



Department of Energy
Office of Civilian Radioactive Waste Management
Yucca Mountain Site Characterization Office
P.O. Box 364629
North Las Vegas, NV 89036-8629

QA: N/A

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OVERNIGHT MAIL

Janet R. Schlueter, Chief
High-Level Waste Branch
Division of Waste Management
Office of Nuclear Materials Safety
and Safeguards
U.S. Nuclear Regulatory Commission
Two White Flint North
Rockville, MD 20852

TRANSMITTAL OF REPORT ADDRESSING KEY TECHNICAL ISSUE (KTI) IGNEOUS
ACTIVITY (IA) AGREEMENT ITEM 2.10

References: (1) Ltr, Brocoum to Reamer, dated 2/2/01
(2) Ltr, Reamer to Brocoum, dated 4/30/01

This letter transmits the report, *Relative Contributions of Releases From Zones 1 and 2*, addressing the subject KTI agreement. Agreement Item IA 2.10 is as follows:

“Document the ICN to the Igneous Consequences analysis and model report (AMR) and the Dike Propagation AMR regarding the calculation of the number of waste packages hit by the intrusion. Include in these or other documents (1) the intermediate results of releases from Zones 1 and 2, separately, and (2) the evaluation of thermal and mechanical effects, as well as shock, in assessing the degree of waste package damage in Zones 1 and 2.”

“DOE agreed and will provide ICN 1 of the following AMRs: Igneous Consequence Modeling for TSPA-SR AMR [ANL-WIS-MD-000017], the Dike Propagation Near Drifts AMR [ANL-WIS-MD-000015], the Characterize Framework for Igneous Activity at Yucca Mountain, Nevada AMR [ANL-MGR-GS-000001], and the calculation Number of Waste Packages Hit by Igneous Intrusion [CAL-WIS-PA-000001]. This will be available to the NRC in January 2001. DOE will provide the results showing the relative contributions of releases from Zones 1 and 2 in a calculation document. This will be available to the NRC in FY2002. DOE will provide the evaluation of thermal mechanical effects on waste package damage in Zones 1 and 2 in ICN 1 of the Dike Propagation Near Drifts AMR [ANL-WIS-MD-000015]. This will be available to the NRC in January 2001.”

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NRC
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The documents identified in the agreement for January 2001 availability to the U.S. Nuclear Regulatory Commission (NRC) were transmitted by Reference 1. Reference 2 provided the results of the NRC review of these documents and identified additional information needed.

As discussed at the April 15-16, 2002, NRC/U.S. Department of Energy Technical Exchange and Management Meeting on KTIs, the information on the relative contribution of releases from Zones 1 and 2 would be provided in a different document than that specified in the agreement, and the remaining information would be provided in response to KTI IA Agreement Items 2.18 and 2.19.

The enclosed report documents the releases from Zones 1 and 2 and the associated contributions to doses. Collection of additional information addressing the part of the agreement that specifies the evaluation of thermal mechanical effects on waste packages, and the additional information needed as specified in Reference 2, are being planned as part of the work associated with KTI IA Agreement Items 2.18 and 2.19. The enclosed report, together with the information to be provided in response to KTI Agreement Items IA 2.18 and 2.19, should satisfy KTI IA Agreement Item 2.10.

This letter makes no new regulatory commitments. Please direct any questions concerning this letter and its enclosure to Timothy C. Gunter at (702) 794-1343 or Eric T. Smistad at (702) 794-5073.



Joseph D. Ziegler
Acting Assistant Manager, Office of
Licensing & Regulatory Compliance

OL&RC:TCG-1284

Enclosure:
*Relative Contributions of Releases
from Zones 1 and 2*

JUL 01 2002

cc w/encl:

J. W. Andersen, NRC, Rockville, MD
J. S. Trapp, NRC, Rockville, MD
D. D. Chamberlain, NRC, Arlington, TX
R. M. Latta, NRC, Las Vegas, NV
S. H. Hanauer, DOE/HQ (RW-2), Las Vegas, NV
B. J. Garrick, ACNW, Rockville, MD
Richard Major, ACNW, Rockville, MD
W. D. Barnard, NWTRB, Arlington, VA
Budhi Sagar, CNWRA, San Antonio, TX
W. C. Patrick, CNWRA, San Antonio, TX
Steve Kraft, NEI, Washington, DC
J. H. Kessler, EPRI, Palo Alto, CA
J. R. Egan, Egan & Associates, McLean, VA
R. R. Loux, State of Nevada, Carson City, NV
John Meder, State of Nevada, Carson City, NV
Alan Kalt, Churchill County, Fallon, NV
Irene Navis, Clark County, Las Vegas, NV
George McCorkell, Esmeralda County, Goldfield, NV
Leonard Fiorenzi, Eureka County, Eureka, NV
Andrew Remus, Inyo County, Independence, CA
Michael King, Inyo County, Edmonds, WA
Mickey Yarbrow, Lander County, Battle Mountain, NV
Lola Stark, Lincoln County, Caliente, NV
L. W. Bradshaw, Nye County, Pahrump, NV
David Chavez, Nye County, Tonopah, NV
Josie Larson, White Pine County, Ely, NV
Arlo Funk, Mineral County, Hawthorne, NV
R. I. Holden, National Congress of American Indians, Washington, DC
Allen Ambler, Nevada Indian Environmental Coalition, Fallon, NV
CMS Coordinator, BSC, Las Vegas, NV

cc w/o encl:

