APPENDIX L

IMPACT REVIEW DOCUMENTATION FOR POSTCLOSURE PERFORMANCE ASSESSMENT

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OFFICE OF CIVILIAN RADIOACTIVE WASTE MANAGEMENT
IMPACT REVIEW ACTION NOTICE

1. QA: QA

Page: 1 Of: 3

2. Responsible Manager (print name) Miguel A. Lugo		3. Date 11/09/2001
4a. Affected Manager (print name) Jerry A. McNeish	4b. Affected Manager (signature) Jerry A McNeish	5. Reviewer (print name) Jerry McNeish

Review the document/data/software/parameter described below to determine the impact on technical products/data. Document results below, indicating required actions to ensure consistency between inputs and technical products/data or that no actions are required. Include document and revision numbers of technical products/data to be revised.

6. Document/Data/ Software/Parameter to be Evaluated:	Title See Attached (10 White Papers and 10 Preliminary Impact Evaluations)		7. Complete Impact Review by: (Date) 11/09/01
	Document Identifier (including Rev. No.) N/A	☐ Initial Issue ☐ Supersession N/A ☐ Revision or Change ☐ Status Change ☐ Cancellation	8. Technical Review in Process? (N/A for data reviews) ☐ Yes ☑ No

9a. Impacted Documents

Document No.	Rev.	Document Title	9b. Results of Impact Review
TDR-WIS-PA-000001	REV 00 ICN 1	Total System Performance Assessment for the Site Recommendation	Expected impacts to results are documented in the attached (approximately an order of magnitude decrease or increase). The impact is insignificant to TSPA results, but will be considered in future TSPA analyses.
TDR-MGR-PA-000001	REV 0	Supplemental Science and Performance Analyses - Volume 2	Same as above

9c. Proposed Trend Description

10a. Reviewer (print name) Jerry McNeish	10b. Reviewer (signature) Jerry A McNeish	11. Date 11.9.01
12. Affected Manager/Responsible Manager (signature) Miguel A. Lugo		13. Date 11/9/01

AP-2.14Q.2

Rev. 08/01/2001

IMPACT REVIEW ACTION NOTICE
CONTINUED

These White Papers and Preliminary Impact Evaluations are to become part of the appendices in the Technical Update Impact Letter Report.

Title

10 White Papers

- Appendix A - Summary of Recent Information Relevant to the Integrated Site Model
- Appendix B - Summary of Recent Information Relevant to the Unsaturated Zone Flow and Transport Process Model
- Appendix C - Summary of Recent Information Relevant to Near-Field Environment Process Model
- Appendix D - Summary of Recent Information Relevant to the Engineered Barrier System Degradation, Flow, and Transport Process Model
- Appendix E - Summary of Recent Information Relevant to Waste Package and Drip Shield Process Model
- Appendix F - Summary of Recent Information Relevant to Waste Form Degradation Process Models
- Appendix G - Summary of Recent Information Relevant to the Saturated Zone Process Model
- Appendix H - Summary of Recent Information Relevant to the Biosphere Process Model
- Appendix I - Summary of Recent Information Relevant to Disruptive Events-Volcanism and Seismicity
- Appendix J - Summary of Recent Information Relevant to Disruptive Events-Criticality

10 Preliminary Impact Evaluations (Portions of Appendix L)

1. Preliminary Impact Evaluation for Recent Information Relevant to the Integrated Site Model
2. Preliminary Impact Evaluation for Recent Information Relevant to the Unsaturated Zone Flow and Transport Process Model
3. Preliminary Impact Evaluation for Recent Information Relevant to Near-Field Environment Process Model
4. Preliminary Impact Evaluation for Recent Information Relevant to the Engineered Barrier System
5. Preliminary Impact Evaluation for Recent Information Relevant to Waste Package and Drip Shield Process Model
6. Preliminary Impact Evaluation for Recent Information Relevant to Waste Form Degradation Process Models

Preliminary Impact Evaluations Cont'd.

7. Preliminary Impact Evaluation for Recent Information Relevant to the Saturated Zone Process Model
8. Preliminary Impact Evaluation for Recent Information Relevant to the Biosphere Process Model
9. Preliminary Impact Evaluation for Recent Information Relevant to Disruptive Events-Volcanism and Seismicity
10. Preliminary Impact Evaluation for Recent Information Relevant to Disruptive Events-Criticality

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IMPACT REVIEW DOCUMENTATION FOR POSTCLOSURE PERFORMANCE ASSESSMENT

The postclosure analyses done in support of the *Yucca Mountain Science and Engineering Report* (DOE 2001a) and the *Yucca Mountain Preliminary Site Suitability Evaluation* (DOE 2001b) are documented in the *Total System Performance Assessment for the Site Recommendation* (CRWMS M&O 2000) and the *FY01 Supplemental Science and Performance Analyses* (BSC 2001a; BSC 2001b). A set of white papers were developed to summarize the additional information not available when these reports were prepared. The potential impact of the additional information on the postclosure analyses has been evaluated qualitatively, both at a subsystem level, and at a total system level. With the exception of the dosimetric model for the receptor (see Section 8) and the analyses for the final U.S. Environmental Protection Agency (EPA) and U.S. Nuclear Regulatory Commission (NRC) rules, no new total system performance assessment simulations have been run to evaluate the impact of the additional information.

To put the results of the postclosure impact review in perspective, the results of the reference total system performance assessments are summarized in Table 1.

Table 1. Summary of Reference Total System Performance Assessment Results

Documentation	10,000-Year Peak Mean Dose		Post-10,000-Year Peak Mean Dose	
	Nominal Scenario	Disruptive Scenario	Nominal Scenario	Disruptive Scenario
Total System Performance Assessment for the Site Recommendation (CRWMS M&O 2000)	0.0 mrem/yr	0.08 mrem/yr	490 mrem/yr	0.2 mrem/yr
FY01 Supplemental Science and Performance Analyses (BSC 2001b)	0.0002 mrem/yr	0.1 mrem/yr	35 mrem/yr	0.1 mrem/yr

The postclosure impact review concluded that, compared to the results documented in the *Total System Performance Assessment for the Site Recommendation* (CRWMS M&O 2000) and the *FY01 Supplemental Science and Performance Analyses* (BSC 2001b), the overall potential impact of the additional information on postclosure performance ranges from an order of magnitude decrease to no more than an order of magnitude increase in the postclosure dose. The additional information and analyses provide improved documentation; in some cases they improve the validation; and in others, the additional information may reduce the uncertainty or improve realism. Often the additional information is already included within the data distribution being utilized to model or analyze the process within the total system model.

The detailed impact of the additional information on the postclosure dose is presented in Table 2. This table includes the component level (e.g., saturated zone), the topic of the additional information, and the potential impact on the postclosure dose, for both 10,000 years and after 10,000 years. A summary of the potential system level impacts by component is presented in Table 3. The table provides a range of potential impacts on the calculated dose due to changes in each component and for the total system.

Table 2. Summary of Potential Impact of Additional Information on Total System Performance Assessment Results

Component	Topic	Potential Impact on Postclosure Dose	
		10,000-Year Peak Mean Dose	Post-10,000-Year Peak Mean Dose
Integrated Site Model	Fracture studies	No change	No change
Unsaturated Zone	Systematic hydrologic characterization	No change	No change
	Cross-Drift bulkhead observations	Small increase	Small increase
	Alcove 8/Niche 3 testing	No change	No change
	Seepage testing at niches	Small decrease	Small decrease
	Chlorine-36 and tritium	Negligible increase or decrease	Negligible increase or decrease
	Geochemistry	Small decrease	Small decrease
	Natural analogues	No change	No change
	Busted Butte	Small decrease	Small decrease
	UZ expected case	One order of magnitude decrease	No change
	Discrete fracture model for seepage	Negligible increase or small decrease	Negligible increase or decrease
Near-Field Environment	Drift Scale Test	Impact unknown, but likely the effect is small	Impact unknown, but likely the effect is small
	Natural analogues	Small increase or decrease	Small increase or decrease
Engineered Barrier System	Rockfall	Negligible increase	Negligible increase
	MULTIFLUX	Negligible increase or decrease	Negligible increase or decrease
	CFD-FLUENT	Negligible increase or decrease	Negligible increase or decrease
	Forced ventilation	No change	No change
	Multiscale thermal-hydrologic Model	Negligible increase or decrease	Negligible increase or decrease
	Thermal conductivity	No change	No change
	Condensation	Negligible increase	Negligible increase or decrease
	Invert hydrology	No change	No change
	Invert diffusion	No change	No change
	Incoming chemistry	Negligible increase or decrease	Negligible increase or decrease
	Microbe mass	No change	No change
	Microbe transport	Negligible increase or decrease	Negligible increase or decrease
	Precipitation/salts	Negligible increase or decrease	Negligible increase or decrease
	Invert mixing	Negligible increase or decrease	Negligible increase or decrease
	Cement seepage	No change	No change
	Cross-Drift condensation	Negligible increase	Negligible increase or decrease

