model AMR.

In particular, water to the invert is discussed as potentially resulting from flow around the dripshield, flow around the waste package, and flow through the waste package. In the TSPA-SR model it appears that only flow through the waste package is represented.

References CRWMS M&O. "Physical and Chemical Environmental Abstraction Model AMR." ANL-EBS-MD-000046. Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response The Physical and Chemical Environmental Abstraction Model Analysis/Model Report describes several processes, chemical, physical, and transport, that potentially affect the in-drift environment that is relevant to performance assessment, although results from related Analysis/Model Reports and other documents may show that some of them can be neglected (CRWMS M&O 2000bf, Section 6.3).

Reference: CRWMS M&O 2000bf. Physical and Chemical Environmental Abstraction Model. ANL-EBS-MD-000046 REV 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001204.0023.

Agreement Number TSPAI.3.10

Agreement DOE will provide the documentation of the integrated analyses and comprehensive uncertainty analyses related to the EBS physical and chemical environment in documentation associated with TSPA for any potential license application. The documentation is expected to be available to NRC in FY 2003.

Subissue #3 - Model Abstraction ENG 3.1.6

Tracking # ENG 3.1.6

Comment During the integration of UZ percolation above the repository horizon with the seepage abstraction, DOE combines abstracted statistical distributions (the "seepage bins" from the TH model) with data of positional relevance (the output of the UZ model). This results in a spatial disconnect in the abstractions of the involved process models.

References CRWMS M&O. "Total-System Performance Assessment Model for the Site Recommendation." TDR-WIS-PA-000002. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response As stated in the TSPA-Site Recommendation model Analysis/Model Report (CRWMS M&O 2000aq) and the TSPA-Site Recommendation technical report (CRWMS M&O 2000ar), the percolation flux is taken from the Multiscale Thermo-Hydrologic model (CRWMS M&O 2000ag), not the Unsaturated Zone flow model.

The binning in the TSPA model is based on infiltration rather than spatial location because infiltration is a more important indicator of performance than spatial location. That is, seepage and transport velocity would both be expected to be higher where infiltration is higher.

References: CRWMS M&O 2000aq. Total System Performance Assessment (TSPA) Model for Site Recommendation. MDL-WIS-PA-000002 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001226.0003.

CRWMS M&O 2000ar. Total System Performance Assessment for the Site Recommendation. TDR-WIS-PA-000001 REV 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001220.0045.

CRWMS M&O 2000ag. Multiscale Thermohydrologic Model. ANL-EBS-MD-000049 REV 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001208.0062.

Agreement Number TSPAI.3.11

Agreement DOE will compare the infiltration flux used for the infiltration bins with the 3D Unsaturated Zone flow model and the multi-scale thermohydrologic (MSTH) model results. The technical basis for any approximations in the spatial distribution of flow rates involved in this abstraction will be provided in Abstraction of NFE Drift Thermodynamic Environment and Percolation Flow AMR, ANL-EBS-HS-000003, or other suitable document. In particular, DOE will ensure that the MSTH model output to the seepage abstraction (or any other model that may provide percolation flux to the

seepage abstraction) does not lead to underestimation of seepage. This AMR is expected to be available to NRC in FY 2003.

Subissue #3 - Model Abstraction ENG 3.1.7

Tracking # ENG 3.1.7

Comment During the TEF technical exchange, there was a discussion pertaining to the abstraction of temperature and RH and the representation of those thermodynamic variables in the waste package corrosion models. It was presented that temperature and drift RH were propagated from 610 calculations. A response was not given as to how 610 results are assigned to 400 waste package groups.

References NRC. "Summary Highlights of NRC/DOE Technical Exchange and Management Meeting on Thermal Effects on Flow, January 8-9, 2001." Letter from C.W. Reamer (NRC) to S.Brocoum (DOE) dated January 26, 2001. Washington, DC: NRC. 2001.

DOE Response In the TSPA-Site Recommendation REV 00 Waste Package Degradation Model, the primary effect of the thermal hydrologic files is in determining the corrosion initiation time (the critical relative humidity for corrosion initiation is a function of exposure temperature). The Waste Package Degradation Model used only one of the thermal hydrology files (WDHLW_nbf_high_bin2.ou) which contains information for the 14 High Level Waste, bin2, high infiltration scenario spatial locations. Approximately 28 waste packages were simulated using the information from each spatial location.

References: CRWMS M&O 2000ar. Total System Performance Assessment for the Site Recommendation. TDR-WIS-PA-000001 REV 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001220.0045.

CRWMS M&O 2000az. WAPDEG Analysis of Waste Package and Drip Shield Degradation. ANL-EBS-PA-000001 REV 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001208.0063.

Agreement Number TSPAI.3.40

Agreement DOE will implement program improvements to ensure that the abstractions defined in the AMRs are consistently propagated into the TSPA, or ensure that the TSPA documentation describes any differences. Program improvements may include, for example, upgrades to work plans, procedural upgrades, preparation of desktop guides, worker training, increased review and oversight. The program improvements will be implemented and be made available to the NRC during FY 2002.

Subissue #3 - Model Abstraction ENG 3.1.8

Tracking # ENG 3.1.8

Comment DOE has made an agreement to develop the expected chemical environments considering various sources of uncertainty. An agreement does not exist for DOE to complete testing of corrosion rates in environments similar to those predicted by the modeling. Either this task should be completed to ensure consistency and develop adequate model support for the general and localized corrosion models or a strong argument should be made as to why it is not necessary.

References CRWMS M&O. "Total-System Performance Assessment Model for the Site Recommendation." TDR-WIS-PA-000002. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response Earlier work on the possible ranges of environment focused on carbonate dominated types of Yucca Mountain waters. Results of these studies were used to identify test environments. Container Life and Source Term agreements 1.1 and 1.10 will address other credible ranges of environment on the surfaces of the drip shield and the waste package. This includes introduced materials and other trace elements that could potentially affect the corrosion rates. As was done in the past, corrosion testing environments will be extended to the results of these studies as appropriate. Also, agreement 6.1 includes corrosion testing over the ranges of credible environments as applicable.

Agreement Number TSPAI.3.12

Agreement DOE will conduct testing of corrosion in the credible range of chemical environments predicted by the model in accordance with the scope and schedule for existing agreements CLST 1.4 and 1.6 or provide a technical basis why it is not needed.

Subissue #3 - Model Abstraction ENG 3.1.9

Tracking # ENG 3.1.9

Comment This is a new comment to clarify and complement ENG3.1.8. The model for engineered barrier system failure (WAPDEG) is stated as using environmental information to determine the corrosion rates. In particular, pH is assessed to determine whether localized corrosion would occur. An explanation is needed as to how this is accomplished in the TSPA model. WAPDEG is apparently executed at the beginning of a simulation. How is the pH available for both the external surfaces of the package and from the in-package chemistry calculations for the engineered barrier system failure calculations when WAPDEG is executed first? This comment is also directed at ionic species like chloride and flouride.

References CRWMS M&O. "Total-System Performance Assessment Model for the Site Recommendation." TDR-WIS-PA-000002. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response Seepage chemistry in-drift is characterized in the In-Drift Precipitates/Salts Analysis Analysis/Model Report (CRWMS M&O 2001f). In-package chemistry is characterized in the In-Package Chemistry Abstraction Analysis/Model Report (BSC2001c). These abstraction Analysis/Model Reports provide look-up tables for environmental chemical conditions (e.g., pH and Cl- concentration) as a function of exposure temperature and relative humidity. Because pH is the dominant parameter, among the environmental condition parameters considered, for corrosion potentials and threshold corrosion potentials for localized corrosion initiation, the localized corrosion initiation of waste package and drip shield is expressed as a function of pH only. A thermal hydrology pre-processor is run to provide WAPDEG with time histories of environmental chemical conditions corresponding to the exposure temperature and relative humidity files used.

References: BSC 2001c. In-Package Chemistry Abstraction. ANL-EBS-MD-000037 REV 01. Las Vegas, Nevada: Bechtel SAIC Company. ACC: MOL.20010315.0053.

CRWMS M&O 2001f. In-Drift Precipitates/Salts Analysis. ANL-EBS-MD-000045 REV 00 ICN 02. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20010220.0008.

Agreement Number

Agreement DOE response during Technical Exchange was considered adequate by the NRC. Total System Performance Assessment and Integration Technical Exchange, August 6-10, 2001.

Subissue #3 - Model Abstraction ENG 3.2.1

Tracking # ENG 3.2.1

Comment A comparison is needed between the environments (in particular ionic strength) predicted by the low ionic strength model to the environments utilized in the corrosion tests. The comparison between the testing environments and the modeled environments will determine the amount of support needed for the low ionic strength model (CRWMS M&O, 2000; p 3-70).

References CRWMS M&O. "Total-System Performance Assessment Model for the Site Recommendation." TDR-WIS-PA-000002. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response On-going corrosion tests in the long- term corrosion test facility include a range of environments based on carbonate dominated Yucca Mountain waters, including dilute waters (10X J-13 type). However, focus of the corrosion tests has been to use highly concentrated environments to bound the environmental issues so that the bounding corrosion rates can be established for performance assessment.

The range of chemical environments that could interact with the drip shield and waste package is currently being assessed as part of the Evolution of Near Field Environment agreements 2.6 and 2.10. The results will be compared to the corrosion tests chemistries and modified, if necessary.

Agreement Number TSPAI.3.13

Agreement DOE will provide a comparison of the environments for corrosion predicted in the models, to the testing environments utilized to define empirical corrosion rates in revised documentation consistent with the scope and schedule for existing agreement item CLST 1.1.

Subissue #3 - Model Abstraction ENG 3.2.2

Tracking # ENG 3.2.2

Comment Table 3.3-7 (Page 3-71) for geochemical environments shows that when RH is increasing, Cl(molal) is increasing. Support for this modeled result is needed. I would expect that Cl(molal) should decrease as RH increased, due to more dilution.

References CRWMS M&O. "Total-System Performance Assessment Model for the Site Recommendation." TDR-WIS-PA-000002. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response Less than 50% relative humidity, 100% evaporation is assumed and thus left with salts. As the relative humidity increases, the Cl concentration increases due to the dissolution of salts. The technical basis is documented in the In-drift precipitates and salts Analysis/Model Report (CRWMS M&O 2001f).

Reference: CRWMS M&O 2001f. In-Drift Precipitates/Salts Analysis. ANL-EBS-MD-000045 REV 00 ICN 02. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20010220.0008.

Agreement Number

Agreement DOE response during Technical Exchange was considered adequate by the NRC. Total System Performance Assessment and Integration Technical Exchange, August 6-10, 2001.

Subissue #3 - Model Abstraction ENG 3.3.1

Tracking # ENG 3.3.1

Comment Page 3-35. An assessment is needed of the potential error involved with using calibrated property sets derived for the niches and used for seepage modeling. The different state of the system here is the ventilation processes.

References CRWMS M&O. "Total-System Performance Assessment Model for the Site Recommendation." TDR-WIS-PA-000002. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response The current assumption in Section 5.6 in the Seepage Calibration Model (CRWMS M&O 2001j) is that the effects of evaporation are small. This assumption carries a TBV (4951). DOE will investigate the impact of the ventilation process on calibrated properties.

Reference: CRWMS M&O 2001j. Seepage Calibration Model and Seepage Testing Data. MDL-NBS-HS-000004 REV 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20010122.0093.

Agreement Number

Agreement DOE response during Technical Exchange was considered adequate by the NRC. Total System Performance Assessment and Integration Technical Exchange, August 6-10, 2001.

Subissue #3 - Model Abstraction ENG 3.3.2

Tracking # ENG 3.3.2

Comment Triangular distributions are utilized for parameters in the modeling and abstraction of seepage processes (page 124). Are the ranges of the data and most likely value known well enough that the use of a triangular distribution is appropriate?

References CRWMS M&O. "Total-System Performance Assessment Model for the Site Recommendation." TDR-WIS-PA-000002. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response Data supporting the parameter distributions are included in the seepage model. The distributions are representative of the expected ranges and peak at the best estimate. The data ranges and distributions are discussed in the seepage-abstraction Analysis/Model Report (CRWMS M&O 2001o).

References: CRWMS M&O 2001o. Abstraction of Drift Seepage. ANL-NBS-MD-000005 REV 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20010309.0019.

Agreement Number TSPAI.3.41

Agreement DOE will provide the technical basis for the data distributions utilized in the TSPA to provide support for the mathematical representation of data uncertainty in the TSPA. The documentation of the technical basis will be incorporated in documentation associated with TSPA for any potential license application. The documentation is expected to be available to NRC in FY 2003.

Subissue #3 - Model Abstraction ENG 3.TT.1

Tracking # ENG 3.TT.1

Comment How is the spatial variability of the UZ percolation flux above the repository horizon (see e.g. Fig. 3.2-8 on p. F3-16 of TSPA-SR) carried into the seepage abstraction? What input of percolation flux is used in Fig. 3.2-15 on p. F3-23 of TSPA-SR) to determine seepage properties?

References CRWMS M&O. "Total-System Performance Assessment Model for the Site Recommendation." TDR-WIS-PA-000002. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response 1) Spatial variability of the percolation flux comes from the Multi-scale Thermo-Hydrologic Model (CRWMS M&O 2000ag). The way that spatial variability of percolation and other quantities is incorporated in the Multi-scale Thermo-Hydrologic Model is discussed briefly in Section 3.3.3.2.2 of the TSPA-Site Recommendation technical report (CRWMS M&O 2000ar) and in detail in the Multi-scale Thermo-Hydrologic Model Analysis/Model Report.

2) As stated in Sections 3.2.4.1, 3.2.4.3, and 3.3.3.2.3 of the TSPA-Site Recommendation technical report and Section 6.3.1.2 of the TSPA- Site Recommendation model Analysis/Model Report (CRWMS M&O 2000aq), the percolation flux 5 m above the drift from the Multi-scale Thermo-Hydrologic Model is used as input to the seepage abstraction. (The percolation flux is also modified by the flow-focusing factor as discussed briefly in Section 3.2.4.3 of the TSPA-Site Recommendation technical report and 6.3.1.2 of the TSPA-Site Recommendation model Analysis/Model Report and discussed in more detail in the seepage-abstraction Analysis/Model Report [CRWMS M&O 2001o].)

References: CRWMS M&O 2000ag. Multiscale Thermohydrologic Model. ANL-EBS-MD-000049 REV 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001208.0062.

CRWMS M&O 2000ar. Total System Performance Assessment for the Site Recommendation. TDR-WIS-PA-000001 REV 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001220.0045.

CRWMS M&O 2000aq. Total System Performance Assessment (TSPA) Model for Site Recommendation. MDL-WIS-PA-000002 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001226.0003.

CRWMS M&O 2001o. Abstraction of Drift Seepage. ANL-NBS-MD-000005 REV 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20010309.0019.

Subissue #3 - Model Abstraction ENG 3.TT.1

Agreement Number TSPAI.3.11

Agreement DOE will compare the infiltration flux used for the infiltration bins with the 3D Unsaturated Zone flow model and the multi-scale thermohydrologic (MSTH) model results. The technical basis for any approximations in the spatial distribution of flow rates involved in this abstraction will be provided in Abstraction of NFE Drift Thermodynamic Environment and Percolation Flow AMR, ANL-EBS-HS-000003, or other suitable document. In particular, DOE will ensure that the MSTH model output to the seepage abstraction (or any other model that may provide percolation flux to the seepage abstraction) does not lead to underestimation of seepage. This AMR is expected to be available to NRC in FY 2003.

Subissue #3 - Model Abstraction ENG 4.1.1

Tracking # ENG 4.1.1

Comment The integration and implementation efforts are insufficient since the use of pdfs requires that consistent environmental conditions and assumptions are applied to all of the chemical components. The full range of environmental conditions was not reasonably accounted for in the abstraction of radionuclide concentration limits inside breached WPs.

References CRWMS M&O. "Summary of Dissolved Concentration Limits." ANL-WIS-MD-000010. Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response The full range of environmental conditions will be emphasized in the next revision of the Analysis/Model Report.

Reference: CRWMS M&O 2001p. Summary of Dissolved Concentration Limits. ANL-WIS-MD-000010 REV 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20010223.0061.

Agreement Number TSPAI.3.14

Agreement DOE will update the in-package chemistry model to account for scenarios and their associated uncertainties required by TSPA. This will be documented in the In-Package Chemistry AMR (ANL-EBS-MD-000056) expected to be available to NRC in FY 2003.

Subissue #3 - Model Abstraction ENG 4.1.2

Tracking # ENG 4.1.2

Comment The EQ3/6 thermodynamic database was not used consistently for geochemical modeling throughout the Yucca Mountain Project.

References CRWMS M&O. "Summary of Dissolved Concentration Limits." ANL-WIS-MD-000010. Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response Data to be used in EQ3/6 will be checked and coordinated between all the affected groups.

Agreement Number TSPAI.3.15

Agreement DOE will define a reference EQ3/6 database for the Yucca Mountain Project. DOE will provide documentation of all the deviations from the reference database and justification for those deviations used by different geochemical modeling activities. The database will be available in FY 2003.

Subissue #3 - Model Abstraction ENG 4.1.3

Tracking # ENG 4.1.3

Comment DOE has completed modeling of solubility limits. Some of the simulations would not converge. This is in contradiction of a statement made for quality assurance purposes, that the model has not been utilized outside of the range for which it was validated. It is also not clear how values taken from non-convergent simulations will not lead to underestimation of risk.

References CRWMS M&O. "Summary of Dissolved Concentration Limits." ANL-WIS-MD-000010. Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response Non-convergent EQ3NR simulations occurs at extreme conditions (e.g., either high or low pH) and when it occurs, no solubility values are produced. As a result, the valid environmental condition ranges for the solubility model become narrower than desired. However, this drawback can be remedied by ensuring that the response surface is upwardly concave with respect to the environmental conditions (c.f. p.38 of the Analysis/Model Report on Am solubility response surface.) This upward concave property assures that the response surface will generate higher solubility values when it is applied out of the range from which it is derived. More effort will be devoted to assure this property for solubility models in the next revision of this Analysis/Model Report.

Reference: CRWMS M&O 2001p. Summary of Dissolved Concentration Limits. ANL-WIS-MD-000010 REV 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20010223.0061.

Agreement Number

Agreement DOE response during Technical Exchange was considered adequate by the NRC. Total System Performance Assessment and Integration Technical Exchange, August 6-10, 2001.

Subissue #3 - Model Abstraction ENG 4.1.4

Tracking # ENG 4.1.4

Comment More information is needed on how the abstraction methodology captures the situation where flow into the waste packages is close to the evaporation rate (page 252).

References CRWMS M&O. "Total-System Performance Assessment Model for the Site Recommendation." TDR-WIS-PA-000002. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response DOE used 10X J-13 for sensitivity study. The sensitivity effect of turning off anhydrous products used up a lot of water similar to evaporation.

10 X J-13 is considered representative of the expected brines during the current modeling scenarios for a breached waste package:

Early failures with an intact drip shield

Waste package performance > 10,000 years.

If additional scenarios are developed that result in more aggressive chemistries during the regulatory period, use of 10 X J-13 within the models will be re-assessed.

Reference: BSC 2001g. In-Package Chemistry for Waste Forms. ANL-EBS-MD-000056 REV 00. Las Vegas, Nevada: Bechtel SAIC Company. ACC: MOL.20010322.0490.

Agreement Number

Agreement DOE response during Technical Exchange was considered adequate by the NRC. Total System Performance Assessment and Integration Technical Exchange, August 6-10, 2001.

Subissue #3 - Model Abstraction ENG 4.1.5

Tracking # ENG 4.1.5

Comment The approach of using a random pH over the calculated range is possibly an appropriate way to represent uncertainty in the early time in-package chemistry. However, correlations may be needed in order for the model output to be consistent with the system-state that would be determined by the model input (See page 257).

References CRWMS M&O. "Total-System Performance Assessment Model for the Site Recommendation." TDR-WIS-PA-000002. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response The in-package chemistry component sets the hydronium ion concentration (pH), total carbonate concentration ([CO3]T), ionic concentration [i], carbon dioxide partial pressure (fCO2), and oxygen partial pressure (fO2), that is used by other model components of the waste form model in order to maintain consistency. Hence, there is no need to develop correlations between other distributions to maintain consistency. The terse sentence on p. 257 is referring to the fact that the pH inside the waste package is sampled randomly between pHhigh and pHlow. At each time step, pHhigh and pHlow are calculated as a function of the three regression parameters for each environment ("bins and drip conditions"): the average fraction of intact cladding (fclad), the average seepage (qseep), and rate of High Level Waste degradation (rHLW). The pH range represents the uncertainty not accounted for by these three parameters. Other parameters that influence pH (yet are not important enough to be regression variables) are the degradation rates of various steels and aluminum inside the package. To maximize the differences, these degradation rates were all set at either "high" or "low" values to develop the regression equations for pHhigh and pHlow. In REV 01 of the In-Package Chemistry Abstraction Analysis/Model Report (BSC 2001c), the regression equations have been changed; however, the same approach is used. Rather than discretize the in-package chemistry into two time periods (greater or less than 1000 yr) , four time periods are now used. Also, in REV 01 the degradation rates of various steels and aluminum used to establish pHhigh and pHlow have been decreased.

Reference: BSC 2001c. In-Package Chemistry Abstraction. ANL-EBS-MD-000037 REV 01. Las Vegas, Nevada: Bechtel SAIC Company. ACC: MOL.20010315.0053.

Agreement Number

Agreement DOE response during Technical Exchange was considered adequate by the NRC. Total System Performance Assessment and Integration Technical Exchange, August 6-10, 2001.

Subissue #3 - Model Abstraction ENG 4.1.6

Tracking # ENG 4.1.6

Comment FEP 2.1.08.07.00 (Pathways for unsaturated flow and transport in the waste and engineered barrier system) evaluates unsaturated flow and radionuclide transport that may occur along preferential pathways in the waste and EBS. The DOE indicates that preferential pathways are already "included" via "a series of linked one dimensional flowpaths and mixing cells through the EBS, drip shield, waste package and into the invert (CRWMS M&O, 2000)." Staff are concerned that preferred pathways in the EBS are not being evaluated at the appropriate scale. Water has been observed to drip preferentially along grouted rock bolts in the ECRB, for example, demonstrating that the introduced materials themselves can influence the location of preferred flow pathways. Moreover, interactions with engineered materials, such as cementitious and metallic components, can have a significant effect on evolved water and gas compositions. Variations along water and gas chemistry that occur along preferential flow pathways in the EBS cannot be adequately measured by considering their volumetric contribution to the bulk EBS water and gas composition.

References CRWMS M&O. "Miscellaneous Waste Form FEPs." ANL-WIS-MD-000009. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response Analyses and modeling that takes into account the spatial heterogeneity are included in the Evolution of Near Field Environment agreements 2.4 and 2.6; which address trace elements and rock bolt grout, respectively.

Agreement Number TSPAI.3.16

Agreement DOE will evaluate the effect of localized flow pathways on water and gas chemistry in the engineered barrier system as input to TSPA calculations, including the influence of introduced materials on these preferential flow pathways consistent with existing agreements ENFE 2.4, 2.5, and 2.6. This will be documented in an update to the Physical and Chemical Environment Model AMR (ANL-EBS-MD-000033) or other suitable document. This AMR is expected to be available to NRC in FY 2003.

Subissue #3 - Model Abstraction ENG 4.2.1

Tracking # ENG 4.2.1

Comment On page 1-38 a description is provided that states, "The conceptualization of diffusion resulted in very small diffusive releases (drip rate required substantiation)." What information became available to result in the substantial changes to the conceptualization of diffusive releases?

References CRWMS M&O. "Total System Performance Assessment for the Site Recommendation." TDR-WIS-PA-000001. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response The abstraction for the diffusion coefficient in the TSPA-Site Recommendation [CRWMS M&O 2000ar] is based on the following information that was not incorporated into the TSPA-Viability Assessment [DOE 1998]:

The free water diffusion coefficient for all radionuclides is based on the self-diffusivity of water, 2.299 x 10-5 cm2/sec (Mills 1973, Table III). The self-diffusivity of water provides a bounding value for all radionuclides of interest to performance assessment (CRWMS M&O 2000bg, Section 6.4.1.1).

The dependence of the diffusion coefficient on porosity and saturation (CRWMS M&O 2000bg, Section 6.4.1.2) is based on the experimental data of Conca and Wright (1992) for a variety of granular materials, including crushed tuff from Yucca Mountain. A statistical analysis (CRWMS M&O 2000b) produced an excellent fit to Conca and Wright's data using a power law dependence on moisture content (Archie's law).

The diffusion coefficient is corrected for temperature variation (CRWMS M&O 2000bg, Section 6.4.1.3).

This approach represents the diffusion coefficient as a function of porosity, saturation, and temperature for the TSPA-Site Recommendation. The abstraction for the TSPA-Viability Assessment is a function of saturation only.

References: DOE. 1998. Total System Performance Assessment. Volume 3 of Viability Assessment of a Repository at Yucca Mountain. DOE/RW-0508. Washington, D.C.: U.S. Department of Energy, Office of Civilian Radioactive Waste Management. ACC: MOL.19981007.0030.

CRWMS M&O 2000ar. Total System Performance Assessment for the Site Recommendation. TDR-WIS-PA-000001 REV 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001220.0045.

Conca, J.L. and Wright, J. 1992. "Diffusion and Flow in Gravel, Soil and Whole Rock." Applied Hydrogeology, 1, 5-24. Hanover, Germany: Verlag Heinz Heise GmbH. TIC: 224081.

CRWMS M&O 2000bg. EBS Radionuclide Transport Abstraction. ANL-WIS-PA-000001 REV 00 ICN 02. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001204.0029.

CRWMS M&O 2000. Invert Diffusion Properties Model. ANL-EBS-MD-000031 REV 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20000912.0208.

Mills, R. 1973. "Self-Diffusion in Normal and Heavy Water in the Range 1-45(." The Journal of Physical Chemistry, 77, (5), 685-688. Washington, D.C.: American Chemical Society. TIC: 246404.

Agreement Number

Agreement DOE response during Technical Exchange was considered adequate by the NRC. Total System Performance Assessment and Integration Technical Exchange, August 6-10, 2001.

Subissue #3 - Model Abstraction ENG 4.4.1

Tracking # ENG 4.4.1

Comment In DOE's abstraction of radionuclide transport through the EBS, transport through the invert is dominated by diffusion in the time before advective fluxes are significant (CRWMS M&O, 2000a). Retardation is conservatively neglected under advective transport. Under diffusive transport, the diffusion coefficient employed is adjusted for porosity and water saturation in the invert; an analogous term is used for colloidal transport. DOE analyses show sensitivity of the timing of dose curves to this model (CRWMS M&O, 2000a) and the RSS identifies the invert as a significant barrier (CRWMS M&O, 2000b). Because retardation is not assumed under advective transport, invert barrier performance is related to the diffusive transport model. It appears that the invert diffusive transport model is sensitive to the exponential term applied to water saturation, which is itself highly uncertain. DOE has not shown that model uncertainty with respect to saturation in the invert has been accounted for in sensitivity studies.

References CRWMS M&O. "Total System Performance Assessment for the Site Recommendation." TDR-WIS-PA-000001 Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000a.
CRWMS M&O." Repository Safety Strategy." TDR-WIS-RL-000001 Revision 04 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000b.

DOE Response The formulation for diffusion coefficient in the TSPA-Site Recommendation model directly accounts for uncertainty. The diffusion coefficient in a partly saturated, porous medium, D, is given by:

D = Do × (phi)^1.3 × s^1.849 × 10^[ND(a=0, sigma=0.223)] (the symbol ^ is used to denote exponentiation)

where Do is the free water diffusion coefficient, phi is the porosity, s is the saturation, and ND is a normal distribution with mean of zero and standard deviation, sigma, of 0.223 (Equation 6.4.1-11). The normal distribution spans the range of variability in the diffusivity measurements by Conca and Wright (1992) for a variety of granular materials, including crushed tuff. This normal distribution is sampled for each realization of the TSPA-Site Recommendation model, providing a direct representation of the uncertainty in the experimental data.

Reference: CRWMS M&O 2000bg. EBS Radionuclide Transport Abstraction. ANL-WIS-PA-000001 REV 00 ICN 02. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001204.0029.

Conca, J.L. and Wright, J. 1992. "Diffusion and Flow in Gravel, Soil, and Whole Rock." Applied Hydrogeology, 1, 5-24. Hanover,

Germany: Verlag Heinz Heise GmbH. TIC: 224081.

Agreement Number TSPAI.3.17

Agreement DOE will provide an uncertainty analysis of the diffusion coefficient governing transport of dissolved and colloidal radionuclides through the invert. The analysis will include uncertainty in the modeled invert saturation. The uncertainty analysis will be documented in the EBS Radionuclide Transport Abstraction AMR, ANL-WIS-PA-000001, expected to be available to NRC in FY 2003.

Subissue #3 - Model Abstraction ENG 4.4.2

Tracking # ENG 4.4.2

Comment The abstraction process may result in elimination of important uncertainty/variability in NFE model output. For example, on page 37 the highest and lowest waste package temperatures are listed as 316 and 235 C. However, the temperatures for the bin-averages resulted in 292 and 274 C. A demonstration is needed that the abstraction process is not eliminating important uncertainty and variability.

References CRWMS M&O. "Abstraction of NFE Drift Thermodynamic Environment and Percolation Flux AMR." ANL-EBS-HS-000003 Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response Potential waste package temperature variability is not eliminated during the thermal-hydrologic abstraction process. The thermal-hydrologic abstraction parses the process-level thermal-hydrologic data into 5 discrete infiltration rate ranges (see section 5.1.1 of the referenced AMR). Each raw temperature curve is placed into one of 5 bins until all curves have been placed. From there, a bin weighted average waste package temperature is computed for each of the bins as a function of the entries in a bin. This "average" curve is passed to TSPA as an abstracted TH result. This result is shown in Figure 26 in CRWMS M&O 2000c (Figure 33 in CRWMS M&O 2000d). Additionally, the maximum waste package temperature curve (that is found in a bin) and the minimum max waste package temperature curve (found in a bin) are also passed to TSPA. This is shown in Figure 24 (for the mean infiltration rate case only) in CRWMS M&O 20000c (Figure 30 in CRWMS M&O 2000d). This same procedure is followed for the low, mean, and high infiltration flux cases. Therefore, the TSPA model receives from the thermal-hydrologic abstraction, the maximum waste package temperature curve, the temperature curve with the minimum max, and a bin averaged waste package temperature based on the bin entries. This same procedure followed for every infiltration bin for all flux cases.

The 316 and 235 C are the extreme cases. Since Figure 26 in the Near Field Abstraction Analysis/Model Report (CRWMS M&O 2000c) only shows the plot for the mean infiltration flux case, the 316 C is not shown. However, the abstraction searches the entire population of parameters within a bin, thus finding the hi max and lo max and feeds these values to TSPA. Although not plotted, all of the data was passed to TSPA.

Reference: CRWMS M&O 2000c. Abstraction of NFE Drift Thermodynamic Environment and Percolation Flux. ANL-EBS-HS-000003 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20000504.0296.

CRWMS M&O 2000d. Abstraction of NFE Drift Thermodynamic Environment and Percolation Flux. ANL-EBS-HS-000003 REV 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001206.0143.

Agreement Number

Agreement DOE response during Technical Exchange was considered adequate by the NRC. Total System Performance Assessment and Integration Technical Exchange, August 6-10, 2001.

Subissue #3 - Model Abstraction ENG 4.4.3

Tracking # ENG 4.4.3

Comment In the description of the colloid release abstraction in the TSPA-SR model report (CRWMS M&O, 2000a, page 326), it does not appear proper to say that Condition B is 1 if Ionic_Str_CDSP is greater than "either" of the two calculated values. The value to compare with is dependent on the pH range (see Fig 11 of CRWMS M&O, 2000b). Ionic strength may be below one calculated value and above another, and still be in the region of stability. The way Condition B is described ("either"), a combination of Condition A and Condition B both being 1 is not sufficient to be in the zone of instability.This potential inconsistency may be related to CNWRA staff's inability to reproduce results on FeOx colloid concentration in the TSPA-SR colloid model verification discussion (CRWMS M&O, 2000a, page 332, paragraph 3).

References CRWMS M&O. "Total System Performance Assessment (TSPA) Model for Site Recommendation." MDL-WIS-PA-000002 Revision 00. Las Vegas, NV. Las Vegas, Nevada: CRWMS M&O. 2000a. CRWMS M&O. "Waste Form Colloid-Associated Concentration Limits: Abstraction and Summary." ANL-WIS-MD-000012 Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000b

DOE Response The NRC has asked about an apparent discrepancy in the stepwise procedure that has been programmed into GoldSim to calculate FeOx stability. As the reviewer points out, pH is important in this determination, but this parameter is already accounted for in the calculation. At each time step in the GoldSim calculations, ionic strength (I) and pH derived from in package chemistry calculations are supplied as input (Equations 6-5 and 6-6 on p. 326 of the TSPA-Site Recommendation model report, CRWMS M&O aq) and the code then determines whether [pH, I] plots above or below either of the two "slanting" lines in Figure 11.

The text in the TSPA-Site Recommendation report on colloid model verification (CRWMS M&O, 2000ar, page 332, paragraph 3) is conceptually correct as currently written, but minor word changes will be made in the next revisions to the document to clarify implementation the of I and pH in the stepwise procedure that calculates FeOx stability.

References: CRWMS M&O 2000aq. Total System Performance Assessment (TSPA) Model for Site Recommendation. MDL-WIS-PA-000002 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001226.0003.

CRWMS M&O 2000ar. Total System Performance Assessment for the Site Recommendation. TDR-WIS-PA-000001 REV 00 ICN 01.

Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001220.0045.

CRWMS M&O 2000ba. Waste Form Colloid-Associated Concentrations Limits: Abstraction and Summary. ANL-WIS-MD-000012 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20000525.0397.

Agreement Number

Agreement DOE response during Technical Exchange was considered adequate by the NRC. Total System Performance Assessment and Integration Technical Exchange, August 6-10, 2001.

Subissue #3 - Model Abstraction ENG 4.4.4

Tracking # ENG 4.4.4

Comment Discussions of colloid release abstraction implementation (CRWMS M&O, 2000, pages 328 and 333) appear to imply that any Pu or Am removed from a waste cell by irreversible attachment is then subtracted from the amount available to be removed as a soluble species. This does not seem conceptually consistent with the model of irreversible attachment. Radionuclide irreversibly attached to colloids should not reduce the amount in solution. This is potentially significant to the modeled masses released.

References CRWMS M&O. "Total System Performance Assessment (TSPA) Model for Site Recommendation." MDL-WIS-PA-000002 Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response GoldSim calculates the quantities of chemical constituents made available from the degradation of the waste form and components in the waste package. This calculation is executed for each time step in a "mixing cell" subcomponent of the TSPA model report (CRWMS M&O 2000aq). The TSPA calculations partition the chemical constituents into aqueous and precipitated phases. The concentrations in the aqueous phase, as well as in the solid phase(s), are determined according to calculated aqueous chemical conditions, solubility limits, reactions, etc. Pu and Am are also partitioned into waste form colloids (irreversibly attached) which are generated from high level waste glass degradation. The basis for this apportioning is an established relationship based on experimental data. The Pu and Am assigned to the waste form colloids are subtracted from the total Pu and Am quantities in the mixing cell, and not from the Pu and Am calculated for the aqueous phase. The very small quantities of Pu and Am that are in solution and irreversibly attached to the waste form colloids do not materially affect the determination of aqueous species and precipitation of solid phases in the geochemical calculations.

Evolution of Near Field agreement 3.5 addresses the bounding concentration of Pu in solution and a Container Life and Source Term agreement 3.5 addresses solubility limits.

Reference: CRWMS M&O 2000aq. Total System Performance Assessment (TSPA) Model for Site Recommendation. MDL-WIS-PA-000002 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001226.0003

Agreement Number

Agreement DOE response during Technical Exchange was considered adequate by the NRC. Total System Performance Assessment and Integration Technical Exchange, August 6-10, 2001.

Subissue #3 - Model Abstraction ENG 4.4.5

Tracking # ENG 4.4.5

Comment Modeled concentrations of waste form, FeOx, and groundwater colloids during release are extremely sensitive to small shifts in pH and/or ionic strength (CRWMS M&O, 2000a, pages 331-332). The fact that modeled Pu (Am) colloidal concentration drops over three orders of magnitude during one time step, then recovers nearly all that drop in the next time step because of rapid pH change, raises concerns about sensitivity to small uncertainties in modeled pH and ionic strength. A small shift across the line on figure 12 in CRWMS M&O (2000b) can cause this factor of 1000 change in concentration.The concentration of FeOx colloids is either 1 mg/L or 0.001 mg/L; there are no transitional values (CRWMS M&O, 2000a, figure 6-144). A slight shift on the plot of Fig 11 in CRWMS M&O (2000b) can cause this large change in FeOx colloids available for sorbing radionuclides.Groundwater colloid concentration suffers from the same extreme sensitivity to pH as for waste form colloids. The situation is potentially worse, because the minimum and maximum values range over a factor of 10,000 (CRWMS M&O, 2000a, page 332).

References CRWMS M&O. "Total System Performance Assessment (TSPA) Model for Site Recommendation." MDL-WIS-PA-000002 Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000a.
CRWMS M&O. "Waste Form Colloid-Associated Concentration Limits: Abstraction and Summary." ANL-WIS-MD-000012 Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000b.

DOE Response DOE agrees with NRC's observation that colloid concentration (and stability) can be extremely sensitive to relatively small shifts in pH and/or ionic strength (I). This phenomenon is experimentally observed and can be attributed as much to actual colloid behavior as to the random selection of pH and I parameters from stochastic distributions during the modeling procedure. For example, experimental data from Argonne National Laboratory, and elsewhere (CRWMS M&O 2001k, Section 6.2.1.3), indicate that smectite and iron-(hydr)oxide colloid stability tends to decrease drastically above ionic strengths of about 0.05M. DOE is currently conducting further literature reviews and interactions with investigators of iron-(hydr)oxide colloid phenomena to obtain a larger data set for iron-(hydr)oxide colloid concentrations. These additional data will improve the model, however, under the current TSPA model (CRWMS M&O 2000aq) colloid behavior will remain "abrupt" over certain small ranges of pH and ionic strength.

Calculation of groundwater colloid concentration is based on a compilation of colloid concentrations in groundwaters from many different geologic and hydrologic environments. DOE is currently updating the groundwater colloid database to include additional

data specific to the Yucca Mountain region.

References: CRWMS M&O, Total System Performance Assessment (TSPA) Model for Site Recommendation. MDL-WIS-PA-000002 REV 00.

CRWMS M&O 2001k, Waste Form Colloid-Associated Concentration Limits: Abstraction and Summary, ANL-WIS-MD-000012 REV 00 ICN01.

Agreement Number

Agreement DOE response during Technical Exchange was considered adequate by the NRC. Total System Performance Assessment and Integration Technical Exchange, August 6-10, 2001.

Subissue #3 - Model Abstraction ENG 4.TT.1

Tracking # ENG 4.TT.1

Comment Pages 404. An explanation is needed of what physical processes are causing the strong variation in the release curves from the EBS, such as for Pu-239.

References CRWMS M&O. "Total-System Performance Assessment (TSPA) Model for the Site Recommendation." TDR-WIS-PA-000002 Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response The variations are a numerical discretization issue caused by chain decay in the particle tracker, and specifically the decay of discrete particles of the parent radionuclide Am-243. The code was optimized to minimize this discrete behavior for as many chains as possible, but some residual "discreteness" remained for a few radionuclides, such as Pu-239 and U-233. Since there was an upper limit on the number of particles that could be injected into the Unsaturated Zone model based on process size and RAM availability, using a very, very large number of particles to resolve the variations was not possible. The maximum number was used while still remaining within these constraints.