C. W. Reamer, NRC, Rockville, MD
N. K. Stablein, NRC, Rockville, MD
L. L. Campbell, NRC, Rockville, MD
S. L. Wastler, NRC, Rockville, MD
Margaret Chu, DOE/HQ (RW-1) FORS
A. B. Brownstein, DOE/HQ (RW-52) FORS
R. A. Milner, DOE/HQ (RW-2) FORS
S. E. Gomberg, DOE/HQ (RW-2) FORS
N. H. Slater-Thompson, DOE/HQ (RW-52) FORS

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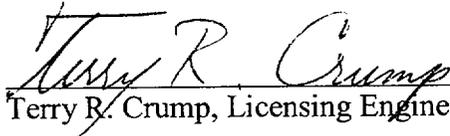
cc w/o encl: (continued)

R. B. Murthy, DOE/OQA (RW-3), Las Vegas, NV
N. H. Williams, BSC, Las Vegas, NV
S. J. Cereghino, BSC, Las Vegas, NV
Donald Beckman, BSC, Las Vegas, NV
K. M. Cline, MTS, Las Vegas, NV
R. B. Bradbury, MTS, Las Vegas, NV
R. P. Gamble, MTS, Las Vegas, NV
R. C. Murray, MTS, Las Vegas, NV
R. D. Rogers, MTS, Las Vegas, NV
Richard Goffi, BAH, Washington, DC
J. R. Dyer, DOE/YMSCO, Las Vegas, NV
D. G. Horton, DOE/YMSCO, Las Vegas, NV
G. W. Hellstrom, DOE/YMSCO, Las Vegas, NV
S. P. Mellington, DOE/YMSCO, Las Vegas, NV
R. E. Spence, DOE/YMSCO, Las Vegas, NV
J. D. Ziegler, DOE/YMSCO, Las Vegas, NV
W. J. Boyle, DOE/YMSCO, Las Vegas, NV
C. M. Newbury, DOE/YMSCO, Las Vegas, NV
T. C. Gunter, DOE/YMSCO, Las Vegas, NV
E. T. Smistad, DOE/YMSCO, Las Vegas, NV
C. L. Hanlon, DOE/YMSCO, Las Vegas, NV
M. C. Tynan, DOE/YMSCO, Las Vegas, NV
J. T. Sullivan, DOE/YMSCO, Las Vegas, NV
G. L. Smith, DOE/YMSCO, Las Vegas, NV
C. A. Kouts, DOE/YMSCO (RW-2) FORS
R. N. Wells, DOE/YMSCO (RW-60) Las Vegas, NV
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RELATIVE CONTRIBUTIONS OF RELEASES FROM ZONES 1 AND 2

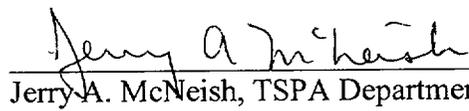
June 2002

Preparation:


Terry R. Crump, Licensing Engineer, LAP

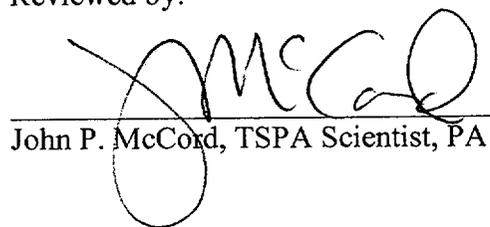
6/26/02
Date

Approval:


Jerry A. McNeish, TSPA Department Manager, PA

6-26-02
Date

Reviewed by:


John P. McCord, TSPA Scientist, PA

6/26/02
Date

ENCLOSURE

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ACRONYMS AND ABBREVIATIONS

AMR	Analysis Model Report
CDF	Cumulative Distribution Function
DOE	U.S. Department of Energy
FY	Fiscal Year
ICN	Interim Change Notice
KTI	Key Technical Issue
LA	License Application
NRC	U.S. Nuclear Regulatory Commission
SR	Site Recommendation
SSPA	Supplemental Science and Performance Assessment
TSPA	Total System Performance Assessment

Relative Contributions of Releases from Zones 1 and 2

This Licensing Letter Report describes the basis to resolve and close parts of agreement item IA 2.10 associated with the consequences subissue of the igneous activity Key Technical Issue (KTI). The item is the U.S Department of Energy (DOE)-U.S. Nuclear Regulatory Commission (NRC) agreement that DOE document the intermediate results of releases from Zone 1 and 2, separately (Crump 2001).