Table 2. Summary of Potential Impact of Additional Information on Total System Performance Assessment Results (Continued)

Component	Topic	Potential Impact on Postclosure Dose	
		10,000-Year Peak Mean Dose	Post-10,000-Year Peak Mean Dose
Waste Package	Environment on drip shield and waste package	No change	No change
	Aging and phase stability	No change	No change
	Passive film stability	No change	No change
	General and localized corrosion	No change	No change
	Stress corrosion cracking	No change	No change
	Stress mitigation	No change	No change
	Waste Package Peer Review Panel	No change	No change
Waste Form	Inventory	Negligible increase	Negligible increase
	Commercial spent nuclear fuel dissolution	No change	No change
	Cladding	No change	No change
	Commercial spent nuclear fuel colloids	No change	No change
	Np secondary phases	Negligible increase or decrease	No change
Saturated Zone	Stratigraphy—Nye County	Negligible decrease	Negligible decrease
	Hydrochemistry—Nye County	No change	No change
	Testing at the Alluvial Testing Complex	Negligible increase or decrease	Negligible increase or decrease
	Different conceptual models	Negligible decrease	Negligible decrease
	Boundary to the accessible environment	Negligible increase	Negligible increase
	Parameter sensitivity analysis	No change	No change
	Uranium mill tailings natural analogues	Negligible increase or decrease	Negligible increase or decrease
	Realistic saturated zone transport case	Negligible decrease	Negligible decrease
	Atomic Energy of Canada Limited (AECL) Busted Butte experiments	Negligible decrease	Negligible decrease
Biosphere	Receptor—Dietary and lifestyle characteristics	N/A	N/A
	Receptor—Dosimetric Model	Negligible increase	Small decrease

Table 2. Summary of Potential Impact of Additional Information on Total System Performance Assessment Results (Continued)

Component	Topic	Potential Impact on Postclosure Dose	
		10,000-Year Peak Mean Dose	Post-10,000-Year Peak Mean Dose
Disruptive Events—Volcanism/Seismicity	Dike/Drift Interaction	No more than one order of magnitude increase	No more than one order of magnitude increase
	Aeromagnetic Data and Analysis	No change	No change
	Geotechnical studies	No change	No change
	Geodetic investigations	No change	No change
Disruptive Events—Criticality	Updated criticality analyses	No change	No change

Table 3. Summary of Potential Impact of Additional Information by Total System Component

Component	Range of Potential Impacts on Postclosure Dose	
	10,000-Year Peak Mean Dose	Post-10,000-Year Peak Mean Dose
Integrated Site Model	No change	No change
Unsaturated Zone	One order of magnitude decrease to small increase	Small decrease to small increase
Near-Field Environment	Small decrease to small increase	Small decrease to small increase
Engineered Barrier System	Negligible decrease to negligible increase	Negligible decrease to negligible increase
Waste Package	No change	No change
Waste Form	Negligible decrease to negligible increase	No change to negligible increase
Saturated Zone	Negligible decrease to negligible increase	Negligible decrease to negligible increase
Biosphere	Negligible increase	Small decrease
Disruptive Events—Volcanism/Seismicity	No change to no more than one order of magnitude increase	No change to no more than one order of magnitude increase
Disruptive Events—Criticality	No change	No change
Total System	**One order of magnitude decrease to no more than one order of magnitude increase**	**Small decrease to no more than one order of magnitude increase**

When described as a *negligible* change, the potential impact on the calculated postclosure dose might be a factor of 2 or less. When described as a *small* change, the potential impact on the calculated postclosure dose might be a factor of 5 or less. The change may also be described as *one order of magnitude*, which is a factor of 10 change in the calculated dose. For the nominal scenario, the potential impact is a one order of magnitude decrease to a small increase in the calculated nominal scenario dose. For the igneous disruptive scenario, the potential impact of the additional information ranges from a small decrease in dose to a one order of magnitude increase in dose.

The area contributing to the largest potential impact is disruptive events—volcanism/seismicity. This is from the information provided on dike–drift interaction by the NRC-funded Center for Nuclear Waste Regulatory Analysis at the Southwest Research Institute (non-Project). These analyses represent an initial attempt to mathematically model in more detail the dike–drift interaction process and present an idealized conceptual model for further evaluating igneous consequences of dike–drift interactions. Even if all assumptions contained in the analyses are valid, and incorporating those assumptions into the Project's total system performance assessment model for extrusive igneous consequences, the number of degraded waste packages are not expected to increase by more than an order of magnitude. Therefore, the dose is not expected to increase by more than an order of magnitude (i.e., from approximately 0.1 mrem/yr to 1 mrem/yr in the supplemental TSPA model). It should be noted that the Project is not adopting the Center's approach until a more thorough evaluation has been done. Should ongoing work performed by Project scientists substantiate the hypothesis proposed by the Center, this may warrant potential inclusion in the total system performance assessment.

An area of considerable interest during the impact review was the near-field environment thermal-hydrologic-chemical data. Four recent water samples condensed from high temperature vapor in the Drift Scale Test show fluoride concentrations as high as 66 ppm and pH values as low as 3.1 at the sample collection temperature of about 50°C (120°F). At present, the source of this solution is unknown. However, it is considered likely to be an experimental artifact, from fluoride leached either from Viton used in borehole packers or from Teflon-lined sampling tubes. This is based on information provided by the Viton packer manufacturer (Dupont Dow Elastomers, LLC) regarding the leaching potential of these packers, as well as experience gained from hydrothermal autoclave experiments using Teflon. This is further discussed in the white paper on the near-field environment (Appendix C). Another possibility for the source of this solution that cannot be ruled out until further information is collected on the behavior of the introduced materials is that the presence of fluoride may have resulted from the interaction of steam with fluoride-bearing minerals in the rock. If this is the case, hydrogen fluoride gas could be produced within the host rock at sustained temperatures as low as 138°C (280°F) If the hydrogen fluoride gas is transported to the engineered barrier system and dissolved into an aqueous phase, this could have the potential to enhance corrosion on the drip shields and waste packages. Analyses have not been conducted to determine the extent of such corrosion or the resulting potential impact on performance. Current Project efforts are focused on determining the actual source of this fluoride solution. As indicated earlier, it is considered likely to be an experimental artifact. To confirm this, some sampling will be conducted in existing "blank" boreholes that are at similar high temperatures to determine if this solution is present. The boreholes will then be filled with Viton and Teflon and additional samples taken. This sampling is to be completed by mid-December 2001.

The details of the specific impacts are provided in subsequent sections in the following areas: integrated site model; unsaturated zone flow and transport; near-field environment; engineered barrier system degradation, flow, and transport; waste package and drip shield degradation; waste form degradation; saturated zone flow and transport; biosphere; and disruptive events—both volcanism and seismicity, and criticality. These sections contain a listing of the participants in the AP-2.14Q review discussions, a table that indicates the potential impact of the additional information on improving documentation, improving validation, improving realism, reducing

uncertainty, and change in dose. The sections also briefly discuss the individual topics of the additional information.

1. PRELIMINARY IMPACT EVALUATION FOR RECENT INFORMATION RELEVANT TO THE INTEGRATED SITE MODEL

Participants in AP-2.14Q impact review discussions: Cliff Ho, Clinton Lum, John Savino, Terry Crump, Michael Chornack, and Drew Coleman.

Table 3. Summary of Potential Impacts of Additional Information (Excavation-Induced Fractures) on the Integrated Site Model

Topic	Improves Documentation	Improves Validation	Reduces Uncertainty	Improves Realism	Change In Dose
Effect of excavation-induced fractures on drift degradation	Yes	No	Yes	Yes	No change
Effect of excavation-induced fractures on seepage	No	No	No	No	No change
Effect of excavation-induced fractures on ventilation/dryout	No	No	No	Yes	No change

1.1 EFFECT OF EXCAVATION-INDUCED FRACTURES ON DRIFT DEGRADATION

The additional information for this topic provides documentation on the differences between the natural and excavation-induced fractures, and also addresses a data quality concern, improves confidence in fracture data set, and eliminates excavation-induced fractures as a technical concern. There is relatively rare occurrence and overall limited depth of influence observed in excavation-induced fractures. There is no effect on TSPA dose.