Agreement Number

Agreement DOE response during Technical Exchange was considered adequate by the NRC. Total System Performance Assessment and Integration Technical Exchange, August 6-10, 2001.

Subissue #3 - Model Abstraction UZ 1.2.1

Tracking # UZ 1.2.1

Comment There are insufficient data to support the use of a distributed-parameter, water-balance plug flow approach for net infiltration. Infiltration is a highly nonlinear process. The effect of capillarity on infiltration and percolation is neglected by the INFIL; it is not clear that the coarse vertical grid spacing would offset the neglect of capillarity. Use of a Richards equation-based solution as a comparison to the water-balance plug flow approach is needed, particularly over the repository where thin soils and bare bedrock dominate the land cover. In addition, corroborating data do not support the results from the INFIL model: chloride mass balance represents a lower bound; temperature and neutron probe data suggest a higher average is supported. The non-uniqueness of the calibration process for parameters in the INFIL model leads to large uncertainty.

References CRWMS M&O. "Total System Performance Assessment for the Site Recommendation." TDR-WIS-PA-000001. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response Distributed-Parameter, Water-Balance

DOE believes that the distributed-parameter, water-balance plug flow approach (aka bucket model) for net infiltration is justified for representing the spatial variability of net infiltration as a function of topography, soil properties, soil depth, bedrock, climate, and surface water re-distribution. However, to demonstrate confidence in the approach, DOE will consider investigating the high uncertainty in net infiltration estimates through comparison with a Richards equation approach. The uncertainty is believed to be due to the coarse vertical resolution and possible over-simplification of physical process with respect to infiltration.

INFIL Model Uncertainty

Uncertainty in infiltration is included in the process-level models and in TSPA. This is captured through the lower and upper bounds for infiltration identified in the process model analyses and the distribution of mean infiltration identified in the infiltration uncertainty analysis.

Reference: Audit Observer Inquiry No. M&O-APR-01-02-02, dated February 9, 2001, for ANL-NBS-HS-000032.

Agreement Number TSPAI.3.18

Agreement DOE will provide a technical basis that the water-balance plug-flow model adequately represents the non-linear flow processes represented by Richard's equation, particularly over the repository

where there is thin soil. The technical basis will be documented in an update to the Simulation of Net Infiltration for Modern and Potential Future Climates AMR, ANL-NBS-HS-000032. The AMR is expected to be available to NRC in FY 2003.

Subissue #3 - Model Abstraction UZ 1.3.1

Tracking # UZ 1.3.1

Comment It is not clear that the evapotranspiration model adequately represents the conditions during future climates at YM. Overestimates of evapotranspiration would lead to underestimates of shallow infiltration. Adjustments of vegetation cover and rooting depth for potential future climates are not supported by data. In addition, it is not clear if the temperature data from geographic analog sites (Arizona and Washington) reflect conditions expected at YM, specifically, the effect of radiation differences on temperature.

References CRWMS M&O. "Total System Performance Assessment for the Site Recommendation." TDR-WIS-PA-000001. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response Preliminary model sensitivity analysis in the Analysis of Infiltration Uncertainty Analysis/Model Report (CRWMS M&O 2000bi) indicated that the model sensitivity to the vegetation cover term is low, based on most net infiltration occurs during the winter and early spring when potential evapotranspiration is low. Thus, doubling or halving vegetation cover only changes daily evapotranspiration by a small amount.

A more important source of uncertainty than vegetation cover is the root density term for the lower soil layers. There is no data on vegetation cover or rooting depths. One method of addressing the effects of vegetation on infiltration during future climates is to calibrate the model using study areas representative of the analog sites.

References: CRWMS M&O 2000bi. Analysis of Infiltration Uncertainty. ANL-NBS-HS-000027 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20000525.0377.

USGS 2001. Simulation of Net Infiltration for Modern and Potential Future Climates. ANL-NBS-HS-000032 REV 00 ICN 01. Denver, Colorado: U.S. Geological Survey. ACC: MOL.20010405.0002.

Audit Observer Inquiry No. M&O-APR-01-02-01, dated February 9, 2001, for ANL-NBS-HS-000033.

Agreement Number TSPAI.3.19

Agreement DOE will provide justification for the use of the evapotranspiration model, and justify the use of the analog site temperature data. The justification will be documented in an update to the Simulation of Net Infiltration for Modern and Potential Future Climates AMR, ANL-NBS-HS-000032, and the Future Climate Analysis AMR, ANL-NBS-GS-000008. The AMRs are expected to be available to NRC in FY

2003.

Subissue #3 - Model Abstraction UZ 1.3.2

Tracking # UZ 1.3.2

Comment Without access to the data, it is difficult to assess the reasonableness of 100-yr synthetic meteorologic records used to calculate shallow infiltration for the mean modern climate, lower bound modern climate, and upper bound modern climate. These data sets need to be analyzed to determine if sufficient annual, multi-year, and decadel oscillations in precipitation are reflected in the meteorological inputs. Initially, DOE maintained that the synthetic records were an intermediate data set, therefore, it would not be included in the technical database available to NRC. The concern is that under-representation of climate variability leads to underprediction of shallow infiltration.

References CRWMS M&O. "Total System Performance Assessment for the Site Recommendation." TDR-WIS-PA-000001. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response The 100-year synthetic meteorological records used for infiltration calculations are being compiled.

Agreement Number TSPAI.3.20

Agreement DOE will provide data supporting the synthetic meteorologic records (specifically, data files 4JA.s01 and Area12.s01). These data files will be provided to NRC September 2001.

Subissue #3 - Model Abstraction UZ 1.5.1

Tracking # UZ 1.5.1

Comment The effect of lateral surface or near-surface flow on net infiltration may be underestimated. The watershed calibrations are constrained by 2 rainfall-runoff events, thus leaving parameterization highly uncertain. Recent integration of data from the ECRB and ESF into the net infiltration analysis suggested an underestimation of net infiltration beneath wash channels in the repository footprint, particularly for potential future climates.

References Flint, L. "Distribution of Water Potential Measured with Heat Dissipation Probes in Underground Volcanic Tuffs." Paper at Geological Society of America meeting November 13-17. Reno, Nevada: Geological Society of America. 2000.

DOE Response The net infiltration model as documented in the Simulation of Net Infiltration for Modern and Future Potential Climates (USGS 2001) is considered to provide an adequate representation of the areal distribution of net infiltration at spatial scales and over time durations for the intended application of the model (i.e., to provide an upper boundary condition for the site-scale unsaturated zone flow and transport model).

Sensitivity studies in the Unsaturated Zone Flow Models and Submodels (CRWMS M&O 2000bj) Analysis/Model Report looked at Chloride using two independent methods. Both methods indicated that spatial variability is not important.

References: USGS 2001. Simulation of Net Infiltration for Modern and Potential Future Climates. ANL-NBS-HS-000032 REV 00 ICN 01. Denver, Colorado: U.S. Geological Survey. ACC: MOL.20010405.0002.

CRWMS M&O 2000bj. UZ Flow Models and Submodels. MDL-NBS-HS-000006 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19990721.0527.

Audit Observer Inquiry No. M&O-APR-01-02-03, dated February 9, 2001, for ANL-NBS-HS-000032.

Agreement Number TSPAI.3.21

Agreement DOE will demonstrate that effects of near surface lateral flow on the spatial variability of net infiltration are appropriately considered in an update to the Simulation of Net Infiltration for Modern and Potential Future Climates AMR (ANL-NBS-HS-000032) and UZ Flow Models and Submodels AMR (MDL-NBS-HS-000006). These AMRs are expected to be available to NRC in FY 2003.

Subissue #3 - Model Abstraction UZ 2.3.1

Tracking # UZ 2.3.1

Comment Page 3-32 (CRWMS M&O, 2000). An assessment is needed of the potential error involved with using a hydrologic property set obtained by calibrating a model on current climate conditions and using that model to forecast flow for future climate conditions. In addition, an assessment of the applicability of this property set for thermohydrology models is needed.

Page 3-52 (CRWMS M&O, 2000). Similar issue but with respect to the use of the active fracture model for thermohydrological processes.

References CRWMS M&O. "Total System Performance Assessment for the Site Recommendation." TDR-WIS-PA-000001 Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response (CRWMS M&O 2000ar, page 3-32)

Test predictions for field tests (such as Alcove 8 - Niche 3) will be conducted at higher flow rates that are expected to encompass flow behavior representative of future climates. Modeling predictions for these tests will be compared with testing results, which should validate the potential error of using property sets calibrated under present-day climate for future climates. These predictions will be in revisions to the referenced Analysis/Model Reports.

(CRWMS M&O 2000ar, page 3-52)

DOE has modeled the Drift Scale Test using property sets for the active fracture model for thermohydrologic processes. Comparisons between the Drift Scale Test results and model predictions have been performed. The test results validate the model. The results will be documented in the Drift-Scale Coupled Processes thermohydrologic Analysis/Model Report (CRWMS M&O 2000o).

References: CRWMS M&O 2000ar. Total System Performance Assessment for the Site Recommendation. TDR-WIS-PA-000001 REV 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001220.0045.

CRWMS M&O 2000bj. UZ Flow Models and Submodels. MDL-NBS-HS-000006 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19990721.0527.

CRWMS M&O 2000bk. Radionuclide Transport Models Under Ambient Conditions. MDL-NBS-HS-000008 REV 00. Las Vegas,

Nevada: CRWMS M&O. ACC: MOL.19990721.0529.

CRWMS M&O 2001j. Seepage Calibration Model and Seepage Testing Data. MDL-NBS-HS-000004 REV 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20010122.0093.

CRWMS M&O 2000o. Drift-Scale Coupled Processes (DST and THC Seepage) Models. MDL-NBS-HS-000001 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19990721.0523.

Agreement Number TSPAI.3.22

Agreement DOE will provide an assessment or discussion of the uncertainty involved with using a hydrologic property set obtained by calibrating a model on current climate conditions and using that model to forecast flow for future climate conditions. This assessment will be documented in the UZ Flow Models and Submodels AMR, MDL-NBS-HS-000006, expected to be available to NRC in FY 2003.

Subissue #3 - Model Abstraction UZ 2.3.2

Tracking # UZ 2.3.2

Comment Current DOE results suggest the Paintbrush Tuff is a barrier to episodic infiltration as a result of diffusion into the matrix. However, independent modeling "demonstrates that heterogeneity of rock properties is a primary source of uncertainty in the spatial and temporal distribution of unsaturated flow through fractured rock and reveals development of preferential pathways and flow focusing, both of which can have significant consequences on the performance of waste disposal facilities constructed in unsaturated, fractured rocks." Technical basis is needed that heterogeneity within hydrostratigraphic units is not an important source of uncertainty.

References CRWMS M&O. "Unsaturated Zone Flow and Transport Model Process Model Report".TDR-NBS-HS-000002, Revision 00 ICN 02. Las Vegas, Nevada: CRWMS M&O. 2000.
Illman, W.A. and D. Hughson. "Numerical Modeling of Unsaturated Flow in Thick Vadose Zones of Fractured Rocks." Presentation at the Spring 2001 Meeting of the American Geophysical Union.

DOE Response It is expected that the overall behavior of site-scale flow and transport processes is determined mainly by relatively large-scale heterogeneities associated with the geologic stratification of the mountain. Stratification and faulting, which places units with highly different properties against each other, are the major heterogeneities within the unsaturated zone at Yucca Mountain. Within the same geologic unit, hydrological properties are relatively uniformly distributed because of the intra-strata homogenization induced by the tuff depositional environments. In the geology-based, deterministic approach, subunits are defined within the major hydrogeologic units to capture variability in the vertical stratification. Within these subunits, important lateral heterogeneity can be accounted for by defining lateral boundaries, differentiating areas with significant differences in hydrological properties.

The complexity of a heterogeneity model needs to be consistent with the availability of the data. More complicated models introduce larger degrees of uncertainties in rock property estimations when data are limited. The layered approach is also supported by field observations, such as the relatively uniform matrix water saturations within a given layer. Flow and transport models based on a layered approach can be relatively easily calibrated with multiple data sets and provide a means to incorporate a significant amount of the available site data.

It is straightforward to upscale using inverse modeling when a layered approach is employed (CRWMS M&O 2000aw, Section 3.4.1.4.4).

DOE agrees that it is important to investigate the effects of smaller-scale heterogeneity. Larger-scale heterogeneity is captured in the flow and transport models in terms of hydrogeologic unit stratification and structure, and major faults. Some aspects of smaller scale heterogeneity were investigated and reported in the Supplemental Science and Performance Analysis, Volume 1 (BSC 2001e). DOE is considering future work that addresses heterogeneity in the PTn (FY02) and in the CHn (FY03 and FY04). The PTn analysis will be used to address Unsaturated and Saturated Flow under Isothermal Conditions agreement 4.4.

References: CRWMS M&O 2000aw. Unsaturated Zone Flow and Transport Model Process Model Report. TDR-NBS-HS-000002 REV 00 ICN 02. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20000831.0280.

BSC 2001e. FY01 Supplemental Science and Performance Analyses, Volume 1: Scientific Bases and Analyses. TDR-MGR-MD-000007 REV 00. Las Vegas, Nevada: Bechtel SAIC Company. ACC: MOL.20010712.0062.

Agreement Number TSPAI.3.23

Agreement DOE will evaluate spatial heterogeneity of hydrologic properties within hydrostratigraphic units and the effect this heterogeneity has on model results of unsaturated flow, seepage into the drifts and transport. This evaluation will be documented in the UZ Flow Models and Submodels AMR, MDL-NBS-HS-000006, Radionuclide Transport Models under Ambient Conditions, MDL-NBS-HS-000008, and Seepage Models for PA Including Drift Collapse AMR, MDL-NBS-HS-000002, expected to be available to NRC in FY 2003. DOE will also provide a technical basis for the assessment that bomb-pulse Cl-36 found below the PTn can be linked to a negligible amount of fast flowing water. The technical basis will be documented in the UZ Flow Models and Submodels AMR , MDL-NBS-HS-000006, expected to be available to NRC in FY 2003.

Subissue #3 - Model Abstraction UZ 2.3.3

Tracking # UZ 2.3.3

Comment There are insufficient water potential and geochemical data to support the flow fields predicted by the 3D UZ site-scale model in the CHn, Prow Pass, and Bullfrog units below the repository. Of particular concern is the estimated fraction of water that may travel significant distances through permeable nonwelded vitric tuff matrix versus the fraction that may be laterally diverted atop layers of low-permeability zeolitized or moderate to densely welded tuff to fast pathways to the water table (e.g., through faults). The focus of this concern is areas where no perched water is predicted, and in unsaturated zones in the lower CHn, Prow Pass, and Bullfrog units below the perched water. In addition, a basis should be presented for the use of current hydraulic properties, rather than thermally perturbed properties; specifically, zeolitization of the nonwelded, nonaltered Tptpv1, Tptb1, and upper Tac may be caused by the thermal pulse. Note also that statistics of flow percent in faults versus matrix and fractures that are relevant to the entire 3D UZ site-scale model domain may not reflect flow regimes below the repository footprint.

References CRWMS M&O. "Total System Performance Assessment for the Site Recommendation." TDR-WIS-PA-000001. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response Uncertainty in the Calico Hills flow model will be addressed through sensitivity studies for unsaturated zone radionuclide transport under a range of potential Calico Hills flow conditions. This will be addressed in the revisions to Unsaturated Zone Flow Models and Submodels (CRWMS M&O 2000bj), Radionuclide Transport Models under Ambient Conditions (CRWMS M&O 2000bk), and in Analysis of Geochemical Data for Unsaturated Zone (BSC 2001h).

The Unsaturated Zone Flow Models and Submodels (CRWMS M&O 2000bj) Analysis/Model Report will be updated to include the flow path and flow field for moisture tension and geochemical data. Documentation of the analysis is an extension of Unsaturated and Saturated Flow under Isothermal Conditions agreement 4.5 and related Radionuclide Transport agreement 1.1.

References: (future revisions)

CRWMS M&O 2000aw. Unsaturated Zone Flow and Transport Model Process Model Report. TDR-NBS-HS-000002 REV 00 ICN 02. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20000831.0280.

CRWMS M&O 2000bk. Radionuclide Transport Models Under Ambient Conditions. MDL-NBS-HS-000008 REV 00. Las Vegas,

Nevada: CRWMS M&O. ACC: MOL.19990721.0529.

CRWMS M&O 2000bj. UZ Flow Models and Submodels. MDL-NBS-HS-000006 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19990721.0527.

BSC 2001h. Analysis of Geochemical Data for the Unsaturated Zone. ANL-NBS-HS-000017 REV 00 ICN 01. Las Vegas, Nevada: Bechtel SAIC Company. ACC: MOL.20010405.0013.

Agreement Number TSPAI.3.24

Agreement DOE will provide an analysis of available geochemical and hydrological data (water content, water potential, and temperature) used for support of the flow field below the repository, particularly in the Calico Hills, Prow Pass, and Bullfrog hydrostratigraphic layers. The analyses will demonstrate that potential bypassing of matrix flow pathways below the area of the proposed repository, as opposed to the entire site-scale model area, is adequately incorporated for performance assessment, or provide supporting analyses that the uncertainties are adequately included in the TSPA. These analyses will be documented in the UZ Flow Models and Submodels AMR, MDL-NBS-HS-000006, In-Situ Field Testing of Processes AMR, ANL-NBS-HS-000005,, and Calibrated Properties Model AMR, MDL-NBS-HS-000003, expected to be available to NRC in FY 2003.

Subissue #3 - Model Abstraction UZ 2.3.4

Tracking # UZ 2.3.4

Comment Results of subsurface seepage and tracer studies, including the Passive Cross Drift Hydrologic test, Alcove 8-Niche 3 tests, and Niche 5 test, need to be documented to provide validation of or a basis for revising the TSPA seepage abstraction and associated parameter values (e.g., flow focusing factor, van Genuchten alpha for fracture continuum).

References CRWMS M&O. "Total System Performance Assessment for the Site Recommendation." TDR-WIS-PA-000001. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response See also response to 1.b. The flow model accounts for measurements from boreholes and tunnels. Future revisions to the referenced Analysis/Model Reports will document:

- data used for calibration
- conflicting results from the different methodologies
- tests results

The associated Unsaturated and Saturated Flow under Isothermal Conditions agreements for seepage are 4.1a), 4.1 b); 4.2; 4.3 and 6.3 for seepage. Radionuclide Transport agreement 3.4 will address the units below the repository. The results of the agreements will be documented in future revisions to the referenced Analysis/Model Reports.

References (future revisions):

CRWMS M&O 2000bl. In Situ Field Testing of Processes. ANL-NBS-HS-000005 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20000504.0304.

CRWMS M&O 2001j. Seepage Calibration Model and Seepage Testing Data. MDL-NBS-HS-000004 REV 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20010122.0093.

CRWMS M&O 2000bk. Radionuclide Transport Models Under Ambient Conditions. MDL-NBS-HS-000008 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19990721.0529.

Agreement Number TSPAI.3.25

Agreement DOE will utilize field test data (e.g., the Passive Cross Drift Hydrologic test, the Alcove 8 - Niche 3 tests, the Niche 5 test, and other test data) to either provide additional confidence in or a basis for revising the TSPA seepage abstraction and associated parameter values (e.g., flow focusing factor, van Genuchten alpha for fracture continuum, etc.), or provide technical basis for not

using it. This will be documented in Seepage Calibration Model and Seepage Testing Data AMR, MDL-NBS-HS-000004, expected to be available to NRC in FY 2003.

Subissue #3 - Model Abstraction UZ 2.3.5

Tracking # UZ 2.3.5

Comment The site-scale UZ flow model for TSPA is not calibrated using the most recent in situ measurements of saturations and water potentials.

References CRWMS M&O. "Total System Performance Assessment for the Site Recommendation." TDR-WIS-PA-000001. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response The flow model accounts for measurements from boreholes and tunnels. Current measurements of moisture tension and saturation are in good agreement with the model. Revisions to the Unsaturated Zone flow model Analysis/Model Reports will incorporate the recent in-situ measurements.

References (future revisions):

CRWMS M&O 2000bm. Analysis of Hydrologic Properties Data. ANL-NBS-HS-000002 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19990721.0519.

CRWMS M&O 2000bn. Calibrated Properties Model. MDL-NBS-HS-000003 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19990721.0520.

CRWMS M&O 2000bj. UZ Flow Models and Submodels. MDL-NBS-HS-000006 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19990721.0527.

Agreement Number TSPAI.3.26

Agreement DOE will calibrate the UZ flow model using the most recent data on saturations and water potentials, and document the sources of calibration data and data collection methods. The results will be documented in the Calibrated Properties Model AMR (MDL-NBS-HS-000003) expected to be available to NRC in FY 2003.

Subissue #3 - Model Abstraction UZ 2.5.1

Tracking # UZ 2.5.1

Comment Page 143 (CRWMS M&O, 2000). A discussion is provided of perched water bodies. Information is needed on what the model is producing with respect to perched water bodies for example (How do the modeled perched water body ages compare to the dated ages of observed perched water bodies? Would perched water bodies be expected to have the same ages for future climate conditions as they do now? Do perched water bodies drain and what is the impact on dose?).

References CRWMS M&O. "Total System Performance Assessment for the Site Recommendation." TDR-WIS-PA-000001 Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response Treatment of perched water for the flow model is discussed in Unsaturated Zone Flow Models and Submodels Analysis/Model Report (CRWMS M&O 2000bj). The perched water conceptual model and calibration are discussed in sections 6.2.2 and 6.2.3. See pages 65, 66, and 67 for flow results.

The Analysis of Base-Case Particle Tracking Results of the Base-Case Flow Fields Analysis/Model Report (CRWMS M&O 2000bo,Section 6.2.2) discusses the effects of different perched water models on unsaturated zone transport.

Water does drain through, as well as along, perched water bodies in the unsaturated zone flow model. Therefore, these effects are included in the TSPADOSE calculations.

Comparison of transport for alternative perched water models is documented in the Analysis of Base-Case Particle Tracking Results of the Base-Case Flow Fields Analysis/Model Report, (CRWMS M&O 2000bo, Section 6.2.2). The sensitivity study suggests that residence time for transport along more extensive perched water bodies is slower than vertical transport to the water table. However, the overall differences in transport times are not large.

Flow models assumed steady state resident times for perched water bodies. Transients in the fracture system resulting from climate change are expected to propagate through the unsaturated zone in 100's of years (less than 1000 years). Climate change periods and the regulatory time period are long compared with the transient time period, therefore the neglect of transient flow due to climate change is reasonable.

References: CRWMS M&O 2000bj. UZ Flow Models and Submodels. MDL-NBS-HS-000006 REV 00. Las Vegas, Nevada:

CRWMS M&O. ACC: MOL.19990721.0527.

CRWMS M&O 2000bo. Analysis of Base-Case Particle Tracking Results of the Base-Case Flow Fields (ID: U0160). ANL-NBS-HS-000024 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20000207.0690.

Agreement Number

Agreement DOE response during Technical Exchange was considered adequate by the NRC. Total System Performance Assessment and Integration Technical Exchange, August 6-10, 2001.

Subissue #3 - Model Abstraction UZ 2.TT.1

Tracking # UZ 2.TT.1

Comment There is a lack of transparency pertaining to the presented parameter histories.

References CRWMS M&O. "Abstraction of NFE Drift Thermodynamic Environment and Percolation Flux AMR." ANL-EBS-HS-000003 Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response The parameter time-histories are given to specifically illustrate in the Near Field Abstraction Analysis/Model Report (CRWMS M&O 2000c) the potential thermohydrologic variability infiltration bin average thermohydrologic variability associated with the infiltration rate uncertainty (low, mean, and high infiltration flux cases) specified future climates repository design issues such as repository center and edge effects and other issues, such as different waste package types.

The time-histories specifically indicate that for the thermohydrologic process-model assumptions, such as conceptual flow model, boundary conditions, etc (as described in the Multiscale Analysis/Model Report [CRWMS M&O 2000ag]), these are the thermohydrologic distributions for temperature, relative humidity, etc, that are made available for TSPA (and other downstream models).

Furthermore, the actual thermohydrologic abstraction data passed to TSPA either for further abstraction and/or direct use is specifically given in Tables 3 and 4 in the Near Field Abstraction Analysis/Model Report. TSPA thermohydrologic data is used in direct process model results or infiltration rate bin averaged and is described in the downstream models that apply the abstracted thermohydrologic data as inputs. The illustrated time-histories shown in the Analysis/Model Report give an idea as to what is being passed/implemented into the downstream models including the TSPA model.

References: CRWMS M&O 2000c. Abstraction of NFE Drift Thermodynamic Environment and Percolation Flux. ANL-EBS-HS-000003 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20000504.0296.

CRWMS M&O 2000ag. Multiscale Thermohydrologic Model. ANL-EBS-MD-000049 REV 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001208.0062.

Agreement Number

Agreement DOE response during Technical Exchange was considered adequate by the NRC. Total System Performance Assessment and

Subissue #3 - Model Abstraction UZ 2.TT.2

Tracking # UZ 2.TT.2

Comment Water densities are used inconsistently to model evaporation.

References CRWMS M&O. "Multiscale Thermal Hydrologic Model Abstraction AMR." ANL-EBS-MD-000049. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response The abstracted average invert evaporation rate used a constant water density of 1000 kg/m3. Section 6.3.10 in the Multiscale Analysis/Model Report (CRWMS M&O 2000ag) utilized both a constant water density and a temperature dependent water density to compute the average evaporation rate at the top of the drip shield surface. The constant water density used in the drip shield calculation was 983.19 kg/m3, not 1000 kg/m3. However, Figure 53 in the Multiscale Analysis/Model Report indicates that the difference in evaporation rate at the drip shield surface was not very sensitive to the choice of water density temperature dependence (e.g., approximately 500 years after waste emplacement, both evaporation response curves, temperature dependent and constant density, are the same).

In the drip shield calculations for evaporation rate, the water densities used in the calculations varied by about 4% (from 25°C to about 100°C) in accordance with Figure 53. No differences in the evaporation rates are noted after about 500 years. Subsequently, the difference between the invert water density and the drip shield water density was actually less than 2%, thus indicating that the choice in water densities (in this range 2-4% difference) will not affect the evaporation rates.

Based on the above, the choice of water density used to calculate the evaporation rate is not dependent on the value selected in the 25°C to 100°C range (CRWMS M&O 2000ag, Figure 53, for the drip shield evaporation rate).

Reference: CRWMS M&O 2000ag. Multiscale Thermohydrologic Model. ANL-EBS-MD-000049 REV 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001208.0062.

Agreement Number

Agreement DOE response during Technical Exchange was considered adequate by the NRC. Total System Performance Assessment and Integration Technical Exchange, August 6-10, 2001.

Subissue #3 - Model Abstraction UZ 2.TT.3

Tracking # UZ 2.TT.3

Comment What is the water mass flux balance used above, at, and below the repository horizon in the TSPA (CRWMS M&O, 2000)?

References CRWMS M&O. "Total-System Performance Assessment (TSPA) Model for the Site Recommendation." TDR-WIS-PA-000002 Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response Mass balances are based on mass conservation equations in the flow calculations.

The unsaturated zone flow fields are mass balanced. Any seepage that enters and then exits the drifts would be assumed to be a small perturbation that does not disturb the steady state flow fields.

The conceptual model for water flow within the drift accounts for the various possible flow paths (e.g., some water flows around the drip shield, some flows through the drip shield and around the waste package, and some flow through the drip shield and through the drip shield). The effects of the drift in perturbing the water flow (for example, the "shadow zone" below the drift) are not taken into account, but the approximations made are conservative (i.e., account for increased flux because of thermally mobilized water above the drift, no credit for thermal dryout, no credit for drift shadow zone).

Agreement Number TSPAI.3.27

Agreement DOE will provide an overview of water flow rates used in the UZ model above and below the repository, in the Multi-Scale Thermohydrologic Model (MSTHM), in the seepage abstraction, and in the in drift flow path models, to ensure appropriate integration between the various models. This will be documented in the TSPA for any potential license application expected to be available to NRC in FY 2003.

Subissue #3 - Model Abstraction UZ 3.5.1

Tracking # UZ 3.5.1

Comment Page 3-30 (CRWMS M&O, 2000). "Field observations suggest limited interaction between the fractures and matrix." A comparison is needed that the abstraction and implementation of matrix diffusion in the TSPA model is consistent with the field observations.

References CRWMS M&O. "Total System Performance Assessment for the Site Recommendation." TDR-WIS-PA-000001 Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response Existing field observations concerning fracture-matrix interaction do not provide much constraint on the range of potential behavior. Further field testing is being conducted in the Alcove 8/Niche 3 tests. The results of these tests will be analyzed and implemented in TSPA.

Alcove 1 tracer tests indicate that matrix diffusion plays an important role in tracer transport behavior. The Alcove 1 tracer tests are in documented in Section 6.8.1 of the Unsaturated Zone Flow Models and Submodels Analysis/Model Report (CRWMS M&O 2000bj) and the following sections of the Unsaturated Zone Process Model Report Sections 2.2.2.2.3; 3.7.4.4; 3.11.11.1.

Another observation in section 3.8.2 of the Unsaturated Zone Process Model Report (CRWMS M&O 2000aw) suggests matrix diffusion is important is the uniform geochemical signature in pore water of the TSw.

References: CRWMS M&O 2000bj. UZ Flow Models and Submodels. MDL-NBS-HS-000006 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19990721.0527.

CRWMS M&O 2000aw. Unsaturated Zone Flow and Transport Model Process Model Report. TDR-NBS-HS-000002 REV 00 ICN 02. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20000831.0280.

Agreement Number TSPAI.3.28

Agreement DOE will provide independent lines of evidence to provide additional confidence in the use of the active fracture continuum concept in the transport model. This will be documented in Radionuclide Transport Models under Ambient Conditions AMR (MDL-NBS-HS-000008) and UZ Flow Models and Submodels AMR (MDL-NBS-HS-000006) expected to be available to NRC in FY 2003.

Subissue #3 - Model Abstraction UZ 3.TT.1

Tracking # UZ 3.TT.1

Comment Page 433 (CRWMS M&O, 2000). An explanation is needed of what physical processes are causing the strong variation in the release curves from the UZ, such as for Pu-239.

References CRWMS M&O. "Total-System Performance Assessment (TSPA) Model for the Site Recommendation." TDR-WIS-PA-000002 Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response The variations are a numerical discretization issue caused by chain decay in the particle tracker, specifically the decay of discrete particles of the parent radionuclide Am-243. The code was optimized to minimize this discrete behavior for as many chains as possible, but some residual "discreteness" remained for a few radionuclides, such as Pu-239 and U-233. Since there was an upper limit on the number of particles that could be injected into the unsaturated Zone model based on process size and RAM availability, using a very, very large number of particles to resolve the variations was not possible. The maximum number was used while still remaining within these constraints.

Agreement Number

Agreement DOE response during Technical Exchange was considered adequate by the NRC. Total System Performance Assessment and Integration Technical Exchange, August 6-10, 2001.

Subissue #3 - Model Abstraction UZ 3.TT.2

Tracking # UZ 3.TT.2

Comment The AMR describes in general terms how FEHM and resulting data will be implemented, but does not include detail about implementation into GoldSim. Data resulting from this AMR will be used in the UZ Flow and Transport PMR and the TSPA-SR.

References CRWMS M&O. "Abstraction of Flow Fields for RIP." ANL-NBS-HS-000023 Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response Total System Performance Assessment Model for Site Recommendation (CRWMS M&O 2000aq, Section 6.3.6) describes the implementation of FEHM into GoldSim.

Reference: CRWMS M&O 2000aq. Total System Performance Assessment (TSPA) Model for Site Recommendation. MDL-WIS-PA-000002 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001226.0003.

Agreement Number

Agreement DOE response during Technical Exchange was considered adequate by the NRC. Total System Performance Assessment and Integration Technical Exchange, August 6-10, 2001.

Subissue #3 - Model Abstraction UZ 3.TT.3

Tracking # UZ 3.TT.3

Comment Matrix diffusion in the UZ has emerged, somewhat surprisingly, as a significant natural barrier for attenuation of potential radionuclide releases. This increased importance seems to have come after the incorporation of the active-fracture concept into the transport model. The integration of active fracture concept within the transport abstraction is not transparent.

References CRWMS M&O. "Unsaturated Zone Flow and Transport Model PMR." TDR-NBS-HS-000002 Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000.
CRWMS M&O. "Particle Tracking Model and Abstraction of Transport Processes AMR." ANL-NBS-HS-000026 Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response The active fracture model is a flow focusing model that results in reduced fracture-matrix area (and increased flowing fracture-spacing). The geometric interpretation of the Active Fracture Model is transferred directly to the matrix diffusion transport model.

The Alcove 8 test results will be documented in the In-Situ Field Testing of Processes, Analysis/Model Report (CRWMS M&O 2000bl).

The differences found in matrix diffusion in radionuclide transport calculations for the TSPA-Viability Assessment and TSPA-Site Recommendation models are primarily due to the differences in calibrated model parameters including the fracture-matrix interaction factors. In the TSPA-Viability Assessment, a constant fracture-matrix interaction factor was calibrated for each hydrogeologic model unit. For TSPA-Site Recommendation, the active fracture model was used in which the fracture-matrix interaction factor is a function of the effective fracture water saturation.

The fracture-matrix interaction factors are different in the Site Recommendation model due to changes in other hydrologic parameters for TSPA-Viability Assessment versus TSPA-Site Recommendation such as permeability and van Genuchten alpha. This has lead to differences in the fracture-matrix reduction factors in TSPA-Site Recommendation compared with TSPA-Viability Assessment.

A more complete description of how the active fracture model is integrated with the transport model will be given in an update to the Radionuclide Transport Models under Ambient Conditions Analysis/Model Report.

References: (future revisions)

CRWMS M&O 2000bl. In Situ Field Testing of Processes. ANL-NBS-HS-000005 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20000504.0304.

CRWMS M&O 2000bk. Radionuclide Transport Models Under Ambient Conditions. MDL-NBS-HS-000008 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19990721.0529.

Agreement Number TSPAI.3.29

Agreement DOE will provide verification that the integration of the active fracture model with matrix diffusion in the transport model is properly implemented in the TSPA abstraction. This verification will be documented in the Particle Tracking Model and Abstraction of Transport Processes, ANL-NBS-HS-000026, expected to be available to NRC in FY 2003.

Subissue #3 - Model Abstraction UZ.Ltr.1.b

Tracking # UZ.Ltr.1.b

Comment The ongoing and planned testing under agreement USFIC.4.01 are a reasonable approach for a licensing application with the following comments:

i. Consider a mass balance of water for alcove 8/Niche 3 cross over test.
ii. Monitor evaporation during all testing.
iii. Provide the documentation of the test plan for the Passive Cross Drift Hydrologic test.
iv. Provide the NRC with any Cross Drift seepage predictions that may have been made for the Passive Cross Drift Hydrologic test.
v. Provide documentation of the results obtained and the analysis for the Passive Cross Drift Hydrologic test. This documentation should include the analysis of water samples collected during entries into the Cross Drift (determination whether the water comes from seepage or condensation).
vi. Provide documentation of the results obtained and the analysis for the Alcove 7 test. This documentation should include the analysis of water samples collected during entries into Alcove 7 (determination whether the water comes from seepage or condensation).
vii. Provide the documentation of the test plan for the Niche 5 test.
viii. Provide documentation of the results obtained and the analysis for the Niche 5 test.
ix. Provide documentation of the results obtained and the analysis for the Systematic Hydrologic Characterization test.
x. Provide documentation of the results obtained and the analysis for the Niche 4 test.
xi. Provide documentation of the results obtained from the calcite filling test. Include interpretation of the observed calcite deposits found mostly at the bottom of the lithophysal

References

DOE Response Test plans and pre-test predictions will be made available as they are developed.

Exceptions:

vi. [Original NRC comment] Provide the documentation of the test plan for the Alcove 7 test
(vi) [DOE response] Test plan for Alcove 7 is not needed since test is near completion.

xiii. [Original NRC comment] Provide documentation of the results

obtained from the Comparison of Continuum and Discrete Fracture Network Models modeling study. Alternatively, provide justification of the continuum approach at the scale of the seepage model grid.
(xiii) [DOE response] This is a modeling issue that is not related to testing. An agreement on the comparison of continuum versus discrete fracture seepage models is not needed because this is ongoing work.

xiv. [Original NRC comment] Provide documentation of the results obtained from the Natural Analogs modeling study. The study was to apply conceptual models and numerical approaches developed from Yucca Mountain to natural analog sites with observations of seepage into drifts, drift stability, radionuclide transport, geothermal effects and preservation of artifacts.
(xiv) [DOE response] This is a modeling issue that is not related to testing. An agreement on the comparison of continuum versus discrete fracture seepage models is not needed because this is ongoing work.

Agreement Number

Agreement The following statement by DOE was considered adequate to the NRC, and was recorded under Attachment 3 of the Summary Highlights of NRC/DOE Technical Exchange and Management Meeting on Total System Performance Assessment and Integration, August 6-10, 2001.

Unsaturated and Saturated Flow Under Isothermal Conditions, Agreement Modifications and Additions:

1) A mass balance of water for the Alcove 8/Niche 3 test has been considered, but is not feasible due to the size of the collection system that would be required. A collection system to obtain a mass balance is being developed for the Niche 5 test. (i)
2) Evaporation will be monitored for all tests where evaporation is a relevant process. (ii)
3) Test plans for Niche 5 and the Cross Drift Hydrologic tests are expected to be available to NRC FY 2002. (iii, viii)
4) The Cross Drift seepage predictions will be documented in the Seepage Calibration Model and Seepage Testing Data AMR (MDL-NBS-HS-000004) expected to be available to NRC by FY 2003. (iv)
5) DOE will document the results for the tests identified above (except calcite filling observations) in the In-Situ Field Testing of Processes AMR (ANL-NBS-HS-000005) expected to be available to NRC in FY 2003. (v, vi, vii, ix, x)
6) Results of the calcite filling observations will be documented in Analysis of Geochemical Data for the Unsaturated Zone (ANL-NBS-HS-000017) and the UZ Flow Models and Submodels (MDL-NBS-

HS-000006) expected to be available to NRC FY 2003. (xi)

Subissue #3 - Model Abstraction UZ.Ltr.1.c

Tracking # UZ.Ltr.1.c

Comment Provide the analysis of geochemical and hydrological data (water content, water potential, and temperature) used for support of the flow field below the repository, particularly in the Calico Hills, Prow Pass and Bullfrog hydrostratigraphic layers. Demonstrate that potential bypassing of matrix flow pathways below the area of the proposed repository, as opposed to the entire site-scale model area, is adequately incorporated for performance assessment.

References CRWMS M&O. "Total System Performance Assessment for the Site Recommendation." TDR-WIS-PA-000001. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response See [response to comment] UZ.2.3.3 above.

Agreement Number TSPAI.3.24

Agreement DOE will provide an analysis of available geochemical and hydrological data (water content, water potential, and temperature) used for support of the flow field below the repository, particularly in the Calico Hills, Prow Pass, and Bullfrog hydrostratigraphic layers. The analyses will demonstrate that potential bypassing of matrix flow pathways below the area of the proposed repository, as opposed to the entire site-scale model area, is adequately incorporated for performance assessment, or provide supporting analyses that the uncertainties are adequately included in the TSPA. These analyses will be documented in the UZ Flow Models and Submodels AMR (MDL-NBS-HS-000006), In-Situ Field Testing of Processes AMR (ANL-NBS-HS-000005), and Calibrated Properties Model AMR (MDL-NBS-HS-000003) expected to be available to NRC in FY 2003.

Subissue #3 - Model Abstraction UZ.Ltr.1.d

Tracking # UZ.Ltr.1.d

Comment The NRC staff does not believe that the agreement USFIC.5.04 needs to be rewritten; however, it would like to confirm that the effects of water table rise on groundwater flux will be addressed in the two documents cited by DOE for this agreement.