The original agreement is documented in the Summary Highlights of NRC/DOE Technical Exchange and Management Meeting on Igneous Activity, August 29-31, 2000 (Reamer and Williams 2000). The agreement was revised during the NRC/DOE Technical Exchange and Management Meeting on Igneous Activity, June 21-22, 2001 (Crump 2001).

1. BACKGROUND

For Total System Performance Assessment (TSPA) for the Site Recommendation (SR), DOE defined two damage zones for the igneous activity scenarios, Zone 1 and Zone 2, based on the assumed extent of damage to various engineered barrier system components (CRWMS M&O 2000, Sections 3.10.2.3 and 5.2.9.7). Zone 1 was defined as waste packages near the point(s) of intersection between an ascending dike and repository drifts. Zone 1 featured damage to waste packages so extensive that the packages provided no further protection to the waste. Zone 2 included those packages that were further down drifts and were damaged but still provided some protection for the waste (BSC 2001 Section 14.2.1). However, the TSPA-SR did not report intermediate releases from the zones separately, nor were contributions to dose from the separate releases calculated.

The NRC questioned the contributions to dose from the separate releases from Zone 1 and Zone 2. Analyses describing the dose contributions from Zone 1 and Zone 2 releases were documented in the Supplemental Science and Performance Assessment (SSPA) Volume 1 (BSC 2001, Section 14.3.3.3) and Volume 2 (BSC 2001, Section 3.3.1.2.3).

1.1 NRC INITIAL COMMENTS

The NRC questioned the modeling and analysis of interactions between an ascending dike and various repository components, in particular the extent of damage to waste packages in terms of both the number of waste packages damaged and the intensity of the damage. The NRC requested identification of the contribution to dose of releases from Zone 1 and Zone 2 separately to assist them in evaluating these concerns.

1.2 DOE INITIAL COMMENTS

DOE completed an analysis of the releases from Zones 1 and 2 and of the effects of those releases on dose for the SSPA Volume 1 (BSC 2001, Section 14.3.3.3) and Volume 2 (BSC 2001, Section 3.3.1.2.3). The results indicate that the dose from releases from Zone 1 dominate the probability-weighted mean annual dose for the first 20,000 years.

1.3 STATEMENT OF DIFFERENCES

SSPA analyses indicate that the dose is dominated by releases from Zone 1 for the first 20,000 years. Dose from Zone 2 releases reach a maximum of about 0.01 mrem at about 150,000 years. The NRC questioned the extent of waste package damage, the dose contribution from Zone 2 damage, and whether DOE could be underestimating the dose from disruption of the repository by igneous activity. However, the SSPA information indicates that during the first 20,000 years, the contribution to mean annual dose from Zone 2 damage is negligible and even if Zone 2 damage were underestimated, the dose during the first 20,000 years would not be significantly underestimated.

1.4 DEFINITION OF TECHNICAL TERMS

Zone 1 is an area of damage to waste packages so intense that the waste packages no longer provide protection for the waste (BSC 2001, Section 14.2.1).

Zone 2 is an area of damage peripheral to Zone 1, and in which waste packages are damaged but still provide some protection for the waste (BSC 2001, Section 14.2.1). The damage mode in Zone 2 is breach of endcaps by apertures of variable width.

2. APPLICABLE NUCLEAR SAFETY STANDARDS/REQUIREMENTS/GUIDANCE

2.1 APPLICABLE REQUIREMENTS

The Yucca Mountain disposal regulations include a requirement to provide the technical basis for models used in the performance assessment (10CFR63.114(g)). However, the KTI agreement item, described below, is the only specification applicable to the evaluation of Zone 1 and Zone 2 releases and their potential contributions to dose caused by igneous disruption of a repository at Yucca Mountain. No regulatory requirements, applicable to the evaluation of Zone 1 and Zone 2 releases, have been identified.

2.2 KTI AGREEMENT

Document the Interim Change Notices (ICNs) to the Igneous Consequences Analysis Model Report (AMR) and the Dike Propagation AMR regarding the calculation of the number of waste packages hit by the intrusion. Include in these or other documents (1) the intermediate results of releases from Zone 1 and 2, separately, and (2) the evaluation of thermal and mechanical effects, as well as shock, in assessing the degree of waste package damage in Zone 1 and 2 (Intrusive AC-1 to 4).