1.2 EFFECT OF EXCAVATION-INDUCED FRACTURES ON SEEPAGE

If the fracture frequency increases by a factor of 10, the parameters b (aperture) and van Genuchten alpha will only decrease by a factor of 2. This factor is already included in the range of uncertainty of input parameters. The calculations by Cliff Ho for fracture frequency/aperture/van Genuchten alpha relationship—which assume that bulk fracture permeability, as measured by air-permeability tests, remains the same—are shown below. Where:

$$b = aperture\,[m]$$

$$f = frequency\left[\frac{1}{m}\right]$$

$$\alpha = van\ Genuchten\left[\frac{1}{m}\right]$$

k_b measured is

$$k_b = \frac{b^2}{12} bf = \frac{b^3 f}{12}$$

Therefore,

$$b = \sqrt[3]{\frac{12k_b}{f}}$$

If k_b stays the same, and f is increased by, for example, 10,

Then b is decreased by 2.

$$P_c = \frac{1}{\alpha} = \frac{2\sigma}{b}$$

Therefore,

$$\alpha = \frac{b}{2\sigma}$$

and, α is proportional to b.

If $b \downarrow 2$, then $\alpha \downarrow 2$.

Thus, an increase in fracture frequency by a factor of 10 (to account for the inclusion of small-scale fractures, perhaps induced by excavation) decreases the aperture and van Genuchten alpha parameter only by a factor of 2. This variation (factor of 2) is already contained in the range of uncertainty in reference models. Therefore, there is no effect on TSPA dose.

1.3 EFFECT OF EXCAVATION-INDUCED FRACTURES ON VENTILATION/ DRYOUT

The excavation-induced and enhanced natural fractures could increase the movement of water vapor and gases away from the drifts. This might increase the dryout zone surrounding the drift, but is not expected to increase dose.

2. PRELIMINARY IMPACT EVALUATION FOR RECENT INFORMATION RELEVANT TO THE UNSATURATED ZONE FLOW AND TRANSPORT PROCESS MODEL

Participants in AP-2.14Q impact review discussions: Michael Wilson, Jim Houseworth, Bo Bodvarsson, David Dobson, Jerry McNeish, James Paces, Zell Peterman, Brian Marshall, Gary Patterson, Kevin Mon, Ronald Linden, Krishna Iyengar, Len Skoblar, Cliff Ho, Michael Chornack, Eric Smistad, Verann Chipman, Drew Coleman, David Hudson, and Mark Peters.

Table 4. Summary of Potential Impacts of Additional Information on the Unsaturated Zone Flow and Transport Process Model

Topic	Improves Documentation	Improves Validation	Reduces Uncertainty	Improves Realism	Change in Dose
Systematic hydrologic characterization	No	Yes	No	No	No change
Cross-Drift bulkhead observations	No	Yes	No	Yes	Small increase
Alcove 8–Niche 3 testing	No	Yes	No	No	No change
Seepage testing at niches	No	Yes	No	Yes	Small decrease
Chlorine-36 and tritium	No	Yes	No	No	Negligible increase or decrease
UZ geochemistry	No	Yes	No	Yes	Small decrease
Natural analogues	No	Yes	No	No	No change
Busted Butte	No	Yes	No	Yes	Small decrease
UZ expected case	No	No	No	Yes	Supplemental TSPA model: one order of magnitude decrease within 10,000 years
Discrete fracture model for seepage	No	No	No	Yes	Negligible increase or small decrease

NOTE: While simulations haven't been conducted to determine the actual changes in dose, the potential changes are characterized as follows: Negligible—up to a factor of 2; Small—up to a factor of 5; one order of magnitude-up to a factor of 10.

2.1 SYSTEMATIC HYDROLOGIC CHARACTERIZATION

The additional data support the unsaturated zone model. No impact.

2.2 CROSS-DRIFT BULKHEAD MOISTURE MONITORING AND SEEPAGE OBSERVATIONS

1. Observations of water in the bulkheaded section of the Cross-Drift raise the question of its origin and potential impact on performance.

2. Recent test results suggest that the water is condensate, but the amount of seepage associated with this is not yet known. A model is being developed to evaluate the likely source of this water and the expected evolution of the hydrologic system behind the bulkhead.

3. Water has little effect on the current waste-package and drip-shield corrosion models, as indicated in the TSPA-SR and supplemental TSPA models. This is due to the fact that the aqueous corrosion mode in the waste package corrosion model is initiated under humid-air conditions and does not require water seeps. The humid-air condition for aqueous corrosion always occurs prior to any seepage.

4. Furthermore, there is no effect of seepage or condensation water on unsaturated zone transport in the baseline TSPA-SR. All radionuclides enter undisturbed fracture flow (flow as if drifts were not present), and the seepage/condensation flow from the drift would not be a significant factor if included in this model, especially considering the range of percolation and seepage included as uncertainty.

5. For the supplemental TSPA model, the TSPA radionuclide transport model includes a flux-splitting method for radionuclides entering the rock; radionuclides that diffuse from the drift initially enter the matrix, and radionuclides that advect from the drift initially enter the fractures. The effects of condensate may result in more advective releases, but the impact of this on TSPA (supplemental TSPA model) is not expected to be large.

6. Therefore, the impact on dose, if any, is expected to be small.

2.3 PRELIMINARY OBSERVATIONS FROM THE FAULT TEST AT ALCOVE 8–NICHE 3

The additional data support the unsaturated zone model. No impact.

2.4 SEEPAGE TESTING AT NICHES

Results for Niche 5 to date indicate less seepage than expected; limited data suggest the seepage abstraction used in TSPA-SR model and supplemental TSPA model is conservative. Therefore, any impact on TSPA is expected to be positive (i.e., resulting in a small decrease in calculated doses).

2.5 CHLORINE-36 AND TRITIUM

Inconsistencies between tritium and chloride measurements are difficult to explain. However, the unsaturated zone model accounts for fast paths and the amount of water associated with fast

paths is small compared with the overall percolation. Therefore, the impact, if any, is expected to be negligible because the effect would only be seen in this relatively small portion of the system with fast paths.

2.6 UNSATURATED ZONE GEOCHEMISTRY

Calcite Abundances—The calcite distribution in SD-6 is different than that found in WT-24. The abundance profile at SD-6 indicates lower percolation flux, especially below the TSw upper lithophysal unit. This lower flux would be a conservatism with respect to the present models supporting TSPA. Therefore, any impact on TSPA is expected to be positive (i.e., resulting in a small decrease in calculated doses).

Estimates of Seepage from Calcite—Estimates of the rate of calcite deposition in lithophysal cavities suggest lower seepage than currently used in TSPA. Seepage estimates from calcite may be considered lower-bound estimates for waste emplacement drifts due to the effects of drift size compared with typical lithophysal cavity size (theoretical understanding is that seepage is more likely for larger openings). Despite this caveat, these data suggest that the model may be conservative, although the degree of conservatism is uncertain. Therefore, any impact on TSPA is expected to be positive (i.e., resulting in a small decrease in calculated doses).

Pore-Water Geochemistry—The additional data support the unsaturated zone model. No impact.

Fluid Inclusions and Oxygen Isotopes—The additional data support the unsaturated zone model. No impact.

2.7 NATURAL ANALOGUES

The natural analogues discussed generally support the unsaturated zone model and therefore have no impact. The possible exception is fracture sealing in geothermal analogues, which is discussed in the near-field environment impact assessment.

2.8 BUSTED BUTTE

Observations at Busted Butte suggest that the matrix permeability for the Calico Hills vitric tuff may be an order of magnitude or more higher than currently used in the unsaturated zone model. The impact of an increase in matrix permeability would be a possible increase in flow through the matrix (and less flow through fractures), resulting in longer travel times and greater contact opportunity for sorbing radionuclides. Thus, the reference model may be considered conservative and any impact on TSPA is expected to be positive (i.e., resulting in a small decrease in calculated doses).

2.9 AN EXPECTED CASE MODEL OF UNSATURATED ZONE FLOW AND TRANSPORT

The "expected" case has longer transport times than the current TSPA model. The additional transport time would not be expected to affect dose significantly at late times (e.g., when the peak dose occurs), but if the delay is on the order of 10,000 years or more the dose within the

10,000-year regulatory period could be reduced about one order of magnitude in the supplemental TSPA model. Curve (d) in Figure 25 of Appendix B has approximately 70 percent of its breakthrough at times greater than 10,000 years. UZ transport as long as that would be expected to reduce the dose within 10,000 years by about one order of magnitude in TSPA simulations that have radionuclide releases from the potential repository within 10,000 years (e.g., the supplemental TSPA model).