References

DOE Response The effects of water table rise on groundwater flux will be addressed in the Saturated Zone Flow and Transport Process Model Report (CRWMS M&O 2000an) and the Uncertainty Distribution for Stochastic Parameters Analysis/Model Report (CRWMS M&O 2000at) as part of Unsaturated and Saturated Flow under Isothermal Conditions agreement 5.4.

References: (future revisions)

CRWMS M&O 2000an. Saturated Zone Flow and Transport Process Model Report. TDR-NBS-HS-000001 REV 00 ICN 02. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001102.0067.

CRWMS M&O 2000at. Uncertainty Distribution for Stochastic Parameters. ANL-NBS-MD-000011 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20000526.0328.

Agreement Number

Agreement DOE response during Technical Exchange was considered adequate by the NRC. Total System Performance Assessment and Integration Technical Exchange, August 6-10, 2001.

Subissue #3 - Model Abstraction UZ.Ltr.3.a

Tracking # UZ.Ltr.3.a

Comment The UZ AMR U0010, Simulation of Net Infiltration for Modern and Potential Future Climates (U.S. Geological Survey, 2000), notes that the simulation results using three synthetic meteorological data sets are averaged for the lower, mean and upper bound estimates of net infiltration. The NRC is interested in obtaining two of the three synthetic meteorological data sets; 4AJ.s01 and Area12.s01.

References U.S. Geological Survey. "Simulation of Net Infiltration for Modern and Potential Future Climates." Las Vegas, Nevada: U.S. Geological Survey. 2000.

DOE Response See [response to comment] UZ1.3.2 above.

Agreement Number

Agreement This comment was discussed under comment UZ1.3.2. DOE response during Technical Exchange was considered adequate by the NRC. Total System Performance Assessment and Integration Technical Exchange, August 6-10, 2001.

Subissue #3 - Model Abstraction UZ.Ltr.3.b

Tracking # UZ.Ltr.3.b

Comment The NRC is interested in how the results of the Passive Cross Drift Hydrologic and Alcove 8 - Niche 3 Cross-over tests were used to validate or modify the values used for the flow focussing factor in the seepage model for performance assessment. In addition, the NRC is interested in the justification for the van Genuchten alpha for fracture continuum, (f) parameter.

References CRWMS M&O. "Total System Performance Assessment for the Site Recommendation." TDR-WIS-PA-000001. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response See [response to comment] UZ2.3.4 above

Agreement Number

Agreement This comment was discussed under comment UZ2.3.4. DOE response during Technical Exchange was considered adequate by the NRC. Total System Performance Assessment and Integration Technical Exchange, August 6-10, 2001.

Subissue #3 - Model Abstraction UZ.Ltr.3.c

Tracking # UZ.Ltr.3.c

Comment The NRC is interested in additional justification on how fracture continuum properties (i.e., porosity, spacing, aperture) for the unsaturated transport model are calculated and how the active-fracture concept is integrated into these parameter values. The discussion should show that the matrix diffusion and active fracture models are properly integrated.

References CRWMS M&O. "Unsaturated Zone Flow and Transport Model PMR." TDR-NBS-HS-000002 Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000.
CRWMS M&O. "Particle Tracking Model and Abstraction of Transport Processes AMR." ANL-NBS-HS-000026 Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response See [response to comment] UZ 3.TT.3 above

Agreement Number

Agreement This comment was discussed under comment UZ 3.TT.3. DOE response during Technical Exchange was considered adequate by the NRC. Total System Performance Assessment and Integration Technical Exchange, August 6-10, 2001.

Subissue #3 - Model Abstraction UZ.Ltr.3.d

Tracking # UZ.Ltr.3.d

Comment The NRC is interested in an update to the calibrated unsaturated zone flow model using the most recent matrix saturation and water potential data that suggest the rock mass is wetter than previous core-sample saturation measurements have indicated.

References CRWMS M&O. "Total System Performance Assessment for the Site Recommendation." TDR-WIS-PA-000001. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response See [response to comment] UZ2.3.5 above

Agreement Number

Agreement This comment was discussed under comment UZ2.3.5. DOE response during Technical Exchange was considered adequate by the NRC. Total System Performance Assessment and Integration Technical Exchange, August 6-10, 2001.

Subissue #3 - Model Abstraction SZ 2.3.1

Tracking # SZ 2.3.1

Comment Calculation of the Kc parameter, used to simulate reversible colloid attachment during SZ transport by lowering the radioelement Kd, involves a term for colloid concentration in the water (CRWMS M&O, 2000a). The concentration adopted-0.03 mg/L-is claimed to be "for conservatism, the highest observed or expected colloid concentration" (CRWMS M&O, 2000b). However, this concentration is well below the maximum values used in release models for waste form (5 mg/L) and iron (hydr)oxide (1 mg/L) colloids derived from the EBS (CRWMS M&O, 2000c).

References CRWMS M&O. "Uncertainty Distribution for Stochastic Parameters." ANL-NBS-MD-000011. Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000a.
CRWMS M&O. "Total System Performance Assessment (TSPA) Model for Site Recommendation." MDL-WIS-PA-000002. Revision 00. Las Vegas, Nevada. 2000b.
CRWMS M&O. "Waste Form Colloid-Associated Concentration Limits: Abstraction and Summary." ANL-WIS-MD-000012. Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000c.

DOE Response Measurements of natural colloid concentrations in groundwater are more representative of colloid stability in equilibrium with far-field geochemical conditions than are estimates of colloid concentrations at the waste form.

Sensitivity and uncertainty analyses for the Supplemental Science and Performance Analysis (BSC 2001e) include an evaluation of colloid facilitated transport that considers uncertainty in the colloid concentrations in groundwater. This analysis effectively evaluates the impact of a broader range of values (as high as 0.3 mg/L) for the colloid concentrations on the simulated dose rates in TSPA-Site Recommendation (CRWMS M&O 2000aq).

References: BSC 2001e. FY01 Supplemental Science and Performance Analyses, Volume 1: Scientific Bases and Analyses. TDR-MGR-MD-000007 REV 00. Las Vegas, Nevada: Bechtel SAIC Company. ACC: MOL.20010712.0062.

CRWMS M&O 2000aq. Total System Performance Assessment (TSPA) Model for Site Recommendation. MDL-WIS-PA-000002 REV 00. Las Vegas, NV: CRWMS M&O. ACC: MOL.20001226.0003.

Agreement Number TSPAI.3.30

Agreement DOE will provide the technical basis for the contrasting concentrations of colloids available for reversible attachment in the engineered barrier system and the saturated zone. The sensitivity

analyses planned in response to RT Agreement 3.07 will address the effect of colloid concentration on the Kc parameter. The technical basis will be documented in the Waste Form Colloid Associated Concentration Limits: Abstractions and Summary, ANL-WIS-MD-000012, in FY 2003. The Kc parameter will be updated as new data become available from the Yucca Mountain region in the Uncertainty Distribution for Stochastic Parameters AMR, ANL-NBS-MD-000011, in FY2003.

Subissue #3 - Model Abstraction SZ 2.3.2

Tracking # SZ 2.3.2

Comment Five FEPs concerning possible chemical effects on radionuclide transport properties are stated to be included in TSPA to the extent that uncertainty ranges in Kd bound the effects (CRWMS M&O, 2001). These FEPs are:
2.2.08.01.00-Groundwater chemistry/composition in UZ and SZ;
2.2.08.02.00-Radionuclide transport in a carrier plume;
2.2.08.03.00-Geochemical interactions in the geosphere;
2.2.08.06.00-Complexation in the geosphere;
2.2.09.01.00-Microbial activity in geosphere.
The issue common to these five included FEPs is that DOE has not adequately demonstrated that uncertainty distributions bound the possible variations in Kd in the saturated zone below Yucca Mountain (CRWMS M&O, 2000a,b). To support a licensing decision, documentation is necessary to determine how DOE developed the TSPA transport parameter distributions.

References CRWMS M&O. "Features, Events, and Processes in SZ Flow and Transport. ANL-NBS-MD-000002 Revision 01." Las Vegas, Nevada: CRWMS M&O. 2001.
CRWMS M&O. "Uncertainty Distribution for Stochastic Parameters." ANL-NBS-MD-000011 Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000a.
CRWMS M&O. "Unsaturated Zone and Saturated Zone Transport Properties." ANL-NBS-HS-000019 Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000b.

DOE Response Documentation of the justification for uncertainty distributions for radionuclide sorption coefficients will be revised. This comment is addressed in the existing Radionuclide Transport agreements 2.10 and 1.5.

Agreement Number TSPAI.3.31

Agreement DOE will reexamine the FEPs, currently included in the performance assessment, that may lead to temporal changes in saturated zone hydrochemistry. If the DOE determines that these FEPs can be excluded, the results will be documented in the FEP Saturated Zone Flow and Transport AMR, ANL-NBS-MD-000002, in FY 2003. If the DOE determines that these FEPs cannot be excluded from the performance assessment, the DOE will evaluate the effects of temporal changes in the saturated zone chemistry on radionuclide concentrations and will document this evaluation in above mentioned AMR.

Subissue #3 - Model Abstraction SZ 2.4.1

Tracking # SZ 2.4.1

Comment On page 3-174 the transport times for C-14 range from 100 years to greater than 100,000 years. This result appears to be non-physical and brings into question the representation of variability/uncertainty. The proposed dose standard is based on peak of the mean dose.

References CRWMS M&O. "Total System Performance Assessment for the Site Recommendation." TDR-WIS-PA-000001 Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response There is a misprint in the text of the TSPA-Site Recommendation REV 00 ICN01. The statement should be that transport times for C-14 vary from less than 100 years to greater than 10,000 years among the realizations. These results reflect a relatively large aggregate uncertainty in the transport of C-14 in the saturated zone, but are not "non-physical".

Reference: CRWMS M&O 2000ar. Total System Performance Assessment for the Site Recommendation. TDR-WIS-PA-000001 REV 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001220.0045.

Agreement Number TSPAI.3.32

Agreement DOE will provide the technical basis that the representation of uncertainty (i.e., lack-of-knowledge uncertainty) in the saturated zone does not result in an underestimation of risk when propagated to the performance assessment. A deterministic case from Saturated Zone Flow Patterns and Analyses AMR (ANL-NBS-HS-000038) will be compared to TSPA analyses. The comparison will be documented in the TSPA for any potential license application expected to be available to NRC in FY 2003.

Subissue #3 - Model Abstraction DIRECT 1.1.1

Tracking # DIRECT 1.1.1

Comment DOE has not yet assembled the information relating to the potential for volcanic disruption of the waste package needed for a potential license application, and DOE does not yet have a reasonable approach to do so by the time of license application. Available information shows that variations in the amount of HLW disrupted during extrusive and intrusive igneous events can affect significantly the probability-weighted doses to the proposed critical group.

References CRWMS M&O. "Dike Propagation Near Drifts." ANL-WIS-MD-000015 Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2001a.
CRWMS M&O. "Igneous Consequence Modeling for the TSPA-SR." ANL-WIS-MD-000017. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2001b.

DOE Response This item was discussed at the Igneous Activity Technical Exchange, June 21-22, 2001.

Agreement Number

Agreement

Subissue #3 - Model Abstraction DIRECT 1.1.2

Tracking # DIRECT 1.1.2

Comment While the text was updated to reflect the "backfill" to "no-backfill" design change, the model and analysis were not modified to account for this design change.

References CRWMS M&O. "Dike Propagation Near Drifts." ANL-WIS-MD-000015. Revision 00 and Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2001.

DOE Response This item was discussed at the Igneous Activity Technical Exchange, June 21-22, 2001.

Agreement Number

Agreement

Subissue #3 - Model Abstraction DIRECT 1.1.3

Tracking # DIRECT 1.1.3

Comment This AMR uses a pre-VA design to estimate thermal loads and implications on rock mechanics and the thermal-mechanical evolution of the stress states (pp. 15-16, Figs. 2 and 3, p. 49). Since these stress states are used to predict a possible redirection of an ascending dike, the implications are risk-significant. A consistent design and thermal load should be used.

References CRWMS M&O. "Dike Propagation Near Drifts." ANL-WIS-MD-000015. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response The Analysis/Model Report (CRWMS M&O 2000l) cites previous work, which was based on the pre-Viability Assessment design thermal loads, to provide support for the concept of principal stress rotation. The referenced calculation is used to make the point at issue, which is a change or rotation in the stress conditions during the thermal period. The conceptual finding from the cited work indicate that the rotation of principal stress direction remains valid even for thermal loads that differ from the pre-Viability Assessment design.

The Analysis/Model Report (CRWMS M&O 2000l) uses the findings in a conceptual or qualitative sense in development of a decision tree (Figure 1). One of the decision points is whether a dike is intruding into an ambient or thermally perturbed stress environment. The findings are used quantitatively for the plots presented in Figures 2 and 3 to demonstrate the possible magnitude of the change. The magnitude of the stress rotation, the duration of the thermal period, and the distinction between thermal and non-thermal periods are not further considered within the igneous-related TSPA models. For these reasons, citation of the previous work is consistent with the findings presented in the TSPA-Site Recommendation (CRWMS M&O 2000ar).

If the rotation of stress or drift stress conditions are quantitatively considered in future igneous consequence work, the magnitude and direction of the stress rotation with time will be reconsidered and based on the design and thermal load assumptions consistent with the inputs developed for use in the corresponding TSPA.

References: CRWMS M&O 2000l. Dike Propagation Near Drifts. ANL-WIS-MD-000015 REV 00 ICN 1. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001213.0061.

CRWMS M&O 2000ar. Total System Performance Assessment for the Site Recommendation. TDR-WIS-PA-000001 REV 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001220.0045.

Subissue #3 - Model Abstraction DIRECT 1.1.3

Agreement Number

Agreement DOE response during Technical Exchange was considered adequate by the NRC. Total System Performance Assessment and Integration Technical Exchange, August 6-10, 2001.

Subissue #3 - Model Abstraction DIRECT 1.TT.1

Tracking # DIRECT 1.TT.1

Comment This AMR uses a 600 C drift wall temperature (p. 36) to calculate a sample magma solidification time. What is the basis for this value? Is it dependent on thermal load?

References CRWMS M&O. "Dike Propagation Near Drifts." ANL-WIS-MD-000015. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response The drift wall temperature was assumed to be 600 degrees C to be consistent with the conduction calculation for cooling of the pyroclastic material in the previous section of the Analysis/Model Report (CRWMS M&O 2000l, "Pyroclastic Flow"). This calculation indicated the drift wall temperature, based on the thermal power available and conducted away into the rock. The assumed value is also consistent with the available literature as cited and described in Section 5.2 of the Analysis/Model Report. Thermal loading effects from emplaced waste were considered secondary with respect to this assumption.

Note that the calculated duration leads to the bounding assumption for the models that packages in contact with the magma are significantly damaged and provide no further protection. Therefore, changes in the exact value of the wall temperature, unless they were sufficient to reduce the "hot soak" duration to a few hours or days (which is not a credible condition), would not lead to a different assumption.

Reference: CRWMS M&O 2000l. Dike Propagation Near Drifts. ANL-WIS-MD-000015 REV 00 ICN 1. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001213.0061.

Agreement Number

Agreement DOE response during Technical Exchange was considered adequate by the NRC. Total System Performance Assessment and Integration Technical Exchange, August 6-10, 2001.

Subissue #3 - Model Abstraction DIRECT 2.2.1

Tracking # DIRECT 2.2.1

Comment The TSPA model abstraction for incorporation of waste particles into erupting magma makes use of unsupported assumptions related to the size distribution of particles.

References CRWMS M&O. "Total System Performance Assessment for the Site Recommendation." TDR-WIS-PA-000001. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response This item was discussed at the Igneous Activity Technical Exchange, June 21-22, 2001.

Agreement Number

Agreement

Subissue #3 - Model Abstraction DIRECT 2.TT.1

Tracking # DIRECT 2.TT.1

Comment The dose pathways for direct release scenario are discussed on p. 3-206 (CRWMS M&O, 2000). Inhalation and ingestion have been considered, but external exposure from contaminated ash on the ground surface was not listed.

DOE should clarify in TSPA-SR whether ground surface exposure was considered.

See DOSE2.TT.3 (identical comment)

References CRWMS M&O. "Total System Performance Assessment for the Site Recommendation." TDR-WIS-PA-000001 Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response This item was discussed at the Igneous Activity Technical Exchange, June 21-22, 2001.

Agreement Number

Agreement

Subissue #3 - Model Abstraction DOSE 1.1.1

Tracking # DOSE 1.1.1

Comment Climate change is considered in other model abstractions to assess repository performance, but DOE does not consider the impact of climate change on projected well pumping withdrawals. Climate change could reduce groundwater withdrawals without impacting the lifestyle of the critical group. A wetter, cooler climate could reduce groundwater extraction and therefore reduce the volume of water available for dilution. Reduced dilution could result in an increased effective dose.

References CRWMS M&O. "Analysis Model Report -- Groundwater Usage by the Proposed Farming Community." ANL-NBS-MD-000006. Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000a.
CRWMS M&O. "Saturated Zone Flow and Transport PMR." TDR-NBS-HS-000001. Revision 00 ICN 02. Las Vegas, Nevada: CRWMS M&O. 2000b.

DOE Response An evaluation has been performed that takes into account the annual estimate of precipitation (during the growing and irrigation season) both at the present and in future climate conditions and uses these data to predict groundwater usage from alfalfa evapotranspiration estimates. The evaluation is documented in Section 13.3.5 in the Supplemental Science and Performance Analysis, Volume 1.

Reference: BSC 2001e. FY01 Supplemental Science and Performance Analyses, Volume 1: Scientific Bases and Analyses. TDR-MGR-MD-000007 REV 00. Las Vegas, Nevada: Bechtel SAIC Company. ACC: MOL.20010712.0062.

Agreement Number

Agreement DOE response during Technical Exchange was considered adequate by the NRC. Total System Performance Assessment and Integration Technical Exchange, August 6-10, 2001.

Subissue #3 - Model Abstraction DOSE 1.2.1

Tracking # DOSE 1.2.1

Comment The analysis of groundwater usage by the proposed farming community is based on 1990 census data which may not reflect current conditions in the YM region.

References CRWMS M&O. "Analysis Model Report -- Groundwater Usage by the Proposed Farming Community." ANL-NBS-MD-000006. Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000a.
CRWMS M&O. "Saturated Zone Flow and Transport PMR." TDR-NBS-HS-000001. Revision 00 ICN 02. Las Vegas, Nevada: CRWMS M&O. 2000b.

DOE Response The annual groundwater usage distribution cited in the Groundwater Usage Analysis/Model Report (CRWMS M&O 2000w) was based on State published data of land use and irrigation in Amargosa Valley (Attachment II to cited Analysis/Model Report) and not census data. The agricultural groundwater users in Amargosa Valley were used to represent the parent distribution from which the 15 to 25 farms based on the preamble to the proposed 10 CFR 63.

Annual water usage used in the TSPA-Site Recommendation was not based on any census data. The 1990 census data were used in an alternate water usage model based on per population usage rather than per farm usage. The calculations substantiate/support the conservative water usage estimates, but did not use the census data.

Reference: CRWMS M&O 2000w. Groundwater Usage by the Proposed Farming Community. ANL-NBS-MD-000006 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20000407.0785.

Agreement Number

Agreement DOE response during Technical Exchange was considered adequate by the NRC. Total System Performance Assessment and Integration Technical Exchange, August 6-10, 2001.

Subissue #3 - Model Abstraction DOSE 1.2.2

Tracking # DOSE 1.2.2

Comment DOE addresses conservatism and identifies those parameters to which its model are sensitive. However, the data used to develop model parameters are limited and appear insufficient. For example, the agricultural water usage data used to support the model are based on one year of data. Although these data represented the most recent data available at the time the analyses were performed, the DOE has not demonstrated that agricultural water usage data for this year are representative of annual water usage in the region. Furthermore, DOE has not presented any basis for the nominal distribution used to select parameter values for their model.

References CRWMS M&O. "Groundwater Usage by the Proposed Farming Community." ANL-NBS-MD-000006. Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000a.
CRWMS M&O. "Saturated Zone Flow and Transport PMR." TDR-NBS-HS-000001. Revision 00 ICN 02. Las Vegas, Nevada: CRWMS M&O. 2000b.

DOE Response The annual groundwater usage was based on a single year of state published data and is therefore subject to some uncertainty due to temporal variation. DOE will consider including the assessment of multiple year data. There is likely to be a high correlation of usage from one year to the next, so it may be difficult to obtain statistically independent annual usage estimates on which to base unbiased estimates.

The annual groundwater usage distribution in the Groundwater Usage Analysis/Model Report (CRWMS M&O 2000w) was based on State published data of land use and irrigation in Amargosa Valley (CRWMS M&O 2000w, Attachment II). The agricultural groundwater users in Amargosa Valley were used to represent the parent distribution from which the 15 to 25 farms based on the preamble to the proposed 10 CFR 63.

Reference: CRWMS M&O 2000w. Groundwater Usage by the Proposed Farming Community. ANL-NBS-MD-000006 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20000407.0785.

Agreement Number

Agreement DOE response during Technical Exchange was considered adequate by the NRC. Total System Performance Assessment and Integration Technical Exchange, August 6-10, 2001.

Subissue #3 - Model Abstraction DOSE 1.TT.1

Tracking # DOSE 1.TT.1

Comment Improved transparency required to determine if DCFs are consistently used in TSPA and preclosure calculations. In Section 6.4 of (CRWMS M&O, 2000) it is stated that: "Worst case solubility values, provided as part of the code, representing the most conservative conditions for radionuclides under consideration, were used for this analysis." The comparison was clearly made with the worst case DCFs, but it was unclear if the worst case DCFs are consistent with the DCFs used in the TSPA and preclosure dose calculations.

References CRWMS M&O. "Dose Conversion Factor Analysis: Evaluation of GENII-S Dose Assessment Methods AMR." ANL-MGR-MD-000002. Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response The dose conversion factors are consistent. The dose conversion factors for some radionuclides are available as a function of solubility class. Because of the possibility of complex chemistry with the attendant difficulties of defining the species as a function of time in the biosphere, the most conservative values for the dose conversion factors were used. In the case of pre-closure releases, there is a possibility that the chemical species of the release are better known. In this case it may be possible to justify the use of smaller and more realistic dose conversion factors.

Reference: CRWMS M&O 1999a. Dose Conversion Factor Analysis: Evaluation of GENII-S Dose Assessment Methods. ANL-MGR-MD-000002 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19991207.0215.

Agreement Number

Agreement DOE response during Technical Exchange was considered adequate by the NRC. Total System Performance Assessment and Integration Technical Exchange, August 6-10, 2001.

Subissue #3 - Model Abstraction DOSE 2.1.1

Tracking # DOSE 2.1.1

Comment Scenarios in which high concentrations of radionuclides may be found on the ground surface should include a check to ensure the concentration of radionuclides leaching out of the surface soil does not exceed the solubility limit of the radionuclide.

References CRWMS M&O. "Evaluate Soil/Radionuclide Removal by Erosion and Leaching." ANL-NBS-MD-000009. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response In the case of contaminated groundwater, the TSPA-Site Recommendation predicted radionuclide concentrations calculations in soils even after build-up due to continuing irrigation are many orders of magnitude below solubility limits. This may not be the case for contaminated ash deposition (i.e., significant amounts of relatively insoluble species e.g., oxides may be present). In this scenario, the major pathway is inhalation, primarily arising from resuspension of contaminated ash from locations remote from irrigated areas. For this release scenario, credit for leaching should not be taken.

Reference: CRWMS M&O 2000ar. Total System Performance Assessment for the Site Recommendation. TDR-WIS-PA-000001 REV 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001220.0045.

Agreement Number

Agreement DOE response during Technical Exchange was considered adequate by the NRC. Total System Performance Assessment and Integration Technical Exchange, August 6-10, 2001.

Subissue #3 - Model Abstraction DOSE 2.2.1

Tracking # DOSE 2.2.1

Comment The analysis would be strengthened by the use of site-specific Kd values instead of generic values from Sheppard and Thibault (1990) because these values can vary significantly due to variations in soil pH and other soil characteristics.

References CRWMS M&O. "Evaluate Soil/Radionuclide Removal by Erosion and Leaching." ANL-NBS-MD-000009. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response Kd values appropriate for the soil at Amargosa Valley were used. A sensitivity study was performed and documented in Section 13.3.3 in the Supplemental Science and Performance Analysis (BSC 2001e) that evaluated the effect on Biosphere DOSE Conversion Factors of using a distribution of partition coefficients, for several radionuclides identified in the TSPA analyses as important DOSE contributors. The range of Kds was taken from International Atomic Energy Agency Technical Report No. 364 (IAEA 1994). Estimated increases in the mean value of the Biosphere DOSE Conversion Factors distributions, as the result of sampling over the possible variations in the Kd values, were by a factor of 1.4 and 1.3 for iodine and neptunium, respectively, and by a factor of 4.9 for technetium (Table 13.3-9). For the high Kd value Pu has such a protracted build-up time (24,000 years) that the limit is determined by the erosion rate (several hundred years).

References: IAEA 1994. Handbook of Parameter Values for the Prediction of Radionuclide Transfer in Temperate Environments. Technical Report Series No. 364. Vienna, Austria: International Atomic Energy Agency. TIC: 232035

BSC 2001e. FY01 Supplemental Science and Performance Analyses, Volume 1: Scientific Bases and Analyses. TDR-MGR-MD-000007 REV 00. Las Vegas, Nevada: Bechtel SAIC Company. ACC: MOL.20010712.0062.

Agreement Number TSPAI.3.33

Agreement DOE will provide justification that the Kd values used for radionuclides in the soil in Amargosa Valley are realistic or conservative for actual conditions at the receptor location. The justification will be provided in Evaluate Soil/Radionuclide Removal by Erosion and Leaching AMR (ANL-NBS-MD-000009) or other document expected to be available to NRC in FY 2003.

Subissue #3 - Model Abstraction DOSE 2.2.2

Tracking # DOSE 2.2.2

Comment Additional data are needed to support the assumption that the concentration of resuspended particles returns to background values within 10 years of the cessation of an igneous event. This concern is focused on the sustainability of elevated mass loadings over thicker tephra deposits.

References CRWMS M&O. "Input Parameter Values for External and Inhalation Radiation Exposure Analysis." ANL-MGR-MD-000001. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response This item was discussed at the Igneous Activity Technical Exchange meeting (21/22 Jun 01).

Agreement Number

Agreement DOE response during Technical Exchange was considered adequate by the NRC. Igneous Activity Technical Exchange, June 21-22, 2001.

Subissue #3 - Model Abstraction DOSE 2.3.1

Tracking # DOSE 2.3.1

Comment The mixing of temporal variability and parameter uncertainty in the development of the mass loading above a tephra deposit is confusing and will only provide correct results if other time-dependent processes do not result in a significant change in the concentration of radionuclides in the soil over the 10-year period over which the temporal averaging is being performed.

References CRWMS M&O. "Input Parameter Values for External and Inhalation Radiation Exposure Analysis." ANL-MGR-MD-000001. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response This item was discussed at the Igneous Activity Technical Exchange meeting (21/22 Jun 01).

Agreement Number

Agreement DOE response during Technical Exchange was considered adequate by the NRC. Igneous Activity Technical Exchange, June 21-22, 2001.

Subissue #3 - Model Abstraction DOSE 2.3.2

Tracking # DOSE 2.3.2

Comment Sampling from a loguniform distribution between the nominal mass load representing a thin deposit and the average mass load for a thick deposit assumes that the average mass load over the first 10 years following an event is directly proportional to the thickness of the deposit.

References CRWMS M&O. "Input Parameter Values for External and Inhalation Radiation Exposure Analysis." ANL-MGR-MD-000001. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response This item was discussed at the Igneous Activity Technical Exchange meeting (21/22 Jun 01).

Agreement Number

Agreement DOE response during Technical Exchange was considered adequate by the NRC. Igneous Activity Technical Exchange, June 21-22, 2001.

Subissue #3 - Model Abstraction DOSE 2.4.1

Tracking # DOSE 2.4.1

Comment The particle transport model of radionuclide leaching out of the surface soil has not been investigated for its effect on TSPA results.

References CRWMS M&O. "Evaluate Soil/Radionuclide Removal by Erosion and Leaching." ANL-NBS-MD-000009. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response The current approach does not include radionuclide removal from soil by colloidal transport. The model uses the partition coefficient (Kd) to quantify radionuclide removal from top soil by leaching from over watering to avoid salt build up that would affect production efficiency. This approach assumes that only soluble contaminants can be removed by leaching. Suspended solids (colloids) are assumed to remain in the soil where they are available for plant uptake and resuspension and subsequent inhalation. The neglect of an additional loss mechanism is conservative.

Agreement Number

Agreement DOE response during Technical Exchange was considered adequate by the NRC. Total System Performance Assessment and Integration Technical Exchange, August 6-10, 2001.

Subissue #3 - Model Abstraction DOSE 2.5.1

Tracking # DOSE 2.5.1

Comment DOE has not provided support to justify that the mass loading model does not underestimate the concentration of radionuclides in the air.

References CRWMS M&O. "Evaluate Soil/Radionuclide Removal by Erosion and Leaching." ANL-NBS-MD-000009. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response This item was discussed at the Igneous Activity Technical Exchange meeting (21/22 Jun 01).

Agreement Number

Agreement Igneous Activity Technical Exchange, June 21-22, 2001.

Subissue #3 - Model Abstraction DOSE 2.TT.1

Tracking # DOSE 2.TT.1

Comment It is not clear whether these long irrigation periods are realistic, since consideration of factors such as build up of salts, plant toxicity levels, and effect of periods of no irrigation are not documented.

References CRWMS M&O. "Abstraction of BDCF Distributions for Irrigation Periods." ANL-NBS-MD-000007. Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response As noted in responses to DOSE 3.1.4 and 3.2.6, the prior irrigation periods are used as a calculational tool, to ensure that the equilibrium radionuclide concentration in soil is achieved.

The saturated radionuclide concentration in soil is a conservative approach to calculate dose after mitigation erosion (CRWMS M&O 2001q). The method of derivation of irrigation periods is described in detail in the Nominal Performance Biosphere Dose Conversion Factor Analysis Analysis/Model Report (CRWMS M&O 2001h).

References: CRWMS M&O 2001q. Abstraction of BDCF Distributions for Irrigation Periods. ANL-NBS-MD-000007 REV 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20010201.0027.

CRWMS M&O 2001h. Nominal Performance Biosphere DOSE Conversion Factor Analysis. ANL-MGR-MD-000009 REV 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20010123.0123.

Agreement Number

Agreement DOE response during Technical Exchange was considered adequate by the NRC. Total System Performance Assessment and Integration Technical Exchange, August 6-10, 2001.

Subissue #3 - Model Abstraction DOSE 2.TT.2

Tracking # DOSE 2.TT.2

Comment Leaching values for carbon and cesium used in the Disruptive Event Biosphere Dose Conversion Factor AMR (CRWMS M&O, 2000a) are inconsistent with the Evaluate Soil/Radionuclide Removal by Erosion and Leaching AMR (CRWMS M&O, 2000b). The former AMR cites a calculation package instead of the later AMR.

References CRWMS M&O. "Analysis Model Report -- Disruptive Event Biosphere Dose Conversion Factor Analysis." ANL-MGR-MD-000003 Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000a.

CRWMS M&O. "Evaluate Soil/Radionuclide Removal by Erosion and Leaching." ANL-NBS-MD-000009 Revision 00B. Las Vegas, Nevada: CRWMS M&O. 2000b.

DOE Response Disruptive Event Biosphere Dose Conversion Factor Analysis Analysis/Model Report (CRWMS M&O 2000m) used preliminary leaching factors received via input transmittal (DTN SN9912T0512299.001), as noted in Section 4.1 of the report. These values were subsequently revised. Revision 01 of the Disruptive Event Biosphere Dose Conversion Factor Analysis (CRWMS M&O 2001n) uses leaching factors documented in the Evaluate Soil/Radionuclide Removal by Erosion and Leaching Analysis/Model Report (CRWMS M&O 2000r).

References: CRWMS M&O 2000m. Disruptive Event Biosphere Dose Conversion Factor Analysis. ANL-MGR-MD-000003 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20000303.0216.

CRWMS M&O 2001n. Disruptive Event Biosphere Dose Conversion Factor Analysis. ANL-MGR-MD-000003 REV 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20010125.0233.

CRWMS M&O 2000r. Evaluate Soil/Radionuclide Removal by Erosion and Leaching. ANL-NBS-MD-000009 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20000310.0057.

Agreement Number

Agreement DOE response during Technical Exchange was considered adequate by the NRC. Total System Performance Assessment and Integration Technical Exchange, August 6-10, 2001.

Subissue #3 - Model Abstraction DOSE 2.TT.3

Tracking # DOSE 2.TT.3

Comment The dose pathways for direct release scenario are discussed on p. 3-206 in TSPA-SR (CRWMS M&O, 2000). Inhalation and ingestion have been considered, but external exposure from contaminated ash on the ground surface was not listed. TSPA-SR should clearly state whether ground surface exposure was considered.

Note: Same comment as Direct2.TT.1.

References CRWMS M&O. "Total System Performance Assessment for the Site Recommendation." TDR-WIS-PA-000001 Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response Prior irrigation periods are used as a calculational tool to ensure that the equilibrium radionuclide concentration in soil is achieved. The saturated radionuclide concentration in soil is a conservative approach to calculate dose after mitigation erosion (CRWMS M&O 2001q). The method of derivation of irrigation periods is described in detail in the Nominal Performance Biosphere Dose Conversion Factor Analysis (CRWMS M&O 2001h).

External exposure was not considered in the eruption phase dose factors, which are described on page 3-206 (CRWMS M&O 2000ar). These dose factors were not used to calculate doses in the TSPA-Site Recommendation. Instead they were only used in sensitivity studies. Biosphere Dose Conversion Factors for the transition phase used in the TSPA-Site Recommendation analysis for a volcanic eruption included inhalation, ingestion and external exposure.

During the volcanic eruption, only inhalation pathway was considered because for all radionuclides, except 137Cs, external exposure from the ground is insignificant when compared with the inhalation pathway, as can be verified by examining the results of pathway analysis (CRWMS M&O 2001n, Tables 16-20). For the overall external exposure from volcanic eruption, the exposure during the eruption phase (which, on the average, lasts only 8 days) is negligible compared with the exposure during the transition phase. The Biosphere Dose Conversion Factors for the transition phase were calculated for one-year exposure because of the relative duration of these phases. In addition, during the transition phase, 100% of the available activity is already deposited on the ground resulting in the highest external exposure, as opposed to the eruption phase when the deposition is in progress.

The reason that ingestion was included was based on the assumption that the intake of two thirds of the activity (large particles) is through the ingestion pathway. The recent model

considers that the intake of all airborne particles occurs through the inhalation.

Per Igneous Activity 2-15, DOE will clarify that external exposure from high level waste contaminated ash, in addition to inhalation and ingestion was considered in TSPA. DOE will include in the clarification the consideration of external exposure during indoor occupancy times, or provide a basis for dwelling shielding from outdoor gamma emitters in a subsequent revision to the Input Parameter Values for External and Inhalation Radiation Exposure Analysis/Model Report (CRWMS M&O 2000ad) or equivalent document.

References: CRWMS M&O 2001q. Abstraction of BDCF Distributions for Irrigation Periods. ANL-NBS-MD-000007 REV 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20010201.0027.

CRWMS M&O 2001h. Nominal Performance Biosphere Dose Conversion Factor Analysis. ANL-MGR-MD-000009 REV 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20010123.0123.

CRWMS M&O 2000ar. Total System Performance Assessment for the Site Recommendation. TDR-WIS-PA-000001 REV 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001220.0045.

CRWMS M&O 2001n. Disruptive Event Biosphere DOSE Conversion Factor Analysis. ANL-MGR-MD-000003 REV 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20010125.0233.

CRWMS M&O 2000ad. Input Parameter Values for External and Inhalation Radiation Exposure Analysis. ANL-MGR-MD-000001 REV 01 ICN 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001122.0005.

Agreement Number

Agreement DOE response during Technical Exchange was considered adequate by the NRC. Total System Performance Assessment and Integration Technical Exchange, August 6-10, 2001.

Subissue #3 - Model Abstraction DOSE 2.TT.4

Tracking # DOSE 2.TT.4

Comment No reference was provided on p. 3-210 in TSPA-SR (CRWMS M&O, 2000a) to the basis for the assumption that the total suspended particle load is 3 times higher than the mass load.

References CRWMS M&O. "Total System Performance Assessment for the Site Recommendation." TDR-WIS-PA-000001 Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000a.
CRWMS M&O. "Input Parameter Values for External and Inhalation Radiation Exposure Analysis AMR." ANL-MGR-MD-000001 Revision 01 ICN 00. Las Vegas, Nevada: CRWMS M&O. 2000b.

DOE Response The assumption is documented in scoping calculation for the Biosphere Dose Conversion Factors. However, this assumption was not used in the recent version, as explained in DIRECT2.TT.1

Reference: CRWMS M&O 2000av. Scoping Calculation for Volcanic Eruption Biosphere Dose Conversion Factors. CAL-MGR-MD-000003 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20000809.0358.

Agreement Number

Agreement DOE response during Technical Exchange was considered adequate by the NRC. Total System Performance Assessment and Integration Technical Exchange, August 6-10, 2001.

Subissue #3 - Model Abstraction DOSE 3.1.1

Tracking # DOSE 3.1.1

Comment The Disruptive Event Biosphere Dose Conversion Factor Analysis AMR (CRWMS M&O, 2000) does not discuss how the analysis of disruptive event BDCFs would be affected by climate change. Climate change was included in the revised FEP analysis only for the nominal case.

References CRWMS M&O. "Disruptive Event Biosphere Dose Conversion Factor Analysis." ANL-MGR-MD-000003 Revision 00. 2000.

DOE Response This item was discussed at the Igneous Activity Technical Exchange meeting (21/22 Jun 01).

Agreement Number

Agreement DOE response during Technical Exchange was considered adequate by the NRC. Igneous Activity Technical Exchange, June 21-22, 2001.

Subissue #3 - Model Abstraction DOSE 3.1.2

Tracking # DOSE 3.1.2

Comment In Figure 1 of the Non-Disruptive Event Biosphere Dose Conversion Factor Sensitivity Analysis AMR (CRWMS M&O, 2000c), the food transfer factors presented for the reasonable representation are not the same as those used in other reports (CRWMS M&O, 2000a; CRWMS M&O, 2000b). Differences up to a factor of 540 were found.

References CRWMS M&O. "Non-Disruptive Event Biosphere Dose Conversion Factors, Analysis Model Report." ANL-MGR-MD-000009 Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000a.
CRWMS M&O. "Design Basis Event Frequency and Dose Calculation for Site Recommendation." CAL-WHS-SE-000001 Revision 01. Las Vegas, Nevada: CRWMS M&O. 2000b.
CRWMS M&O. "Non-Disruptive Event Biosphere Dose Conversion Factor Sensitivity Analysis AMR. ANL-MGR-MD-000010 Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000c.

DOE Response The difference by a factor of 540 is for carbon, for which an incorrect leaching coefficient was initially developed. This value was used in the Non-Disruptive Event Biosphere Dose Conversion Factor Sensitivity Analysis (CRWMS M&O 2000aj).

Subsequently, the leaching coefficients were revised, which resulted in the change of the value for carbon and other radionuclides. The later reports (e.g., Non-Disruptive Event Biosphere Dose Conversion Factors, Analysis Model Report [CRWMS M&O 2000ai]) used the corrected values, hence the difference.

References: CRWMS M&O 2000aj. Non-Disruptive Event Biosphere Dose Conversion Factor Sensitivity Analysis. ANL-MGR-MD-000010 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20000420.0074.

CRWMS M&O 2000ai. Non-Disruptive Event Biosphere Dose Conversion Factors. ANL-MGR-MD-000009 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20000307.0383.