DOE agreed and will provide ICN 1 of the following AMRs: Igneous Consequence Modeling for TSPA-SR [ANL-WIS-MD-000017], Dike Propagation Near Drifts [ANL-WIS-MD-000015], Characterize Framework for Igneous Activity at Yucca Mountain, Nevada [ANL-MGR-GS-000001], and the calculation Number of Waste Packages Hit by Igneous Intrusion [CAL-WIS-PA-000001]. This will be available to the NRC in January 2001. DOE will provide the results showing the relative contributions of releases from Zones 1 and 2 in a calculation document. This will be available to the NRC in Fiscal Year (FY) 2002 (Intrusive

AC-1 to 4). DOE will provide the evaluation of thermal mechanical effects on waste package damage in Zones 1 and 2 in ICN 1 of the Dike Propagation Near Drifts AMR [ANL-WIS-MD-000015]. This will be available to the NRC in January 2001 (Intrusive AC-1 to 4) (Reamer and Williams 2000 as revised in Crump 2001).

2.3 STATUS OF AGREEMENT(S)

DOE provided the revised documents specified in the agreement to the NRC in February 2001 (i.e. ANL-WIS-MD-000017, Rev 00, ICN 01; ANL-WIS-MD-000015, Rev. 00, ICN 01; ANL-MGR-GS-000001, Rev 00, ICN 01; CAL-WIS-PA-000001, Rev. 01). The remaining agreement items, (1) an analysis showing the relative contributions of releases from Zones 1 and 2 was to be provided to the NRC in a calculation document, and (2) an evaluation of thermal mechanical effects on waste package damage in Zones 1 and 2 were to be provided in an update of the Dike Propagation Near Drifts AMR [ANL-WIS-MD-000015].

The relative contributions to dose of releases from Zones 1 and 2 were documented in SSPA Volume 1 (BSC 2001, Section 14.3.3.3) and Volume 2 (BSC 2001, Section 3.3.1.2.3) and are the subjects of this report.

The evaluation of thermal mechanical effects on waste package damage is to be documented in an analysis that is planned as part of the work to address igneous activity agreement item IA 2.19, and the results are expected in FY 2003.

2.3.1 Analysis of Contributions of Releases from Zones 1 and 2

The analysis specified was completed and documented in the SSPA Volume 1 (BSC 2001, Section 14.3.3.3) and Volume 2 (BSC 2001, Section 3.3.1.2.3). The information about Zone 1 and Zone 2 releases represents a sensitivity study that corroborates the total dose from the igneous intrusion-groundwater release scenario described in the Total System Performance Assessment for Site Recommendation (TSPA-SR). Since the information is corroborative, the information in the SSPA volumes, as summarized in this report, and the specific indication of how DOE intends to address the thermal and mechanical effects of exposure of waste packages to magmatic conditions is sufficient to resolve and close agreement IA 2.10. This information is described in Section 3.2 of this report. For the compliance demonstration for license application, DOE expects to rely on the total dose from Zones 1 and 2 combined and does not expect to repeat the sensitivity analysis.

2.3.2 Evaluation of Thermal and Mechanical Effects on Waste Package Damage

The part of the agreement to address the evaluation of thermal and mechanical effects, as well as shock, in assessing the degree of waste package damage in Zone 1 and 2 is being addressed as part of agreements IA 2.18 and IA 2.19. The thermal and mechanical characteristics of the interaction of magma with a drift are being developed as part of the work associated with agreement IA 2.18, and the analysis of the effects of those characteristics on the degree of waste package damage is being addressed as part of the work associated with agreement IA 2.19. Preliminary results of studies of magma-drift interactions are expected in FY 2003.

3. BASIS FOR REGULATORY COMPLIANCE STATEMENT

DOE has completed the analyses needed to fulfill most of the agreement item, but the documentation was provided in the SSPA Volume 1 and Volume 2 rather than in a calculation document.

3.1 BACKGROUND

DOE defined two damage zones based on the assumed severity of interactions between an ascending dike and various components of the engineered barrier system. As discussed below, DOE evaluated the releases from these damage zones and their relative contributions to dose in the SSPA report. DOE considers that the work documented in SSPA Volumes 1 and 2 is sufficient to resolve the agreement item related to the relative contributions to dose of releases from Zones 1 and 2. The information about Zone 1 and Zone 2 releases represents a sensitivity study that corroborates the total dose from the igneous intrusion-groundwater release scenario described in the Total System Performance Assessment for Site Recommendation (TSPA-SR). DOE has additional work in progress to further evaluate the characteristics of magma-drift and magma-waste package interactions to address the evaluation of thermal mechanical effects on waste package damage and to support TSPA for the License Application (LA).

3.2 SAFETY / TECHNICAL BASIS FOR THE COMPLIANCE STATEMENT

The analysis showing the relative contributions of releases from Zones 1 and 2 was completed and documented in the SSPA Volume 1 (BSC 2001, Section 14.3.3.3) and Volume 2 (BSC 2001, Section 3.3.1.2.3).