2.10 USE OF DISCRETE FRACTURE NETWORK MODEL FOR MODELING FLOW FOCUSING AND SEEPAGE

There are indications that this approach could be used to modify the distribution for the seepage flow-focusing factor. However, the effects of a wide range of flow-focusing factors have already been considered in TSPA, and the calculated dose is not particularly sensitive to flow focusing (see Figure 5.2-2 in the *Total System Performance Assessment for the Site Recommendation* [CRWMS M&O 2000]). Thus, the impact on the TSPA is expected to be negligible. It should be noted that flow focusing may have an effect on TSPA if the effects of this were carried through in the TSPA for radionuclide transport (including drift shadow). Increased flow focusing is likely to improve the performance of the natural barrier as a result of the drift shadow effect.

3. PRELIMINARY IMPACT EVALUATION FOR RECENT INFORMATION RELEVANT TO THE NEAR-FIELD ENVIRONMENT PROCESS MODEL

Participants in AP-2.14Q impact review discussions: Michael Wilson, Jim Houseworth, Bo Bodvarsson, Robert Howard, Jerry McNeish, Bruce Kirstein, Harris Greenberg, Brian Marshall, David Sassani, Gerald Gordon, Dwayne Kicker, Len Skoblar, David Dobson, Dave Sevougian, Wunan Lin, Carl Steefel, Eric Smistad, Rich Metcalf, Darren Jolley, and Don Kalinich.

Table 5. Summary of Potential Impacts of Additional Information on the Near-Field Environment Process Model

Topic	Improves Documentation	Improves Validation	Reduces Uncertainty	Improves Realism	Change in Dose
Drift Scale Test	No	Yes	No	Yes	Impact unknown, but likely the effect is small
Natural analogues	No	Yes	No	Yes	Small increase or decrease

NOTE: While simulations haven't been conducted to determine the actual changes in dose, the potential changes are characterized as follows: Negligible—up to a factor of 2; Small—up to a factor of 5.

3.1 DRIFT SCALE TEST

3.1.1 Thermal-Hydrologic Data

The additional data support the near-field environment model. No impact.

3.1.2 Thermal-Hydrologic-Mechanical Data

Recent Plate Loading Test results indicate higher bulk elastic moduli than earlier tests. This result has no effect on the drift-degradation (rockfall) analysis because that analysis uses independent data for rock joint properties and does not rely on bulk rock elastic modulus as an input. For thermal-hydrologic-mechanical effects, the main question concerns the effects on seepage. If thermal-hydrologic-mechanical effects (such as an increase in permeability due to shear strain) result in a permanent change in permeability around the drift, then there is a potential effect on long-term performance. However, increases in permeability near the drift will result in lower seepage, according to the seepage model. Reductions in permeability are expected to be due to normal stresses, which do not result in permanent changes. Furthermore, the magnitude of the thermal-hydrologic-mechanical changes in permeability are smaller than the natural spatial variability of permeability. Thus, if there are effects on dose, they are expected to be small.

3.1.3 Thermal-Hydrologic-Chemical Data

Recent CO_2 gas-concentrations data support the near-field environment model and therefore have no impact.

Four recent water samples condensed from high-temperature vapor in the Drift Scale Test show fluoride concentrations as high as 66 ppm and pH values as low as 3.1 at the sample collection

temperature of about 50°C (120°F). At present, the source of this solution is unknown, but it is considered likely to be a sampling artifact, from fluoride leached either from Viton used in borehole packers or from Teflon-lined sampling tubes. This is based on information provided by the Viton packer manufacturer (Dupoint Dow Elastomers, LLC) regarding the leaching potential of these packers, as well as experience gained from hydrothermal autoclave experiments using Teflon. This is further discussed in the white paper on the near-field environment (Appendix C).

Another possibility for the source of this solution that cannot be ruled out until further information is collected on the behavior of the introduced materials is that the presence of fluoride may have resulted from the interaction of steam with fluoride-bearing minerals in the rock. If this is the case, hydrogen fluoride gas could be produced within the host rock at sustained temperatures as low as 138°C (280°F). If the hydrogen fluoride gas is transported to the engineered barrier system and dissolved into an aqueous phase, this could have the potential to enhance corrosion on the drip shields and waste packages. Analyses have not been conducted to determine the extent of such corrosion or the resulting potential impact on performance.

Current Project efforts are focused on determining the actual source of this fluoride solution. As indicated earlier, it is considered likely to be an experimental artifact. To confirm this, some sampling will be conducted in existing "blank" boreholes that are at similar high temperatures to determine if this solution is present. The boreholes will then be filled with Viton and Teflon and additional samples taken. This sampling is to be completed by mid-December 2001.

3.2 NATURAL ANALOGUE STUDIES

Thermal-hydrologic-chemical model simulations have suggested that precipitates are volumetrically insignificant, but over long time frames a question remains concerning the potential for fracture sealing. Natural analogue observations suggest that only a small portion of the fracture volume needs to be sealed to effectively retard fluid flow in low-permeability rocks. From a TSPA perspective, the potentially important effect of this sealing would be if it were to result in greater flow focusing above waste emplacement drifts. (If all fractures above the drifts became sealed, seepage could be reduced to zero; however, if only some of the fractures became sealed, it could possibly result in funneling of flow into the unsealed ones.) The effects of a wide range of flow-focusing factors have been considered in TSPA, and the calculated dose is not particularly sensitive to flow focusing (CRWMS M&O 2000, Figure 5.2-2). Thus, even if fracture sealing is more likely than indicated by the current model, impact on the TSPA is expected to be small.

4. PRELIMINARY IMPACT EVALUATION FOR RECENT INFORMATION RELEVANT TO THE ENGINEERED BARRIER SYSTEM DEGRADATION, FLOW, AND TRANSPORT PROCESS MODEL

Participants in AP-2.14Q impact review discussions: Mike Gross, Kirk Lachman, Harris Greenberg, Gerald Gordon, Rob Howard, Carl Steefel, Darren Jolley, Rich Metcalf, Robert Andrews, Bruce Kirsten, Dave Sassani, Bob MacKinnon, Jim Blink, Larry Rickertsen, Dave Sevougian, and Cliff Howard.

Table 6. Summary of Potential Impacts of Additional Information on the Engineered Barrier System Degradation, Flow, and Transport Process Model

Topic	Improves Documentation	Improves Validation	Reduces Uncertainty	Improves Realism	Change in Dose
Rockfall (Drip Shield life)	Yes	No	Yes	Yes	Negligible increase
MULTIFLUX (Ventilation efficiency/temperature–relative humidity)	No	No	Yes	Yes	Negligible increase or decrease
CFD–FLUENT (temperature–relative humidity)	No	Yes	Yes	Yes	Negligible increase or decrease
Forced ventilation tests (Ventilation efficiency)	No	Yes	No	Yes	No change
MSTHM (temperature–relative humidity)	Yes	Yes	Yes	No	Negligible increase or decrease
Thermal K (temperature–relative humidity)	No	Yes	Yes	Yes	No change
Condensation (Liquid flux)	No	No	Yes	Yes	TSPA-SR model: no change. Supplemental TSPA model: negligible, but unlikely, increase
Invert hydrology (Liquid flux/saturation)	No	No	Yes	Yes	No change
Invert diffusion (Diffusion coefficient)	Yes	Yes	Yes	Yes	No change
Incoming chem. (THC boundary conditions)	Yes	Yes	No	Yes	Negligible increase or decrease
Microbe mass (Mass of colloids)	Yes	Yes	Yes	No	No change
Microbe transport (Colloid Mass Transport)	Yes	Yes	No	Yes	Negligible increase or decrease, but increases uncertainty
Precipitates/salts (In-drift chem)	Yes	Yes	No	No	Negligible increase or decrease

Table 6. Summary of Potential Impacts of Additional Information on the Engineered Barrier System Degradation, Flow, and Transport Process Model (Continued)

Topic	Improves Documentation	Improves Validation	Reduces Uncertainty	Improves Realism	Change in Dose
Invert mixing (In-drift chem)	Yes	Yes	No	Yes	Negligible increase or decrease, but increases uncertainty
Cement-seepage (Not in TSPA)	Yes	Yes	Yes	Yes	No change
Cross-Drift condensation (Liquid flux)	No	No	Yes	Yes	No change for TSPA-SR model. Supplemental TSPA model: negligible, but unlikely, increase

NOTE: While simulations haven't been conducted to determine the actual changes in dose, the potential changes are characterized as follows: Negligible—up to a factor of 2; Small—up to a factor of 5.