Agreement Number

Agreement DOE response during Technical Exchange was considered adequate by the NRC. Total System Performance Assessment and Integration Technical Exchange, August 6-10, 2001.

Subissue #3 - Model Abstraction DOSE 3.1.3

Tracking # DOSE 3.1.3

Comment In the Inventory Abstraction AMR (CRWMS M&O, 2000b), the screening arguments for exclusion of a couple of radionuclides in the human intrusion analyses were insufficient.

Example 1:
Insufficient basis was provided to exclude 241Pu. To account for human intrusion as early as 100 yr after the placement of waste, 137Cs, 90Sr, and 63Ni were added to the radionuclides considered for the nominal TSPA-SR analysis. For 10-yr-old, average-pressurized water reactor SNF after 100 yr in the repository (i.e., a total decay time of 110 yr), 137Cs and 90Sr account for the majority of the activity. Although 241Pu can be present in SNF with more activity than the included 63Ni, 241Pu was excluded from the human intrusion scenario.

Example 2:
Insufficient basis was provided to exclude 151Sm. For longer times (~500-1,000 yr), the inventories of 151Sm and 63Ni become more important and their activities remain nearly equal. The inhalation DCF for 151Sm is more than two orders of magnitude larger than for 63Ni, and the ingestion DCF for 151Sm is only slightly less (less than a factor of 1.5 smaller) than that for 63Ni (U.S. Environmental Protection Agency, 1988). Because the inventories of 63Ni and 151Sm tend to be similar during a 1,000-yr period, there appears to be insufficient basis provided to screen out 151Sm and yet consider 63Ni for the human intrusion scenario.

Example 3:
Insufficient basis was provided to exclude the long-lived radionuclide 59Ni. Even for a hypothetical human intrusion event at 100 yr after repository closure, the technical bases for radionuclide screening must be valid for much longer times, associated with the radionuclide travel times to the critical group.

References
CRWMS M&O. "Total System Performance Assessment for the Site Recommendation." TDR-WIS-PA-000001 Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000a.
CRWMS M&O. "Inventory Abstraction AMR." ANL-WIS-MD-000006 Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000b.
U.S. Environmental Protection Agency. "Limiting Values of Radionuclide Intake And Air Concentration and Dose Conversion Factors for Inhalation, Submersion, And Ingestion. Federal Guidance Report 11." EPA-520/1-88-020. Washington, DC: EPA. 1988.

DOE Response The NRC claims insufficient basis for screening 241Pu, 151Sm,

and 59Ni. For 241Pu and 151Sm, the NRC points out that these radioisotopes are potentially more important than 63Ni, which was screened in. However, 63Ni was only mistakenly included in the first iteration of the Inventory Abstraction Analysis/Model Report (CRWMS M&O 2000ae). In ICN 01, 63Ni was correctly screened out (CRWMS M&O 2000bs). Hence, 63Ni cannot be used to argue that other radioisotopes with potentially larger Biosphere DOSE Conversion Factors should be included as well.

The Inventory Abstraction Analysis/Model Report, will be revised to take into account NRC's critique in the Container Life and Source Term IRSR Rev. 3 (NRC 2001); for example, screening factors that account for biological transport will be used for screening radioisotopes in future revisions of the Analysis/Model Report. With this and other modifications, perhaps 241Pu, 151Sm, and 59Ni will be found to be important; however, if past analysis can be used as a guide, 241Pu, 151Sm, and 59Ni were included in TSPA-93 and TSPA-95 (Leigh and Rechard 2001) and found to be unimportant.

References: CRWMS M&O 2000ae. Inventory Abstraction. ANL-WIS-MD-000006 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20000414.0643.

CRWMS M&O 2000bs. Inventory Abstraction. ANL-WIS-MD-000006 REV 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001130.0002.

BSC 2001i. Inventory Abstraction. ANL-WIS-MD-000006 REV 00 ICN 02. Las Vegas, Nevada: Bechtel SAIC Company. ACC: MOL.20010416.0088.

NRC 2001. Issue Resolution Status Report Key Technical Issue: Container Life and Source Term. Rev. 3. Washington, D.C.: U.S. Nuclear Regulatory Commission. ACC: MOL.20010418.0048.

Leigh, C. and Rechard, R.P.. "Radioisotope Inventory for TSPA-SR", Proceedings of the 9th International High-Level Radioactive Waste Management Conference (IHLRWM), April 29-May 3, 2001, Alexis Park Resort, Las Vegas, Nevada. La Grange, Illinois: American Nuclear Society. ACC: MOL.20010313.0012.

Agreement Number

Agreement DOE response during Technical Exchange was considered adequate by the NRC. Total System Performance Assessment and Integration Technical Exchange, August 6-10, 2001.

Subissue #3 - Model Abstraction DOSE 3.1.4

Tracking # DOSE 3.1.4

Comment The prior irrigation times contained within the referenced document (CRWMS M&O, 1999) were inconsistent with those used in the Non-Disruptive Event Biosphere Dose Conversion Factors AMR. For both the reasonable and bounding representations, the Input Request for Biosphere Dose Conversion Factors (BDCFs) to be Used in the TSPA-SR listed prior irrigation times for elements (Cs, Ni, Sr, and Mo) not contained within the AMR, and the AMR analyzed elements (Am, Ac, and Th) not contained within the referenced document. For those elements contained within both documents, the prior irrigation times for the reasonable representation did not agree for Pu-240, and the prior irrigation times for the bounding representation did not agree for C-14, U-232, Pu-238, Pu-239, and Pu-240.

References Review of: Non-Disruptive Event Biosphere Dose Conversion Factors AMR (ANL-MGR-MD-000009 Revision 00)
CRWMS M&O. 1999. Input Request for Biosphere Dose Conversion Factors (BDCFs) to be Used in the TSPA-SR (Input Tracking Number PA-R&E-99251.R, ACC: MOL.19990819.0070.

DOE Response The prior irrigation times from the Dose Conversion Factors used in the TSPA-Site Recommendation input transmittal were calculated based on leaching coefficients only, while those used in the Non-Disruptive Event Biosphere Dose Conversion Factors Analysis/Model Report (CRWMS M&O 2000ai) included radionuclide decay.

Although prior irrigation periods are not site nor receptor specific inputs, they are parametric tools used in the Biosphere Dose Conversion Factor abstraction to incorporate soil removal by erosion (with a characteristic time of a few hundred years). The final Biosphere Dose Conversion Factor abstraction does not depend on which specific irrigation periods were used, as long as the trend in the Biosphere Dose Conversion Factor behavior with the duration of the prior irrigation can be observed. Therefore, the lack of agreement pointed out by the reviewer has no effect on the Biosphere Dose Conversion Factor values.

The revised Section 6.3.2 in the Nominal Performance Biosphere Dose Conversion Factor Analysis (CRWMS M&O 2001h) addresses the derivation of the prior irrigation periods.

References: CRWMS M&O 2000ai. Non-Disruptive Event Biosphere Dose Conversion Factors. ANL-MGR-MD-000009 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20000307.0383.

CRWMS M&O 2001q. Abstraction of BDCF Distributions for Irrigation Periods. ANL-NBS-MD-000007 REV 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20010201.0027.

CRWMS M&O 2001h. Nominal Performance Biosphere Dose Conversion Factor Analysis. ANL-MGR-MD-000009 REV 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20010123.0123.

CRWMS M&O 1999d. Input Request for Biosphere Dose Conversion Factors (BDCFs) to be Used in the Total System Performance Assessment for Site Recommendation. Input Request PA-R&E-99251.R. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19990819.0070.

Agreement Number

Agreement DOE response during Technical Exchange was considered adequate by the NRC. Total System Performance Assessment and Integration Technical Exchange, August 6-10, 2001.

Subissue #3 - Model Abstraction DOSE 3.1.5

Tracking # DOSE 3.1.5

Comment In the example pathway contribution for Am-243 on page II-8 of the Non-Disruptive Event Biosphere Dose Conversion Factor Sensitivity Analysis AMR (CRWMS M&O, 2000; Figure 3 of Attachment II) were substantially different to those for Am-243 contained in the Attachment I compact disc file, /Ndesden_5/Pathway/Ndepat_6.xls.

References CRWMS M&O. "Non-Disruptive Event Biosphere Dose Conversion Factor Sensitivity Analysis AMR." ANL-MGR-MD-000010 Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response The purpose of the example presented in Attachment II (CRWMS M&O 2000aj) was to show the mechanics of the pathway calculations using a spreadsheet routine. This specific example used the data from Disruptive Event Biosphere Dose Conversion Factor Sensitivity Analysis (CRWMS M&O 2000bt), hence the difference. Although DOE agrees that the data from the report in question could have been used, the purpose of the attachment was not compromised by using some other numerical values.

References: CRWMS M&O 2000aj. Non-Disruptive Event Biosphere Dose Conversion Factor Sensitivity Analysis. ANL-MGR-MD-000010 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20000420.0074.

CRWMS M&O 2000bt. Disruptive Event Biosphere Dose Conversion Factor Sensitivity Analysis. ANL-MGR-MD-000004 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20000418.0826.

Agreement Number

Agreement DOE response during Technical Exchange was considered adequate by the NRC. Total System Performance Assessment and Integration Technical Exchange, August 6-10, 2001.

Subissue #3 - Model Abstraction DOSE 3.2.1

Tracking # DOSE 3.2.1

Comment DOE selection criteria for parameters includes selection based on the appearance of a parameter in more than half of the documents reviewed. DOE interprets this to represent consensus among the scientific community that the parameter is the best available data. This selection criteria is subject to manipulation and/or bias based on the initial selection and number of reviewed reports. The approach has no technical basis when the reason for frequent selection/use by the referenced reports is not known or provided.

References CRWMS M&O. " Environmental Transport Analysis." ANL-MGR-MD-000007 Revision 00. Las Vegas, Nevada: CRWMS M&O. 1999a.
CRWMS M&O. "Transfer Coefficient Analysis." ANL-MGR-MD-000008 Revision 00 ICN 1. Las Vegas, Nevada: CRWMS M&O. 1999b.

DOE Response The selection criteria include several items, not just one "more than half" as indicated in the comments. Due to lack of site-specific data, generic data were used. All data were initially selected to be applicable to the Yucca Mountain biosphere model. The cited data were all from reputable sources, including NRC Guidance (Regulatory Guide, and NUREG/CR), National Labs' reports (Oak Ridge, PNL, Sandia, Argonne, and EPRI), and international sources (IAEA and AECL). The documents provide the comprehensive reviews of related parameters and/or completed radiation DOSE assessment. To refine the initially selected data, the selection criteria were created and used.

The bases for parameter selections were included in the referenced documents. Because the parameter values were selected using compilations of data produced by reputable organizations, the original technical reports were not evaluated from the perspective of their technical merits. Instead, data selection was invoked based on the premise that the technical evaluation had been performed by the data compilers. Where possible, the parameter values were selected such that they were applicable to the environmental conditions at Yucca Mountain region, such as the soil type and pH. If such specific values were unavailable, generic ones were used.

References: CRWMS M&O 1999b. Environmental Transport Parameters Analysis. ANL-MGR-MD-000007 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19991115.0238.

CRWMS M&O 1999e. Transfer Coefficient Analysis. ANL-MGR-MD-000008 REV 00 ICN 1. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20000413.0692.

Subissue #3 - Model Abstraction DOSE 3.2.1

Agreement Number TSPAI.3.34

Agreement For the radionuclides that dominate the TSPA dose, DOE will provide the technical basis for selection of radionuclide or element specific biosphere parameters (except for Kds which are addressed in TSPAI 3.33) that are important in the BDCF calculations (e.g. soil to plant transfer factors). The technical basis will be documented in the Transfer Coefficient Analysis AMR (ANL-MGR-MD-000008) or other document and is expected to be available to NRC in FY 2003.

Subissue #3 - Model Abstraction DOSE 3.2.2

Tracking # DOSE 3.2.2

Comment Rationale for not using site specific studies for transfer coefficients that data have not been collected and is expensive/time consuming appears to ignore EPA research on the Nevada Test Site and possibility to show relevance of the few important coefficients using available information.

References CRWMS M&O. "Transfer Coefficient Analysis." ANL-MGR-MD-000008 Revision 00 ICN 1. Las Vegas, Nevada: CRWMS M&O. 1999.

DOE Response The Environmental Protection Agency research on the Nevada Test Site was not available to the author when the report was written. Procedurally, cited literature must be publicly available, as these documents may be in the public reading room. However, the applicability of the research will be reviewed in future and will be documented in a subsequent revision of the Analysis Model Report -- Transfer Coefficient Analysis (CRWMS MYO 1999e).

Reference: CRWMS M&O 1999e. Transfer Coefficient Analysis. ANL-MGR-MD-000008 REV 00 ICN 1. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20000413.0692.

Agreement Number

Agreement DOE response during Technical Exchange was considered adequate by the NRC. Total System Performance Assessment and Integration Technical Exchange, August 6-10, 2001.

Subissue #3 - Model Abstraction DOSE 3.2.3

Tracking # DOSE 3.2.3

Comment The AMR Transfer Coefficient Analysis (CRWMS M&O, 1999a) incorrectly states an NRC contractor report reflects the NRC position. Example: Justification for use of GENII-S code inappropriately includes CNWRA use. The depth and types of analyses conducted to prepare for review of a license application (e.g., CNWRA use) are different than what may be required to support a license application.

References CRWMS M&O. "Transfer Coefficient Analysis." ANL-MGR-MD-000008 Revision 00 ICN 1. Las Vegas, Nevada: CRWMS M&O. 1999a.
CRWMS M&O. "Environmental Transport Analysis." ANL-MGR-MD-000007 Revision 00. Las Vegas, Nevada: CRWMS M&O. 1999b.

DOE Response The incorrect statements have been removed from the latest revisions to these documents, and will not be used in the future.

References: CRWMS M&O 2000bu. Transfer Coefficient Analysis. ANL-MGR-MD-000008 REV 00 ICN 02. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001016.0005.

CRWMS M&O 2001r. Environmental Transport Parameter Analysis. ANL-MGR-MD-000007 REV 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20010208.0001.

Agreement Number

Agreement DOE response during Technical Exchange was considered adequate by the NRC. Total System Performance Assessment and Integration Technical Exchange, August 6-10, 2001.

Subissue #3 - Model Abstraction DOSE 3.2.4

Tracking # DOSE 3.2.4

Comment The selected value for inhalation exposure time is based on average value for U. S. citizens age 18 to 64. No rationale is provided for excluding adults over age 64. It also appears possible that the average member of a farming community would spend more time outdoors than the average American.

References CRWMS M&O. "Input Parameter Values for External and Inhalation Radiation Exposure Analysis." ANL-MGR-MD-000001. Las Vegas, Nevada: CRWMS M&O. 1999.

DOE Response Inhalation exposure time was based primarily on the assumed occupation (farming) of the critical group members. Their work-related inhalation exposure time amounted to 2000 - 3,120 hours per year and was unrelated to age. The recreational component of the inhalation exposure time (827 hours per year) was based on the results of a nation-wide survey for adults 18-64 years old. Recreational exposure time for people older than 64 years is about 3% higher than that for those in the 18-64 years age bracket. Considering that people 18-64 years old account for 61.8 % of the US population, while people older than 64 years old constitute 12.7% of the population (KiplingersForecasts.com), inclusion of people over 64 would only result in the 0.6% increase in the recreational exposure time. Considering that the recreational exposure time accounts for less than 25% of the total time spent outdoors, the effect of including recreational exposure time of people over 64 years old would result in a negligible increase (about 0.04%) in the mean inhalation exposure time for the critical group.

The critical group is composed of farmers, who because of the nature of their work, spend more time outdoors (CRWMS M&O 2000ad, Sections 6.2 and 6.4) than an average American and more than the average Amargosa Valley resident.

Reference: CRWMS M&O 2000ad. Input Parameter Values for External and Inhalation Radiation Exposure Analysis. ANL-MGR-MD-000001 REV 01 ICN 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001122.0005.

Agreement Number

Agreement DOE response during Technical Exchange was considered adequate by the NRC. Total System Performance Assessment and Integration Technical Exchange, August 6-10, 2001.

Subissue #3 - Model Abstraction DOSE 3.2.5

Tracking # DOSE 3.2.5

Comment Applicability of beryllium data for determination of crop interception fraction for all radionuclides was not sufficiently discussed in the Identification of Ingestion Exposure Parameters AMR (CRWMS M&O, 2000a). Although based on beryllium, a single distribution for the crop interception fraction would be applied for all radionuclides. The analysis included a comparison between the interception fractions of iodine and beryllium, but further justification is needed to ensure that the interception fractions for beryllium will not likely be exceeded for other radionuclides. The crop interception fraction has been shown to be a significant parameter for most of the radionuclides considered in the sensitivity analyses for non-disruptive events (CRWMS M&O. 2000b).

References CRWMS M&O. " Identification of Ingestion Exposure Parameters AMR." ANL-MGR-MD-000006 Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000a.
CRWMS M&O."Non-Disruptive Event Biosphere Dose Conversion Factor Sensitivity Analysis." ANL-MGR-MD-000010 Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000b.

DOE Response The crop interception fraction was derived based on a series of studies done by the Hoffman et al. The experiment was conducted using two radionuclides, Be-7 and I-131. However, the type of radionuclide used in this study, was less significant than the ionization of the atoms. In this study beryllium was in form of cations (positive ions, +2) while iodine was in form of anions (negative ions, -1).

The study established the empirical equation to estimate the crop interception fraction, which depends on crop type, crop yield, irrigation methods, irrigation rate, and the type of ions present in the water. The study showed that interception is higher for cations than anions, due to the mainly negative charge on leaf surface.

Most radionuclides in groundwater form various complexes and their molecules are either positively (cations) or negatively (anions) charged. Because of the negative charge on the leaves, the interception fraction for the negative beryllium ion is assumed to serve as a conservative estimate of the interception fraction for other radionuclides of interest. In addition, small molecules, like those of beryllium, will tend to stick better to leaf surfaces than large molecules, such as NpO2+.

References: Hoffman, F.O.; Frank, M.L.; Blaylock, B.G.; von Bernuth, R.D.; Deming, E.J.; Graham, R.V.; Mohrbacher, D.A.; and Waters, A.E. 1989. Pasture Grass Interception and Retention of

(131) I, (7)BE, and Insoluble Microspheres Deposited in Rain. ORNL-6542. Oak Ridge, Tennessee: Oak Ridge National Laboratory. TIC: 237241.

Hoffman, F.O.; Thiessen, K.M.; and Rael, R.M. 1995. "Comparison of Interception and Initial Retention of Wet-Deposited Contaminants on Leaves of Different Vegetation Types." Atmospheric Environment, 29, (15), 1771-1775. New York, New York: Pergamon Press. TIC: 243593.

Hoffman, F.O.; Thiessen, K.M.; Frank, M.L.; and Blaylock, B.G. 1992. "Quantification of the Interception and Initial Retention of Radioactive Contaminants Deposited on Pasture Grass by Simulated Rain." Atmospheric Environment, 26A, (18), 3313-3321. New York, New York: Pergamon Press. TIC: 243594.

Agreement Number TSPAI.3.35

Agreement DOE will provide additional justification to support that the assumed crop interception fraction is appropriate for all radionuclides that dominate the TSPA dose and does not result in underestimations of dose. The justification will include the impacts of electrostatic charge and particle size on the interception fraction. This justification will be documented in Identification of Ingestion Exposure Parameters (ANL-MGR-MD-000006) or other document expected to be available to NRC in FY 2003.

Subissue #3 - Model Abstraction DOSE 3.2.6

Tracking # DOSE 3.2.6

Comment While other parameters are assigned distributions that are sampled or fixed values, the prior irrigation time parameter has been grouped into six periods in the Non-Disruptive Event Biosphere Dose Conversion Factors AMR. For a given period (except for period 1 where a prior irrigation time of 0 yr was assigned for all radionuclides), different values of prior irrigation time were assigned to individual radionuclides.

References CRWMS M&O. "Non-Disruptive Event Biosphere Dose Conversion Factors AMR." ANL-MGR-MD-000009 Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response As noted in the DOSE 3.1.4 response, the prior irrigation time periods are used as a calculational tool to determine the equilibrium Biosphere Dose Conversion Factor values (CRWMS M&O 2001q; CRWMS M&O 2001s). The exact numerical value is not required as long as they cover most of the period during which activity in soil builds up until the equilibrium conditions (steady-state) are reached. The time periods necessary for the equilibrium in soil to be achieved are different for different radionuclides. It is about a single year for mobile radionuclides such as technetium-99, and on the order of thousands of years, for the isotopes of thorium, if soil erosion is not considered. In the build-up analysis (CRWMS M&O 2001q) erosion has been considered.

Section 6.3.2 of the Nominal Performance Biosphere Dose Conversion Factor Analysis (CRWMS M&O 2001h) addresses the derivation of the prior irrigation periods.

References: CRWMS M&O 2001q. Abstraction of BDCF Distributions for Irrigation Periods. ANL-NBS-MD-000007 REV 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20010201.0027.

CRWMS M&O 2001s. Distribution Fitting to the Stochastic BDCF Data. ANL-NBS-MD-000008 REV 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20010221.0148.

CRWMS M&O 2001h. Nominal Performance Biosphere Dose Conversion Factor Analysis. ANL-MGR-MD-000009 REV 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20010123.0123.

Agreement Number

Agreement DOE response during Technical Exchange was considered adequate by the NRC. Total System Performance Assessment and Integration Technical Exchange, August 6-10, 2001.

Subissue #3 - Model Abstraction DOSE 3.2.7

Tracking # DOSE 3.2.7

Comment The Non-Disruptive Event Biosphere Dose Conversion Factors AMR (CRWMS M&O, 2000a) provides the supporting data for the Non-Disruptive Event Biosphere Dose Conversion Factor Sensitivity Analysis AMR (CRWMS M&O, 2000b). However, the Non-Disruptive Event Biosphere Dose Conversion Factor Sensitivity Analysis AMR included two radionuclides, 90Sr and 137Cs, which were not included in the Non-Disruptive Event Biosphere Dose Conversion Factors AMR.

References CRWMS M&O. "Non-Disruptive Event Biosphere Dose Conversion Factors AMR." ANL-MGR-MD-000009 Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000a.
CRWMS M&O. "Non-Disruptive Event Biosphere Dose Conversion Factor Sensitivity Analysis AMR." ANL-MGR-MD-000010 Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000b.

DOE Response The two radionuclides cited were identified too late to be included in the referenced Analysis/Model Report. REV 00 of the Analysis/Model Report (CRWMS M&O 2000ai) concerned the nominal scenario, while the two additional radionuclides were considered for human intrusion. The Biosphere Dose Conversion Factors were generated in a calculation but were available for the sensitivity study as documented in the Non-Disruptive Event Biosphere DOSE Conversion Factor Sensitivity Analysis Analysis/Model Report (CRWMS M&O 2000aj).

These two relatively short-lived radionuclides were added after the Non-Disruptive Event Biosphere DOSE Conversion Factors Analysis/Model Report (CRWMS M&O 2000ai) was completed. Calculation of the Biosphere Dose Conversion Factors for 90Sr and 137Cs is documented in the calculation report (CRWMS M&O 2000bv). The Non-Disruptive Event Biosphere DOSE Conversion Factor Sensitivity Analysis Analysis/Model Report (CRWMS M&O 2000aj) applies the Biosphere Dose Conversion Factors developed in both reports.

References: CRWMS M&O 2000aj. Non-Disruptive Event Biosphere Dose Conversion Factor Sensitivity Analysis. ANL-MGR-MD-000010 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20000420.0074.

CRWMS M&O 2000ai. Non-Disruptive Event Biosphere Dose Conversion Factors. ANL-MGR-MD-000009 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20000307.0383.

CRWMS M&O 2000bv. Biosphere Dose Conversion Factors for Reasonably Maximally Exposed Individual and Average Member of

Critical Group. CAL-MGR-MD-000002 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20000306.0251.

Agreement Number

Agreement DOE response during Technical Exchange was considered adequate by the NRC. Total System Performance Assessment and Integration Technical Exchange, August 6-10, 2001.

Subissue #3 - Model Abstraction DOSE 3.3.1

Tracking # DOSE 3.3.1

Comment Uncertainty in Soil leaching factors supplied to GENII-S code is accounted for by running a reasonable case (probabilistic) and a bounding case (deterministic). The AMR is unclear as to how the uncertainty is accounted for in the TSPA modeling to fully account for data uncertainty.

References CRWMS M&O. "Disruptive Event Biosphere Dose Conversion Factor Analysis." ANL-MGR-MD-000003 Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response Uncertainty in soil leaching has not been accounted for in the TSPA-Site Recommendation analyses. Additional evaluation of the uncertainty resulting from using a fixed value of leaching coefficient is presented in Section 13.3.4 in the Supplemental Science and Performance Analysis, Vol.1 (BSC 2001e).

The bounding case was not used as compounded conservatism assumptions provided unrealistically large Biosphere Dose Conversion Factors. Volume 1 contains a sensitivity study of this parametric uncertainty in leaching. GENII-S cannot sample from the leaching parameter. A more integrated model that will allow stochastic sampling from the available Kd distributions is being proposed for any potential License Application.

Reference: BSC 2001e. FY01 Supplemental Science and Performance Analyses, Volume 1: Scientific Bases and Analyses. TDR-MGR-MD-000007 REV 00. Las Vegas, Nevada: Bechtel SAIC Company. ACC: MOL.20010712.0062.

Agreement Number TSPAI.3.36

Agreement DOE will document the methodology used to incorporate the uncertainty in soil leaching factors into the TSPA analysis. This will be documented in Nominal Performance Biosphere Dose Conversion Factor Analysis AMR (ANL-MGR-MD-000009), Disruptive Event Biosphere Dose Conversion Factor Analysis (ANL-MGR-MD-000003) or other document expected to be available to NRC in FY 2003.

Subissue #3 - Model Abstraction DOSE 3.4.1

Tracking # DOSE 3.4.1

Comment The approach used to propagate uncertainty in BDCFs for the biosphere abstraction in the TSPA SR model introduces unnatural correlation (e.g.,samples from radionuclie-specific BDCF distributions are correlated to the Np-237 BDCF distribution and no justification for this approach is provided). Biosphere factors that influence the magnitude of BDCFs vary by radionuclide and the justification for the selected approach is not self evident. Failure to maintain vectors from initial GENII-S BDCF modeling leads to inconsistencies in sampled biosphere/critical group parameters across radionuclides when resampling in TSPA SR model.

References CRWMS M&O. "Total System Performance Assessment Model for Site Recommendation." TDR-WIS-PA-000002. Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000aq. (p. 439).

DOE Response GENII-S is unable to consider the correlation between the equivalent parameters for multiple radionuclides. It also cannot track the results of such correlation.

Most of the time, there is only one dominant radionuclide in which case correlation has no effect. For the limited time where there are two or more radionuclides contributing to dose, the Biosphere Dose Conversion Factor correlation is assumed to be unity (Rn#1 to Np to Rn#2). A distribution of dose with the correct mean value is obtained. The distribution is wider than it would have been if the correlation had been less than unity.

Agreement Number TSPAI.3.37

Agreement DOE will provide a quantitative analysis that the sampling method including the correlations between BDCFs utilized by the TSPA code to abstract the GENII-S process model data adequately represent the uncertainty and variability and correlations for the biosphere process model. This will be documented in Nominal Performance Biosphere Dose Conversion Factor Analysis AMR, ANL-MGR-MD-000009, Disruptive Event Biosphere Dose Conversion Factor Analysis, ANL-MGR-MD-000003, or other document expected to be available to NRC in FY 2003. Results of these analyses will be documented in the TSPA for any potential license application expected to be available to NRC in FY 2003.

Subissue #3 - Model Abstraction DOSE 3.5.1

Tracking # DOSE 3.5.1

Comment It is unclear how DOE will show that GENII-S is a valid model for the Yucca Mountain system.The AMR includes a comprehensive description of other AMRs that rely on the GENII-S code and also identifies AMRs that provided input to the validation analysis. The validation of GENII-S focuses on investigation the bases for the conceptual model and verifying that the mathematical model is performing as intended, but no discussion is provided of the scientific bases for the mathematical model.

References CRWMS M&O. " Abstraction of BDCF Distributions for Irrigation Periods." ANL-NBS-MD-000007. Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000.

CRWMS M&O. "Evaluation of the Applicability of Biosphere Related Features, Events, and Processes." ANL-MGR-MD-00001. Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response Biosphere model validation is presented as attachments to Disruptive Event Biosphere Dose Conversion Factor Analysis (CRWMS M&O 2001n) and Nominal Performance Biosphere DOSE Conversion Factor Analysis (CRWMS M&O 2001h). Additional model validation is in progress in accordance with the model validation corrective action report.

References: CRWMS M&O 2001n. Disruptive Event Biosphere Dose Conversion Factor Analysis. ANL-MGR-MD-000003 REV 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20010125.0233.

CRWMS M&O 2001h. Nominal Performance Biosphere DOSE Conversion Factor Analysis. ANL-MGR-MD-000009 REV 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20010123.0123.

Agreement Number

Agreement DOE response during Technical Exchange was considered adequate by the NRC. Total System Performance Assessment and Integration Technical Exchange, August 6-10, 2001.

Subissue #3 - Model Abstraction DOSE 3.TT.1

Tracking # DOSE 3.TT.1

Comment The AMR references supporting AMRs. The AMR does not identify where generated data will be used, but does indicate that the output will be used to develop BDCFs.

References CRWMS M&O. "Identification of the Critical Group (Consumption of Locally Produced Food and Tap Water)". ANL-MGR-MD-000005. Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response Procedurally, Analysis/Model Reports must cite the source of all data used. The Data Tracking Number of the data generated is identified. Any user requiring the data generated can get the data from the Technical Data Management System by the Data Tracking Number.

Regarding the biosphere modeling, the Biosphere Process Model Report (CRWMS M&O 2000bw) described relationship between the Analysis/Model Reports contributing to the final output of the model. Note that the Process Model Report shows the interrelationship of input and outputs of applicable Analysis/Model Reports.

Reference: CRWMS M&O 2000bw. Biosphere Process Model Report. TDR-MGR-MD-000002 REV 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20000620.0341.

Agreement Number

Agreement DOE response during Technical Exchange was considered adequate by the NRC. Total System Performance Assessment and Integration Technical Exchange, August 6-10, 2001.

Subissue #3 - Model Abstraction DOSE 3.TT.2

Tracking # DOSE 3.TT.2

Comment More references should be made to other documents that contain related analyses. Irrigation with contaminated ground water is the only deposition process considered in this AMR. The ingestion analyses within this AMR did not include root uptake. Neither deposition from airborne releases nor effluents from preclosure operations nor ash deposition and remobilization were addressed in this AMR. It would be helpful if the appropriate documents that account for these processes and factors be referenced within this AMR. In addition, it appears that food washing and crop retention fraction after food washing has not been sufficiently discussed in this AMR.

References CRWMS M&O. "Identification of Ingestion Exposure Parameters." ANL-MGR-MD-000006. Revision 00. Las Vegas, Nevada: CRWMS M&O 2000.

DOE Response The Identification of Ingestion Exposure Parameters Analysis/Model Report has a very limited scope. This Analysis/Model Report is one of many that develop input parameters for the biosphere model implementing code, GENII-S. It does not, in itself document any analyses of radionuclide transport to plants. Parameters for the root uptake were developed in another model input, Transfer Coefficient Analysis. Input parameters related to retention fraction for various crops are documented in another the Environmental Transport Analysis. The model uses many different parameters, which are documented in several input Analysis/Model Reports.

Food processing, which results in removal of radionuclides from edible parts of crops, was not included in the biosphere model. This is a conservative approach. GENII-S does not allow the user to include food processing.

Biosphere Process Model Report (CRWMS M&O 2000bw) explains the relationship between and scope of work for each Analysis/Model Report.

Deposition of radionuclides from the preclosure operations is outside the scope of the postclosure analysis.

The issues of ash deposition and remobilization were addressed at the Igneous Activity Technical Exchange 21/22 June 2001.

References: CRWMS M&O 2000bw. Biosphere Process Model Report. TDR-MGR-MD-000002 REV 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20000620.0341.

CRWMS M&O 2000y. Identification of Ingestion Exposure Parameters. ANL-MGR-MD-000006 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20000216.0104.

CRWMS M&O 2000bu. Transfer Coefficient Analysis. ANL-MGR-MD-000008 REV 00 ICN 02. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001016.0005.

CRWMS M&O 2001r. Environmental Transport Parameter Analysis. ANL-MGR-MD-000007 REV 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20010208.0001.

Agreement Number

Agreement DOE response during Technical Exchange was considered adequate by the NRC. Total System Performance Assessment and Integration Technical Exchange, August 6-10, 2001.

Subissue #3 - Model Abstraction DOSE 3.TT.3

Tracking # DOSE 3.TT.3

Comment This AMR concludes with a summary tabulation consisting of BDCFs for each radionuclide and prior irrigation time, but it is unclear how the information from the six prior irrigation periods will be used in the total system performance analyses.

References CRWMS M&O. "Non-Disruptive Event Biosphere Dose Conversion Factors." ANL-MGR-MD-000009. Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response Information developed in the Non-Disruptive Event Biosphere Dose Conversion Factors Analysis/Model Report (CRWMS M&O 2000ai) was not used directly in the TSPA. The Biosphere Dose Conversion Factors used in TSPA are documented in the Distribution Fitting to the Stochastic BDCF Data (CRWMS M&O 2001s) and the Abstraction of BDCF Distributions for Irrigation Periods (CRWMS M&O 2001q).

References: CRWMS M&O 2000ai. Non-Disruptive Event Biosphere Dose Conversion Factors. ANL-MGR-MD-000009 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20000307.0383.

CRWMS M&O 2001s. Distribution Fitting to the Stochastic BDCF Data. ANL-NBS-MD-000008 REV 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20010221.0148.

CRWMS M&O 2001q. Abstraction of BDCF Distributions for Irrigation Periods. ANL-NBS-MD-000007 REV 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20010201.0027.

Agreement Number

Agreement DOE response during Technical Exchange was considered adequate by the NRC. Total System Performance Assessment and Integration Technical Exchange, August 6-10, 2001.

Subissue #3 - Model Abstraction DOSE 3.TT.4

Tracking # DOSE 3.TT.4

Comment Improvements should be made in the documentation of data acquisition and traceability.

References CRWMS M&O. "Abstraction of BDCF Distributions for Irrigation Periods." ANL-NBS-MD-000007. Revision 00. 2000.

DOE Response Biosphere Process Model Report (CRWMS M&O 2000bw) explains the relationship between Analysis/Model Reports, and scope of work for each Analysis/Model Report in which a well-defined analysis or model is presented. It is redundant to explain them in each individual supporting Analysis/Model Report.

Reference: CRWMS M&O 2000bw. Biosphere Process Model Report. TDR-MGR-MD-000002 REV 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20000620.0341.

Agreement Number

Agreement DOE response during Technical Exchange was considered adequate by the NRC. Total System Performance Assessment and Integration Technical Exchange, August 6-10, 2001.

Subissue #3 - Model Abstraction DOSE 3.TT.5

Tracking # DOSE 3.TT.5

Comment The AMR states that no assumptions were used for the analysis, yet numerous assumptions, implicit or otherwise, are made throughout the report. Some example assumptions include: (i) that parameter value selections made from literature sources or GENII-S default values are appropriate for the Yucca Mountain region, (ii) that fraction of roots in upper soil is one, and (iii) that 1/2 of forage is stored and 1/2 of forage is fresh for beef and dairy cattle consumption.

References CRWMS M&O. "Environmental Transport Analysis." ANL-MGR-MD-000007. Las Vegas, Nevada: CRWMS M&O. 1999.

DOE Response In a subsequent revision of the Analysis/Model Report, Environmental Transport Analysis, DOE will ensure that all major assumptions are listed in the Assumption section In addition, DOE will cite where the assumptions are documented and used.

Reference: CRWMS M&O 1999b. Environmental Transport Parameters Analysis. ANL-MGR-MD-000007 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19991115.0238.

Agreement Number

Agreement DOE response during Technical Exchange was considered adequate by the NRC. Total System Performance Assessment and Integration Technical Exchange, August 6-10, 2001.

Subissue #3 - Model Abstraction DOSE 3.TT.6

Tracking # DOSE 3.TT.6

Comment AMR is unclear how soil to plant transfer factors were combined when a food group value was needed yet the source data applied to a number of specific crops (e.g., arithmetic or geometric mean etc). AMR is also unclear how it was determined which plants were most likely to be planted in a farmers garden. The AMR states fish is not an important pathway w/ no justification or reference to support.

References CRWMS M&O. "Transfer Coefficient Analysis." ANL-MGR-MD-000008. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 1999.

DOE Response The initially selected transfer coefficients were based on the reputable sources, including NRC Guidance (Regulatory Guide, and NUREG/CR), National Lab's reports (Oak Ridge, PNL, Sandia, Argonne, and EPRI), and international sources (IAEA and AECL).

The documents provide the comprehensive reviews of related parameters and/or completed radiation dose assessment.

There were no specific crops for each group data, and no specific information on crop grown in the farmer garden.

The process of the transfer factor selection, and grouping is documented in Transfer Coefficient Analysis (CRWMS M&O 1999e, 2000bu).

Ingestion of fish was included in REV 01 of the Nominal Performance Biosphere Dose Conversion Factor Analysis (CRWMS M&O 2001h) and it turned out to be a significant pathway for carbon-14.

References: CRWMS M&O 1999e. Transfer Coefficient Analysis. ANL-MGR-MD-000008 REV 00 ICN 1. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20000413.0692.

CRWMS M&O 2000bu. Transfer Coefficient Analysis. ANL-MGR-MD-000008 REV 00 ICN 02. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001016.0005.

CRWMS M&O 2001h. Nominal Performance Biosphere Dose Conversion Factor Analysis. ANL-MGR-MD-000009 REV 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20010123.0123.

Agreement Number

Agreement DOE response during Technical Exchange was considered adequate by the NRC. Total System Performance Assessment and

Subissue #3 - Model Abstraction DOSE 3.TT.7

Tracking # DOSE 3.TT.7

Comment AMR ambiguously defines conservatism as "...a value that would lead to a higher dose."

References CRWMS M&O. "Transfer Coefficient Analysis." ANL-MGR-MD-000008. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 1999.

DOE Response The Analysis/Model Report definition of conservatism will be clarified in the next.

Reference: CRWMS M&O 1999e. Transfer Coefficient Analysis. ANL-MGR-MD-000008 REV 00 ICN 1. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20000413.0692.

Agreement Number

Agreement DOE response during Technical Exchange was considered adequate by the NRC. Total System Performance Assessment and Integration Technical Exchange, August 6-10, 2001.

Subissue #3 - Model Abstraction DOSE 3.TT.8

Tracking # DOSE 3.TT.8

Comment Some areas in this AMR were unclear.
Example 1: The AMR is unclear on how "period of prior irrigation" values were derived for the analysis. The AMR states that the parameters were based on the soil leaching factor and half life but provides no additional information. No explanation is provided why this parameter varies by radionuclide.
Example 2: The AMR includes an assumption that model, mathematical model, numerical solution, and computer model uncertainty is negligible and cites a code validation exercise in another AMR (Non-disruptive Event BDCF) as the basis. The cited AMR does not contain the referenced model validation analysis results nor provides any indication on where to find it.

References CRWMS M&O. "Distribution Fitting to the Stochastic BDCF Data." ANL-NBS-MD-000008. Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response For Example 1 in cited the Analysis/Model Report (CRWMS M&O 2000n), these values are simply input data. The Analysis/Model Report Rev 01 (CRWMS M&O 2001h) documenting Biosphere Dose Conversion Factor generation, discusses this period selection. The prior irrigation time was calculated in Biosphere Dose Conversion Factor Analysis/Model Report (CRWMS M&O 2000ai). The data provided as input for each radionuclide consisted of a set of 150 stochastic realization. The distribution of the data was assumed to capture uncertainties in the data generation process.