As described in SSPA Volume 1, Section 14.3.3.3, Zone 1 consists of the area immediately around the dike/drift intersection. As described in TSPA-SR (CRWMS M&O 2000; Sections 3.10.2.3.1, 3.10.2.3.2 and Table 3.10-5) waste package behavior in Zone 1 is bounded by the assumption that three packages on either side of the intersection and at least one package in the path of the dike, are sufficiently damaged that they provide no further protection for the waste. For multiple dikes, seven packages are damaged for each dike that intersects the repository.

Zone 2 consists of the portion of an emplacement drift that has been crossed by a dike but is not included in Zone 1. Waste packages in Zone 2 are exposed to the shock wave and pyroclastic flow resulting from the dike encountering the repository. Waste package damage would be produced by exposure to high pressures and temperatures attending intersection of one or more dikes with the repository. In the TSPA-SR model for the repository without backfill, all Zone 2 damage features removal of drip shields, failure of fuel cladding, and failure of welds on package lids (endcaps).

Endcap failure is used as a surrogate for all types of Zone 2 damage related to dike/waste package interaction. In the case of endcap failures, relatively small aperture failures are considered most likely because they would be sufficient to allow gas pressure to equilibrate quickly between the inside and outside of the package. The minimum value of area in the distribution is 1 cm², and the maximum area is 1.9×10⁴ cm², which is approximately the full cross-sectional area of a representative endcap with a radius of 77 cm. The mean value of the

distribution is 10 cm^2 . Although smaller apertures are considered more likely, larger apertures could not be ruled out; so the log-normal distribution was chosen with a relatively small mean value and a low-probability tail that includes the full cross-sectional area of the endcap as the upper bound.

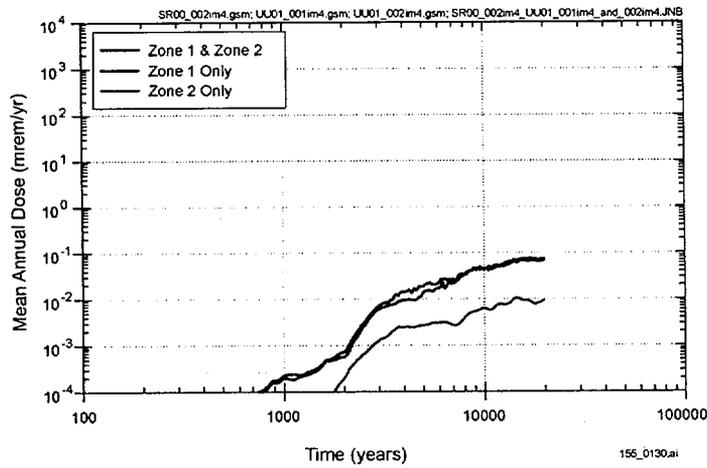
SSPA Volume 2 (BSC 2001, Section 3.3.1.2.3) documents the results of the analysis of igneous event Zone 1 and Zone 2 sensitivity. Analyses conducted since completion of the TSPA-SR resulted in revisions of the cumulative distribution functions (CDFs) describing the number of packages damaged in Zone 1 and Zones 1 and 2 combined. As shown in SSPA Volume 2 (BSC 2001, Table 3.3.1.2-1), the median number of waste packages in Zone 1 increased from 192 for TSPA-SR to 197 for SSPA, and the median number of packages in Zones 1 and 2 combined increased from 1720 for TSPA-SR to 1838 for SSPA.

The effects on dose of increasing the number of packages in Zone 1 and Zone 2 were also examined (BSC 2001; see Figures 1, 2, and 3 of this report). Figure 1 shows the relative contributions of releases from Zones 1 and 2 to probability-weighted mean annual doses from igneous intrusion. Figure 1a shows that the probability-weighted mean annual dose is dominated by Zone 1 releases for the first 20,000 years. Figures 1b and 1c show the mean, median, and 95th percentile dose curves for Zone 1 and Zone 2, respectively.

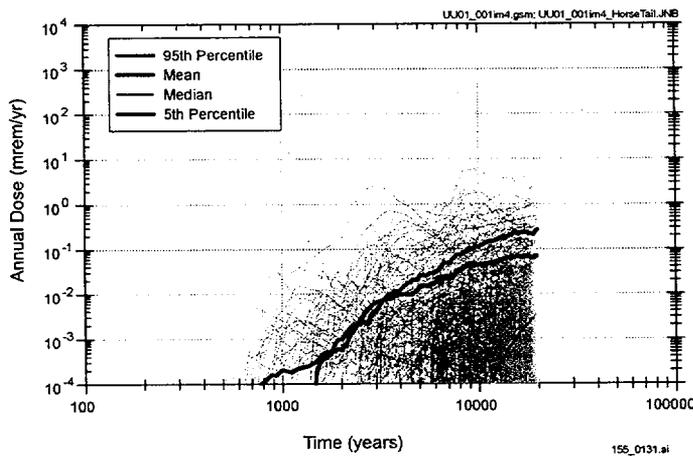
Figure 2 shows probability-weighted mean annual doses from igneous intrusion, Zone 1 releases only and compares results using TSPA-SR information with results using new CDFs in SSPA. Figure 2a shows that the revised distribution results in an increase in the calculated dose at all times, with a maximum change of a factor of approximately 2. Figure 2b shows the set of realizations calculated for Zone 1 with the revised distribution and shows mean, median, and 95th percentile dose curves.