4.1 EFFECTS OF ROCKFALL

The additional information supports the approach of screening out the effects of drip shield failure from the TSPA model. Rockfall on the drip shield during the first 10,000 years (before substantial strength loss due to corrosion) will not cause large-scale failure. Stress corrosion cracking subsequent to rockfall would produce limited breach size in the drip shield. Any impact is expected to be negligible.

4.2 COMPARISON OF HEAT TRANSFER AND HEAT/MASS TRANSFER MODELS FOR PRECLOSURE VENTILATION

The submodels implemented in the ANSYS and MULTIFLUX codes are consistent with analytic solutions of simplified situations. Refining the axial mesh implemented in the ANSYS code for the ventilation model results in preclosure temperatures similar to those reported in *FY01 Supplemental Science and Performance Analyses* (BSC 2001a). MULTIFLUX calculations using the ANSYS inputs, but accounting for latent heat cooling and dryout warming, are similar to ANSYS results at early preclosure times and locations near the drift entrance. The same MULTIFLUX calculations produce 5 to 10 C° (9 to 18 F°) warmer temperatures than the ANSYS results at later preclosure times and at distances farther into the drift. Any impact is expected to be negligible.

4.3 COMPUTATIONAL FLUID DYNAMICS MODELING OF FORCED AND NATURAL COVECTION IN SCALED TESTS AND REPOSITORY SCALE

The FLUENT CFD code results reasonably simulate scaled tests and agree with published correlations for idealized geometries. Impacts are negligible.

4.4 RESULTS OF 25-PERCENT-SCALE FORCED VENTILATION TESTS

The tests are designed to validate the ventilation model. The ventilation efficiencies used in the TSPA-SR model (70 percent) and the supplemental TSPA model (70 percent for the higher-temperature operating mode, 80 percent for the lower-temperature operating mode) are similar to the 25-percent-scale test results. No impact expected to TSPA.

4.5 VALIDATION OF THE MULTISCALE THERMAL-HYDROLOGIC MODEL

Comparison of the multiscale thermal-hydrologic model with a nested thermal-hydrologic model demonstrated that the fundamental concept of combining multiple-location and multiple-scale submodels in the multiscale thermal-hydrologic model is valid. This concept is to use multiple location-specific two-dimensional thermal-hydrologic submodels as the core of the model, and use three-dimensional mountain and drift scale thermal submodels to assemble and modify the location-specific two-dimensional thermal-hydrologic results to include three-dimensional effects. Impacts are expected to be negligible.

4.6 THERMAL CONDUCTIVITY MODELING AND DATA AT LABORATORY AND FIELD SCALES

The laboratory and field thermal conductivity measurement program will reduce the intrinsic uncertainty and quantify the spatial variability in thermal conductivity. The field tests will include the effects of lithophysae too large to be included in laboratory samples. Initial results from the field program (1.7 W/m·K) are consistent with the range of thermal conductivities used in the supplemental TSPA model. No impact expected to TSPA.

4.7 MODELING CONDENSATION ON EBS SURFACES

The effects of evaporation and condensation will tend to reduce the waste-package-to-waste-package temperature variability and the larger scale variability between the repository edges and repository center. The rates of condensation in cooler sections of the drift could be comparable to host rock percolation flux at times shortly following closure, and one-to-two orders of magnitude less than the host rock percolation flux at later times. No impact expected to TSPA-SR model and negligible impact to the supplemental TSPA model.

4.8 DUAL-PERMEABILITY MODELING OF THE INVERT

The single continuum approach in the TSPA-SR model and the supplemental TSPA model, using measured diffusivities for samples of granular materials at varying moisture contents, remains a reasonable approach to determining radionuclide transport through the invert. No impact expected.

4.9 IN-DRIFT DIFFUSION STUDY

New measured values of diffusivity with the electrical conductivity analogue method confirm the fit to the dependence of diffusivity versus moisture content used in the TSPA. No impact expected.

4.10 ENGINEERED BARRIER SYSTEM PHYSICAL AND CHEMICAL ENVIRONMENT MODEL

4.10.1 Incoming Chemistry

New analyses corroborate TSPA-SR incoming water and gas composition abstraction model and show results that are similar to those used in the TSPA-SR model and supplemental TSPA. Impact expected to be negligible.

4.10.2 Microbe Mass

Data qualification and model validation results corroborate the TSPA-SR model microbial mass calculations and show that they are still bounding by a factor of two. No impact is expected.

4.10.3 Microbe Transport

Microbial transport was not included in TSPA-SR model. New calculations indicate that microbial sorption of uranium may reduce aqueous releases from the engineered barrier system if pH in the invert remains below 8. The key uncertainty in this model is the fact that once pH goes above 8 or an organism dies and is ultimately destroyed, desorption of uranium could occur. While uncertainty is increased, impact on dose is expected to be negligible.

4.10.4 Precipitates/Salts

New analyses corroborates TSPA-SR model and supplemental TSPA model precipitates/salts analyses and results. Negligible impacts expected.

4.10.5 Invert Mixing

This model was first introduced in *FY01 Supplemental Science and Performance Analyses* (BSC 2001a), but it was not implemented in the supplemental TSPA model (BSC 2001b). Mixing model results show that water chemistry in the invert will tend to be controlled by evaporation in the invert and chemistry of the waters entering the invert by crown seepage and capillary suction, rather than by waste package leachate. While uncertainty is increased, impact on dose is expected to be negligible.

4.11 MODELING OF CEMENT-SEEPAGE INTERACTIONS

New analyses corroborates TSPA-SR model results and show that interactions between rock bolt grout and seepage could produce seepage pH values ranging from 7 to 13. No impact expected.

4.12 ENHANCED CHARACTERIZATION OF THE REPOSITORY BLOCK BULKHEAD TEST RESULTS

ECRB Cross-Drift data and modeling indicate most of the condensation will occur during the thermal period, which lasts a few thousand years. During the first 10,000 years, no waste packages failed in the TSPA-SR model and only one waste package failed in one-fourth of the

realizations in the supplemental TSPA model. Therefore, no impact is expected to the TSPA-SR model, with negligible impact to the supplemental TSPA model.

5. PRELIMINARY IMPACT EVALUATION FOR RECENT INFORMATION RELEVANT TO THE WASTE PACKAGE AND DRIP SHIELD DEGRADATION MODEL

Participants in AP-2.14Q impact review discussions: Larry Rickertsen, Don Kalinich, Mark Peters, Tammy Summers, Frank Wong, Kevin Mon, Ali Haghi, and David Sevougian.

Table 7. Summary of Potential Impacts of Additional Information on the Waste Package and Drip Shield Degradation Model

Topic	Improves Documentation	Improves Validation	Reduces Uncertainty	Improve Realism	Change in Dose
Environment on drip shield and waste package	No	No	No	Yes	No change
Aging and phase stability	No	Yes	No	No	No change
Passive film stability	No	Yes	No	No	No change
General and localized corrosion	No	Yes	No	No	No change
Stress corrosion cracking	No	No	No	Yes	No change
Stress mitigation	No	Yes	No	No	No change
Waste Package Peer Review Panel	No	No	No	Yes	No change

5.1 ENVIRONMENT ON DRIP SHIELD AND WASTE PACKAGE

Additional information supports a different model for these environments with impacts on the model for general and localized corrosion susceptibility. However, the impacts would result in a negligible change in the time of initial waste package failure because general corrosion rates are so slow, resulting in no impact on the 10,000-year annual dose or the magnitude of the peak dose.

5.2 AGING AND PHASE STABILITY

Additional information corroborates the assumption of no degradation enhancement due to aging of the base metal. This information has no implications for the use of the current enhancement factor applied to the closure weld regions. Consequently, no change to the current model is indicated.

5.3 PASSIVE FILM STABILITY

The current model assumes the passive film is stable. The additional information corroborates this assumption. Accordingly, the additional information corroborates the current model, and no impact is expected.

5.4 GENERAL AND LOCALIZED CORROSION

The additional information corroborates the current models. No impact expected.

5.5 STRESS CORROSION CRACKING

The additional information suggests the current model is conservative. For example, the information suggests a more realistic representation of crack growth (and growth arrest). A more realistic model would not affect the 10,000-year annual dose and would only affect the timing of the peak dose, delaying it due to later waste package failures.