The Nominal Performance Biosphere Dose Conversion Factor Analysis (CRWMS M&O 2001h, Section 6.3.2) addresses the derivation of the prior irrigation periods.

For Example 2, biosphere model validation is presented as attachments to ANL-MGR-MD-000003 Rev 01 and ANL-MGR-MD-000009 Rev 01. Additional model validation is in progress. Code validation is an ongoing activity, and status of the validation activity was reported in the Analysis/Model Report.

References: CRWMS M&O 2000n. Distribution Fitting to the Stochastic BDCF Data. ANL-NBS-MD-000008 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20000517.0258; MOL.20000601.0753.

CRWMS M&O 2001h. Nominal Performance Biosphere Dose Conversion Factor Analysis. ANL-MGR-MD-000009 REV 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20010123.0123.

CRWMS M&O 2000ai. Non-Disruptive Event Biosphere Dose Conversion Factors. ANL-MGR-MD-000009 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20000307.0383.

CRWMS M&O 2001n. Disruptive Event Biosphere Dose Conversion Factor Analysis. ANL-MGR-MD-000003 REV 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20010125.0233.

Agreement Number

Agreement DOE response during Technical Exchange was considered adequate by the NRC. Total System Performance Assessment and Integration Technical Exchange, August 6-10, 2001.

Subissue #3 - Model Abstraction DOSE 3.TT.9

Tracking # DOSE 3.TT.9

Comment Transfer factors used in the AMR (Table 3) do not match values in the cited source report (Analysis Model Report -- Transfer Coefficient Analysis, ANL-MGR-MD-000008 REV 00).

References CRWMS M&O. "Disruptive Event Biosphere Dose Conversion Factor Analysis." ANL-MGR-MD-000003. Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response It was verified that transfer factors used in the Disruptive Event Biosphere Dose Conversion Factor Analysis (CRWMS M&O 2000m) match the values in Rev 00 of the Transfer Coefficient Analysis (CRWMS M&O 1999g).

Transfer factors used in Table 3 of the Analysis/Model Report (CRWMS M&O 2000m) are the same as the source report (CRWMS M&O 1999g) and were changed when the document was updated. Updated data was used in the Analysis Model Report, Disruptive Event Biosphere DOSE Conversion Factor Analysis. (CRWMS M&O 2001n).

References: CRWMS M&O 2000m. Disruptive Event Biosphere Dose Conversion Factor Analysis. ANL-MGR-MD-000003 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20000303.0216.

CRWMS M&O 1999g. Transfer Coefficient Analysis. ANL-MGR-MD-000008 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19991115.0237.

CRWMS M&O 1999e. Transfer Coefficient Analysis. ANL-MGR-MD-000008 REV 00 ICN 1. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20000413.0692.

CRWMS M&O 2001n. Disruptive Event Biosphere Dose Conversion Factor Analysis. ANL-MGR-MD-000003 REV 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20010125.0233.

Agreement Number

Agreement DOE response during Technical Exchange was considered adequate by the NRC. Total System Performance Assessment and Integration Technical Exchange, August 6-10, 2001.

Subissue #3 - Model Abstraction DOSE 3.TT.10

Tracking # DOSE 3.TT.10

Comment 1) In section 6.12.(5), Radionuclides Present, discusses the dependency of interception fraction on the particle charge (e.g., for cations and anions), but it was unclear how this information was included in the analysis.
2) It appears that the determination of yield and growing time for hay and forage are inconsistent. The estimated effective yield for hay and forage was based on alfalfa and "other hay" production, while the growing time for hay and forage was based only on alfalfa. An explanation for why this approach was taken should be added.
3) The basis for applying a single distribution to the crop irrigation time for all of the leafy vegetables should be enhanced.

References CRWMS M&O. "Identification of Ingestion Exposure Parameters." ANL-MGR-MD-000006. Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response For comment No. 1, please see response to DOSE 3.2.5.

Regarding comment No. 2, the discrepancy has been corrected in REV 01 of the Nominal Performance Biosphere DOSE Conversion Factor Analysis (CRWMS M&O 2001h, Attachment III).

Regarding comment No. 3, it is not possible in GENII-S to use more than one distribution for the crop irrigation time for leafy vegetables.

A subsequent revision of the Analysis/Model Report will directly address the NRC comments.

Reference: CRWMS M&O 2001h. Nominal Performance Biosphere Dose Conversion Factor Analysis. ANL-MGR-MD-000009 REV 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20010123.0123.

Agreement Number

Agreement DOE response during Technical Exchange was considered adequate by the NRC. Total System Performance Assessment and Integration Technical Exchange, August 6-10, 2001.

Subissue #3 - Model Abstraction DOSE 3.TT.11

Tracking # DOSE 3.TT.11

Comment The AMR contains a table of input parameters for BDCF calculations. This is a very useful table, however, it uses data tracking numbers rather than AMRs to link to source data. A link to AMRs would facilitate NRC review since we could easily locate the reports where the parameters are discussed. The present AMR approach has segmented the BDCF input into a large number of separate AMRs which increases difficulty/time to find the bases for specific parameter values.

References CRWMS M&O. "Non-Disruptive Event Biosphere Dose Conversion Factors." ANL-MGR-MD-000009. Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response Revision 01 of this report (CRWMS M&O 2001h, Table 1) links input data to individual Analysis/Model Reports. Procedurally, input data refer to Reference Information Base item or Data Tracking Number, instead of Analysis/Model Report. The cross-link could be found from Reference Information Base item or Data Tracking Number.

Reference: CRWMS M&O 2001h. Nominal Performance Biosphere Dose Conversion Factor Analysis. ANL-MGR-MD-000009 REV 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20010123.0123.

Agreement Number

Agreement DOE response during Technical Exchange was considered adequate by the NRC. Total System Performance Assessment and Integration Technical Exchange, August 6-10, 2001.

Subissue #3 - Model Abstraction DOSE 3.TT.12

Tracking # DOSE 3.TT.12

Comment The selected value for soil exposure time is based on the assumption the individual is not exposed when indoors. This is true for many radionuclides due to shielding provided by the house. However, this is not true for high energy gamma emitters (the only radionuclides where direct exposure is significant pathway). This is particularly true for the direct release scenario where the house would be surrounded by deposited ash. Staff were unable to locate the argument for exclusion of this exposure pathway.

References CRWMS M&O. " Input Parameter Values for External and Inhalation Radiation Exposure Analysis." ANL-MGR-MD-000001. Revision 00. Las Vegas, Nevada: CRWMS M&O. 1999.

DOE Response This item was discussed at the Igneous Activity Technical Exchange, June 21-22, 2001. The parameter value has been updated in the revision of AMR (CRWMS M&O 2000ad). External exposure was not considered in indoors in a direct way. Most radionuclides considered in the postclosure assessment are not strong gamma emitters, therefore do not contribute significantly to the exposure indoors. Strong gamma emitters like cesium-137 are relatively short lived and will not contribute to the dose at times greater than a few hundred years.

In addition, for groundwater release scenario, external exposure during the period of time spent outdoors was calculated using home (lawn) irrigation rate of, on the average, 74 inches, which is about twice the average irrigation rate for the crops. This results in the higher radionuclide concentration in the lawn soil than that for agricultural land, and, consequently, higher external exposure. This approach is conservative, because the receptor does not spend all of his outdoor time on the lawn, and more than compensates for not considering external exposure while indoors.

Reference: CRWMS M&O 2000ad. Input Parameter Values for External and Inhalation Radiation Exposure Analysis. ANL-MGR-MD-000001 REV 01 ICN 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001122.0005.

Agreement Number

Agreement DOE response during Technical Exchange was considered adequate by the NRC. Igneous Activity Technical Exchange, June 21-22, 2001.

Subissue #3 - Model Abstraction DOSE 3.TT.13

Tracking # DOSE 3.TT.13

Comment In addition to the data sets, the corresponding AMRs that include discussions of the parameter value selections should be referenced within the Non-Disruptive Event Biosphere Dose Conversion Factors AMR. For example, the animal product consumption rates for the Reasonable Representation and Bounding calculations were presented in Tables 1 and 2, respectively, with their data sources. However, no connection was made from the data sources to the AMRs that provide the justification for the parameter value selection.

References CRWMS M&O. "Non-Disruptive Event Biosphere Dose Conversion Factors." ANL-MGR-MD-000009. Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response Revision 01 of this report (CRWMS M&O 2001h, Table 1) links input data to individual Analysis/Model Reports. Procedurally, input data refer to Reference Information Base item or Data Tracking Number, instead of Analysis/Model Report. The cross-link could be found from Reference Information Base item or Data Tracking Number. Revision 1 considers only the reasonable representation cases.

Reference: CRWMS M&O 2001h. Nominal Performance Biosphere Dose Conversion Factor Analysis. ANL-MGR-MD-000009 REV 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20010123.0123.

Agreement Number

Agreement DOE response during Technical Exchange was considered adequate by the NRC. Total System Performance Assessment and Integration Technical Exchange, August 6-10, 2001.

Subissue #3 - Model Abstraction TSPA001

Tracking # TSPA001

Comment There are a number of positive examples in the documentation related to transparency and traceability. However, there are some areas that need improvement. In particular, there are numerous examples where the discussion in a summary section or an individual abstraction section is inconsistent with other sections or the actual TSPA-model. In particular, there are contradictory statements about the role of environmental variables in the corrosion models. The summation of the inconsistencies makes it difficult for the reviewers to identify what is being done in some parts of the TSPA-model. Two specific areas where transparency and traceability were lacking were (1) the abstraction of colloid modeling and (2) The use of WAPDEG in modeling the failure of the engineered barrier system.

See list of examples that follow (labeled TSPA001.Ex1, etc.) for details.

References CRWMS M&O. "Total System Performance Assessment (TSPA) Model for Site Recommendation." MDL-WIS-PA-000002 Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000a.
CRWMS M&O. "Total System Performance Assessment for the Site Recommendation." TDR-WIS-PA-000001 Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000b.

DOE Response DOE agrees that improvement on transparency and traceability of the documents can be made. Activities to improve transparency and traceability include:

a. Update review procedures with emphasis on vertical slice, e.g., by chapter and between documents to improve consistency.

b. Improve/update the documents as mentioned in the specific examples noted by the NRC

c. Conduct vertical slice review for consistency. (currently ongoing)

d. Develop additional transparency tools, such as
- flow chart of model
- data source flow to model
- additional graphics

e. Provide for additional reviews
- International Peer Review Panel
- internal review teams
- technical editors

DOE also will revisit the (1) the abstraction of colloid modeling and (2) the use of Waste Package Degradation Model in modeling the failure of the engineered barrier system.

The following TSPA examples are categorized as follows:

CAT 1. Clarification required primarily in terms of rewording text. Limited additional work required.

CAT 2. Clarification and additional analysis required. Additional analyses or plots required to fully clarify the point.

CAT 3. Not the scope of the document. Some of the comments ask for more than the model document is intended to serve. For example, additional TSPA analyses in the model document that indicates the significance of the component to long term DOSE. These should be referred to the other documents.

CAT 4. Not used.

CAT 5. Correction required to the text.

CAT 6. Provide abstraction defensibility of the abstraction utilized.

CAT 7. No change required. Suggestions for transparency/traceability may not require any changes.

CAT 8. NRC points out a few instances where we have obtained transparency, or provided abstraction defensibility.

Agreement Number

Agreement DOE general response addressing transparency and traceability during Technical Exchange was considered adequate by the NRC. Total System Performance Assessment and Integration Technical Exchange, August 6-10, 2001.

Subissue #3 - Model Abstraction TSPA001.Ex1

Tracking # TSPA001.Ex1

Comment Page 3-93: The level of detail provided about the coupling of the in-package chemistry model to the degradation rates is excellent. This allows the reviewer to understand what was done.

References CRWMS M&O. "Total System Performance Assessment for the Site Recommendation." TDR-WIS-PA-000001. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response No response required (CAT 1, see DOE Response to TSPA001)

Agreement Number

Agreement See Agreement statement under TSPA001.

Subissue #3 - Model Abstraction TSPA001.Ex2

Tracking # TSPA001.Ex2

Comment Page 2-20: "The Alloy-22 layer degrades only in the presence of liquid water, i.e. when water drips directly on the waste package." If this statement were correct, then only 13% of the waste packages should fail in the TSPA-SR model.

References CRWMS M&O. "Total System Performance Assessment for the Site Recommendation." TDR-WIS-PA-000001. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response DOE will correct the text. (CAT 5, see DOE Response to TSPA001)

Agreement Number

Agreement See Agreement statement under TSPA001.

Subissue #3 - Model Abstraction TSPA001.Ex3

Tracking # TSPA001.Ex3

Comment Page 2-20: There is a lengthy discussion of items that can cause variability in the corrosion rates. Later in the document (pages 3-82, 4-7, 5-12), it is stated that the degradation rates are insensitive to environmental conditions except when relative humidity increases above a threshold value. A clarification of which statements are accurate is needed and the inaccurate statements removed. If the environmental parameters influence the general corrosion rates, it would be useful to provide plots to illustrate the effects.

References CRWMS M&O. "Total System Performance Assessment for the Site Recommendation." TDR-WIS-PA-000001. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response DOE will correct the text. (CAT 1, see DOE Response to TSPA001)

Agreement Number

Agreement See Agreement statement under TSPA001.

Subissue #3 - Model Abstraction TSPA001.Ex4

Tracking # TSPA001.Ex4

Comment Page F2-20: The figure shows temperature, RH, drip/no-drip, and chemical conditions supplying input to the waste package degradation model. Based on the later descriptions, only temperature/RH are used and they only define the initial conditions. A clarification is needed.

References CRWMS M&O. "Total System Performance Assessment for the Site Recommendation." TDR-WIS-PA-000001. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response DOE will clarify the inputs to the Figure. (CAT 1, see DOE Response to TSPA001)

Agreement Number

Agreement See Agreement statement under TSPA001.

Subissue #3 - Model Abstraction TSPA001.Ex5

Tracking # TSPA001.Ex5

Comment Page 3-34: The water travel time for the fraction of flow that occurs in faults would be a useful addition to the results.

References CRWMS M&O. "Total System Performance Assessment for the Site Recommendation." TDR-WIS-PA-000001. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response No change is required. (CAT 7, see DOE Response to TSPA001)

Agreement Number

Agreement See Agreement statement under TSPA001.

Subissue #3 - Model Abstraction TSPA001.Ex6

Tracking # TSPA001.Ex6

Comment Page 3-43: "The environments are important to the potential repository performance to the extent that they help determine degradation rates of the engineered barrier components ..." This statement does not appear to describe the corrosion model abstraction accurately.

References CRWMS M&O. "Total System Performance Assessment for the Site Recommendation." TDR-WIS-PA-000001. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response It is agreed that the corrosion model abstractions do not have degradation rates that depend on environmental conditions. It should be noted that the general corrosion initiation criteria is based on the temperature-dependent deliquescence points of an assumed always present surface layer of a sodium nitrate salt film. The localized corrosion initiation criteria are based on in-drift chemical conditions (the pH). The general corrosion rates used are derived from weight-loss measurements in several solutions with compositions that are considered bounding. The chemical modeling done in support of TSPA provides some of the basis for the assumption that the solution compositions used is bounding. (CAT 1, see DOE Response to TSPA001)

Agreement Number

Agreement See Agreement statement under TSPA001.

Subissue #3 - Model Abstraction TSPA001.Ex7

Tracking # TSPA001.Ex7

Comment Page 3-65: From the paragraph at the top of the page, it is difficult to tell what is in the model and what is not in the model.

References CRWMS M&O. "Total System Performance Assessment for the Site Recommendation." TDR-WIS-PA-000001. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response DOE will clarify the text. (CAT 1, see DOE Response to TSPA001)

Agreement Number

Agreement See Agreement statement under TSPA001.

Subissue #3 - Model Abstraction TSPA001.Ex8

Tracking # TSPA001.Ex8

Comment Page 3-66, 3.3.4.2.2: "Knowledge of water compositions on the drip shield is required to predict drip shield corrosion." While in theory this is correct, the current drip shield corrosion values are abstracted independently of chemistry.

References CRWMS M&O. "Total System Performance Assessment for the Site Recommendation." TDR-WIS-PA-000001. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response DOE will clarify the text (CAT 1, see DOE Response to TSPA001)

Agreement Number

Agreement See Agreement statement under TSPA001.

Subissue #3 - Model Abstraction TSPA001.Ex9

Tracking # TSPA001.Ex9

Comment Page 1-46: "Use engineered components to tailor the environmental variables (i.e., temperature, relative humidity, seepage flux to be as benign as possible." This is a good concept but it is unclear how it has been done. If the drift spacing is called an engineered component then maybe this would be true, but typically engineered components are referring to waste packages, drip shields, tunnel support, etc.

References CRWMS M&O. "Total System Performance Assessment for the Site Recommendation." TDR-WIS-PA-000001. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response DOE will clarify the text. (CAT 1, see DOE Response to TSPA001)

Agreement Number

Agreement See Agreement statement under TSPA001.

Subissue #3 - Model Abstraction TSPA001.Ex10

Tracking # TSPA001.Ex10

Comment Page 3-84: The reader would benefit from identification of the fraction of cracks that start and then stop.

References CRWMS M&O. "Total System Performance Assessment for the Site Recommendation." TDR-WIS-PA-000001. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response In the Waste Degradation Model, once stress corrosion cracking initiates cracks continue to grow to failure. No cracks start and then stop in the Waste Degradation Model. The statement quoted refers to a general description of the slip-dissolution model. (CAT 2, see DOE Response to TSPA001)

Reference: CRWMS M&O 2000az. WAPDEG Analysis of Waste Package and Drip Shield Degradation. ANL-EBS-PA-000001 REV 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001208.0063.

Agreement Number

Agreement See Agreement statement under TSPA001.

Subissue #3 - Model Abstraction TSPA001.Ex11

Tracking # TSPA001.Ex11

Comment Page 350: The flux-splitting algorithm was not used for the drip-shield as implied in the documentation.

References CRWMS M&O. "Total System Performance Assessment Model for Site Recommendation." TDR-WIS-PA-000001. Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response DOE will clarify the text. (CAT 1, see DOE Response to TSPA001)

Agreement Number

Agreement See Agreement statement under TSPA001.

Subissue #3 - Model Abstraction TSPA001.Ex12

Tracking # TSPA001.Ex12

Comment Page 3-100: The term "coupling" is used at the bottom of 3.5.2 to mean linkage or something else. Coupling implies a more complex solution than what is done.

References CRWMS M&O. "Total System Performance Assessment for the Site Recommendation." TDR-WIS-PA-000001. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response DOE will clarify the text by changing "coupling" to "linkage". (CAT 1, see DOE Response to TSPA001)

Agreement Number

Agreement See Agreement statement under TSPA001.

Subissue #3 - Model Abstraction TSPA001.Ex13

Tracking # TSPA001.Ex13

Comment Page 3-101: A comparison of the output values generated with the stochastic model, such as water flux into the failed containers, with the values selected to develop the conceptual model (3.5.2.1), would be useful to help judge the adequacy of the approach.

References CRWMS M&O. "Total System Performance Assessment for the Site Recommendation." TDR-WIS-PA-000001. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response The comparison between assumed flux based on TSPA-Viability Assessment and values calculated in TSPA-Site Recommendation was performed. The much lower range of flux values calculated in TSPA-Site Recommendation into the waste package where used in the second iteration of the TSPA-Site Recommendation. See In-Package Chemistry for Waste Forms (BSC 2001g) for more discussion on flux values. (CAT 2, see DOE Response to TSPA001)

References: DOE (U.S. Department of Energy) 1998. Total System Performance Assessment. Volume 3 of Viability Assessment of a Repository at Yucca Mountain. DOE/RW-0508. Washington, D.C.: U.S. Department of Energy, Office of Civilian Radioactive Waste Management. ACC: MOL.19981007.0030.

BSC 2001g. In-Package Chemistry for Waste Forms. ANL-EBS-MD-000056 REV 00. Las Vegas, Nevada: Bechtel SAIC Company. ACC: MOL.20010322.0490.

CRWMS M&O 2000aq. Total System Performance Assessment (TSPA) Model for Site Recommendation. MDL-WIS-PA-000002 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001226.0003.

CRWMS M&O 2000ar. Total System Performance Assessment for the Site Recommendation. TDR-WIS-PA-000001 REV 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001220.0045.

Agreement Number

Agreement See Agreement statement under TSPA001.

Subissue #3 - Model Abstraction TSPA001.Ex14

Tracking # TSPA001.Ex14

Comment Page 3-104, Third paragraph: The discussion is very good and an appropriate amount of detail is put here. However, more information showing the comparison would be very useful to the reader.

References CRWMS M&O. "Total System Performance Assessment for the Site Recommendation." TDR-WIS-PA-000001. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response DOE believes the text provided is sufficient for this report since this report is not intended to fully justify the models used. Rather the Analysis/Model Reports provide this justification. DOE plans to provide more figures comparing the model with data in the Analysis/Model Reports which should provide adequate support for the statements. (CAT 2, see DOE Response to TSPA001)

Agreement Number

Agreement See Agreement statement under TSPA001.

Subissue #3 - Model Abstraction TSPA001.Ex15

Tracking # TSPA001.Ex15

Comment Page 3-81: The last sentence of the second paragraph under 3.4.1.1 implies that in-package chemistry is an input to the waste package degradation model. Considering that WAPDEG is run up front it is unclear how this is done. It is also unclear what information is passed to TSPA.

References CRWMS M&O. "Total System Performance Assessment for the Site Recommendation." TDR-WIS-PA-000001. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response DOE will clarify the text (CAT 1, see DOE Response to TSPA001)

Agreement Number

Agreement See Agreement statement under TSPA001.

Subissue #3 - Model Abstraction TSPA001.Ex16

Tracking # TSPA001.Ex16

Comment Page 198: The top paragraph is misleading. It implies that chemistry information at 400 locations is abstracted when in fact little chemistry information is abstracted to the corrosion models.

References CRWMS M&O. "Total System Performance Assessment Model for Site Recommendation." TDR-WIS-PA-000001. Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response DOE will clarify the text. (CAT 1, see DOE Response to TSPA001)

Agreement Number

Agreement See Agreement statement under TSPA001.

Subissue #3 - Model Abstraction TSPA001.Ex17

Tracking # TSPA001.Ex17

Comment Page 40,Table 4: This is a good table for the reader but it also may be a source of confusion as to what is used/important in the TSPA-SR model and what is simply a capability of the TSPA-SR model but is never really activated (chemistry and waste package/drip shield corrosion).

References CRWMS M&O. "Total System Performance Assessment Model for Site Recommendation." TDR-WIS-PA-000001. Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response DOE will clarify Table 4-1 (CAT 1, see DOE Response to TSPA001)

Agreement Number

Agreement See Agreement statement under TSPA001.

Subissue #3 - Model Abstraction TSPA001.Ex18

Tracking # TSPA001.Ex18

Comment Page 104: Figure 6-21 is somewhat misleading because WAPDEG is run up front and only passes information to GoldSim, so it should be in the first group of codes.

References CRWMS M&O. "Total System Performance Assessment Model for Site Recommendation." TDR-WIS-PA-000001. Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response DOE will clarify Figure 6-21 (CAT 1, see DOE Response to TSPA001)

Agreement Number

Agreement See Agreement statement under TSPA001.

Subissue #3 - Model Abstraction TSPA001.Ex19

Tracking # TSPA001.Ex19

Comment Page 109: It is unclear if any strongly sorbing radionuclides were modeled through the saturated zone and how they would contribute to very long time DOSEs.

References CRWMS M&O. "Total System Performance Assessment Model for Site Recommendation." TDR-WIS-PA-000001. Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response The Analysis/Model Report (CRWMS M&O 2000at, Section 6.10) discusses the sorption coefficients that are modeled in the saturated zone site scale model. Analysis/Model Report (CRWMS M&O 2000bx) discusses the simulated radionuclide mass breakthrough curves, Section 6.3.2. (CAT 3, see DOE Response to TSPA001)

References: CRWMS M&O 2000at. Uncertainty Distribution for Stochastic Parameters. ANL-NBS-MD-000011 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20000526.0328.

CRWMS M&O 2000bx. Input and Results of the Base Case Saturated Zone Flow and Transport Model for TSPA. ANL-NBS-HS-000030 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20000526.0330.

Agreement Number

Agreement See Agreement statement under TSPA001.

Subissue #3 - Model Abstraction TSPA001.Ex20

Tracking # TSPA001.Ex20

Comment Page 113: It would be helpful if each of the items described as key attributes to the repository system could be better quantified in terms of their significance to risk. In order for the NRC to perform a risk-informed review, it is necessary to have a clear and convincing identification of those components that are risk-significant.

References CRWMS M&O. "Total System Performance Assessment Model for Site Recommendation." TDR-WIS-PA-000001. Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response Analyses quantifying the contribution of particular attributes to overall risk have not yet been conducted. We believe that it is not part of the scope of Total-System Performance Assessment Model for the Site Recommendation. (CAT 3, see DOE Response to TSPA001)

Reference: CRWMS M&O 2000aq. Total System Performance Assessment (TSPA) Model for Site Recommendation. MDL-WIS-PA-000002 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001226.0003.

Agreement Number

Agreement See Agreement statement under TSPA001.

Subissue #3 - Model Abstraction TSPA001.Ex21

Tracking # TSPA001.Ex21

Comment Page 128: It would be useful to prepare a plot of the release rate of the gap and bulk-fuel radionuclides versus the flow-focusing factor for all realizations to determine if the maximum risk occurs at an intermediate value.

References CRWMS M&O. "Total System Performance Assessment Model for Site Recommendation." TDR-WIS-PA-000001. Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response This evaluation has not yet been conducted; however, it will be considered for the future work. The measure of risk is the mean annual DOSE. In the current calculational model, sensitivity of the mean annual DOSE to the flow focusing factor could be evaluated in a straightforward way. (CAT 3, see DOE Response to TSPA001)

Agreement Number

Agreement See Agreement statement under TSPA001.

Subissue #3 - Model Abstraction TSPA001.Ex22

Tracking # TSPA001.Ex22

Comment Page 555: The arrows for the curves in Figure 6-245 and 6-247 are backwards.

References CRWMS M&O. "Total System Performance Assessment Model for Site Recommendation." TDR-WIS-PA-000001. Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response DOE will correct the Figures. (CAT 1, see DOE Response to TSPA001)

Agreement Number

Agreement See Agreement statement under TSPA001.

Subissue #3 - Model Abstraction TSPA001.Ex23

Tracking # TSPA001.Ex23

Comment Page 183: A statement to the effect that "[t]he resulting pH and concentration of dissolved solids are key parameters in determining the waste package and drip shield..." does not accurately reflect how the corrosion model is actually implemented in TSPA. The pH values are used only to examine whether or not localized corrosion occurs, which is never the case. Please clarify this statement.

References CRWMS M&O. "Total System Performance Assessment Model for Site Recommendation." TDR-WIS-PA-000001. Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response DOE will clarify the statement. (CAT 1, see DOE Response to TSPA001)

Agreement Number

Agreement See Agreement statement under TSPA001.

Subissue #3 - Model Abstraction TSPA001.Ex24

Tracking # TSPA001.Ex24

Comment Page 1-32: It is stated that the iterative process of performance assessment reduces uncertainty in the forecasted performance of the potential repository. A historical comparison of past performance assessments would be useful to support this assertion.

References CRWMS M&O. "Total System Performance Assessment for the Site Recommendation." TDR-WIS-PA-000001. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response The treatment of uncertainty in earlier assessments is not the same as the treatment today. For example, initial performance assessments (TSPA-91 and TSPA-93) were deterministic. Therefore, a comparison of quantified uncertainties has not been performed. (CAT 2, see DOE Response to TSPA001)

Agreement Number

Agreement See Agreement statement under TSPA001.

Subissue #3 - Model Abstraction TSPA001.Ex25

Tracking # TSPA001.Ex25

Comment Page 237: Talks about 1600 different histories for thermodynamic variables (temperature, RH, etc.), which is different from what is mentioned elsewhere.

References CRWMS M&O. "Total System Performance Assessment Model for Site Recommendation." TDR-WIS-PA-000001. Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response Per NRC Clarification, this comment does not need to be addressed.

Agreement Number

Agreement See Agreement statement under TSPA001.

Subissue #3 - Model Abstraction TSPA001.Ex26

Tracking # TSPA001.Ex26

Comment Page 250: We understand the need for an overview, but the current one is misleading. Many factors are listed, but only some of them are actually connected to one another (e.g. chemistry variables).

References CRWMS M&O. "Total System Performance Assessment Model for Site Recommendation." TDR-WIS-PA-000001. Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response DOE will clarify the text (CAT 1, see DOE Response to TSPA001)

Agreement Number

Agreement See Agreement statement under TSPA001.

Subissue #3 - Model Abstraction TSPA001.Ex27

Tracking # TSPA001.Ex27

Comment Page 252: "The actual waste package corrosion rate is randomly sampled from the range bounded by these high and low values." This statement implies that there is a dependence of waste package corrosion rate on pH. We are not aware that the data demonstrate this conclusion. Maybe just a language clarification needed.

References CRWMS M&O. "Total System Performance Assessment Model for Site Recommendation." TDR-WIS-PA-000001. Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response DOE will clarify the text. (CAT 1, see DOE Response to TSPA001)

Agreement Number

Agreement See Agreement statement under TSPA001.

Subissue #3 - Model Abstraction TSPA001.Ex28

Tracking # TSPA001.Ex28

Comment Page 4-8: An excellent discussion of how things are working is provided on this page.

References CRWMS M&O. "Total System Performance Assessment for the Site Recommendation." TDR-WIS-PA-000001. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response No response required (CAT 1, see DOE Response to TSPA001)

Agreement Number

Agreement See Agreement statement under TSPA001.

Subissue #3 - Model Abstraction TSPA001.Ex29

Tracking # TSPA001.Ex29

Comment Page 406: It would be useful to show a plot comparing the results for the three-dimensional model to those for the pipe model. This information would help give NRC assurance that the models were operating correctly.

References CRWMS M&O. "Total System Performance Assessment Model for Site Recommendation." TDR-WIS-PA-000001. Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response Analysis/Model Report (CRWMS M&O 2000bx) Figure 25 compares results from the 3-D and 1-D models (CAT 2, see DOE Response to TSPA001)

Reference: CRWMS M&O 2000bx. Input and Results of the Base Case Saturated Zone Flow and Transport Model for TSPA. ANL-NBS-HS-000030 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20000526.0330.

Agreement Number

Agreement See Agreement statement under TSPA001.

Subissue #3 - Model Abstraction TSPA001.Ex30

Tracking # TSPA001.Ex30

Comment Page II-21: Equations II-2a, II-2b, II-4, and II-5 are all incorrect in the document.

References CRWMS M&O. "Total System Performance Assessment Model for Site Recommendation." TDR-WIS-PA-000001. Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response DOE will correct the text. (CAT 5, see DOE Response to TSPA001)

Agreement Number

Agreement See Agreement statement under TSPA001.

Subissue #3 - Model Abstraction TSPA001.Ex31

Tracking # TSPA001.Ex31

Comment Page 148. The paragraph should clearly identify that the near-field environment outputs are being used by other models. As currently stated, there is a discrepancy with other statements made about model implementation.

References CRWMS M&O. "Total System Performance Assessment Model for Site Recommendation." TDR-WIS-PA-000001. Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response It is agreed that the corrosion model abstractions do not have degradation rates that depend on environmental conditions. It should be noted that the general corrosion initiation criteria is based on the temperature-dependent deliquescence points of an assumed always present surface layer of a sodium nitrate salt film. The localized corrosion initiation criteria are based on in-drift chemical conditions (the pH). The general corrosion rates used are derived from weight-loss measurements in several solutions with compositions that are considered bounding. The chemical modeling done in support of TSPA provides some of the bases for the assumption that the solution compositions used are bounding.

In addition, chemical conditions are used in GoldSim to calculate upper caps on radionuclide concentrations in the invert. Wording can be clarified in revisions to document. (CAT 1, see DOE Response to TSPA001)

Agreement Number

Agreement See Agreement statement under TSPA001.

Subissue #3 - Model Abstraction TSPA001.Ex32

Tracking # TSPA001.Ex32

Comment Page 3-123, second paragraph under 3.5.5.4: The explanation for why 237Np solubility does not appear to have a significant influence on the uncertainty of the DOSE needs further clarification.

References CRWMS M&O. "Total System Performance Assessment for the Site Recommendation." TDR-WIS-PA-000001. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response The importance of a parameter is primarily a function of the range of uncertainty of the parameter. While the overall potential variation is greater for TSPA-Site Recommendation than used before, this potential variation of 237Np solubility is a combination of the range that occurs in commercial spent nuclear fuel and codisposed packages and the range before and after 1000 yr after breach of the packages. (See Figure 2. in Y. Chen and R.P. Rechard). The DOSE in the TSPA-Site Recommendation is dominated by the 237Np released from the commercial spent nuclear fuel 1000 years after breach of the package. This particular range in uncertainty of 237Np is much narrower than the range used for TSPA-95 and TSPA-Viability Assessment. Hence, the importance of 237Np is less in TSPA-Site Recommendation. (CAT 2, see DOE Response to TSPA001)

Note: DOE has not "settled" on the "best" uncertainty to use for 237Np. For the PA work accomplished to support the Supplemental Science and Performance Analysis, the uncertainty for 237Np solubility was again greatly increased.

Reference: Chen, Y. and Rechard, R.P. 2001. "Dissolved Concentration Component of Waste Form Degradation Model in TSPA-SR." Proceedings of the 2001 International High-Level Radioactive Waste Management Conference, April 29 -May 3, 2001, Las Vegas, Nevada. La Grange, IL: American Nuclear Society.

Agreement Number

Agreement See Agreement statement under TSPA001.

Subissue #3 - Model Abstraction TSPA001.Ex33

Tracking # TSPA001.Ex33

Comment Page 4-40: The second paragraph provides a qualitative example that corrosion doesn't depend at all on water.

References CRWMS M&O. "Total System Performance Assessment for the Site Recommendation." TDR-WIS-PA-000001. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response Per NRC Clarification, this comment does not require a response.

Agreement Number

Agreement See Agreement statement under TSPA001.

Subissue #3 - Model Abstraction TSPA001.Ex34

Tracking # TSPA001.Ex34

Comment Page 5-11: The last statement on the page is inaccurate or inconsistent with the description of flux-splitting provided earlier in the document.

References CRWMS M&O. "Total System Performance Assessment for the Site Recommendation." TDR-WIS-PA-000001. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response DOE will clarify the text. (CAT 1, see DOE Response to TSPA001)

Agreement Number

Agreement See Agreement statement under TSPA001.

Subissue #3 - Model Abstraction TSPA001.Ex35

Tracking # TSPA001.Ex35

Comment Page F5-12 (Figure 5.1-12): It would be useful to present a plot of the probability density function of the dissolution rate for commercial spent nuclear fuel along with this figure. This would clarify why dissolution rate was identified as a sensitive parameter.

References CRWMS M&O. "Total System Performance Assessment for the Site Recommendation." TDR-WIS-PA-000001. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response DOE will add a probability distribution function plot to the figure. (CAT 2, see DOE Response to TSPA001)

Agreement Number

Agreement See Agreement statement under TSPA001.

Subissue #3 - Model Abstraction TSPA001.Ex36

Tracking # TSPA001.Ex36

Comment Pages EF-5 and following: Many of these figures have puzzling connections that need to be explained, such as the connection of General Corrosion and Localized Corrosion of the Waste Package Outer Barrier to the AMR for Environments on the Surfaces of those engineered systems. Without identification of the information passed, transparency and traceability is more hindered than improved.

References CRWMS M&O. "Total System Performance Assessment for the Site Recommendation." TDR-WIS-PA-000001. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response DOE will clarify the Figures. (CAT 1, see DOE Response to TSPA001)

Agreement Number

Agreement See Agreement statement under TSPA001.

Subissue #3 - Model Abstraction TSPA001.Ex37

Tracking # TSPA001.Ex37

Comment Page 3-173: The presentation of curves using median values may be misleading for overall system performance. The stochastic behavior of the saturated zone should be represented in order to appropriately risk-inform. Probability density functions of travel times for important radionuclides developed considering the full stochastic behavior of the saturated zone would be appropriate.

References CRWMS M&O. "Total System Performance Assessment for the Site Recommendation." TDR-WIS-PA-000001. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response Analysis/Model Report (CRWMS M&O 2000bx) presents simulated unit breakthrough curves from 100 stochastic realizations, for the radionuclides considered, Figures 12 - 19. (CAT 2, see DOE Response to TSPA001)

Reference: CRWMS M&O 2000bx. Input and Results of the Base Case Saturated Zone Flow and Transport Model for TSPA. ANL-NBS-HS-000030 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20000526.0330.

Agreement Number

Agreement See Agreement statement under TSPA001.

Subissue #3 - Model Abstraction TSPA002

Tracking # TSPA002

Comment An appropriately rigorous methodology has not been utilized for model abstraction simplifications and selection of "conservative" parameter distributions, conceptual models, or modeling approaches.

In addition to integration of various abstractions into the TSPA, DOE needs an integrated and consistent approach in other areas of the performance assessment. The system-model, or even individual abstractions, rapidly become too complex. Human intuition cannot be relied on to make accurate decisions consistently.

For complex, nonlinear models embodied into the TSPA, it may be impossible to determine the effect of a parameter a priori. Because of the interactions at the system-level, some intermediate outputs may have a maximum impact on risk for some intermediate value rather than at its bounds. For example, if ionic strength affected both colloid stability and cladding corrosion, it is possible that minimizing ionic strength in order to maximize colloid stability may not result in maximizing risk (due to lessor cladding corrosion).

See list of examples that follow (labeled TSPA002.EX1, etc.) for details.

References CRWMS M&O. "Total System Performance Assessment (TSPA) Model for Site Recommendation." MDL-WIS- PA-000002 Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000a.
CRWMS M&O. "Total System Performance Assessment for the Site Recommendation." TDR-WIS-PA-000001 Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000b.

DOE Response Several activities will support improvement in this area. Additional documentation and training will be provided

a. Systematize/characterize abstraction process.
b. Systematize/characterize selection of conservatism in components.
c. Provide more guidance for abstractions in procedures, such as in AP3.10Q.

DOE will evaluate and define approaches to deal with:

a. Evaluating non-linear models as to what is their most conservative settings
b. Dealing with the "complexity" issue in the TSPA model
c. Including some "basis" slides from the Analysis/Model Reports as Appendix.

Subissue #3 - Model Abstraction TSPA002

The following TSPA examples are categorized as follows:

CAT 1. Clarification required primarily in terms of rewording text. Limited additional work required.

CAT 2. Clarification and additional analysis required. Additional analyses or plots required to fully clarify the point.

CAT 3. Not the scope of the document. Some of the comments ask for more than the model document is intended to serve. For example, additional TSPA analyses in the model document that indicates the significance of the component to long term DOSE. These should be referred to the other documents.

CAT 4. Not used.

CAT 5. Correction required to the text.

CAT 6. Provide abstraction defensibility of the abstraction utilized.

CAT 7. No change required. Suggestions for transparency/traceability may not require any changes.

CAT 8. NRC points out a few instances where we have obtained transparency, or provided abstraction defensibility.

Agreement Number TSPAI.3.38

Agreement DOE will develop written guidance in the model abstraction process for model developers so that (1) the abstraction process, (2) the selection of conservatism in components, and (3) representation of uncertainty, are systematic across the TSPA model. These guidelines will address: (1) evaluation of non-linear models when conservatism is being utilized to address uncertainty, and (2) utilization of decisions based on technical judgement in a complex system. These guidelines will be developed, implemented, and be made available to the NRC in FY 2002.