Figure 3 shows probability-weighted, mean annual doses from igneous intrusion, Zone 2 releases only and compares results using TSPA-SR information with results using new CDFs in SSPA. Figure 3a shows that the revised distribution results in an increase in the calculated dose at all times, but the maximum change is much less than that for the Zone 1 case. Figure 3b shows the set of realizations calculated for Zone 2 with the revised distribution and shows mean, median, and 95th percentile dose curves.

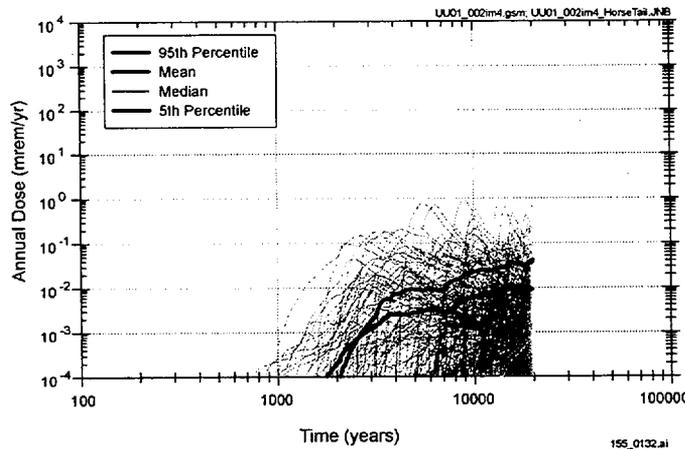
The analyses described show the releases from Zone 1 and Zone 2 and the probability-weighted mean annual doses from Zone 1 and Zone 2, separately. The results indicate that the dose from releases from Zone 1 dominate the probability-weighted mean annual dose for the first 20,000 years. The SSPA information adequately addresses and is sufficient to close the agreement item to provide results showing the relative contributions of releases from Zones 1 and 2 because separate calculations of releases from Zone 1 and Zone 2 are not essential to demonstrate compliance with the disposal regulations. DOE intends to address the evaluation of thermal mechanical effects on waste package damage in an analysis that is planned as part of the work to address igneous activity agreement items IA 2.18 and IA 2.19, and the results are expected in FY 2003.