5.6 STRESS MITIGATION

The current model is based on assumptions regarding the feasibility and effectiveness of local induction annealing and laser peening to mitigate stresses. The additional information indicates these techniques are both practicable and effective. Consequently, the additional information corroborates these assumptions and no impact is expected.

5.7 WASTE PACKAGE PEER REVIEW PANEL

The Waste Package Peer Review Panel confirms the DOE's understanding of waste package and drip shield material performance in almost all areas. The panel noted that the current crack growth model is conservative in that it does not address crack growth arrest (addressed in the stress corrosion cracking considerations). It also concludes the current model for stress corrosion cracking threshold stress intensity may not be conservative—it may be too optimistic for crack initiation in the event of sharp cracks. A new model could result in earlier initial failure of some unknown quantity of waste packages. In particular, initial failure could occur before 10,000 years. The TSPA-SR model did not show any initial failures before 10,000 years; consequently, the new model could result in a contribution to annual dose in this period, different from the TSPA-SR model results. The annual dose would be negligible since release would be through tight cracks. The supplemental TSPA model included early failure of a small number of waste packages. Consequently, the new model would not result in a change to the 10,000-year annual dose in this case, because the failure of waste packages with tight cracks is expected to be bounded by the supplemental TSPA model results. Likewise, the discussion concludes the new model would not affect the peak dose estimate.

6. PRELIMINARY IMPACT EVALUATION FOR RECENT INFORMATION RELEVANT TO THE WASTE FORM DEGRADATION MODEL

Participants in AP-2.14Q impact review discussions: Paige Russell, Frank Wong, Christine Stockman, Guy Ragan, Krishna Iyengar, Eric Siegmann, and Dave Sevougian.

Table 8. Summary of Potential Impacts of Additional Information on the Waste Form Degradation Model

Topic	Improves Documentation	Improves Validation	Reduces Uncertainty	Improves Realism	Change in Dose
Inventory (Release Rate)	Yes	Yes	No	Yes	Negligible increase
CSNF dissolution (CSNF Degradation Rate)	Yes	Yes	No	No	No change
Cladding (Cladding Degradation Rate)	Yes	No	No	Yes	No change
CSNF colloids (Colloid Generation Rate and Concentration)	Yes	Yes	Yes	No	No change
Np secondary phases (Np Solubility)	Yes	Yes	No	Yes	Negligible increase or decrease in first 10,000 years in supplemental TSPA model. Also, no change in supplemental TSPA model mean peak dose

NOTE: While simulations haven't been conducted to determine the actual changes in dose, the potential changes are characterized as follows: Negligible—up to a factor of 2; Small—up to a factor of 5.

6.1 INVENTORY

New analysis shows that up to about one-fifth of the commercial spent nuclear fuel (CSNF) C-14 inventory is in the stainless steel assembly hardware components and not protected by the fuel cladding. This C-14 for all the assemblies within a waste package may be released within 1,000 years of waste package breach. This may increase early C-14 releases from an early failure package by an order of magnitude. However, the increase in dose is expected to be negligible.

6.2 COMMERCIAL SPENT NUCLEAR FUEL DISSOLUTION

New analysis quantified experimental uncertainty in the CSNF dissolution model. The new analysis supports the current model and no impact is expected.

6.3 CLADDING

New tests show rapid splitting of defected CSNF cladding in humid conditions at 175°C (347°F). Qualitative aspects of the splitting model were verified. The supplemental TSPA model gave rapid splitting a 22 percent chance of occurrence. No impact to the dose is expected.

6.4 COMMERCIAL SPENT NUCLEAR FUEL COLLOIDS

The CSNF dissolution model is based on tests that use fast flow rates to prevent secondary phase formation. These fast flow rates not expected to be representative of repository flow rates. New analysis suggests that up to 20 percent of the uranium release may be due to colloid release. This conclusion is not yet confirmed.

New CSNF drip testing redesigned to maximize colloid release showed no increase in colloid concentrations in the catch basin. This further justifies the neglect of CSNF colloids in TSPA modeling. No impact is expected.

6.5 NEPTUNIUM SOLUBILITY

New tests to track the fate of neptunium in a uranium-dominated system have been performed with Np:U ratios of 1:8 and 1:80. Tests at 90°C (194°F) and Np:U ratio of 1:8 show the formation of both Np_2O_5 and NpO_2. This evidence supports the use of a broad range of uncertainty for the concentration of Np, such as that used in the supplemental TSPA model. Consequently, a negligible impact is expected for the first 10,000 years, with no impact in peak dose.

7. PRELIMINARY IMPACT EVALUATION FOR RECENT INFORMATION RELEVANT TO THE SATURATED ZONE FLOW AND TRANSPORT MODEL

Participants in AP-2.14Q impact review discussions: Michael Wilson, Al Eddebbarh, Jerry McNeish, Mickey McDonnell, M.J. Umari, Michael Chornack, Richard Salness, Drew Coleman, Gary Patterson, Zell Peterman, Brian Marshall, Jim Paces, August Matthusen, Mark Peters, and Bill Arnold (by phone).

Table 9. Summary of Potential Impacts of Additional Information on the Saturated Zone Flow and Transport Model

Topic	Improves Documentation	Improves Validation	Reduces Uncertainty	Improves Realism	Change in Dose
Stratigraphy from Nye County EWDP	No	No	Yes	Yes	Negligible decrease
Hydrochem. from Nye County EWDP	No	Yes	No	No	No change
Testing at the Alluvial Testing Complex	No	Yes	Yes	Yes	Negligible increase or decrease
Different conceptual models	Yes	No	No	No	Negligible decrease
Boundary to the accessible environment	Yes	No	No	No	Negligible increase
Parameter sensitivity analysis	Yes	No	No	No	No change
Natural analogues	No	Yes	No	No	Negligible increase or decrease
Realistic SZ Case	No	No	No	Yes	Negligible decrease
AECL Busted Butte experiments Natural analogues	No	Yes	No	No	Negligible decrease

NOTE: While simulations haven't been conducted to determine the actual changes in dose, the potential changes are characterized as follows: Negligible—up to a factor of 2; Small—up to a factor of 5.

7.1 STRATIGRAPHY OF THE NYE COUNTY EWDP BOREHOLES

This information helps to reduce uncertainty in alluvium location. The effect so far is somewhat positive, as there is less chance of a very short alluvium component to the transport pathways (there is more sorption in alluvium than tuff for some important radionuclides, inlcuding neptunium, so the longer the flow path in alluvium, the better). This should result in a negligible decrease in TSPA results.

7.2 HYDROCHEMISTRY DATA FROM NEW NYE COUNTY EWDP WELLS

The additional data support the saturated zone model. No impact.

7.3 HYDRAULIC AND TRACER TESTING AT THE ALLUVIAL TESTING COMPLEX

This information helps to reduce uncertainty in groundwater specific discharge and other parameters. Some reduction in specific-discharge uncertainty has already been included in the supplemental TSPA model. Negligible impact (especially relative to supplemental TSPA model).

7.4 CALIBRATION OF DIFFERENT CONCEPTUAL MODELS OF THE LARGE HYDRAULIC GRADIENT

There is some impact on the saturated zone flow paths and radionuclide transport times, tending toward improved performance (i.e., tending to longer transport time). Negligible decrease in TSPA dose, if any.

7.5 EVALUATION OF BOUNDARY TO THE ACCESSIBLE ENVIRONMENT

There is some impact on radionuclide transport times—shorter transport times, since the boundary is closer by 2 km. A TSPA sensitivity analysis shows that there is negligible effect on the calculated dose, at least for the nominal scenario. The closer boundary was already used for the FEIS TSPA simulations (BSC 2001c).

7.6 PARAMETER SENSITIVITY ANALYSIS

This section is included simply to provide additional information on the saturated zone model. There is no model change and thus no impact on TSPA.

7.7 URANIUM MILL TAILINGS SITES AS ANALOGUES FOR TRANSPORT OF RADIONUCLIDES IN ALLUVIUM AT YUCCA MOUNTAIN

There is some possible impact, in that the study suggested that the effective sorption coefficient in the field is smaller than the sorption coefficient measured in the lab, suggesting an upscaling issue. The data are only for uranium, which contributes very little to the calculated dose for Yucca Mountain (although there is a great deal of uranium in the waste, most of it is in the form of uranium-238, which has very low radioactivity). There is some concern, though, that the same effect could occur for other radionuclides that are more important to potential repository performance. It is likely that the difference in sorption between the field and the lab was largely due to difference in sorption between the field and the lab was largely due to differences in water chemistry. The lab sorption tests for the New Rifle site were performed using an artificial water, which may not have been representative of the actual groundwater in the contamination plume. The lab sorption tests for Yucca Mountain have been performed using actual groundwater, so they are expected to be representative of actual saturated zone conditions. Finally, degraded-barrier and neutralized-barrier sensitivity analyses for the TSPA-SR model showed that

reduced saturated-zone performance has little effect on TSPA results, at least for the nominal scenario.