Subissue #3 - Model Abstraction TSPA002.Ex1

Tracking # TSPA002.Ex1

Comment Page 3-57: It is unclear that the neglect of the dry-out effect is conservative with respect to near-field chemistry or temperatures.

References CRWMS M&O. "Total System Performance Assessment for the Site Recommendation." TDR-WIS-PA-000001. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response Dryout (by ventilation) during the preclosure period is neglected. This ultimately results in lower near-field/engineered barrier system temperatures since the thermal conductivity in the rock is effectively the wet thermal conductivity (higher than dry), thus resulting in higher heat transfer rates away from the repository horizon. It is true that neglecting dryout may or may not result in a conservative condition for temperature. However, it can be argued that this effect on final DOSE, either conservative or nonconservative, does not matter. Two cases can be considered.

In the case of lower early time temperatures being adverse to DOSE, this is the current method of calculation and, if it occurs, this influence would be captured within the limitations of modeling assumptions and/or conceptual model usage (particularly associated with the corrosion models).

In the case of higher early time temperatures, it can be argued that high early time temperatures have been applied in the current analysis. It is noted that the much higher rock temperatures associated with full power heating (e.g., initial postclosure period) and rock dryout did not adversely affect the corrosion models. Therefore, even if preclosure ventilation host rock dryout would have been included (and hence caused engineered barrier system/near-field temperatures to be higher due to a lower host rock thermal conductivity), it is unlikely that the (higher) temperatures during this short time period (50 years) would be any greater than those being used immediately after repository closure. The high temperatures immediately after closure don't adversely affect the corrosion models (and hence DOSE). Therefore, an assumed condition of lower temperatures for the first 50 years does not impact DOSE.

More moisture left in the model is expected to result in earlier appearance of water with dissolved constituents on engineered barrier system materials such as the drip shield or waste, resulting in potential for earlier radionuclide release. (CAT 2, see DOE Response to TSPA002)

Agreement Number TSPAI.3.38

Agreement See Agreement statement under TSPA002.

Subissue #3 - Model Abstraction TSPA002.Ex2

Tracking # TSPA002.Ex2

Comment Page 5-32: Using the 5th or 95th values might not capture the highest DOSE or sensitivity, because for some processes the worst case might be somewhere in the middle of the distribution rather than at its bounds.

References CRWMS M&O. "Total System Performance Assessment for the Site Recommendation." TDR-WIS-PA-000001. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response The use of 5th and 95th percentile values in the one-off sensitivity analysis implicitly assumes a monotonic relationship between the uncertain input and the model output. For most processes, this is indeed the case, i.e., the worst outcome can be traced to extreme values of the underlying parameters. As part of the screening for the one-off analyses, the TSPA-Site Recommendation analysts examined the nature of the input-output relationship. When it was felt that extreme behavior may not be reflected by 5th and 95th percentile parameter values (e.g., solubility of secondary mineral phases), alternative conceptual/parametric models were used to stress the system. Such analyses have been documented in Section 5.2 of the TSPA-Site Recommendation report. (CAT 2, see DOE Response to TSPA002)

Reference: CRWMS M&O 2000ar. Total System Performance Assessment for the Site Recommendation. TDR-WIS-PA-000001 REV 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001220.0045.

Agreement Number TSPAI.3.38

Agreement See Agreement statement under TSPA002.

Subissue #3 - Model Abstraction TSPA002.Ex3

Tracking # TSPA002.Ex3

Comment Page 3-86: It is unclear that DOE considered combined effects such as chemistry+radiolysis+coupled electrochemical processes when evaluating whether a process can cause a shift in potential large enough to initiate localized corrosion.

References CRWMS M&O. "Total System Performance Assessment for the Site Recommendation." TDR-WIS-PA-000001. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response DOE will clarify the text. (CAT 1, see DOE Response to TSPA002)

Agreement Number TSPAI.3.38

Agreement See Agreement statement under TSPA002.

Subissue #3 - Model Abstraction TSPA002.Ex4

Tracking # TSPA002.Ex4

Comment Page 3-59: It is unclear that forcing seepage is conservative with respect to near-field chemistry or temperatures.

References CRWMS M&O. "Total System Performance Assessment for the Site Recommendation." TDR-WIS-PA-000001. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response Earlier appearance of water in the drift, although all effects are less clear in this case.

There is currently not a direct process-level link between emplacement drift seepage and predicted engineered barrier system temperatures. The multiscale thermo-hydrological process-level model treats the emplacement drift as a capillary barrier that does not allow seepage moisture to enter the drift during the simulation. Some preliminary studies have been performed using selected submodels of the multiscale thermo-hydrological model to determine the influence of seepage water on the in-drift temperatures and relative humilities. (CAT 2, see DOE Response to TSPA002)

Agreement Number TSPAI.3.38

Agreement See Agreement statement under TSPA002.

Subissue #3 - Model Abstraction TSPA002.Ex5

Tracking # TSPA002.Ex5

Comment Page 1-5: DOE stated that some abstractions have very little detail eliminated, while others are simplified greatly. NRC staff were unable to determine where guidance is provided to project staff to ensure a consistent approach is taken for the abstraction process (much simplification vs. little). The criteria to be applied to determine the amount of simplification are likely subjective.

References CRWMS M&O. "Total System Performance Assessment for the Site Recommendation." TDR-WIS-PA-000001. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response DOE will clarify the text. (CAT 1, see DOE Response to TSPA002)

Agreement Number TSPAI.3.38

Agreement See Agreement statement under TSPA002.

Subissue #3 - Model Abstraction TSPA002.Ex6

Tracking # TSPA002.Ex6

Comment Page 251: It is unclear how a "conservative" abstraction is selected when the chemistry model outputs can impact so many system components.

References CRWMS M&O. "Total System Performance Assessment Model for Site Recommendation." TDR-WIS-PA-000001. Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response For degradation of cladding, commercial spent nuclear fuel. High level waste, solubility, and colloids generation are all greater at low pH values; (only colloid solubility decreases as pH decreases). Hence, for the time period where pH was low, a bounding low value was chosen. (CAT 2, see DOE Response to TSPA002)

Agreement Number TSPAI.3.38

Agreement See Agreement statement under TSPA002.

Subissue #3 - Model Abstraction TSPA002.Ex7

Tracking # TSPA002.Ex7

Comment Page 3-60: It is unclear that setting preclosure RH artificially high is conservative with respect to near-field chemistry or temperatures.

References CRWMS M&O. "Total System Performance Assessment for the Site Recommendation." TDR-WIS-PA-000001. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response High relative humidity promotes earlier appearance of water with dissolved constituents on engineered barrier system materials such as the drip shield or waste, resulting in potential for earlier radionuclide release.

Since rock dryout during preclosure is not included in the models, the in-drift relative humidity is made artificially high during the 50 year preclosure period. Temperatures and relative humidity are dynamically calculated by the multiscale thermo-hydrological model. Therefore, if moisture removal would have been modeled during the preclosure period, the resultant temperatures would be higher (see above), relative humidity lower. However, an assumed high relative humidity (results from not removing moisture during preclosure) during this 50 year period was deemed to be a more conservative response for potential corrosion since it requires higher relative humidity values to initiate. (CAT 2, see DOE Response to TSPA002)

Agreement Number TSPAI.3.38

Agreement See Agreement statement under TSPA002.

Subissue #3 - Model Abstraction TSPA003

Tracking # TSPA003

Comment Inadequate basis is provided for the simplifications utilized for some model abstractions.

We recognize that it is intractable to represent all of the spatial and temporal uncertainty and variability, as well as conceptual model uncertainty in the overall TSPA-model. The abstraction process is typically a simplification of process-model results into a form that represents an appropriate amount of uncertainty/variability, while allowing a computationally efficient solution.

A number of instances have been identified where inadequate justification has been provided for the amount of information retained by the abstraction. In particular, DOE needs to justify the simplifications used with consideration of all affected subsystems or models. The risk-significance of the models or subsystems will determine the degree of support needed for the simplifications.

See list of examples that follow (labeled TSPA003.EX1, etc.) for details.

References CRWMS M&O. "Total System Performance Assessment Model for Site Recommendation." TDR-WIS-PA-000001. Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000a.
CRWMS M&O. "Total System Performance Assessment for the Site Recommendation." TDR-WIS-PA-000001. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000b.

DOE Response As NRC has recognized, it is intractable to represent all of the spatial and temporal uncertainty and variability, as well as conceptual model uncertainty in the overall TSPA-model. DOE acknowledges the comment. We believe that adequate technical basis has been provided for the simplification utilized for model abstractions. Please see our responses to all of the specific examples identified by NRC as inadequate justification.

In TSPA-License Application, documentation of the simplifications will be updated per TSPA002 activities. The justification will be provided to show that the simplification appropriately represents the necessary processes. The following TSPA examples are categorized as follows:

CAT 1. Clarification required primarily in terms of rewording text. Limited additional work required.

CAT 2. Clarification and additional analysis required. Additional analyses or plots required to fully clarify the point.

CAT 3. Not the scope of the document. Some of the comments ask for more than the model document is intended to serve. For example, additional TSPA analyses in the model document that indicates the significance of the component to long term DOSE. These should be referred to the other documents.

CAT 4. Not used.

CAT 5. Correction required to the text.

CAT 6. Provide abstraction defensibility of the abstraction utilized.

CAT 7. No change required. Suggestions for transparency/traceability may not require any changes.

CAT 8. NRC points out a few instances where we have obtained transparency, or provided abstraction defensibility.

Agreement Number TSPAI.3.38

Agreement DOE will document the simplifications utilized for abstractions per TSPAI.3.38 activities for all future performance assessments. Justification will be provided to show that the simplifications appropriately represent the necessary processes and appropriately propagate process model uncertainties. Comparisons of output from process models to performance assessment abstractions will be provided, with the level of detail in the comparisons commensurate with any reduction in propagated uncertainty and the risk significance of the model. The documentation of the information will be provided in abstraction AMRs in FY 2003.

Subissue #3 - Model Abstraction TSPA003.Ex1

Tracking # TSPA003.Ex1

Comment Pages 167: It is unclear whether inputs for the thermo-hydro-chemical model came from the TSPA or from the process model.

References CRWMS M&O. "Total System Performance Assessment Model for Site Recommendation." TDR-WIS-PA-000001. Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response DOE will clarify the text. (CAT 1, see DOE Response to TSPA003)

Agreement Number TSPAI.3.39

Agreement See Agreement statement under TSPA003.

Subissue #3 - Model Abstraction TSPA003.Ex2

Tracking # TSPA003.Ex2

Comment Page 360: Because of the strong dependence of diffusivity in the invert on liquid saturation, you should provide the technical basis that it is appropriate to represent the invert as one mixing cell and to not consider heterogeneities in the engineered materials.

References CRWMS M&O. "Total System Performance Assessment Model for Site Recommendation." TDR-WIS-PA-000001. Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response The representation of the invert as one mixing cell is a reasonable simplification for two reasons. First, the saturation in the invert is essentially uniform, as explained below, so there is no need to represent this heterogeneity. Second, a one cell representation for the invert provides a conservative calculation of diffusive transport through the invert in comparison to multiple cells through the invert.

An analysis was performed with the NUFT computer code to evaluate the saturation gradients in the invert during the recent evaluation of unquantified uncertainties for the Nuclear Waste Technical Review Board. The new analysis is documented in Section 10.3.3.3.3 of Volume I of the Supplemental Science and Performance Analysis (BSC 2001e). This analysis considers a low-temperature operating mode for the latest engineered barrier system design. The grid for the simulation is finer than that used for typical calculations with the multiscale thermal-hydrologic model in order to provide more resolution in the invert. The NUFT calculation predicts essentially constant saturation in the invert underneath the drip shield, demonstrating that the saturation beneath the waste package is essentially constant (uniform). In this case, the use of a volume-averaged saturation for the invert provides acceptable accuracy for calculating the effect of saturation on the diffusion coefficient. (CAT 6, see DOE Response to TSPA003)

Reference: BSC 2001e. FY01 Supplemental Science and Performance Analyses, Volume 1: Scientific Bases and Analyses. TDR-MGR-MD-000007 REV 00. Las Vegas, Nevada: Bechtel SAIC Company. ACC: MOL.20010712.0062.

Agreement Number TSPAI.3.39

Agreement See Agreement statement under TSPA003.

Subissue #3 - Model Abstraction TSPA003.Ex3

Tracking # TSPA003.Ex3

Comment Page 184: Technical basis is needed for the "subset of combinations" that were used in the chemistry modeling.

References CRWMS M&O. "Total System Performance Assessment Model for Site Recommendation." TDR-WIS-PA-000001. Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response The "subset of combinations" used for the lookup tables that constitute the response surface span the entire range used in the TSPA. Interpolation was used to obtain values between the values in the tables. (CAT 6, see DOE Response to TSPA003)

Agreement Number TSPAI.3.39

Agreement See Agreement statement under TSPA003.

Subissue #3 - Model Abstraction TSPA003.Ex4

Tracking # TSPA003.Ex4

Comment Page 183: "...abstracted to representative constant values..." We are not aware of the criteria used to interpret whether the process model was an appropriate abstraction. Also, we do not know what you mean by a "representative constant value", and whether the simplification you employed eliminates significant amounts of uncertainty and variability.

References CRWMS M&O. "Total System Performance Assessment Model for Site Recommendation." TDR-WIS-PA-000001. Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response Discussion of the appropriateness of the abstraction and uncertainty are in Abstraction of Drift-Scale Coupled Processes (CRWMS M&O 2000b). As stated in that document, "Section 6.1 provides the details of the thermal-hydrologic-chemical abstraction of water chemistry and gas-phase composition adjacent to the drift wall. It provides a tabulation of the abstracted time-histories of the aqueous species concentrations, pH, and CO2 component concentration in the gas phase. In addition, Section 6.1 contains a discussion of the uncertainty in these values based on the differences in the thermal-hydrologic-chemical results from the other infiltration flux cases." (CAT 6, see DOE Response to TSPA003)

Reference: CRWMS M&O 2000b. Abstraction of Drift-Scale Coupled Processes. ANL-NBS-HS-000029 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20000525.0371.

Agreement Number TSPAI.3.39

Agreement See Agreement statement under TSPA003.

Subissue #3 - Model Abstraction TSPA003.Ex5

Tracking # TSPA003.Ex5

Comment Page 372: DOE needs to demonstrate that heterogeneities in the flow paths are adequately captured by the abstraction; i.e., releasing from the unsaturated zone to four random points in the saturated zone. It is unclear whether the peak mean DOSE will be larger if the releases are distributed over the total flow area to the saturated zone or to four discrete points.

References CRWMS M&O. "Total System Performance Assessment Model for Site Recommendation." TDR-WIS-PA-000001. Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response The horizontal placement of the point source in each of the four source regions is varied stochastically from realization to realization, reflecting uncertainty in the location of leaking waste packages and transport pathways in the unsaturated zone. This is described in more detail in the Section 6.2.2 of the Analysis/Model Report (CRWMS M&O 2000bx) (CAT 6, see DOE Response to TSPA003)

Reference: CRWMS M&O 2000bx. Input and Results of the Base Case Saturated Zone Flow and Transport Model for TSPA. ANL-NBS-HS-000030 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20000526.0330.

Agreement Number TSPAI.3.39

Agreement See Agreement statement under TSPA003.

Subissue #3 - Model Abstraction TSPA003.Ex6

Tracking # TSPA003.Ex6

Comment Pages 167 and 170: DOE should provide further clarification of the temporal variability of the thermohydrology parameters and the significance of the variation considering the large time-step used in the TSPA model. It is unclear how the model is constructed so that processes operating at faster time constants than the model time steps are captured. Figure 6-41 illustrates the point; it shows that the temperature responds very dynamically in the first 500 years. If a 500-year timestep was used in the TSPA simulation, it is unclear how the dynamic response of this process would be captured. We suggest at least a few test cases using smaller time steps to demonstrate sensitivity.

References CRWMS M&O. "Total System Performance Assessment Model for Site Recommendation." TDR-WIS-PA-000001. Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response Efforts are made to ensure time steps are not too long to prevent resolution of system dynamics. The time step is generally tested as a part of model implementation. For example, such testing helped identify appropriate times steps for the early period when temperatures are changing and for the periods when the climate transitions occur. (CAT 2, see DOE Response to TSPA003)

Agreement Number TSPAI.3.39

Agreement See Agreement statement under TSPA003.

Subissue #3 - Model Abstraction TSPA003.Ex7

Tracking # TSPA003.Ex7

Comment Page 118: There is inadequate justification that representing seepage threshold by three levels (low, medium, and high) captures the contribution from the tails of the distribution, especially on the upper side.

References CRWMS M&O. "Total System Performance Assessment Model for Site Recommendation." TDR-WIS-PA-000001. Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response To resolve this issue, we propose to use the 90th percentile infiltration case identified in the Monte-Carlo analysis for the upper-bound infiltration map of the glacial transition climate. Parameters from this case will be used in the infiltration model to calculate the upper-bound infiltration map. Using this in the infiltration weighting scheme the weights for lower bound, mean and upper bound infiltration cases will be recalculated. The upper bound infiltration cases for the monsoon and modern climates will be computed by the ratio of the spatial average infiltration for the upper bound infiltration map to the mean infiltration map for the glacial transition climate multiplied by the mean infiltration map for the monsoon and modern climates. These new infiltration maps will be incorporated into the process model calculations that are used to support TSPA and the new weighting factors will be used directly for TSPA sampling. (CAT 6, see DOE Response to TSPA003)

Agreement Number TSPAI.3.39

Agreement See Agreement statement under TSPA003.

Subissue #3 - Model Abstraction TSPA003.Ex8

Tracking # TSPA003.Ex8

Comment Page 118: There is inadequate technical basis provided that it is unimportant to represent uncertainty in the infiltration map at each climate state.

References CRWMS M&O. "Total System Performance Assessment Model for Site Recommendation." TDR-WIS-PA-000001. Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response Performing an uncertainty analysis of infiltration for the other climate states is included in the Unsaturated and Saturated Flow under Isothermal Conditions agreement 3.1. The resolution for representing uncertainty is described in the response to the second NRC Comment for Model-Page118. (CAT 6, see DOE Response to TSPA003)

Agreement Number TSPAI.3.39

Agreement See Agreement statement under TSPA003.

Subissue #3 - Model Abstraction TSPA003.Ex9

Tracking # TSPA003.Ex9

Comment Page 107: Engineered barrier system environment section. TSPA uses an equilibrium batch reactor in simulation of the engineered barrier system environments. There is inadequate technical basis provided that the simplification is appropriate to represent the dynamic processes.

References CRWMS M&O. "Total System Performance Assessment Model for Site Recommendation." TDR-WIS-PA-000001. Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response The statement that an equilibrium batch reaction calculations were used is an oversimplification. As stated in the In Drift Precipitates/Salts Analysis (CRWMS M&O 2000bz), "The conceptual model is that boiling and evaporation of water within the drift will cause dissolved solids in the water to concentrate and precipitate. The degree of vaporization of H2O and precipitation of salts and minerals may change with time as conditions change. The precipitates that form will depend on the temperature, gas fugacities, vaporization rate, seepage rate, and seepage composition."..."The Precipitates/Salts model was developed to simulate the conceptual model."

The precipitates/Salts model consists of a low relative humidity model and a high relative humidity model. Those two models are linked at 85% relative humidity.

"In the low relative humidity salts model, seepage water enters a specified location within the drift where it is subjected to evaporation processes. This location is called a "reactor" in this document.

"The EQ3/6 high relative humidity model is used in two modes, a simple evaporation mode and a mode that simulates both flow-through and evaporation simultaneously. The first mode is used to predict the simple evolution of a given solution as water evaporates. The second mode is used to predict the evaporative evolution of a constant incoming seepage." (CAT 6, see DOE Response to TSPA003)

Reference: CRWMS M&O 2000bz. In-Drift Precipitates/Salts Analysis. ANL-EBS-MD-000045 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20000512.0062.

Agreement Number TSPAI.3.39

Agreement See Agreement statement under TSPA003.

Subissue #3 - Model Abstraction TSPA003.Ex11

Tracking # TSPA003.Ex11

Comment Page 129: The seepage uncertainty parameter is randomly sampled from 0 to 1 and is not considered data. It seems that if it is representing uncertainty but no data exists to support its selection, then DOE should favor the value that produces the largest risk.

References CRWMS M&O. "Total System Performance Assessment Model for Site Recommendation." TDR-WIS-PA-000001. Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response The random number from 0 to 1 is only necessary because the parent triangular distributions for seepage uncertainty are evaluated in the seepage dynamically linked library (DLL - a subroutine external to GoldSim) rather than in GoldSim itself. These parent distributions are based on data (see Table 6-4, p. 125). If the triangular distributions were in GoldSim itself, then GoldSim would utilize exactly the same method of using a uniform random number surrogate for sampling the seepage uncertainty distributions. (CAT 7, see DOE Response to TSPA003)

Agreement Number TSPAI.3.39

Agreement See Agreement statement under TSPA003.

Subissue #3 - Model Abstraction TSPA003.Ex12

Tracking # TSPA003.Ex12

Comment Page 182: On the electronic figure (6-65), it looks like that even for median value simulations, there is significant underprediction of peak temperatures.

References CRWMS M&O. "Total System Performance Assessment Model for Site Recommendation." TDR-WIS-PA-000001. Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response DOE will clarify the Figure. (CAT 1, see DOE Response to TSPA003)

Agreement Number TSPAI.3.39

Agreement See Agreement statement under TSPA003.

Subissue #3 - Model Abstraction TSPA004

Tracking # TSPA004

Comment As part of the model development process it is necessary to verify that the model is calculating properly, validate that an appropriate model has been developed for the problem being examined, and complete analyses to explain the detailed functioning of the model. The DOE has provided information on all three of these topics in the TSPA-SR documentation. Support for the process model results abstracted in the TSPA was lacking. The DOE has issued a Corrective Action Report (CAR) BSC-01-C-001 dated 5/3/01 that found "the area of model validation is considered to be a significant condition adverse to quality." The CAR indicates that 18 of 24 Analysis Model Reports (AMR's) were inadequately validated, including eight that were not validated at all. In general, the DOE did not present comparisons of the process model output to the abstractions used in the TSPA. Also, as the CAR indicates, the other methods deemed acceptable to develop support for process models were not satisfied.

See list of examples labeled TSPA004.Ex1, TSPA004.Ex2, etc. for additional details.

References CRWMS M&O. "Total System Performance Assessment for the Site Recommendation." TDR-WIS-PA-000001 Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000a.
CRWMS M&O. "Total System Performance Assessment (TSPA) Model for Site Recommendation." MDL-WIS-PA-000002 Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000b.

DOE Response DOE will provide comparisons of process model output to the abstractions used in the TSPA. A root cause analysis for Corrective Action Report (BSC-01-C-001) is being performed. This comment seems more applicable for Analysis/Model Report model and abstraction validation, not for TSPA model abstractions. The following TSPA examples are categorized as follows:

CAT 1. Clarification required primarily in terms of rewording text. Limited additional work required.

CAT 2. Clarification and additional analysis required. Additional analyses or plots required to fully clarify the point.

CAT 3. Not the scope of the document. Some of the comments ask for more than the model document is intended to serve. For example, additional TSPA analyses in the model document that indicates the significance of the component to long term DOSE. These should be referred to the other documents.

CAT 4. Not used.

CAT 5. Correction required to the text.

CAT 6. Provide abstraction defensibility of the abstraction utilized.

CAT 7. No change required. Suggestions for transparency/traceability may not require any changes.

CAT 8. NRC points out a few instances where we have obtained transparency, or provided abstraction defensibility.

Agreement Number TSPAI.4.05, TSPAI.4.06

Agreement TSPAI.4.05
DOE will document the process used to develop confidence in the TSPA models (e.g., steps similar to those described in NUREG-1636). The detailed process is currently documented in the model development procedures that are being evaluated for process improvement in response to the model validation corrective action report CAR-BSC-01-C-001. The upgraded model validation procedures will be available for NRC review in FY 2002.

TSPAI.4.06
DOE will document the implementation of the process for model confidence building and demonstrate compliance with model confidence criteria in accordance with the applicable procedures. This will be documented in the respective AMR revisions and made available to NRC in FY 2003.

Subissue #3 - Model Abstraction TSPA004.Ex1

Tracking # TSPA004.Ex1

Comment Page 421: We expect that the pipe model has an analytical solution that can be verified. We also believe that the more-complex models should be compared to simple models to provide model support.

References CRWMS M&O. "Total System Performance Assessment Model for Site Recommendation." TDR-WIS-PA-000001. Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response The Analysis/Model Report (CRWMS M&O 2000bx), Section 6.5.2, discusses the 1-D model validation. (CAT 2, see DOE Response to TSPA004)

Reference: CRWMS M&O 2000bx. Input and Results of the Base Case Saturated Zone Flow and Transport Model for TSPA. ANL-NBS-HS-000030 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20000526.0330.

Agreement Number TSPAI.4.05, TSPAI.4.06

Agreement See Agreement statement under TSPA004.

Subissue #3 - Model Abstraction TSPA004.Ex2

Tracking # TSPA004.Ex2

Comment Page F3-23: Model support is needed for the percolation flux modeling results, such as comparison to the ECRB observations or other natural systems.

References CRWMS M&O. "Total System Performance Assessment for the Site Recommendation." TDR-WIS-PA-000001. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response DOE has quantitative support for the levels of percolation flux used in the unsaturated zone flow model from hydrological (water saturation and potential), geochemical (Cl and Sr), temperature, and mineralogical (calcite) measurements. For seepage, model predictions have been compared with seepage testing at Niche 3650 and seepage studies conducted during systematic characterization of the Enhanced Characterization of the Repository Block. (CAT 6, see DOE Response to TSPA004)

Agreement Number TSPAI.4.05, TSPAI.4.06

Agreement See Agreement statement under TSPA004.

Subissue #3 - Model Abstraction TSPA004.Ex3

Tracking # TSPA004.Ex3

Comment Page 3-149: A comparison of the unsaturated zone results from this abstraction with basic information about fractures and flow should be provided for adequate model support.

References CRWMS M&O. "Total System Performance Assessment for the Site Recommendation." TDR-WIS-PA-000001. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response DOE will consider providing in tabular form, a comparison between infiltration rates and water flow travel times. (CAT 6, see DOE Response to TSPA004)

Agreement Number TSPAI.4.05, TSPAI.4.06

Agreement See Agreement statement under TSPA004.

Subissue #3 - Model Abstraction TSPA004.Ex4

Tracking # TSPA004.Ex4

Comment Page 3-117: In order for the reader to agree with the assertion that the corrosion of Zircalloy in boiling seawater and geothermal solutions provides adequate model support, a comparison of the corrosion rates of Zircalloy in those environments and a comparison of those environments to the ionic strength solutions of the other solutions would be appropriate.

References CRWMS M&O. "Total System Performance Assessment for the Site Recommendation." TDR-WIS-PA-000001. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response DOE intends to document the technical basis for the assertion that the corrosion of Zircalloy in boiling seawater and geothermal solutions provides adequate model support in the Waste Form Degradation Process Model Report (CRWMS M&O 2000by) and Cladding Analysis/Model Report (CRWMS M&O 2001t). (CAT 2, see DOE Response to TSPA004)

Reference: CRWMS M&O 2000by. Waste Form Degradation Process Model Report. TDR-WIS-MD-000001 REV 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20000713.0362. (future revision)

CRWMS M&O 2001t. Clad Degradation - Summary and Abstraction. ANL-WIS-MD-000007 REV 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20010214.0229.

Agreement Number TSPAI.4.05, TSPAI.4.06

Agreement See Agreement statement under TSPA004.

Subissue #3 - Model Abstraction TSPA004.Ex5

Tracking # TSPA004.Ex5

Comment Page 3-114: Is the frequency of 1.1E-6/yr for cladding failure due to severe seismic activity a modeled result? If so, what is the model support for this result?

References CRWMS M&O. "Total System Performance Assessment for the Site Recommendation." TDR-WIS-PA-000001. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response DOE will clarify the text. (CAT 1, see DOE Response to TSPA004)

Agreement Number TSPAI.4.05, TSPAI.4.06

Agreement See Agreement statement under TSPA004.

Subissue #3 - Model Abstraction TSPA004.Ex6

Tracking # TSPA004.Ex6

Comment Page 3-107 (last paragraph under Basis for High-level Radioactive Waste Glass Degradation Model): The description is for a comparison of a model to other models. A comparison of models to models is a questionable method to develop model support.

References CRWMS M&O. "Total System Performance Assessment for the Site Recommendation." TDR-WIS-PA-000001. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response The Analysis/Model Report on high level waste glass degradation explains that the model for glass degradation in humid air was based on drip tests on Savannah River glass. DOE will add sentence "The better model, in turn, was based on drip tests using results from high level waste glass." (CAT 6, see DOE Response to TSPA004)

Agreement Number TSPAI.4.05, TSPAI.4.06

Agreement See Agreement statement under TSPA004.

Subissue #3 - Model Abstraction TSPA004.Ex7

Tracking # TSPA004.Ex7

Comment Page 3-73: Technical basis is needed for the pH values applied below 85% RH.

References CRWMS M&O. "Total System Performance Assessment for the Site Recommendation." TDR-WIS-PA-000001. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response The EQ3/6 database and code are now being further developed to make pH predictions at far lower values of relative humidity. Extrapolation of values from 85% relative humidity to lower values was chosen in lieu of any other rational approach. The duration of relative humidity below 85% is relatively short compared with the period of performance. (CAT 6, see DOE Response to TSPA004)

Agreement Number TSPAI.4.05, TSPAI.4.06

Agreement See Agreement statement under TSPA004.

Subissue #3 - Model Abstraction TSPA004.Ex8

Tracking # TSPA004.Ex8

Comment Page 3-61: DOE needs to address more thoroughly the observation: "The use of the simplified THC model results for the abstraction is based on the fact that it reproduces more accurately the observed changes to water and gas compositions in the drift-scale heater test..." Specifically, we are concerned by the fact that the field data show better agreement with the abstraction than with the process model, which may be anecdotal rather than real.

References CRWMS M&O. "Total System Performance Assessment for the Site Recommendation." TDR-WIS-PA-000001. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response The "simplified model" and the "complex model" are both process-level models (run with TOUGHREACT), not abstractions. The main difference is that the "complex model" has more trace constituents. In CRWMS M&O 2000cc, the simplified process-level model better matches the results of the drift-scale heater test, therefore, it was used as the basis for the thermal-hydrologic-chemical abstraction in TSPA, i.e., the "simplified" process-level model was further simplified (abstracted) for use in TSPA. (CAT 7, see DOE Response to TSPA004)

Reference: CRWMS M&O 2000cc. Near Field Environment Process Model Report. TDR-NBS-MD-000001 REV 00, ICN 02. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001005.0001.

Agreement Number TSPAI.4.05, TSPAI.4.06

Agreement See Agreement statement under TSPA004.

Subissue #3 - Model Abstraction TSPA004.Ex9

Tracking # TSPA004.Ex9

Comment Page 424: "...it can be concluded that the SZ component model is verified." DOE should provide the technical basis that demonstrates the approach taken satisfies the requirements for model verification.

References CRWMS M&O. "Total System Performance Assessment Model for Site Recommendation." TDR-WIS-PA-000001. Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response The intent of this statement is not to verify the sub-component model, but to show that the saturated zone site-scale model is correctly implemented in the TSPA model and working as intended. The specific Analysis/Model Reports (CRWMS M&O 2000ca, 2000cb), flow and transport respectively, discuss model verification. (CAT 6, see DOE Response to TSPA004)

References: CRWMS M&O 2000ca. Calibration of the Site-Scale Saturated Zone Flow Model. MDL-NBS-HS-000011 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20000825.0122.

CRWMS M&O 2000cb. Saturated Zone Transport Methodology and Transport Component Integration. MDL-NBS-HS-000010 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20000824.0513.

Agreement Number TSPAI.4.05, TSPAI.4.06

Agreement See Agreement statement under TSPA004.

Subissue #3 - Model Abstraction TSPA004.Ex10

Tracking # TSPA004.Ex10

Comment Page 191: The pH and ionic strength should also be checked at time periods between calculational switch points.

References CRWMS M&O. "Total System Performance Assessment Model for Site Recommendation." TDR-WIS-PA-000001. Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response The current model switches in-package water chemistry at times chosen to represent the dynamics of the chemistry evolution. It would be straightforward to provide finer resolution on these switches. However, the effect of doing so would not be very important in the calculational construct. The evolution of chemistry within each waste package is not tracked. Instead, an average chemistry is used to represent performance of groups of waste packages. Since the waste packages within a group fail at very different times, this averaging means that fine details of the changes in chemistry after the time of package failure are blurred over. Consequently, finer resolution on the chemistry changes is not likely to change the calculated DOSE rate very much. (CAT 2, see DOE Response to TSPA004)

Agreement Number TSPAI.4.05, TSPAI.4.06

Agreement See Agreement statement under TSPA004.

Subissue #3 - Model Abstraction TSPA004.Ex11

Tracking # TSPA004.Ex11

Comment Page 120: The paragraph basically shows that the Infiltration_Scenario parameter was implemented correctly at the local, limited basis. The technical basis for evaluating the Infiltration_Scenario implementation on a limited basis was not provided. In particular, the Infiltration_Scenario is listed as being utilized by UZ flow fields, thermohydrology, and seepage and is described as being linked to 137 other parameters.

References CRWMS M&O. "Total System Performance Assessment Model for Site Recommendation." TDR-WIS-PA-000001. Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response Verification that the correct value of Infiltration_Scenario is used in the various submodels is generally described in the subsection of the Model Document devoted to that submodel. These subsections are referred to on p. 120. For example, see Table 6-6 (CRWMS M&O 2000aq, Section 6.3.1.2) for the value of Infiltration_Scenario used in the seepage submodel. If additional proof is needed, the GoldSim model file can be opened and the external links for Infiltration_Scenario can be followed individually to each place that the parameter is used. (CAT 6, see DOE Response to TSPA004)

Reference: CRWMS M&O 2000aq. Total System Performance Assessment (TSPA) Model for Site Recommendation. MDL-WIS-PA-000002 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001226.0003.

Agreement Number TSPAI.4.05, TSPAI.4.06

Agreement See Agreement statement under TSPA004.

Subissue #3 - Model Abstraction TSPA004.Ex12

Tracking # TSPA004.Ex12

Comment Page 50, #7: It doesn't appear that points on which experts disagree have been discussed in the documentation, as implied by the comment. It is unclear how the DOE has handled these issues in the TSPA.

References CRWMS M&O. "Total System Performance Assessment Model for Site Recommendation." TDR-WIS-PA-000001. Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response DOE will clarify the text. (CAT 1, see DOE Response to TSPA004)

Agreement Number TSPAI.4.05, TSPAI.4.06

Agreement See Agreement statement under TSPA004.

Subissue #3 - Model Abstraction TSPA004.Ex13

Tracking # TSPA004.Ex13

Comment Page 4-6: Model support is needed for the glacial transition climate or monsoon climate ratios of infiltration to precipitation.

References CRWMS M&O. "Total System Performance Assessment for the Site Recommendation." TDR-WIS-PA-000001. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response See the response to NRC Comment for Page 3-37. If the technical basis is sufficient to support the model calculations of infiltration for future climates (NRC Comment for Page 3-37) then DOE considers it is sufficient to support the computed ratios of infiltration to precipitation for future climates. (CAT 6, see DOE Response to TSPA004)

Agreement Number TSPAI.4.05, TSPAI.4.06

Agreement See Agreement statement under TSPA004.

Subissue #3 - Model Abstraction TSPA004.Ex14

Tracking # TSPA004.Ex14

Comment Page 3-37: The conceptual model for infiltration is based on field studies at Yucca Mountain under current climate conditions. Technical basis is needed that the same infiltration model will apply under future climate conditions, which are roughly 94% of the 10,000 year compliance period.

References CRWMS M&O. "Total System Performance Assessment for the Site Recommendation." TDR-WIS-PA-000001. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response The infiltration model has been compared with alternative methods for estimating infiltration over a range of precipitation corresponding to wetter future climates. These comparisons include the Maxey-Eakin method and the chloride mass balance method. These comparisons support the conclusion that the net infiltration model is appropriate for estimating the spatial distribution of net infiltration at Yucca Mountain. (CAT 6, see DOE Response to TSPA004)

Agreement Number TSPAI.4.05, TSPAI.4.06

Agreement See Agreement statement under TSPA004.

Subissue #3 - Model Abstraction General.TT.1

Tracking # General.TT.1

Comment Table D.1-1 defines the subissues of the NRC Key Technical Issues (KTIs), when the NRC structure is shifting from KTIs to Integrated Subissues (ISIs).

References CRWMS M&O. "Total System Performance Assessment for the Site Recommendation." TDR-WIS-PA-000001. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response Table D.1-1 is a synopsis of the TSPAI Issue Resolution Status Report Key Technical Issue (NRC 2000) and their related Subissues. The relationship between NRC Integrated Subissues and Key Technical Issue subissues is in Table D.1-2. Table D.1-1 will be deleted in the next revision of TSPA-Site Recommendation.

Reference: NRC 2000. Issue Resolution Status Report Key Technical Issue: Total System Performance Assessment and Integration. Rev. 3. Washington, D.C.: U.S. Nuclear Regulatory Commission. TIC: 249045.

Agreement Number

Agreement DOE response during Technical Exchange was considered adequate by the NRC. Total System Performance Assessment and Integration Technical Exchange, August 6-10, 2001.

Subissue #3 - Model Abstraction General.TT.2

Tracking # General.TT.2

Comment Table B-1 of the Repository Safety Strategy, REV04 presents process model factors. Table D.1-3 of TSPA-SR presents process model reports and process model factors. The list of process model factors (for the nominal case) do not match between the two documents. Specifically, a process model factor, equivalent to "EBS(invert) degradation and performance" (from Table B-1 of the RSS), was not apparent in Table D.1-3 of TSPA-SR. Similarly, process model factors, equivalent to "In-Package Environments" and "Changes to SZ Flow" (from Table D.1-3 of TSPA-SR), were not apparent in Table B-1 of the RSS.

References CRWMS M&O. "Total System Performance Assessment for the Site Recommendation." TDR-WIS-PA-000001. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

CRWMS M&O. "Repository Safety Strategy: Plan to Prepare the Safety Case to Support Yucca Mountain Site Recommendation and Licensing Considerations." TDR-WIS-RL-000001. Revision 04 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response DOE agrees that Table D.1-3 should be same with Table B-1 of Repository Safety Strategy Rev. 4 (CRWMS M&O 2001i). DOE will verify the accuracy of the information in Table D.1-3 and update it as necessary.

Reference: CRWMS M&O 2001i. Repository Safety Strategy: Plan to Prepare the Safety Case to Support Yucca Mountain Site Recommendation and Licensing Considerations. TDR-WIS-RL-000001 REV 04 ICN 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20010329.0825.

Agreement Number

Agreement DOE response during Technical Exchange was considered adequate by the NRC. Total System Performance Assessment and Integration Technical Exchange, August 6-10, 2001.

Subissue #3 - Model Abstraction General.TT.3

Tracking # General.TT.3

Comment It seems that it would be more helpful if the IRSR tracking database, described in Appendix D of TSPA-SR (CRWMS M&O, 2000), included the content of the IRSR (i.e., the comments and how they have been addressed) in addition to listing the acceptance criteria from the TSPAI IRSR (NRC, 2000).

References CRWMS M&O. "Total System Performance Assessment for the Site Recommendation." TDR-WIS-PA-000001. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

NRC. "Issue Resolution Status Report. Key Technical Issue: Total System Performance Assessment and Integration." Revision 3. Washington, DC: NRC. 2000.

DOE Response In the next revision to TSPA-Site Recommendation, references and content of the Issue Resolution Status Report database will be removed from Appendix D. Considering the impending release of the Yucca Mountain Review Plan, DOE does not believe that it is prudent to update Appendix D since the acceptance criteria may change in the Review Plan.