(a) Zones 1 and 2



(b) Zone 1 only

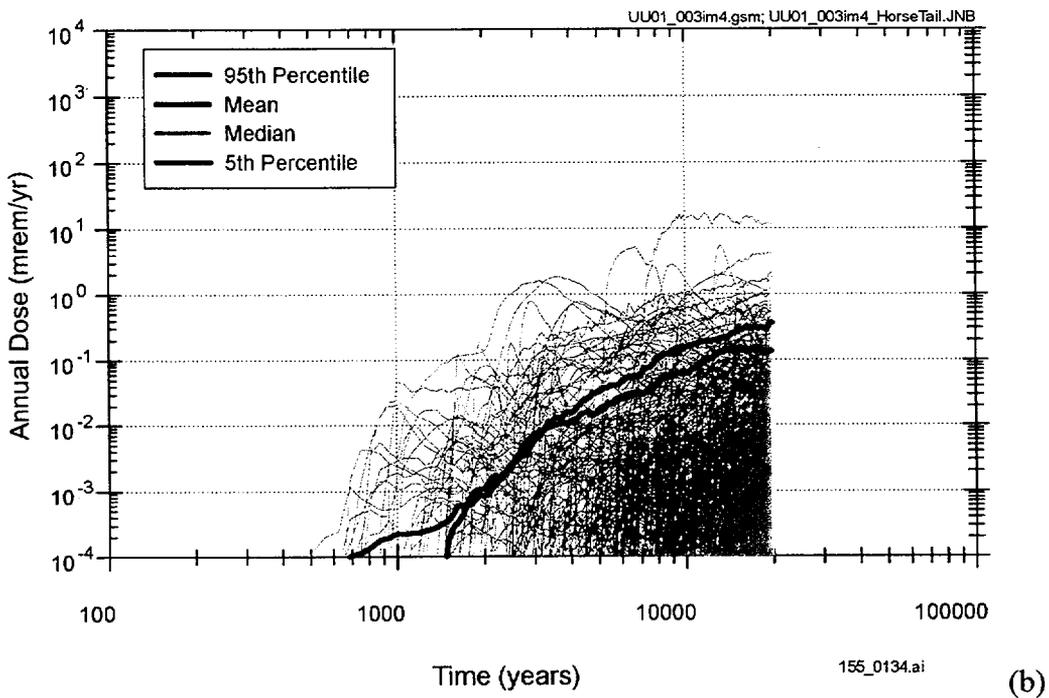
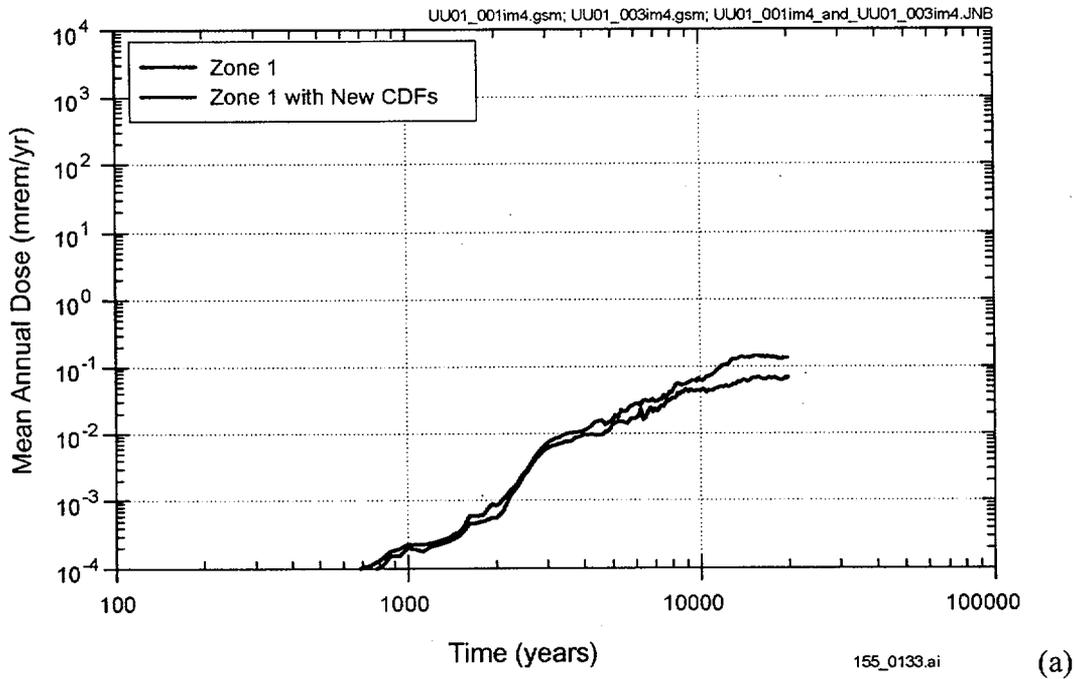


(c) Zone 2 only

Source: TSPA-SR (CRWMS M&O 2000 [DIRS 153246], Sections 3.10.2.2 through 3.10.2.4)

NOTE: Models and input parameters are identical to those used in TSPA-SR. In (b) Zone 1 and (c) Zone 2, the 5th percentile curve plots below the lowest value shown on the y-axis.