7.8 A REALISTIC CASE OF SATURATED ZONE FLOW AND TRANSPORT

The "realistic" case has longer transport times, as shown in Figure 9 of Appendix G. This slower transport has the potential to reduce doses, especially within the first 10,000 years, but the change is probably not important because the "realistic" breakthrough curve still has a significant amount of breakthrough within a few thousand years. Also, the majority of the change appears to result from the changes in the UZ model, rather than from the SZ changes. A negligible decrease in dose is expected.

7.9 SATURATED ZONE RESULTS FROM THE AECL BUSTED BUTTE EXPERIMENTS

The results for Na, Cs and Co are consistent with results using batch sorption measurements, so they provide confirmation of the previous work. The results for Np and Tc seem to indicate greater sorption than expected from batch sorption tests, but the reason for the higher sorption is apparently that the water chemistry within the experimental block is reducing. Reducing conditions are not expected in the saturated zone at Yucca Mountain, so these results may not be applicable to transport in the saturated zone. If there really were reducing conditions in the saturated zone, leading to greater sorption for Np and Tc, this could result in a negligible decrease in dose, especially within the first 10,000 years.

8. PRELIMINARY IMPACT EVALUATION FOR RECENT INFORMATION RELEVANT TO THE BIOSPHERE PROCESS MODEL

Participants in AP-2.14Q impact review discussions: James E. Clark, Terry R. Crump, Donald A. Kalinich, Daniel McGregor, J.K. Prince, Eric Smistad, Anthony J. Smith, and Maryla A. Wasiolek.

Table 10. Summary of Potential Impacts of Additional Information on the Biosphere Process Model

Topic	Improves Documentation	Improves Validation	Reduces Uncertainty	Improves Realism	Change in Dose
Receptor—dietary & lifestyle characteristics (2000 Census data)	N/A	N/A	N/A	N/A	N/A
Receptor—dosimetric model	Yes	Yes	No	Yes	Negligible increase for first 10,000 year; small decrease for peak dose

NOTE: The year 2000 Census data are not available (N/A) for this particular analysis. While simulations haven't been conducted to determine the actual changes in dose, the potential changes are characterized as follows: Negligible—up to a factor of 2; Small—up to a factor of 5.

8.1 DIETARY AND LIFESTYLE CHARACTERISTICS OF THE RECEPTOR

The year 2000 census data that are needed for dietary and lifestyle characteristics are not yet available.

8.2 DOSIMETRIC MODELS USED IN BIOSPHERE ASSESSMENTS

ICRP-72 biosphere dose conversion factors (BDCFs) result in a negligible increase in the early portion of the dose curve (^{99}Tc BDCF increases by about 7 percent) and small decrease in the peak dose of approximately a factor of 4 (^{237}Np BDCF decreases by a factor of about 12).

There is no impact of the new work for the biosphere process model on the analyses and documents supporting possible site recommendation. The new work consisted of the development of the ICRP-72-based BDCFs to supplement the previous BDCFs based on ICRP-30 for the reasonably maximally exposed individual (RMEI). However, because the applicable regulations (10 CFR Part 63 [66 FR 55732]) express the individual protection standard in terms of total effective dose equivalent (TEDE), the BDCFs that are used for demonstration of regulatory compliance have to be based on ICRP-30 dosimetric methods. The new work was conducted because an IAEA Peer Review Report recommended testing alternative models using the more recent ICRP-72 data to provide an alternative modeling capability to compare to the model based on ICRP-30. Generating ICPP-72-based BDCFs provides an alternative model, provides additional confidence in the TSPA calculations, and also allows the TSPA annual dose predictions to be compared with the results of other performance assessments generated internationally.

The TSPA analyses using the ICRP-72-based BDCFs were conducted by performing simulation runs of the supplemental TSPA model (BSC 2001a). The supplemental TSPA model is a

modified TSPA-SR model that incorporates new submodels and input parameter values for some components. Application of the ICRP-72 dosimetric methods results in doses expressed as the sum of the committed effective dose from internal exposure and the effective dose from external exposure. This produces a dosimetric quantity different from the TEDE.

The results of the supplemental TSPA model analyses are shown in Figures 1 and 2 for the nominal performance and the igneous disruption performance, respectively. The overall impact of the BDCFs on dose history, given that the mix of potential contributing radionuclides changes over time, depends on the details of the TSPA predictions of radionuclides entering the accessible environment.

Figure 1 shows the million-year mean annual dose for the supplemental TSPA model for the higher-temperature operating mode (HTOM) case for both the ICRP-30- and ICRP-72-based BDCFs. During the period up to about 80,000 years, the doses are dominated by the relatively mobile radionuclides, such as technetium-99 and iodine-129 whose BDCF for the groundwater release do not change significantly if the ICRP 72 dosimetric methods are applied. Therefore, the annual doses obtained using ICRP-30 and ICRP-72-based BDCFs are nearly identical. After about 80,000 years, the ICRP-72 annual doses are lower than the ICRP-30-based doses. The largest contribution to this decrease comes from neptunium-237 whose BDCF is about 12 times lower with the ICRP-72-based BCDF than with the ICRP-30-based BDCF.

The TSPA results for the igneous disruption performance, shown in Figure 2, indicate that up to about 20,000 years the differences in annual doses are negligible because the doses are dominated by radionuclides such as americium-241, plutonium-239 and plutonium-240, whose BDCF for the volcanic release exposure scenario are practically unaffected by the selection of either ICRP-30-based or ICRP-72 dose coefficients. After about 20,000 years, the doses are primarily due to the igneous intrusion groundwater transport. Therefore, application of ICRP-72 BDCFs for groundwater release yields lower results, similar to the nominal performance case.

