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

JUN 13 2002

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

TRANSMITAL OF INFORMATION ADDRESSING IGNEOUS ACTIVITY (IA) KEY TECHNICAL ISSUE (KTI) AGREEMENT ITEM 2.12

This letter transmits the report entitled *Particulate Inhalation,* which provides information to satisfy the subject KTI agreement. Agreement IA 2.12 is to provide clarifying information on how airborne particulate matter with a mass median aerodynamic diameter less than or equal to 10 micrometers (PM_{10}) and total suspended particulate (TSP) values are used to develop distributions of mass concentrations of airborne particulates for the inhalation exposure pathway.

The enclosed report addresses the difference in behavior between PM_{10} and TSP values under both static and disturbed conditions and describes a change in the process for developing distributions of mass concentrations of airborne particulates for the inhalation exposure pathway within the biosphere model. The new process incorporates a human behavior/microenvironmental model. Exposure to contaminated particles within microenvironments is being calculated as a function of time spent in the environment, concentrations of TSP associated with human behaviors to occur within that microenvironment, and the breathing rate associated with these behaviors. Distributions of airborne particle mass concentrations are being developed based either on measurements of TSP when possible, or by scaling measurements of smaller particles using ratios appropriately based on the dynamic or static conditions of associated behaviors.

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

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

OL&RC:TCG-1266

Enclosure:
Particulate Inhalation

YMP-5

WM5507
WM-11

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
B. J. Garrick, ACNW, Rockville, MD
Richard Major, ACNW, Rockville, MD
S. H. Hanauer, DOE/HQ (RW-2), Las Vegas, NV
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
Harriet Ealey, Esmeralda County, Goldfield, NV
Leonard Fiorenzi, Eureka County, Eureka, NV
Andrew Remus, Inyo County, Independence, CA
Michael King, Inyo County, Edmonds, WA
Mickey Yarbro, 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:
N. K. Stablein, NRC, Rockville, MD
A. C. Campbell, NRC, Rockville, MD
C. W. Reamer, 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
Ram Murthy, DOE/OQA (RW-3), Las Vegas, NV
E. P. Opelski, NQS, Las Vegas, NV
N. H. Williams, BSC, Las Vegas, NV
S. J. Cereghino, BSC, Las Vegas, NV
Donald Beckman, BSC, Las Vegas, NV

cc w/o encl: (continued)
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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PARTICULATE INHALATION

May 2002

Preparation:

J.K. Prince, License Application Project — Date: 5/13/02

Approval:

A.J. Smith, Natural Systems — Date: 13 MAY 02

Reviewed by:

K.R. Rautenstrauch, Environmental Compliance — Date: 5/13/02

ENCLOSURE

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ACRONYMS AND ABBREVIATIONS

BDCF	biosphere dose conversion factors
DOE	U.S. Department of Energy
FY	Fiscal Year
KTI	Key Technical Issue
LA	License Application
NRC	U.S. Nuclear Regulatory Commission
RMEI	reasonably maximally exposed individual
SSPA	Supplemental Science and Performance Assessment
TSP	total suspended particulate
TSPA	Total System Performance Assessment

Particulate Inhalation

This report describes the basis for resolving an agreement item (IA 2.12) associated with the consequences subissue of the igneous activity Key Technical Issue (KTI). The item in question is the U.S. Department of Energy (DOE)-U.S. Nuclear Regulatory Commission (NRC) agreement that DOE provide clarification of how distributions of total suspended particulate (TSP) concentrations are extrapolated from measurements of PM_{10} in calculations of the inhalation exposure pathway within the biosphere model.

The Analysis/Model Report, *Input Parameter Values for External and Inhalation Radiation Exposure Analysis* (ANL-MGR-MD-000001) (CRWMS M&O 2000) discusses the basis used in Total System Performance Assessment for Site Recommendation and supplemental analyses for determining distributions of annual average concentrations of inhaled resuspended particles. Inhalation of resuspended particulate matter is an exposure pathway that contributes to the calculation of biosphere dose conversion factors (BDCF). The BDCFs are used in the Total System Performance Assessment (TSPA) model to estimate potential radiation dose to the reasonably maximally exposed individual (RMEI) based on the concentrations of radionuclides in groundwater and in volcanic ash deposited on the ground.