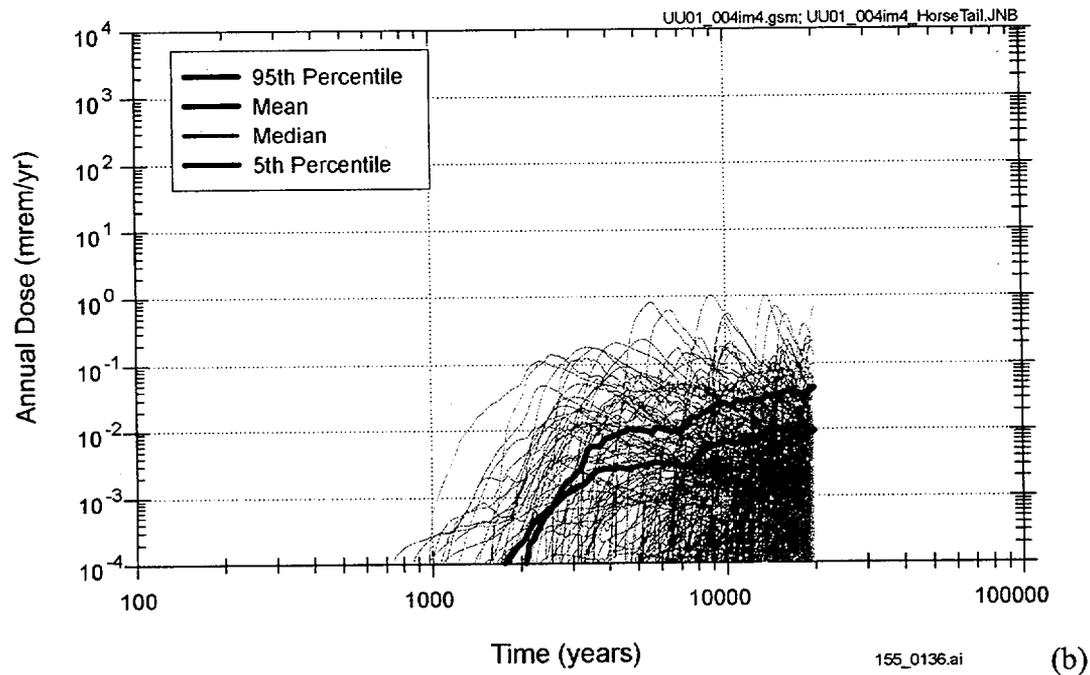
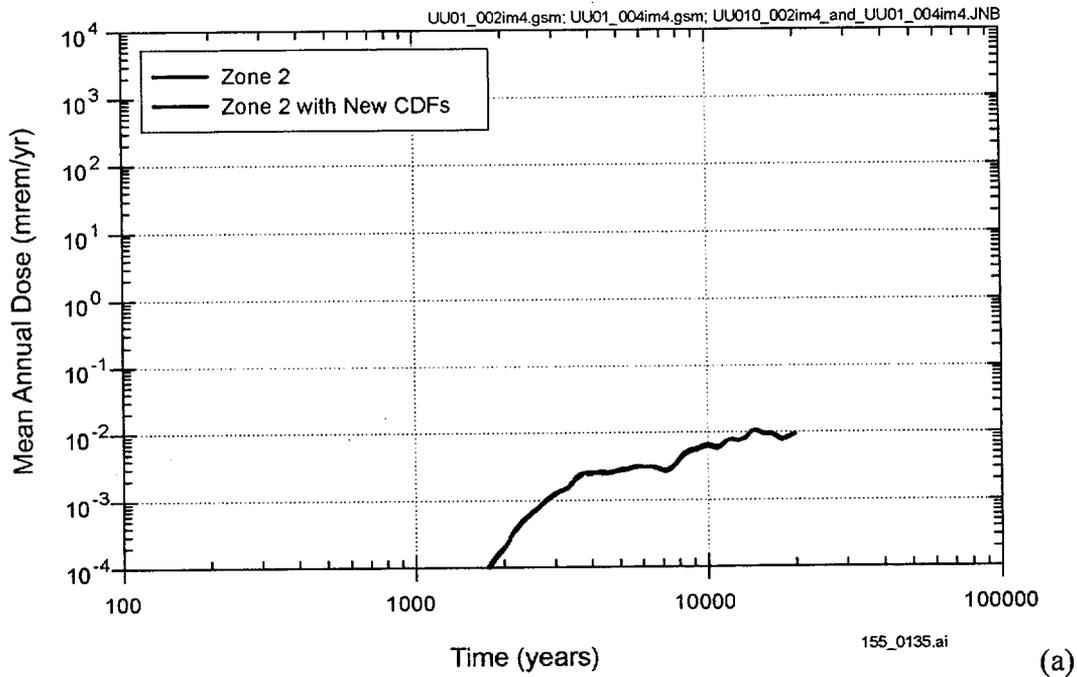
Figure 1. Same as Figure 3.3.1.2-3 from SSPA Volume 2. Relative Contributions of Releases from Zones 1 and 2 to Probability-Weighted Mean Annual Doses from Igneous Intrusion



Source: TSPA-SR (CRWMS M&O 2000 [DIRS 153246], Sections 3.10.2.2 through 3.10.2.4)

NOTE: All other models and input parameters are identical to those used in the TSPA-SR. In (b), the 5th percentile curve plots below the lowest value shown on the y-axis.

Figure 2. Same as Figure 3.3.1.2-4 from SSPA Volume 2. Comparison of Probability-Weighted Mean Annual Doses from Igneous Intrusion, Zone 1 Releases Only, Calculated using the TSPA-SR and Revised Distributions for the Number of Packages Damaged in Zone 1



Source: TSPA-SR (CRWMS M&O 2000 [DIRS 153246], Sections 3.10.2.2 through 3.10.2.4)

NOTE: All other models and input parameters are identical to those used in TSPA-SR. In (b), the 5th percentile curve plots below the lowest value shown on the y-axis.

Figure 3. Same as Figure 3.3.1.2-5 from SSPA Volume 2. Comparison of Probability-Weighted Mean Annual Doses from Igneous Intrusion, Zone 2 Releases Only, Calculated Using the TSPA-SR and Revised Distributions for the Number of Packages Damaged in Zone 2

4. REFERENCES

4.1 DOCUMENTS CITED

BSC (Bechtel SAIC Company) 2001. *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. DIRS 154657

BSC (Bechtel SAIC Company) 2001. *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. DIRS 154659

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4.2 CODES, STANDARDS, REGULATIONS, AND PROCEDURES

10 CFR 63. Energy: Disposal of High-level Radioactive Wastes in a Geologic Repository at Yucca Mountain, Nevada. Readily available.