Agreement Number

Agreement DOE response during Technical Exchange was considered adequate by the NRC. Total System Performance Assessment and Integration Technical Exchange, August 6-10, 2001.

Subissue #3 - Model Abstraction General.TT.4

Tracking # General.TT.4

Comment The contents of Table E-1 seemed to have missed the intent implied by the title to Appendix E called "Analyses Model and Data Traceability". The reader likely will assume that the information in the table will provide a way to trace the source of input data through the TSPA system; however, the poorly formatted and confusing information is more useful for tracking document contents through the system than data items. Consider the data input item of a geologic layer thickness in the unsaturated zone. The "Reference Document" column could be scanned to locate possible locations of the data. For example ,"Abstraction of Flow Fields for RIP", Abstraction of Drift Seepage", and Draft of "MR Abstraction of NFE Drift Thermodynamic Environment and Percolation Flux". With an educated guess one might select the "Abstraction of Flow Fields for RIP," but there is no verification in the Table that the data actually exists in this document or any other. Indeed, the data may not exist in any of the documents listed.

References CRWMS M&O. "Total System Performance Assessment for the Site Recommendation." TDR-WIS-PA-000001. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response DOE will consider updating Table E-1 to add another layer to identify the type of information that will be fed into the models.

Agreement Number

Agreement DOE response during Technical Exchange was considered adequate by the NRC. Total System Performance Assessment and Integration Technical Exchange, August 6-10, 2001.

Subissue #4 - Overall Performance Objective J-H2.1

Tracking # J-H2.1

Comment Assumptions made in the analysis of the effects of human intrusion do not appear to be justified or appropriate based on proposed 10 CFR Part 63.

Specific Examples:
- Volume and chemistry of drilling fluids are ignored in analysis: Sufficient support is not provided for ignoring the impact of these aspects on the human intrusion scenario analyses.

- Rate of infiltration is unaffected by the presence of the borehole: The technical basis for this assumption used for the human intrusion scenario analyses is neither transparent nor traceable.

- Cladding in the penetrated WP is perforated due to the event, but not completely failed. The cladding still needs to unzip, which can take a very long time.

- The properties of the rubblized borehole (porosity, fluid saturation, and dispersivity) are represented by the matrix properties of a UZ fault.

References CRWMS M&O. "Total System Performance Assessment for the Site Recommendation." TDR-WIS-PA-000001 Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response The human intrusion analysis was formulated using the nominal case scenario. Unsaturated Zone and Engineered Barrier System components were replaced to produce a simplified representation of the human intrusion scenario as specified in the proposed !0 CFR Part 63 (64 FR 8640) and 40 CFR 197 (66 FR 32074). Human intrusion scenario inputs will be re-evaluated following promulgation of final Environmental Protection Agency, NRC, and DOE rules.

References:

64 FR 8640. Disposal of High-Level Radioactive Wastes in a Proposed Geologic Repository at Yucca Mountain, Nevada. Proposed rule 10 CFR Part 63. Readily available.

66 FR 32074. 40 CFR Part 197, Public Health and Environmental Radiation Protection Standards for Yucca Mountain, NV; Final Rule. Readily available.

Agreement Number

Agreement DOE response during Technical Exchange was considered adequate by the NRC. Total System Performance Assessment and

Subissue #4 - Overall Performance Objective J-H2.2

Tracking # J-H2.2

Comment The results of the human intrusion analyses do not appear to be consistent with other models in the TSPA.

Examples:
- The peak expected dose resulting from human intrusion is shown to occur approximately 200 years after the single WP is breached by drilling. This result suggests that the travel time in the saturated zone is extraordinarily short. Elsewhere in the TSPA-SR Technical Document it appears that the 3D SZ model predicts a median travel time for unretarded carbon-14 of about 600 years while for slightly retarded technetium-99, the median travel time is around 1000 to 1500 years. These findings seem inconsistent.

References CRWMS M&O. "Total System Performance Assessment for the Site Recommendation." TDR-WIS-PA-000001 Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response See above response to J-H2.1.

For the specific example shown, this may be due to comparison of a mean peak dose from the TSPA HI calculation (Figure 4.4-11) to breakthrough curves calculated using median inputs to the 3D Saturated Zone model (Figure 3.8-18). Note that the mean HI dose is strongly dominated by the early breakthroughs. The TSPA median HI dose peaks after 10,000 years, consistent with retardation of Np and Pu. The probabilistic breakthrough curves shown in Figure 3.8-19 provide insight into the distribution of breakthrough curves that contribute to the distribution of dose curves.

Reference: CRWMS M&O 2000ar. Total System Performance Assessment for the Site Recommendation. TDR-WIS-PA-000001 REV 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001220.0045.

Agreement Number

Agreement DOE response during Technical Exchange was considered adequate by the NRC. Total System Performance Assessment and Integration Technical Exchange, August 6-10, 2001.

Subissue #4 - Overall Performance Objective J-O3.1

Tracking # J-O3.1

Comment DOE appears to be weighting the results of alternative conceptual models without an appropriate technical basis for the weighting factor used.

Specific Examples:
Igneous dike propagation model identifies two alternatives: (i) the dike either centralizes above the repository due to flow into the drifts; or (ii) the dike centralizes randomly along the drift length. Without any technical basis, each of these alternatives is weighted by 50%.

Seepage uncertainty parameter is randomly sampled from 0 to 1 without any justification for selecting a value less than 1.

Information on the correlation of Kds among different UZ units is limited, but the most conservative model is neither identified nor selected.

The anisotropic and isotropic alternative conceptual models for saturated zone flow are weighted equally without a technical basis.

References CRWMS M&O. "Dike Propagation near drifts." ANL-WIS-MD-000015. Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000.
CRWMS M&O. "Igneous Consequence Modeling for the TSPA-SR." ANL-WIS-MD-000017. Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000.
CRWMS M&O. "Total System Performance Assessment (TSPA) Model for Site Recommendation." MDL-WIS-PA-000002 Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000. Pages 129 and 398.
CRWMS M&O. "Total System Performance Assessment for the Site Recommendation." TDR-WIS-PA-000001. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000. Page 3-163.

DOE Response DOE agrees that weighting for alternative conceptual models should be appropriately justified. Note that in some cases (e.g. seepage) the distribution has been chosen to capture uncertainty, and it is not always clear a priori which end of the distribution is more conservative. The DOE has therefore included the full uncertainty in the analysis to allow determination of sensitivity.

Seepage Uncertainty - The seepage uncertainty parameter does not represent alternative conceptual models, but rather the uncertainty in the hydrologic properties around the drifts. This uncertainty is discussed in detail in the seepage-abstraction Analysis/Model Report (CRWMS M&O 2001o)

Unsaturated Zone Kds - The Kd measurements and abstraction

are done in terms of rock type, not stratigraphic unit. This is appropriate because it is the rock chemistry (i.e., mineral abundances, etc.) that will determine the Kd.

Saturated Zone Anistropy - Given the lack of any additional basis for assigning probability weights to alternative conceptual models of horizontal anisotropy, the least biased approach is to assign equal weights to the two alternatives.

Reference: CRWMS M&O 2001o. Abstraction of Drift Seepage. ANL-NBS-MD-000005 REV 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20010309.0019.

Agreement Number TSPAI.4.01

Agreement DOE will document the methodology that will be used to incorporate alternative conceptual models into the performance assessment. The methodology will ensure that the representation of alternative conceptual models in the TSPA does not result in an underestimation of risk. DOE will document the guidance given to process-level experts for the treatment of alternative models. The implementation of the methodology will be sufficient to allow a clear understanding of the potential effect of alternative conceptual models and their associated uncertainties on the performance assessment. The methodology will be documented in the TSPA-LA methods and assumptions document in FY02. The results will be documented in the appropriate AMRs or the TSPA for any potential license application in FY 2003.

Subissue #4 - Overall Performance Objective J-O3.2

Tracking # J-O3.2

Comment The treatment of alternative conceptual models in the DOE sensitivity and uncertainty analysis is not clear.

DOE briefly mentions alternative conceptual models only as an example in the TSPA-SR Technical Document (page 5-9): "An example of a parameter with this effect is neptunium solubility (see Section 5.2.4.2). An example of a conceptual model that might have this effect is the dual-porosity UZ transport model, which may result in faster transport than a dual continuum model."

References CRWMS M&O. "Total System Performance Assessment for the Site Recommendation." TDR-WIS-PA-000001 Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response Where a particular conceptual model is technically justified, there is no requirement to consider more conservative alternatives. DOE will clarify the incorporation of alternative conceptual models in the next revisions to the Analysis/Model Reports.

Agreement Number

Agreement DOE response during Technical Exchange was considered adequate by the NRC. Total System Performance Assessment and Integration Technical Exchange, August 6-10, 2001.

Subissue #4 - Overall Performance Objective J-O3.3

Tracking # J-O3.3

Comment Inappropriate characterization of data uncertainty may affect the results of calculated repository performance even if the mean of the distribution is reasonable. Selecting too wide of an uncertainty band may dilute the risk by spreading the peak dose in time, thereby reducing the peak value. Selecting too narrow of an uncertainty band may underestimate peak dose during the compliance period by delaying dose beyond the regulatory period of interest. DOE needs to discuss what, if any, analyses that they have used to provide confidence that their choice of parameter distributions is appropriate and will not lead to risk dilution by reducing the peak expected annual dose.

Specific Examples
Use of uniform distributions for the Kd value for several radionuclides (Am, Pu, Ra, Pb, Pa, Sn) gives equal probability to all values, which is likely not appropriate. A more biased distribution could increase peak dose by reducing the spread in travel times.

Selection of non-zero lower value for distributions of Kds for Pu, Pb, Ra, and Sn without an appropriate technical basis may inappropriately delay doses beyond compliance period.

Lower values in uncertainty bands for the stress intensity factor (Ki) include values below 0, which have no risk significance. This may inappropriately dilute risk.

References CRWMS M&O. "Total System Performance Assessment for the Site Recommendation." TDR-WIS-PA-000001 Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000. Figure 3.4-11.

DOE Response Parameter distributions utilized in the TSPA model are documented in the TSPA model report (CRWMS M&O 2000aq) or in the supporting Analysis/Model Reports. For the TSPA-License Application, the documentation of the selection of parameter distributions and associated impact on peak expected annual dose will be enhanced.

Kd Distributions - Uncertainty distributions for Kd values are based on statistical analyses of data in most cases. Additional justification for uncertainty distributions will be included in revision of existing documentation, as covered by an existing Radionuclide Transport agreements 2.10, 1.5).

Stress Intensity Factor - The stress intensity factor (KI) could become negative depending on the stress state and crack geometry. Negative stress intensity factor values included in the

uncertainty range do not have any impact on the waste package performance because no stress corrosion cracks grow with the stress intensity factor less than zero. As a result, DOE does not believe that this results in any dilution of risk.

DOE will provide a plot of Pu Kd vs. distribution function.

Reference: CRWMS M&O 2000aq. Total System Performance Assessment (TSPA) Model for Site Recommendation. MDL-WIS-PA-000002 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001226.0003.

Agreement Number

Agreement DOE response during Technical Exchange was considered adequate by the NRC. Total System Performance Assessment and Integration Technical Exchange, August 6-10, 2001.

Subissue #4 - Overall Performance Objective J-O3.4

Tracking # J-O3.4

Comment The 10,000-year water residence time in the WP does not appear to be consistent with the assumption that diffusion in the WP is instantaneous.

References CRWMS M&O. "Total System Performance Assessment for the Site Recommendation." TDR-WIS-PA-000001 Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000. Page 4-8, first paragraph.

DOE Response Diffusion out of the waste package is not instantaneous because of the relatively small area available for diffusion. Later on as the hole becomes larger, diffusion does increase.

Agreement Number

Agreement DOE response during Technical Exchange was considered adequate by the NRC. Total System Performance Assessment and Integration Technical Exchange, August 6-10, 2001.

Subissue #4 - Overall Performance Objective J-O3.5

Tracking # J-O3.5

Comment DOE has not demonstrated that the results of all of their analyses are stable with respect to the number of realizations performed in the simulations. For example, submodels such as BDCFs and saturated zone transport transfer functions are developed from a limited number of realizations, which is not increased for tests of the stability of the results.

References CRWMS M&O. "Total System Performance Assessment for the Site Recommendation." TDR-WIS-PA-000001 Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response TSPA-Site Recommendation model results have been determined to be stable only with respect to their inputs. For postclosure, the analyses focussed on stability for the first 10,000 years. Multiple replicate TSPA runs are being considered to provide additional insight regarding stability of model results.

Biosphere Dose Conversion Factors - Testing was not used to demonstrate Biosphere Dose Conversion Factors stability. This testing would be more appropriate post-Site Recommendation and DOE recognizes that additional work is required to demonstrate stability of the results in TSPA-License Application.

Reference: CRWMS M&O 2000aq. Total System Performance Assessment (TSPA) Model for Site Recommendation. MDL-WIS-PA-000002 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001226.0003.

Agreement Number TSPAI.4.03

Agreement DOE will document the method that will be used to demonstrate that the overall results of the TSPA are stable. DOE will provide documentation that submodels (including submodels used to develop input parameters and transfer functions) are also numerically stable. DOE will address in the method the stability of the results with respect to the number of realizations. DOE will describe in the method the statistical measures that will be used to support the argument of stability. The method will be documented in TSPA LA Methods and Assumptions Document in FY02. The results of the analyses will be provided in the TSPA (or other appropriate documentation) for any potential license application in FY 2003.

Subissue #4 - Overall Performance Objective J-O3.6

Tracking # J-O3.6

Comment DOE has not presented justification that the model results appropriately address variability (e.g., fom the level of discretization within the system). For example, DOE should demonstrate that results are stable with respect to the number of infiltration bins, number of climate states, number of thermohydrology bins, and time step size.

References CRWMS M&O. "Total System Performance Assessment for the Site Recommendation." TDR-WIS-PA-000001 Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response Spatial and temporal variability and discretization apply at all scales of all of the process-level and abstraction models, and the TSPA model. The level of discretization/variability used in the models represents an optimization that strives to achieve the greatest amount of variability within the constraints of available scientific data and available computational resources. For example, the five thermo-hydrological/infiltration bins represent a discretization of the source term behavior that is a compromise between modeling the source term releases at each individual waste package environment (total of about 12,000) versus assuming an average behavior for the entire repository. The four saturated zone source regions represent a similar compromise. Studies indicate that little difference in repository behavior would be expected using either one source saturated zone region or four saturated zone source regions (CRWMS M&O 2000ar, Figure 4.1-18). Chapter 3 includes discussions of uncertainty and variability as implemented in the various TSPA submodels. Variability ranges used in the models represent a combination of scientific data and judgement, generally biased toward conservatism when specific data is lacking.

Number of infiltration bins - The infiltration bins are used to divide the waste packages into groups for purposes of calculating radionuclide mobilization, release, and transport within the Engineered Barrier System. It is not possible to model all 11,770 waste packages individually. However, the following observations apply:

(1) The infiltration bins used (0-3 mm/yr, 3-10 mm/yr, 10-20 mm/yr, 20-60 mm/yr, and 60+ mm/yr during the glacial-transition climate) cover a wide range of infiltration, and therefore do capture important aspects of the effects of infiltration variability.

(2) The TSPA results have been found not to be particularly sensitive to infiltration (see Section 5.2.1.1 of the TSPA-Site Recommendation technical report). Thus, including greater detail in its TSPA implementation would not be expected to have a great

effect.

Number of climate states - The climate states, including their number and properties (e.g., precipitation, temperature, etc.), are justified in detail in the future-climate Analysis/Model Report (USGS 2000b).

Number of thermohydrology bins - The thermal-hydrology results are binned according to the infiltration bins that are discussed above.

Timestep size - Timestep size in the total system model was conducted to optimize: (1) convergence (timestep size and substep size), (2) result file size and the amount of data that could be saved within the Windows NT 2GB limit, and (3) computational time. The first constraint forces smaller timesteps, while the latter two constraints force larger timesteps. The timestep sizes used in the TSPA-Site Recommendation model (CRWMS M&O 2000aq) are small enough to capture the key changes in the system (e.g., the climate oscillations), but large enough to allow storage of key data from a multiple-realization, million-year simulation using currently available computational resources. The internal substep used for convergence of the model allows the much larger timesteps (e.g., 500 years) to cycle as low as 1 month in order to attain convergence. Further internal substep reductions, e.g., on the order of hours, do not give noticeably different results. Sensitivity studies on timestep size and substep size in GoldSim will be available for the TSPA-License Application.

References: CRWMS M&O 2000ar. Total System Performance Assessment for the Site Recommendation. TDR-WIS-PA-000001 REV 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001220.0045.

USGS 2000b. Future Climate Analysis. ANL-NBS-GS-000008 REV 00. Denver, Colorado: U.S. Geological Survey. ACC: MOL.20000629.0907.

CRWMS M&O 2000aq. Total System Performance Assessment (TSPA) Model for Site Recommendation. MDL-WIS-PA-000002 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001226.0003.

Agreement Number TSPAI.4.04

Agreement DOE will conduct appropriate analyses and provide documentation that demonstrates the results of the performance assessment are stable with respect to discretization (e.g. spatial and temporal) of

the TSPA model. This will be documented in the TSPA for any potential license application in FY 2003.

Subissue #4 - Overall Performance Objective J-O3.7

Tracking # J-O3.7

Comment The TSPA code is not properly verified, such that there is confidence that the code is correctly modeling the physical processes in the repository system. The TSPA code needs to be verified by the time of a License Application (if one is submitted). See Comment TSPA004. NRC Clarification: The proposed rule at 10 CFR 63.114(g) requires that the DOE provide the technical basis for the models used in the Total System Performance Assessment (TSPA). The technical basis includes appropriate efforts to ensure the quality of the code results, where verification and validation are integral to assuring the quality of code results. Verification ensures that software performs properly prior to its use for the intended purpose. The verification process should demonstrate that(i) the models used have been adequately tested for calculational correctness with all relevant data together with associated uncertainties; (ii) a well-defined and rational assessment procedure has been followed; and (iv) results have been fully disclosed and subjected to QA and review procedures. The verification process encompasses (i) tests that provide evidence of correct and successful implementation of algorithms, as appropriate, and (ii) bench-marking or comparative testing against results from other software for cases where accuracy of the code or the correctness of the code cannot judged otherwise, because there is no analytical method to use for comparison. Verification must be clearly distinguished from model validation. Model validation (e.g., conceptual or mathematical) deals with the conceptual basis of the model used for representing the real system. Therefore, model validation is a demonstration of suitability of a model to accurately represent a stipulated component (e.g., waste package) or aspect (e.g., heat flow) of a real system. Whether the processes are properly formulated mathematically and parameterized following accepted theories (or if a new theory is used [e.g., the active fracture model] then is this new theory tested), numerical schemes used have acceptable convergence properties, dimensionality (space and time) is appropriate, etc. are part of model validation. The validation of the TSPA model, which is essentially an abstracted model or a combination of models, has a special requirement that the simplification introduced does not cause optimistic biases in the results.

References

DOE Response Code verification and model validation are accomplished through DOE's Quality Assurance procedures. AP-SI.1Q is used for code verification and AP-3.10Q is used for model validation.

Examples of model verification and validation methods include:

- Software verifications by the developer (Golder)

- Input to TSPA model checked to ensure that the input is used for its intended purpose and is working appropriately

- Intermediate and expected value results checked to ensure subsystem linkages and overall system performance are performing properly

Corrective action reports have been initiated to assess recent discrepancies identified with software and model verification and validation. In addition, root cause analyses have been initiated to identify systemic causes of the discrepancies and programmatic improvements, if necessary. Periodic updates on the root cause findings and corrective actions are being reported in accordance with the DOE Management Plan for TSPA Quality Issues.

References: AP-3.10Q, Rev. 2, ICN 4. Analyses and Models. Washington, D.C.: U.S. Department of Energy, Office of Civilian Radioactive Waste Management. ACC: MOL.20010405.0009.

AP-SI.1Q, Rev. 3, ICN 1, ECN 1. Software Management. Washington, D.C.: U.S. Department of Energy, Office of Civilian Radioactive Waste Management. ACC: MOL.20010705.0239.

CRWMS M&O 2000aq. Total System Performance Assessment (TSPA) Model for Site Recommendation. MDL-WIS-PA-000002 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001226.0003.

CRWMS M&O 2000ar. Total System Performance Assessment for the Site Recommendation. TDR-WIS-PA-000001 REV 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001220.0045.

Brocoum, S.J. Letter from S.J. Brocoum to W. Reamer, Total System Performance Assessment Quality Issues, dated July 6, 2001.

Agreement Number TSPAI.4.05, TSPAI.4.06, TSPAI.4.07

Agreement TSPAI.4.05
DOE will document the process used to develop confidence in the TSPA models (e.g., steps similar to those described in NUREG-1636). The detailed process is currently documented in the model development procedures that are being evaluated for process improvement in response to the model validation corrective action report CAR-BSC-01-C-001. The upgraded model validation

procedures will be available for NRC review in FY 2002.

TSPAI.4.06
DOE will document the implementation of the process for model confidence building and demonstrate compliance with model confidence criteria in accordance with the applicable procedures. This will be documented in the respective AMR revisions and made available to NRC in FY 2003.

TSPAI.4.07
DOE's software qualification requirements are currently documented in procedure AP SI.1Q which is under review for process improvement as part of software CAR-BSC-01-C-002. During its review of AP SI.1Q, DOE will consider: 1) the procedure it would follow to conduct a systematic and uniform verification — all areas of a code analyzed at a consistent level, 2) the process it would follow to ensure correct implementation of algorithms, and 3) the process it would follow for the full disclosure of calculations and results. DOE will document compliance with the improved process in the verification documentation required by AP SI.1Q. Software qualification record packages for the affected programs will be available for NRC review in FY 2003.

Subissue #4 - Overall Performance Objective J-O3.7.Ex1

Tracking # J-O3.7.Ex1

Comment In the TSPA-SR Technical Document (CRWMS M&O 2000), the DOE presented various levels of analyses to demonstrate the verification of selected aspects of the performance assessment model. However, the verification was not sufficiently comprehensive; carrying the calculations forward to step through different parts of the model in larger segments would provide a more robust verification of the TSPA code.

References CRWMS M&O. "Total System Performance Assessment for the Site Recommendation." TDR-WIS-PA-000001 Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response In a future revision of the TSPA model report, DOE will provide additional documentation regarding the TSPA modules and their integration into the overall TSPA.

Agreement Number TSPAI.4.07

Agreement DOE's software qualification requirements are currently documented in procedure AP SI.1Q which is under review for process improvement as part of software CAR-BSC-01-C-002. During its review of AP SI.1Q, DOE will consider: 1) the procedure it would follow to conduct a systematic and uniform verification - all areas of a code analyzed at a consistent level, 2) the process it would follow to ensure correct implementation of algorithms, and 3) the process it would follow for the full disclosure of calculations and results. DOE will document compliance with the improved process in the verification documentation required by AP SI.1Q. Software qualification record packages for the affected programs will be available for NRC review in FY 2003.

Subissue #4 - Overall Performance Objective J-O3.7.Ex2

Tracking # J-O3.7.Ex2

Comment DOE has issued a Corrective Action Request (CAR) BSC-01-C-001 on model validation. The condition described in the CAR is that the DOE requirements for model validation (AP-3.10Q) have not been consistently implemented, which places the validation status of the TSPA model in question.

References AP-3.10Q, Rev. 2, ICN 4. Analyses and Models. Washington, D.C.: U.S. Department of Energy, Office of Civilian Radioactive Waste Management. ACC: MOL.20010405.0009.

DOE Response Model validation and its impact on TSPA results is within the scope of Corrective Action Report BSC-01-C-001.

Agreement Number TSPAI.4.05, TSPAI.4.06

Agreement TSPAI.4.05
DOE will document the process used to develop confidence in the TSPA models (e.g., steps similar to those described in NUREG-1636). The detailed process is currently documented in the model development procedures that are being evaluated for process improvement in response to the model validation corrective action report CAR-BSC-01-C-001. The upgraded model validation procedures will be available for NRC review in FY 2002.

TSPAI.4.06
DOE will document the implementation of the process for model confidence building and demonstrate compliance with model confidence criteria in accordance with the applicable procedures. This will be documented in the respective AMR revisions and made available to NRC in FY 2003.

Subissue #4 - Overall Performance Objective J-O3.7.Ex3

Tracking # J-O3.7.Ex3

Comment It is not clear that validation of the corresponding detailed model truly validates the abstracted model for the span over which the abstracted model has been applied (e.g., whether the simplified model is appropriate over the full range of conditions for which the model is used, including the treatment of coupled phenomena).

References

DOE Response Model validation is within the scope of Corrective Action Report BSC-01-C-001. Process and abstracted models will be validated. DOE understands that abstracted models must honor process models and that process models must be representative.

Agreement Number TSPAI.4.05, TSPAI.4.06

Agreement TSPAI.4.05
DOE will document the process used to develop confidence in the TSPA models (e.g., steps similar to those described in NUREG-1636). The detailed process is currently documented in the model development procedures that are being evaluated for process improvement in response to the model validation corrective action report CAR-BSC-01-C-001. The upgraded model validation procedures will be available for NRC review in FY 2002.

TSPAI.4.06
DOE will document the implementation of the process for model confidence building and demonstrate compliance with model confidence criteria in accordance with the applicable procedures. This will be documented in the respective AMR revisions and made available to NRC in FY 2003.

Subissue #4 - Overall Performance Objective J-O3.7.Ex4

Tracking # J-O3.7.Ex4

Comment DOE has collected field and laboratory data to support detailed hydrologic calculations from which abstractions were made when representing the data in tabular form. Whether the data that support the original model also support the abstracted model (in the form of tabular data) has not been investigated consistently throughout the document. Also, objective comparisons have not been made for all the constituent models to validate the parameters and/or the abstraction. Lack of validation (i.e., objective comparison) of the colloidal transport model with the C-wells Alluvium Testing Complex results (although the model is based on such data) is one example.

References

DOE Response Model validation is within the scope of Corrective Action Report BSC-01-C-001. Process and abstracted models will be validated. DOE understands that abstracted models must honor process models and that process models must be representative.

Agreement Number TSPAI.4.05, TSPAI.4.06

Agreement TSPAI.4.05
DOE will document the process used to develop confidence in the TSPA models (e.g., steps similar to those described in NUREG-1636). The detailed process is currently documented in the model development procedures that are being evaluated for process improvement in response to the model validation corrective action report CAR-BSC-01-C-001. The upgraded model validation procedures will be available for NRC review in FY 2002.

TSPAI.4.06
DOE will document the implementation of the process for model confidence building and demonstrate compliance with model confidence criteria in accordance with the applicable procedures. This will be documented in the respective AMR revisions and made available to NRC in FY 2003.

Subissue #4 - Overall Performance Objective J-O3.7.Ex5

Tracking # J-O3.7.Ex5

Comment A peer review is not a substitute for objective confidence building measures such as comparison with field data, laboratory data, or natural analogs. Although field investigations and natural analogs may not present the whole spectrum of information needed to validate the TSPA model, comparisons against field investigations and natural analogs may be used to provide objective support that a large portion (i.e., multiple components) of the TSPA model is validated. If, however, a peer review is used to help validate the TSPA code, the peer review should be documented with an appropriate level of detail to allow an independent assessment of its value in the validation process.

References CRWMS M&O. "Total System Performance Assessment (TSPA) Model for Site Recommendation." MDL-WIS-PA-000002 Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response AP3.10Q allows validation by peer review. DOE understands that use of field investigations or natural analogs is preferred, if available.

Reference: AP-3.10Q, Rev. 2, ICN 4. Analyses and Models. Washington, D.C.: U.S. Department of Energy, Office of Civilian Radioactive Waste Management. ACC: MOL.20010405.0009.

Agreement Number TSPAI.4.05, TSPAI.4.06

Agreement TSPAI.4.05
DOE will document the process used to develop confidence in the TSPA models (e.g., steps similar to those described in NUREG-1636). The detailed process is currently documented in the model development procedures that are being evaluated for process improvement in response to the model validation corrective action report CAR-BSC-01-C-001. The upgraded model validation procedures will be available for NRC review in FY 2002.

TSPAI.4.06
DOE will document the implementation of the process for model confidence building and demonstrate compliance with model confidence criteria in accordance with the applicable procedures. This will be documented in the respective AMR revisions and made available to NRC in FY 2003.

Subissue #4 - Overall Performance Objective J-O3.7.Ex6

Tracking # J-O3.7.Ex6

Comment There are several instances where DOE has validated results by comparing with NRC calculations. While DOE may use NRC's published work in light of its technical merit, the NRC results do not necessarily reflect a regulatory position. If DOE chooses to use NRC results to support their technical findings, it is the sole responsibility of the DOE to provide validation for such results.

References

DOE Response DOE will not use NRC calculations as the sole line of evidence. Instead, NRC calculations will be used as corroborating evidence.

Agreement Number TSPAI.4.05, TSPAI.4.06

Agreement TSPAI.4.05
DOE will document the process used to develop confidence in the TSPA models (e.g., steps similar to those described in NUREG-1636). The detailed process is currently documented in the model development procedures that are being evaluated for process improvement in response to the model validation corrective action report CAR-BSC-01-C-001. The upgraded model validation procedures will be available for NRC review in FY 2002.

TSPAI.4.06
DOE will document the implementation of the process for model confidence building and demonstrate compliance with model confidence criteria in accordance with the applicable procedures. This will be documented in the respective AMR revisions and made available to NRC in FY 2003.

Subissue #4 - Overall Performance Objective J-O3.7.Ex7

Tracking # J-O3.7.Ex7

Comment There appears to be some confusion in the understanding of validation and verification. Although Section 6.5 of the TSPA-SR Model Report (CRWMS M&O 2000aq) is titled "Model Validation," the discussion only pertains to software verification. From those parts of the report where validation is discussed in its proper sense, it appears that validation is only partially done. For example, DOE has performed validation of the conceptual model for the biosphere, but they have not applied the same validation procedures to the mathematical model of the biosphere (GENII-S). No attempts have been made to validate the model to show the mathematical model accurately represents the physical system.

References CRWMS M&O. "Total System Performance Assessment (TSPA) Model for Site Recommendation." MDL-WIS-PA-000002 Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response DOE will clarify Section 6.5 (CRWMS M&O 2000aq) to distinguish between model verification and model validation. Biosphere model validation (includes GENII-S) is presented in attachments to CRWMS M&O 2001n and CRWMS M&O 2001h. Additional model validation is in progress in accordance with the corrective action reports on software and model validation.

References: CRWMS M&O 2000aq. Total System Performance Assessment (TSPA) Model for Site Recommendation. MDL-WIS-PA-000002 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001226.0003.

CRWMS M&O 2001n. Disruptive Event Biosphere Dose Conversion Factor Analysis. ANL-MGR-MD-000003 REV 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20010125.0233.

CRWMS M&O 2001h. Nominal Performance Biosphere Dose Conversion Factor Analysis. ANL-MGR-MD-000009 REV 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20010123.0123.

Agreement Number TSPAI.4.05, TSPAI.4.06

Agreement TSPAI.4.05
DOE will document the process used to develop confidence in the TSPA models (e.g., steps similar to those described in NUREG-1636). The detailed process is currently documented in the model development procedures that are being evaluated for process improvement in response to the model validation corrective action report CAR-BSC-01-C-001. The upgraded model validation procedures will be available for NRC review in FY 2002.

TSPAI.4.06

Subissue #4 - Overall Performance Objective J-O3.7.Ex7

DOE will document the implementation of the process for model confidence building and demonstrate compliance with model confidence criteria in accordance with the applicable procedures. This will be documented in the respective AMR revisions and made available to NRC in FY 2003.

Subissue #4 - Overall Performance Objective J-O3.7.Ex8

Tracking # J-O3.7.Ex8

Comment There is no indication that DOE has conducted tests that systematically verify the operations of the TSPA-SR model (CRWMS M&O 2000) to ascertain that the code is functioning properly over the full range of conditions being modeled. Sufficient tests have not been conducted for the code to be relatively error free. The verification of the TSPA model (as it is implemented using GoldSim and the associated codes called through dynamically linked libraries [DLLs]) does not appear to satisfy the intent of systematic verification.

References CRWMS M&O. "Total System Performance Assessment (TSPA) Model for Site Recommendation." MDL-WIS-PA-000002 Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response In a future revision of the TSPA model report, DOE will provide additional documentation regarding the TSPA modules and their integration into the overall TSPA.

Agreement Number TSPAI.4.07

Agreement DOE's software qualification requirements are currently documented in procedure AP SI.1Q which is under review for process improvement as part of software CAR-BSC-01-C-002. During its review of AP SI.1Q, DOE will consider: 1) the procedure it would follow to conduct a systematic and uniform verification - all areas of a code analyzed at a consistent level, 2) the process it would follow to ensure correct implementation of algorithms, and 3) the process it would follow for the full disclosure of calculations and results. DOE will document compliance with the improved process in the verification documentation required by AP SI.1Q. Software qualification record packages for the affected programs will be available for NRC review in FY 2003.

Subissue #4 - Overall Performance Objective J-O3.7.Ex9

Tracking # J-O3.7.Ex9

Comment DOE has the elements of verification in their TSPA-SR and supporting documents. However, rigorous verification of the modules and the full code has either not been conducted, not been adequately reported, or is not yet available for review. The description of the verification in Section 6.5 (CRWMS M&O 2000aq) is not adequate. A specific verification plan was not found, and the verification was not uniform across the document.

References CRWMS M&O. "Total System Performance Assessment (TSPA) Model for Site Recommendation." MDL-WIS-PA-000002 Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response See above response to J-O3.7.

Agreement Number TSPAI.4.07

Agreement DOE's software qualification requirements are currently documented in procedure AP SI.1Q which is under review for process improvement as part of software CAR-BSC-01-C-002. During its review of AP SI.1Q, DOE will consider: 1) the procedure it would follow to conduct a systematic and uniform verification - all areas of a code analyzed at a consistent level, 2) the process it would follow to ensure correct implementation of algorithms, and 3) the process it would follow for the full disclosure of calculations and results. DOE will document compliance with the improved process in the verification documentation required by AP SI.1Q. Software qualification record packages for the affected programs will be available for NRC review in FY 2003.

Subissue #4 - Overall Performance Objective J-O3.7.Ex10

Tracking # J-O3.7.Ex10

Comment Sufficient rationale was not provided to describe why verification of the median value results is an appropriate verification for a model that relies on stochastic simulations. There is no indication that verification of the TSPA model behavior included stochastic simulation of the model, sensitivity analyses, or uncertainty importance analyses. These analyses provide insights into whether the code is computing properly near the extremes of the input value ranges.

References CRWMS M&O. "Total System Performance Assessment (TSPA) Model for Site Recommendation." MDL-WIS-PA-000002 Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response TSPA-Site Recommendation model results have been determined to be stable only with respect to their inputs. For postclosure, the analyses focussed on stability for the first 10,000 years. Multiple replicate TSPA runs are being considered to provide additional insight regarding stability of model results.

Reference: CRWMS M&O 2000aq. Total System Performance Assessment (TSPA) Model for Site Recommendation. MDL-WIS-PA-000002 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001226.0003.

Agreement Number TSPAI.4.07

Agreement DOE's software qualification requirements are currently documented in procedure AP SI.1Q which is under review for process improvement as part of software CAR-BSC-01-C-002. During its review of AP SI.1Q, DOE will consider: 1) the procedure it would follow to conduct a systematic and uniform verification - all areas of a code analyzed at a consistent level, 2) the process it would follow to ensure correct implementation of algorithms, and 3) the process it would follow for the full disclosure of calculations and results. DOE will document compliance with the improved process in the verification documentation required by AP SI.1Q. Software qualification record packages for the affected programs will be available for NRC review in FY 2003.

Subissue #4 - Overall Performance Objective J-O3.7.Ex11

Tracking # J-O3.7.Ex11

Comment An extensive GoldSim error log file was generated by execution of the "median value" file by the DOE. DOE documents do not discuss the significance of the warnings and errors in the GoldSim error log file.

References

DOE Response The impact of run log error messages is assessed by the analysts to determine their effect on model results. The run log errors will be documented in future revisions of the TSPA model report. Specific concerns regarding GoldSim errors have been addressed in the DOE Management Plan. See also above response to J-O3.7.

Agreement Number TSPAI.4.07

Agreement DOE's software qualification requirements are currently documented in procedure AP SI.1Q which is under review for process improvement as part of software CAR-BSC-01-C-002. During its review of AP SI.1Q, DOE will consider: 1) the procedure it would follow to conduct a systematic and uniform verification - all areas of a code analyzed at a consistent level, 2) the process it would follow to ensure correct implementation of algorithms, and 3) the process it would follow for the full disclosure of calculations and results. DOE will document compliance with the improved process in the verification documentation required by AP SI.1Q. Software qualification record packages for the affected programs will be available for NRC review in FY 2003.

Subissue #4 - Overall Performance Objective J-O3.7.Ex12

Tracking # J-O3.7.Ex12

Comment Although DOE states that no abstractions in the PA model operate outside of their intended ranges, the NRC review found models being utilized outside the range of conditions for which the abstractions were developed.

References

DOE Response See above response to J-O3.7. Specific concerns regarding range of conditions for a given model have been addressed in the DOE Management Plan.

Agreement Number TSPAI.4.05, TSPAI.4.06, TSPAI.4.07

Agreement TSPAI.4.05
DOE will document the process used to develop confidence in the TSPA models (e.g., steps similar to those described in NUREG-1636). The detailed process is currently documented in the model development procedures that are being evaluated for process improvement in response to the model validation corrective action report CAR-BSC-01-C-001. The upgraded model validation procedures will be available for NRC review in FY 2002.

TSPAI.4.06
DOE will document the implementation of the process for model confidence building and demonstrate compliance with model confidence criteria in accordance with the applicable procedures. This will be documented in the respective AMR revisions and made available to NRC in FY 2003.

TSPAI.4.07
DOE's software qualification requirements are currently documented in procedure AP SI.1Q which is under review for process improvement as part of software CAR-BSC-01-C-002. During its review of AP SI.1Q, DOE will consider: 1) the procedure it would follow to conduct a systematic and uniform verification - all areas of a code analyzed at a consistent level, 2) the process it would follow to ensure correct implementation of algorithms, and 3) the process it would follow for the full disclosure of calculations and results. DOE will document compliance with the improved process in the verification documentation required by AP SI.1Q. Software qualification record packages for the affected programs will be available for NRC review in FY 2003.

Subissue #4 - Overall Performance Objective J-O3.7.Ex13

Tracking # J-O3.7.Ex13

Comment Inputs and outputs to process-level models were verified with hand calculations. The NRC review of several hand calculations has identified various errors.

References

DOE Response See above response to J-O3.7. Specific concerns regarding use of hand calculations have been addressed in the DOE Management Plan.

Agreement Number TSPAI.4.07

Agreement DOE's software qualification requirements are currently documented in procedure AP SI.1Q which is under review for process improvement as part of software CAR-BSC-01-C-002. During its review of AP SI.1Q, DOE will consider: 1) the procedure it would follow to conduct a systematic and uniform verification - all areas of a code analyzed at a consistent level, 2) the process it would follow to ensure correct implementation of algorithms, and 3) the process it would follow for the full disclosure of calculations and results. DOE will document compliance with the improved process in the verification documentation required by AP SI.1Q. Software qualification record packages for the affected programs will be available for NRC review in FY 2003.

Subissue #4 - Overall Performance Objective J-O3.7.Ex14

Tracking # J-O3.7.Ex14

Comment NRC believes that to demonstrate model validation, DOE should present the validation of the conceptual basis for the model. This should include: (i) proper mathematical formulation of the processes and correct parameterization following accepted theories (or if a new theory is used (e.g., the active fracture model) then is this new theory tested), (ii) acceptable convergence properties of numerical schemes, and (iii) appropriate dimensionality (in space and time).