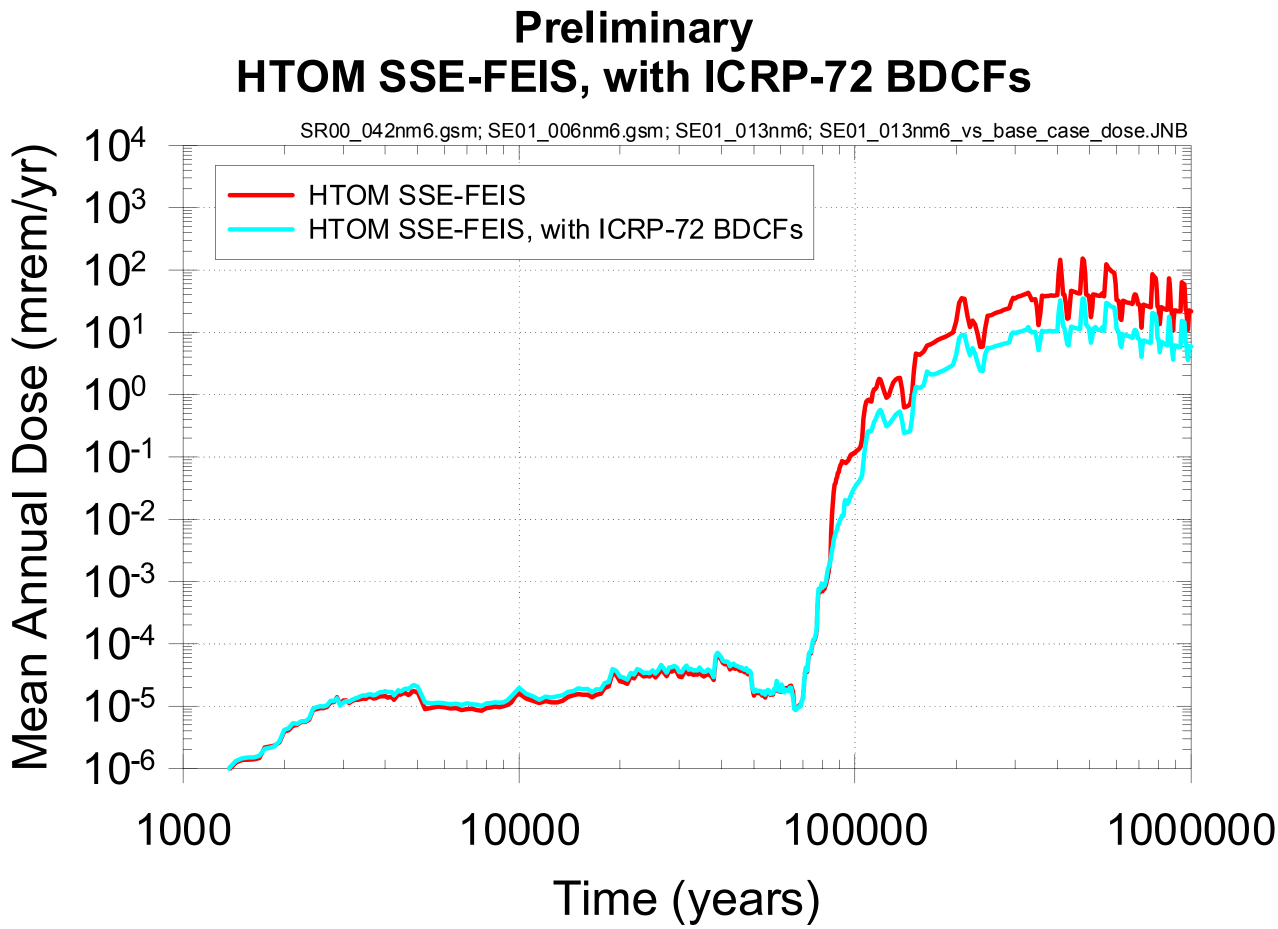

Figure 1. ICRP-30 and ICRP-72 Dose Histories for the Nominal Performance Calculated with the Supplemental TSPA Model HTOM

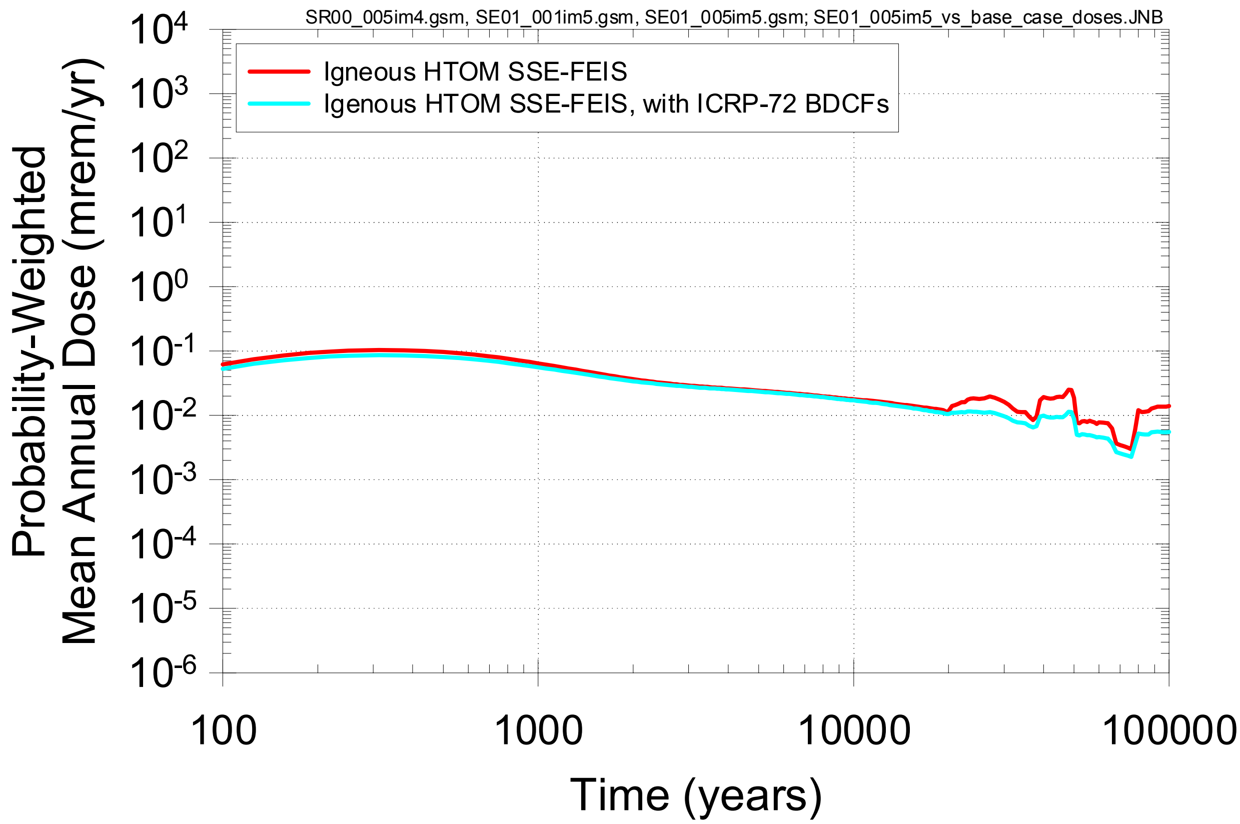

Figure 2. ICRP-30 and ICRP-72 Dose Histories for the Igneous Disruption Performance Calculated with the Supplemental TSPA Model HTOM

9. PRELIMINARY IMPACT EVALUATION FOR RECENT INFORMATION RELEVANT TO DISRUPTIVE EVENTS—VOLCANISM AND SEISMICITY

Participants in AP-2.14Q impact review discussions: Michael Chornack, Drew Coleman, Terry Crump, Donald A. Kalinich, Daniel McGregor, Mark Peters, Richard Quittmeyer, John Savino, Dave Sevougian, Eric Smistad, and Tim Sullivan.

Table 11. Summary of Potential Impacts of Additional Information on the Understanding of Volcanism and Seismicity

Topic	Improves Documentation	Improves Validation	Reduces Uncertainty	Improves Realism	Change in Dose
Dike–drift interaction —CNWRA work	No	No	No	No	No more than one order of magnitude increase
Aeromagnetic data & analysis	No	No	No	No	No change
Geotechnical studies	No	Yes	Yes	No	No change
Geodetic investigations	No	Yes	No	No	No change

NOTE: While simulations haven't been conducted to determine the actual changes in dose, the expected changes are characterized as follows: Negligible—up to a factor of 2; Small—up to a factor of 5; one order of magnitude—up to a factor of 10.

9.1 CNWRA-SPONSORED RESEARCH AND JOURNAL ARTICLES RELATED TO DIKE/DRIFT INTERACTION

Even if all assumptions contained in the analyses done by the Center for Nuclear Waste Regulatory Analysis are valid, and those assumptions were incorporated into the supplemental TSPA model for extrusive igneous consequences, the number of degraded packages are not expected to increase by more than an order of magnitude. Therefore, the dose is not expected to increase by more than an order of magnitude for the disruptive scenario.

9.2 ADDITIONAL AEROMAGNETIC DATA AND INTERPRETATION

Additional aeromagnetic information has been collected. However, the additional information is not expected to change the conclusions of the expert elicitation that supports the current igneous event probability distribution because it included a factor for hidden events that would account for new volcanic locations. The use of the factor may compensate for the presence of some limited number of additional igneous features, which suggests that, if needed, adjustments in the calculated probability may be minor. Furthermore, the TSPA-SR model sampled a probability distribution ranging to as high as 10^{-7}/yr, which would tend to further minimize the effect on any minor change in probability estimates and thus on TSPA dose.

9.3 COLLECTION OF GEOTECHNICAL DATA TO SUPPORT SEISMIC ANALYSES

Work is largely for preclosure issues. Ground motion may be reduced.

9.4 GEODETIC RESULTS FROM CONTINUOUS GLOBAL POSITIONING SYSTEM MEASUREMENTS

Additional data indicate a notably lower strain rate than reported by Wernicke et al. (1998). No impact is expected.

10. PRELIMINARY IMPACT EVALUATION FOR RECENT INFORMATION RELEVANT TO DISRUPTIVE EVENTS—CRITICALITY

Participants in AP-2.14Q impact review discussions: Jerry McNeish, Rob Howard, Paige Russell, Dan Thomas, and Doug Brownson.

Table 12. Summary of Potential Impacts of Additional Information on Criticality

Topic	Improves Documentation	Improves Validation	Reduces Uncertainty	Improves Realism	Change in Dose
Updated criticality analyses	Yes	No	No	Yes	No change

The features, events, and processes screening for criticality had screened the event out for the TSPA-SR model. Based on the supplemental TSPA model results that incorporated waste package failures prior to 10,000 years, it was determined that a new review of the potential for a criticality was required. The new analyses indicated that the criticality can still be screened out of the TSPA analyses. This analysis results in no impact on TSPA dose.

11. REFERENCES

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