DOE has the elements of model validation in their documents supporting the TSPA-SR Technical Document (CRWMS M&O 2000). However, a model validation plan does not appear to exist. Rigorous model validation at the system level has either not been conducted or has not been adequately reported.

References CRWMS M&O. "Total System Performance Assessment for the Site Recommendation." TDR-WIS-PA-000001 Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response Model validation is within the scope of Corrective Action Report BSC-01-C-001. Successful validation of conceptual as well as mathematical models will be ensured. See above response to J-O3.7.

Agreement Number TSPAI.4.05, TSPAI.4.06

Agreement TSPAI.4.05
DOE will document the process used to develop confidence in the TSPA models (e.g., steps similar to those described in NUREG-1636). The detailed process is currently documented in the model development procedures that are being evaluated for process improvement in response to the model validation corrective action report CAR-BSC-01-C-001. The upgraded model validation procedures will be available for NRC review in FY 2002.

TSPAI.4.06
DOE will document the implementation of the process for model confidence building and demonstrate compliance with model confidence criteria in accordance with the applicable procedures. This will be documented in the respective AMR revisions and made available to NRC in FY 2003.

Subissue #4 - Overall Performance Objective J-O3.8

Tracking # J-O3.8

Comment Throughout section 5 of the TSPA-SR Technical Document, the discussions on the method, data analyses, and model verification information appear to be mixed. For example, the general discussion on sensitivity and uncertainty analysis briefly touches on model sensitivity. However, the section does not appear to have any treatment or analysis of model uncertainty.

References CRWMS M&O. "Total System Performance Assessment for the Site Recommendation." TDR-WIS-PA-000001 Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000. Section 5, Page 5-6.

DOE Response Section 5 (CRWMS M&O 2000ar) discusses uncertainty and sensitivity in model results, conditional on the distributions assigned to model inputs, rather than discussing uncertainty in those distributions, which may be the point of the comment.

DOE will clarify Section 5 in the next revision of the document.

Uncertainty in the model inputs for TSPA is captured in probability distributions. Discussion of the basis for these probability distributions is, in general, outside the scope of the TSPA technical report.

Reference: CRWMS M&O 2000ar. Total System Performance Assessment for the Site Recommendation. TDR-WIS-PA-000001 REV 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001220.0045.

Agreement Number

Agreement DOE response during Technical Exchange was considered adequate by the NRC. Total System Performance Assessment and Integration Technical Exchange, August 6-10, 2001.

Subissue #4 - Overall Performance Objective J-O3.9

Tracking # J-O3.9

Comment Section 5 of the TSPA-SR Technical Document gives an appearance that the section is more geared toward depicting the power of analysis the method(s) and has less emphasis on the analysis of results from sensitivity and uncertainty analysis.

References CRWMS M&O. "Total System Performance Assessment for the Site Recommendation." TDR-WIS-PA-000001 Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000. Section 5, Page 5-6.

DOE Response DOE will clarify Section 5 (CRWMS M&O 2000ar) in the next revision of the document to emphasize results from sensitivity and uncertainty analyses.

Reference: CRWMS M&O 2000ar. Total System Performance Assessment for the Site Recommendation. TDR-WIS-PA-000001 REV 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001220.0045.

Agreement Number

Agreement DOE response during Technical Exchange was considered adequate by the NRC. Total System Performance Assessment and Integration Technical Exchange, August 6-10, 2001.

Subissue #4 - Overall Performance Objective J-O3.10

Tracking # J-O3.10

Comment Sensitivity and uncertainty analysis was emphasized on only one or two parameters, giving an appearance that only one or two parameters are important. It is not clear what quantitative cutoff value (e.g., R square loss, etc.) was used to determine that not more than one or two parameters could be important.
The influence of important parameters and models, identified through sensitivity and uncertainty analyses, on the performance assessment results should be described.

References CRWMS M&O. "Total System Performance Assessment for the Site Recommendation." TDR-WIS-PA-000001. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000a. Section 5.

DOE Response In Section 5 (CRWMS M&O 2000ar, F5-1 through F5-21), most of the uncertainty importance analyses included 3 or 4 important parameters, the only exception being Figure 5.1-19, which had 2 important parameters. The selection of these was based on an uncertainty importance factor cutoff of 0.10, which corresponds to an R-squared loss in the range between 0.07-0.09. Tables of uncertainty importance factors have been developed that show the clusters of unimportant parameters. These tables were not included for reasons of brevity in the current TSPA-SR report. DOE will include these tables in future revisions to better explain the uncertainty importance results.

Reference: CRWMS M&O 2000ar. Total System Performance Assessment for the Site Recommendation. TDR-WIS-PA-000001 REV 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001220.0045.

Agreement Number

Agreement DOE response during Technical Exchange was considered adequate by the NRC. Total System Performance Assessment and Integration Technical Exchange, August 6-10, 2001.

Subissue #4 - Overall Performance Objective J-O3.11

Tracking # J-O3.11

Comment Section 5 of the TSPA-SR Technical Document (Page 5-8) states, "In most cases, the sensitivity to individual parameters is examined by setting a parameter to its 5th and 95th percentile values. This choice keeps most of the range that is considered defensible. The 5th and 95th percentiles are used rather than the entire range (i.e., 0th and 100th percentiles) because in some cases there is a very long tail out to extremely unlikely parameter values. The 5th and 95th percentile values are at the level that they are unlikely, but not so unlikely as to be unreasonable." This does not explain why choice of 95th and 5th percentiles are more appropriate and reasonable than, say, 99.9th and 0.1th percentiles.

References CRWMS M&O. "Total System Performance Assessment for the Site Recommendation." TDR-WIS-PA-000001. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000a. Section 5, Page 5-8.

DOE Response The "one-off" sensitivity analyses are conducted to provide insight into model sensitivity to specific parameter values. They do not provide insight into the appropriate value of expected annual dose for regulatory decision making. The basis for the choice of the 5th and 95th percentiles is as stated, and there does not appear to be any need to choose alternative values for this type of analysis.

Agreement Number

Agreement Written DOE response by the DOE was deemed not satisfactory; however, DOE response during discussions at Technical Exchange was considered adequate by the NRC. Total System Performance Assessment and Integration Technical Exchange, August 6-10, 2001.

Subissue #4 - Overall Performance Objective J-O3.12

Tracking # J-O3.12

Comment Section 5 of the TSPA-SR Technical Document (Page 5-9) states, "...uncertainty analyses based on dose rate as the metric necessarily deal only with those radionuclides that pass through the potential repository system. Those that are retained, for example the majority of the uranium, cannot influence these types of analyses. Thus, a case can be made that the relatively immobile waste form itself (comprised mostly of uranium) is the most important part of the system, rather than the waste package."

References CRWMS M&O. "Total System Performance Assessment for the Site Recommendation." TDR-WIS-PA-000001. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000a. Section 5, Page 5-9.

DOE Response DOE will clarify Section 5 (CRWMS M&O 2000ar) in the next revision of the document. The discussion of important aspects of the overall system will be enhanced to incorporate this topic of the waste form, and it's own immobile characteristics, being an important aspect of the overall system performance.

Reference: CRWMS M&O 2000ar. Total System Performance Assessment for the Site Recommendation. TDR-WIS-PA-000001 REV 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001220.0045.

Agreement Number

Agreement DOE response during Technical Exchange was considered adequate by the NRC. Total System Performance Assessment and Integration Technical Exchange, August 6-10, 2001.

Subissue #4 - Overall Performance Objective J-O3.13T

Tracking # J-O3.13T

Comment While the object oriented approach of the Goldsim software provides connections among modules, it is still difficult to get a clear picture of how process models are working in an integrated fashion within the TSPA model.

References CRWMS M&O. "Total System Performance Assessment (TSPA) Model for Site Recommendation." MDL-WIS-PA-000002 Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response TSPA will continue to attempt to provide clearer descriptions of the modeling system. Appendix E describes the integration of the TSPA models, but will be clarified in the next revision of the document.

Agreement Number

Agreement DOE response during Technical Exchange was considered adequate by the NRC. Total System Performance Assessment and Integration Technical Exchange, August 6-10, 2001.

Subissue #4 - Overall Performance Objective J-O3.14T

Tracking # J-O3.14T

Comment Uncertainty and variability does not appear to have been described adequately for all submodels. Although each TSPA submodel has an associated description of uncertainty and variability, it is difficult to draw a clear picture of where uncertainty was considered or the rationale for not describing it. For example, description of uncertainty in thermal properties could not be found in any of the documents. The TSPA-SR Technical Document (CRWMS M&O 2000a) only indicates, "information on thermal properties and processes has come from laboratory tests and from a series of in situ thermal tests in the ESF at Yucca Mountain (CRWMS M&O 2000b, Section 3.6)". Specific discussions of how uncertainty in thermal conductivity was handled in the TSPA, could not be found.

References CRWMS M&O. "Total System Performance Assessment for the Site Recommendation." TDR-WIS-PA-000001. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000a.
CRWMS M&O. "Near Field Environment Process Model Report." TDR-NBS-MD-000001. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000b.

DOE Response The uncertainty in thermal conductivities was not considered in the TSPA-Site Recommendation thermohydrologic process level submodels. Only the mean thermal conductivities were used in the models that fed TSPA-Site Recommendation (CRWMS M&O 2000ar). Sensitivity studies are planned in the potential License Application time frame to investigate the sensitivity of thermohydrologic process model results to uncertainty of the thermal conductivities in the host units.

To improve transparency and traceability, DOE will consider consolidating and providing additional detail regarding the treatment of uncertainty and variability in the next revision of the TSPA Technical Report.

References: CRWMS M&O 2000ar. Total System Performance Assessment for the Site Recommendation. TDR-WIS-PA-000001 REV 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001220.0045.

Agreement Number

Agreement DOE response during Technical Exchange was considered adequate by the NRC. Total System Performance Assessment and Integration Technical Exchange, August 6-10, 2001.

Subissue #4 - Overall Performance Objective J-O3.15T

Tracking # J-O3.15T

Comment In the presentation TSPA-SR Technical Document (CRWMS M&O 2000a), sometimes 10E-6 and other times 10E-5 mrem/yr has been used as the smallest vaule for displaying dose as a function of time.

In the sensitivity analysis, a value of 10E-5 mrem/year is used as a cutoff below which the response is considered negligible. Has there been any analysis done to ensure that this cutoff value is not partly responsible for zero dose in various figures until much after 10,000 years?

References CRWMS M&O. "Total System Performance Assessment for the Site Recommendation." TDR-WIS-PA-000001. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000a.

DOE Response Cut-off values on the y-axis of dose plots have been chosen for readability and clarity--scales of interest vary from plot to plot.

DOE has verified in TSPA-Site Recommendation (CRWMS M&O 2000ar) that no nominal realizations showed waste package failure before 10,000 years.

References: CRWMS M&O 2000ar. Total System Performance Assessment for the Site Recommendation. TDR-WIS-PA-000001 REV 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001220.0045.

Agreement Number

Agreement Written DOE response by the DOE was deemed not satisfactory; however, DOE response during discussions at Technical Exchange was considered adequate by the NRC. Total System Performance Assessment and Integration Technical Exchange, August 6-10, 2001.

Subissue #4 - Overall Performance Objective J-O3.16T

Tracking # J-O3.16T

Comment The TSPA-SR Technical Document (CRWMS M&O 2000a) specifies that it is difficult to quantify the bias introduced through the use of conservative assumptions. Since the developer knows what is conservative, he/she must, conversely, know what is non-conservative and therefore should be able to at least bound the bias.

References CRWMS M&O. "Total System Performance Assessment for the Site Recommendation." TDR-WIS-PA-000001 Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000. Page 4-3, paragraph 2.

DOE Response Bias introduced through the use of conservative assumptions has been addresses on a component-by-component basis in the Supplemental Science and Performance Analysis Volumes 1 and 2 (BSC 2001e, 2001f).

Note, however, that the developer of inputs does not know, a priori, what the effect of bias will be on system-level performance because of coupled and nonlinear effects within the system model.

References: BSC 2001e. FY01 Supplemental Science and Performance Analyses, Volume 1: Scientific Bases and Analyses. TDR-MGR-MD-000007 REV 00. Las Vegas, Nevada: Bechtel SAIC Company. ACC: MOL.20010712.0062.

BSC 2001f. FY01 Supplemental Science and Performance Analyses, Volume 2: Performance Analyses. TDR-MGR-PA-000001 REV 00. Las Vegas, Nevada: Bechtel SAIC Company. ACC: MOL.20010724.0110.

Agreement Number

Agreement DOE response during Technical Exchange was considered adequate by the NRC. Total System Performance Assessment and Integration Technical Exchange, August 6-10, 2001.

Subissue #4 - Overall Performance Objective J-O3.17

Tracking # J-O3.17

Comment Demonstration of the convergence of the LHS methods as implemented in the TSPA should be more technically robust. Simple graphical demonstration of the increased "stability" of the expect annual dose versus time curve as more realizations are conducted should be bolstered by discussions of how the variance of the variance in the peak of the mean dose decreases as the number of realizations is increased.

References CRWMS M&O. "Total System Performance Assessment for the Site Recommendation." TDR-WIS-PA-000001 Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response DOE will use appropriate statistical approaches to investigating the stability of the mean in future revisions of the TSPA document. (Note that the approach suggested here, of examining changes in the variance in the peak of the mean with changing sample size, may not be the only approach considered.).

TSPA-Site Recommendation Section 4.1.4 (CRWMS M&O 2000ar) shows the probability results for the mean, 5th and 95th percentiles. For 100, 300, and 500 realizations, the results appear to be stable. As an alternative approach consideration will be given to performing additional comparisons (e.g., T-tests) to demonstrate confidence in the limits. Additional calculations will be done as part of the next major update to TSPA-Site Recommendation to demonstrate stability of results.

Reference: CRWMS M&O 2000ar. Total System Performance Assessment for the Site Recommendation. TDR-WIS-PA-000001 REV 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001220.0045.

Agreement Number TSPAI.4.03

Agreement DOE will document the method that will be used to demonstrate that the overall results of the TSPA are stable. DOE will provide documentation that submodels (including submodels used to develop input parameters and transfer functions) are also numerically stable. DOE will address in the method the stability of the results with respect to the number of realizations. DOE will describe in the method the statistical measures that will be used to support the argument of stability. The method will be documented in TSPA LA Methods and Assumptions Document in FY02. The results of the analyses will be provided in the TSPA (or other appropriate documentation) for any potential license application in FY 2003.

Subissue #4 - Overall Performance Objective J-O4.1

Tracking # J-O4.1

Comment Two alternative designs are considered: Backfill and a low temperature operating mode.

-The minimal effect of backfill on dose for volcanism does not appear to completely capture the reduction in the number of waste packages contacted by magma

-Bases of assumptions used for incorporation of a low temperature operating mode into TSPA are not adequately supported.

-It is not apparent from the analysis of the low temperature mode how uncertainties in the thermal regime and thermal effects on performance are reduced.

References CRWMS M&O. "Total System Performance Assessment for the Site Recommendation." TDR-WIS-PA-000001 Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000. Alternative Design section, Page 4-36--4-40.

DOE Response The technical justification for the intrusive damage model was addressed at the Igneous Technical Exchange, June 2001. TSPA results appropriately capture effects consistent with that input.

Low temperature operating mode uncertainties are being examined through Supplemental Science and Performance Analysis and will be addressed in more detail at the Auguts 2001, Operating Range Technical Exchange.

Agreement Number

Agreement

Subissue #4 - Overall Performance Objective J-TT1.1

Tracking # J-TT1.1

Comment Section 5 of the TSPA-SR Technical Document (Page 5-19) states: "Figure 5.2-14 shows the mean dose rate from the base case compared to a case with no matrix diffusion in the UZ and also compared to a case where the UZ anion and cation matrix diffusion coefficients were set at 100 times the matrix diffusion coefficients in the base case. It should be noted that these parameter values are outside the range of base-case probability distributions, in contradiction to most of the other analyses in Section 5.2."

Going outside the range appears to be inconsistent with the general philosophy of the 5th and 95th percentile values used in the sensitivity analysis.

NRC would prefer that TSPA was more self-contained, i.e., more reference material contained within the document. Comments applies to all NRC transparency and traceability comments.

References CRWMS M&O. "Total System Performance Assessment for the Site Recommendation." TDR-WIS-PA-000001. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000. Section 5, Page 5-19.

DOE Response For parameters/models whose base case model was either deterministic (because a conservative/bounding model was used or because the model was well-characterized with little or no uncertainty) or had a very narrow parameter range, a one-off sensitivity on the key stochastic parameters was performed. If an alternative model was available for such cases, it was insightful to substitute an alternative model sensitivity analysis for the one-off 5th/95th analysis. DOE plans to continue to use this approach going forward to License Application. DOE will consider adding clarifying words in the introduction to Section 5.0 (CRWMS M&O 2000ar).

Reference: CRWMS M&O 2000ar. Total System Performance Assessment for the Site Recommendation. TDR-WIS-PA-000001 REV 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001220.0045.

Agreement Number

Agreement DOE response during Technical Exchange was considered adequate by the NRC. Total System Performance Assessment and Integration Technical Exchange, August 6-10, 2001.

Subissue #4 - Overall Performance Objective J-TT1.2

Tracking # J-TT1.2

Comment Input parameters for the DOE TSPA model are not easily traceable. Although Table E-1 of the TSPA-SR Technical Document (TDR-WIS-PA-000001 REV 00 ICN 01) provides a general listing of inputs to the TSPA-SR model, for the parameter values (i.e, parameter range and distribution functions), the reader is pointed to AMRs, PMRs or similar other documents, or to a data tracking number. To obtain a complete picture of the parameters used in the TSPA, the reader has to refer to all AMRs, which makes the task of reviewing all parameters used in the TSPA difficult.

References CRWMS M&O. "Total System Performance Assessment for the Site Recommendation." TDR-WIS-PA-000001. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000. Table E-1.

DOE Response DOE will work to improve traceability and transparency for the potential License Application.

Agreement Number

Agreement DOE response during Technical Exchange was considered adequate by the NRC. Total System Performance Assessment and Integration Technical Exchange, August 6-10, 2001.

Subissue #4 - Overall Performance Objective J-TT1.3

Tracking # J-TT1.3

Comment It is not readily apparent why one would expect the "periodic structure" of WP failures to be preserved in an average WF release curve, unless WP failures occur at the same time(s) for all realizations (CWRMS M&O, 2000; Table E-1, Figure 4.1-11, p. 4-8).

References CRWMS M&O. "Total System Performance Assessment for the Site Recommendation." TDR-WIS-PA-000001. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response The "structure" is a result of the numerical discretization of the temperature and relatively humidity curves at late times.

Agreement Number

Agreement DOE response during Technical Exchange was considered adequate by the NRC. Total System Performance Assessment and Integration Technical Exchange, August 6-10, 2001.

Subissue #4 - Overall Performance Objective J-TT1.4

Tracking # J-TT1.4

Comment The logic in the following sentence is difficult to follow (CRWMS M&O, 2000; p. 4-24).

"Because it is assumed that the nominal models can be used in simulating the igneous disruption scenario, the annual dose for an igneous disruption, including all nominal processes, is approximated by Dn+Di."

References CRWMS M&O. "Total System Performance Assessment for the Site Recommendation." TDR-WIS-PA-000001. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response Dn and Di in this section are used to denote the conditional dose, rather than the probability-weighted dose. This equation simply acknowledges that, if an igneous event occurs, a person may receive doses from both the igneous-related processes and also the nominal processes that have occurred prior to the event and will continue to occur after the event. As stated in the following the probability-weighted dose for the igneous scenario is therefore p (Dn+Di). The probability weighted dose for the nominal scenario is (1-p)(Dn), and the total probability-weighted dose, which is the expected annual dose the NRC requires, is the sum of these two terms, which can be rearranged to yield Dt = Dn + pDi.

The approximation is based on the assumption that nominal release and transport processes are unaffected by the igneous event. If the nominal models are altered by the igneous event, then the conditional igneous dose should more rigorously be given by Dn (modified) + Di. Because Di is >>> Dn (without probability weighting) and is assumed to also be much greater than the unquantified Dn(modified), changes in Dn due to igneous activity can be neglected without significant change to Dt.

Agreement Number

Agreement DOE response during Technical Exchange was considered adequate by the NRC. Total System Performance Assessment and Integration Technical Exchange, August 6-10, 2001.

Subissue #4 - Overall Performance Objective J-TT1.5

Tracking # J-TT1.5

Comment Part of the explanation for the one-off analyses producing a greater difference between base case infiltration and low infiltration than between base case infiltration and high infiltration is that low infiltration has a lower probability. Generally speaking, one would not expect probabilities to be included in a one-off analysis; however, further reading (CRWMS M&O, 2000; Table 3.2-2, p. 3-29 and 5-10) indicates that the so-called probabilities that are assigned to each entry in the infiltration vs. climate table are integral to the model. In the last sentence of this paragraph the statement that the low probability effect in the low infiltration one-off analysis results from the "...low case [being] sampled less often than the others..." implies that the base and high cases are also sampled in the low infiltration one-off analyses. The overall presentation is confusing.

References CRWMS M&O. "Total System Performance Assessment for the Site Recommendation." TDR-WIS-PA-000001. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response The base-case curve includes contributions from the low, medium, and high cases, according to their probabilities. Because the low case has a low probability, the base-case curve includes only a small contribution from that case. Thus, the base-case curve can be very different from the low-infiltration curve.

Agreement Number

Agreement DOE response during Technical Exchange was considered adequate by the NRC. Total System Performance Assessment and Integration Technical Exchange, August 6-10, 2001.

Subissue #4 - Overall Performance Objective J-TT1.6

Tracking # J-TT1.6

Comment It is not readily apparent why the use of a deterministic as opposed to a stochastic approach for the EBS environment explains the one-off analyses for the EBS parameters not being "very enlightening" (CRWM M&O, p. 5-12). Is it the structure of the model that precludes one-off analyses or is it that the computer code prevents the parameters from being modified?

References CRWMS M&O. "Total System Performance Assessment for the Site Recommendation." TDR-WIS-PA-000001. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response There are very few parameters in the engineered barrier system environments that are stochastic and those that are stochastic have little effect on dose. Therefore, there were no "enlightening" or meaningful one-off 5th/95th analyses that could be done for the engineered barrier system environments submodel. Since most of the models are deterministic, it was not possible to carry out 5th/95th percentile analyses as was done with other submodels. However, the text does point the reader to some alternative engineered barrier system environment model studies carried out for the robustness analyses of Section 5.3 (CRWMS M&O 2000ar).

Reference: CRWMS M&O 2000ar. Total System Performance Assessment for the Site Recommendation. TDR-WIS-PA-000001 REV 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001220.0045.

Agreement Number

Agreement DOE response during Technical Exchange was considered adequate by the NRC. Total System Performance Assessment and Integration Technical Exchange, August 6-10, 2001.

Subissue #4 - Overall Performance Objective J-TT1.7

Tracking # J-TT1.7

Comment The finding that dose is relatively insensitive to the range of water usage volume seems to contradict the plot shown in Figure 5.1-11 (CRWMS M&O, 2000; p. 5-21) for uncertainty-importance analysis.

References CRWMS M&O. "Total System Performance Assessment for the Site Recommendation." TDR-WIS-PA-000001. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response As shown in Figure 5.1-11 (CRWMS M&O 2000ar), water usage has an uncertainty importance factor of approximately 0.01 at 100,000 years. This is consistent with the conclusion stated on page 5-21, based on the interpretation of Figure 5.2-16, that dose is relatively insensitive to uncertainty in water usage volume. Although not stated in the text on page 5-21 or in the caption to Figure 5.2-16, the conclusion of relative insensitivity was intended to apply to the first 100,000 years, consistent with the analyses shown in Figure 5.2-16. Figure 5.1-11 shows that the relative importance of water usage rises somewhat after 100,000 years, but it remains a minor contributor, compared to the Alloy 22 general corrosion rate, until quite late in the simulation (900,000 years and beyond). As shown in Figure 5.1-11, relative importance of different components of the system change through time. In particular, importance of parameters affecting radionuclide concentrations in the natural barrier system (groundwater flux) and the biosphere (water usage) tends to increase as engineered barriers degrade.

The relevant figures and text are correct in TSPA-Site Recommendation (CRWMS M&O 2000ar) (except for an editorial error in the last paragraph in Section 5.2.8.2, page 5-21, where "BDCFs" should be "water usage volume"). The conclusions in Section 5.2 are based on interpretation of analyses for 100,000 years only (or 20,000 years for igneous groundwater release cases). The million-year analyses are discussed in Section 5.1.

Reference: CRWMS M&O 2000ar. Total System Performance Assessment for the Site Recommendation. TDR-WIS-PA-000001 REV 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001220.0045.

Agreement Number

Agreement DOE response during Technical Exchange was considered adequate by the NRC. Total System Performance Assessment and Integration Technical Exchange, August 6-10, 2001.

Subissue #4 - Overall Performance Objective J-TT1.8

Tracking # J-TT1.8

Comment The area covered by the infiltration bins do not appear to cover the entire repository waste emplacement area. It is not clear what infiltration rate is used for the areas not covered by the infiltration bins (CRWMS M&O, 2000; Figures 3.3-3 and 4.1-16).

References CRWMS M&O. "Total System Performance Assessment for the Site Recommendation." TDR-WIS-PA-000001. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response The waste-emplacement area does not cover the whole area inside the perimeter drift. The infiltration bins include the entire loaded area, as modeled.

Agreement Number

Agreement DOE response during Technical Exchange was considered adequate by the NRC. Total System Performance Assessment and Integration Technical Exchange, August 6-10, 2001.

Subissue #4 - Overall Performance Objective OPO-1

Tracking # OPO-1

Comment Stability of analyses and calculations has not been demonstrated.

There are many areas in the performance assessment where stochastic (Monte Carlo) calculations are performed. When performing Monte Carlo calculations it is important to verify that stability of the output has been attained. Stability verification applies to the final output (peak mean dose), sensitivity calculations, and process-level analyses where stochastic simulations are performed. Figure F4-23 was provided to address this issue. However, upon examining the data used to construct the figure, the dose at 100,000 years is increasing almost linearly with increasing realizations. Other areas are identified as example with possible stability problems.

References CRWMS M&O. "Total System Performance Assessment for the Site Recommendation." TDR-WIS-PA-000001 Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000a.
CRWMS M&O. "Total System Performance Assessment (TSPA) Model for Site Recommendation." MDL-WIS-PA-000002 Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000b.

DOE Response DOE will provide better justification of the stability of the expected annual dose and supporting analyses. Note that the figure referenced in the NRC comment is Figure 4.1-22 on page F4-23 of the TSPA-Site Recommendation (CRWMS M&O 2000ar).

See also previous response to NRC Comment J-O3.17.

Reference: CRWMS M&O 2000ar. Total System Performance Assessment for the Site Recommendation. TDR-WIS-PA-000001 REV 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001220.0045.

Agreement Number TSPAI.4.03, TSPAI.4.04

Agreement TSPAI.4.03
DOE will document the method that will be used to demonstrate that the overall results of the TSPA are stable. DOE will provide documentation that submodels (including submodels used to develop input parameters and transfer functions) are also numerically stable. DOE will address in the method the stability of the results with respect to the number of realizations. DOE will describe in the method the statistical measures that will be used to support the argument of stability. The method will be documented in TSPA LA Methods and Assumptions Document in FY02. The results of the analyses will be provided in the TSPA (or other appropriate documentation) for any potential license application in FY 2003.

TSPAI.4.04
DOE will conduct appropriate analyses and provide documentation that demonstrates the results of the performance assessment are stable with respect to discretization (e.g. spatial and temporal) of the TSPA model. This will be documented in the TSPA for any potential license application in FY 2003.

Subissue #4 - Overall Performance Objective OPO-1.Ex1

Tracking # OPO-1.Ex1

Comment Has a stability check been done related to Item #3 on page 58 of CRWMS M&O (2000)?

References CRWMS M&O. "Total System Performance Assessment (TSPA) Model for Site Recommendation." MDL-WIS-PA-000002 Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response The stability check has been performed and will be documented in the TSPA-License Application Model Report.

Agreement Number TSPAI.4.04

Agreement DOE will conduct appropriate analyses and provide documentation that demonstrates the results of the performance assessment are stable with respect to discretization (e.g. spatial and temporal) of the TSPA model. This will be documented in the TSPA for any potential license application in FY 2003.

Subissue #4 - Overall Performance Objective OPO-1.Ex2

Tracking # OPO-1.Ex2

Comment Only 100 realizations worth of uncertain SZ results are produced and then replicated for simulations with more realizations (CRWMS M&O, p. 109).

References CRWMS M&O. "Total System Performance Assessment (TSPA) Model for Site Recommendation." MDL-WIS-PA-000002 Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response Multiple replicates of 100 realizations may not get carried forward because of lack of sensitivity of infiltration in the saturated zone.

For future TSPA runs, the use of 300 realizations of the Saturated Zone model results is planned, even though the sensitivity of the overall model results to Saturated Zone parameters is relatively minor.

Agreement Number TSPAI.4.03

Agreement DOE will document the method that will be used to demonstrate that the overall results of the TSPA are stable. DOE will provide documentation that submodels (including submodels used to develop input parameters and transfer functions) are also numerically stable. DOE will address in the method the stability of the results with respect to the number of realizations. DOE will describe in the method the statistical measures that will be used to support the argument of stability. The method will be documented in TSPA LA Methods and Assumptions Document in FY02. The results of the analyses will be provided in the TSPA (or other appropriate documentation) for any potential license application in FY 2003.

Subissue #4 - Overall Performance Objective OPO-1.Ex3

Tracking # OPO-1.Ex3

Comment Are human intrusion calculations stable with respect to realizations and time-stepping (CRWMS M&O, p. 516)?

References CRWMS M&O. "Total System Performance Assessment (TSPA) Model for Site Recommendation." MDL-WIS-PA-000002 Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response Human intrusion calculations for 300 realizations have been conducted. The calculations result in lower peak dose during the 10,000-year time frame. Both 300 and 100 realizations are well below the regulatory limit. The supporting basis the number of realizations will be documented in the TSPA-License Application Technical Report and the time-stepping in the TSPA-License Application Model Report.

Agreement Number TSPAI.4.03, TSPAI.4.04

Agreement TSPAI.4.03
DOE will document the method that will be used to demonstrate that the overall results of the TSPA are stable. DOE will provide documentation that submodels (including submodels used to develop input parameters and transfer functions) are also numerically stable. DOE will address in the method the stability of the results with respect to the number of realizations. DOE will describe in the method the statistical measures that will be used to support the argument of stability. The method will be documented in TSPA LA Methods and Assumptions Document in FY02. The results of the analyses will be provided in the TSPA (or other appropriate documentation) for any potential license application in FY 2003.

TSPAI.4.04
DOE will conduct appropriate analyses and provide documentation that demonstrates the results of the performance assessment are stable with respect to discretization (e.g. spatial and temporal) of the TSPA model. This will be documented in the TSPA for any potential license application in FY 2003.

Subissue #4 - Overall Performance Objective OPO-1.Ex4

Tracking # OPO-1.Ex4

Comment The insensitivity of results to the number of drip-shield patches does not necessarily mean that a larger number of waste package patches will be sufficient. If the waste package functions differently it may still have significant stability problems at 1000 patches (CRWMS M&O, p. 3-89).

References CRWMS M&O. "Total System Performance Assessment for the Site Recommendation." TDR-WIS-PA-000001 Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response Analyses shown in the Waste Package Degradation Model (CRWMS M&O 2000az, Section 6.4.3) serve as sufficient evidence of the appropriateness of the number of drip shield patches, waste package patches, and number of drip shield waste package pairs selected for the analyses. Analogous analyses have been completed in analogous Analysis/Model Reports for other stochastic simulation models used within the TSPA.

Reference: CRWMS M&O 2000az. WAPDEG Analysis of Waste Package and Drip Shield Degradation. ANL-EBS-PA-000001 REV 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001208.0063.

Agreement Number TSPAI.4.04

Agreement DOE will conduct appropriate analyses and provide documentation that demonstrates the results of the performance assessment are stable with respect to discretization (e.g. spatial and temporal) of the TSPA model. This will be documented in the TSPA for any potential license application in FY 2003.

Subissue #4 - Overall Performance Objective OPO-1.Ex5

Tracking # OPO-1.Ex5

Comment Where is the information provided regarding the stability of the results as a function of the size of the time-steps used in the PA (CRWMS M&O, p. 3-93)?

References CRWMS M&O. "Total System Performance Assessment for the Site Recommendation." TDR-WIS-PA-000001 Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response Stability results will be documented in the TSPA-License Application Model Report.

Agreement Number TSPAI.4.04

Agreement DOE will conduct appropriate analyses and provide documentation that demonstrates the results of the performance assessment are stable with respect to discretization (e.g. spatial and temporal) of the TSPA model. This will be documented in the TSPA for any potential license application in FY 2003.

Subissue #4 - Overall Performance Objective OPO-1.Ex6

Tracking # OPO-1.Ex6

Comment Was a test done for the stability of the regression analysis results to verify these important calculations are not numerical aberrations (CRWMS M&O, p. 5-2)?

References CRWMS M&O. "Total System Performance Assessment for the Site Recommendation." TDR-WIS-PA-000001 Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response The statistical significance of regression coefficients was determined using the F-test.

Agreement Number TSPAI.4.03

Agreement DOE will document the method that will be used to demonstrate that the overall results of the TSPA are stable. DOE will provide documentation that submodels (including submodels used to develop input parameters and transfer functions) are also numerically stable. DOE will address in the method the stability of the results with respect to the number of realizations. DOE will describe in the method the statistical measures that will be used to support the argument of stability. The method will be documented in TSPA LA Methods and Assumptions Document in FY02. The results of the analyses will be provided in the TSPA (or other appropriate documentation) for any potential license application in FY 2003.

Subissue #4 - Overall Performance Objective OPO-1.Ex7

Tracking # OPO-1.Ex7

Comment It is likely the sensitivity results are unstable with only 100 realizations completed (CRWMS M&O, p. 5-9).

References CRWMS M&O. "Total System Performance Assessment for the Site Recommendation." TDR-WIS-PA-000001 Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response DOE recognizes that sensitivity analyses that are used to support regulatory compliance (e.g., those that are used for multiple barrier analyses) will need to be done with sufficient sample size to be stable. In TSPA-SR Section 5.1, the calculations were performed with 300 realizations which seems to produce stable results.

Reference: CRWMS M&O 2000ar. Total System Performance Assessment for the Site Recommendation. TDR-WIS-PA-000001 REV 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001220.0045.

Agreement Number TSPAI.4.04

Agreement DOE will conduct appropriate analyses and provide documentation that demonstrates the results of the performance assessment are stable with respect to discretization (e.g. spatial and temporal) of the TSPA model. This will be documented in the TSPA for any potential license application in FY 2003.

Subissue #4 - Overall Performance Objective OPO-1.Ex8

Tracking # OPO-1.Ex8

Comment What are the biggest blocks and the stability or confidence in the Monte Carlo simulations of the biggest block size (CRWMS M&O, p. 3-47)?

References CRWMS M&O. "Total System Performance Assessment for the Site Recommendation." TDR-WIS-PA-000001 Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response The verification that stability of the rockfall model output has been attained is provided in the Drift Degradation Analysis (CRWMS M&O 2000cd, Attachment IV). Additional sensitivity calculations for the rockfall model have been conducted as documented in the Supplemental Science and Performance Analysis Vol. 1 (BSC 2001e, Section 6.3.4), including a more detailed assessment of the stability of the output from the Monte Carlo simulations in the rockfall model. These supplemental analyses provided block size distributions for a range of Monte Carlo simulations up to 800, demonstrating that the rockfall model is stable at 400 simulations (i.e., the model produces a consistent maximum block and a consistent frequency of blocks). The largest blocks simulated in the rockfall model include 14.0 cubic meters in the Tptpmn unit, 1.3 cubic meters in the Tptpll unit, and 57.3 cubic meters in the Tptpln unit (Drift Degradation Analysis, Tables 23, 24, and 25).

References: CRWMS M&O 2000cd. Drift Degradation Analysis. ANL-EBS-MD-000027 REV 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001206.0006.

BSC 2001e. FY01 Supplemental Science and Performance Analyses, Volume 1: Scientific Bases and Analyses. TDR-MGR-MD-000007 REV 00. Las Vegas, Nevada: Bechtel SAIC Company. ACC: MOL.20010712.0062.

Agreement Number TSPAI.4.03, TSPAI.4.04

Agreement TSPAI.4.03
DOE will document the method that will be used to demonstrate that the overall results of the TSPA are stable. DOE will provide documentation that submodels (including submodels used to develop input parameters and transfer functions) are also numerically stable. DOE will address in the method the stability of the results with respect to the number of realizations. DOE will describe in the method the statistical measures that will be used to support the argument of stability. The method will be documented in TSPA LA Methods and Assumptions Document in FY02. The results of the analyses will be provided in the TSPA (or other appropriate documentation) for any potential license application in FY 2003.

TSPAI.4.04
DOE will conduct appropriate analyses and provide documentation that demonstrates the results of the performance assessment are stable with respect to discretization (e.g. spatial and temporal) of the TSPA model. This will be documented in the TSPA for any potential license application in FY 2003.

Subissue #4 - Overall Performance Objective OPO-1.Ex9

Tracking # OPO-1.Ex9

Comment As shown in the figure on page F4-23, the mean base case results continue to increase with increasing number of realizations, exhibiting a 50% increase in the peak dose at 100,000 years when increasing the number of realizations from 100 to 500.

References CRWMS M&O. "Total System Performance Assessment for the Site Recommendation." TDR-WIS-PA-000001 Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response Page F4-23, Instability in mean base case results with increasing sample size: DOE acknowledge that the mean increases somewhat from 100 to 500 realizations. It increases from 62 to 72 or about 15%, not 50%. For any potential License Application DOE will conduct several replicate runs (with different random seeds) to show stability of the mean.

Reference: CRWMS M&O 2000ar. Total System Performance Assessment for the Site Recommendation. TDR-WIS-PA-000001 REV 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001220.0045.

Agreement Number TSPAI.4.03

Agreement DOE will document the method that will be used to demonstrate that the overall results of the TSPA are stable. DOE will provide documentation that submodels (including submodels used to develop input parameters and transfer functions) are also numerically stable. DOE will address in the method the stability of the results with respect to the number of realizations. DOE will describe in the method the statistical measures that will be used to support the argument of stability. The method will be documented in TSPA LA Methods and Assumptions Document in FY02. The results of the analyses will be provided in the TSPA (or other appropriate documentation) for any potential license application in FY 2003.

Subissue #4 - Overall Performance Objective OPO-1.Ex10

Tracking # OPO-1.Ex10

Comment As shown on the figure on page F4-33, 10,000-year igneous results seem to increase significantly with increasing number of realizations per simulation year.

References CRWMS M&O. "Total System Performance Assessment for the Site Recommendation." TDR-WIS-PA-000001 Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response Note that the appropriate test is not whether or not the mean shifts from one sample size to the next, but rather whether or not the mean is stable at the largest sample size shown. Thus, the change from 1000 to 5000 is not unexpected. DOE intends to show that the mean is stable at 5000. For any potential License Application, several replicates will be conducted to show that the mean is stable.

Reference: CRWMS M&O 2000ar. Total System Performance Assessment for the Site Recommendation. TDR-WIS-PA-000001 REV 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001220.0045.

Agreement Number TSPAI.4.03

Agreement DOE will document the method that will be used to demonstrate that the overall results of the TSPA are stable. DOE will provide documentation that submodels (including submodels used to develop input parameters and transfer functions) are also numerically stable. DOE will address in the method the stability of the results with respect to the number of realizations. DOE will describe in the method the statistical measures that will be used to support the argument of stability. The method will be documented in TSPA LA Methods and Assumptions Document in FY02. The results of the analyses will be provided in the TSPA (or other appropriate documentation) for any potential license application in FY 2003.