1. BACKGROUND

DOE originally agreed to document clarification of how PM_{10} measurements have been extrapolated to TSP concentrations in a subsequent revision to the *Input Parameter Values for External and Inhalation Radiation Exposure Analysis* (CRWMS M&O 2000) or equivalent document in Fiscal Year (FY) 02. The successor analysis report will not be available in FY02.

1.1 NRC INITIAL COMMENTS

The NRC is concerned about the potential effect on dose of uncertainties associated with using particle size distributions measured under static conditions to calculate TSP concentrations for all applicable conditions. The concern is generally that measurements of airborne particulate concentrations measured under static conditions may underestimate the concentration of large particles in the air during surface disturbing activities associated with some habits and lifestyles expected for the population in the Amargosa Valley Community.

1.2 DOE INITIAL COMMENTS

A ratio of TSP to PM_{10} was used to develop distributions of inhalation pathway parameters representative of post-volcanic conditions. These parameter values were used in the calculation of BDCFs for the eruptive event, as described in the *FYO1 Supplemental Science and Performance Analyses* (SSPA), Volumes I and II (BSC 2001a, BSC 2001b). DOE agreed to reevaluate and document the methods used to determine total suspended particulates.

1.3 DEFINITION OF TECHNICAL TERMS

Behavior/Microenvironmental Model–A method of estimating potential dose to individuals or populations from exposure to pollutants or contaminants, calculated as a function of time spent

in a series of microenvironments, concentrations of the pollutant within those microenvironments, and the rate of uptake of the pollutant (Duan 1982; Mage 1985; Ryan 1991; EPA 1996, Section 7.5).

PM_{10}–Airborne particulate matter with a mass median aerodynamic diameter less than or equal to 10 micrometers.

Mass Loading–Mass concentration of airborne particulate matter, here expressed in $\mu g/m^3$.

2. APPLICABLE NUCLEAR SAFETY STANDARDS/REQUIREMENTS/GUIDANCE

2.1 APPLICABLE REQUIREMENTS

The KTI agreement item, described below, is the only requirement applicable to document the basis for reevaluation of the ratios used to determine concentrations of TSP. No other regulatory requirements applicable to the documentation of contaminate particle size sensitivity have been identified.

2.2 KTI AGREEMENT

The following KTI agreement statement is based on the Summary Highlights of the NRC/DOE Technical Exchange and Management Meeting on Igneous Activity that occurred on August 29-31, 2000 (Reamer and Williams 2000) as modified in the Summary Highlights of the NRC/DOE Technical Exchange and Management Meeting on Igneous Activity that occurred on June 21-22, 2001 (Crump 2001).

Provide clarifying information on how PM_{10} measurements have been extrapolated to TSP concentrations. This should include consideration of the difference in behavior between PM_{10} and TSP particulates under both static and disturbed conditions.

DOE will provide clarifying information on how PM_{10} measurements have been extrapolated to TSP concentrations. This will include consideration of the difference in behavior between PM_{10} and TSP particulates under both static and disturbed conditions in a subsequent revision to the AMR Input Parameter Values for External and Inhalation Radiation Exposure Analysis (ANL-MGR-MD-000001) or equivalent document.

2.3 STATUS OF AGREEMENT

DOE considers that KTI IA 2.12 is addressed by the approach described by the following information.

3. BASIS FOR REGULATORY COMPLIANCE STATEMENT

The information in the following two sections provides background information (Section 3.1) and a description of the DOE's change in approach for use of TSP and PM_{10} values to develop

distributions of mass concentrations of airborne particulates for the inhalation exposure pathway (Section 3.2).

3.1 BACKGROUND

As described in the SSPA (BSC 2001a, Section 13.3.6), the inhalation pathway component of the biosphere model determines the contribution to BDCFs of inhaling contaminated ash during the ash fall or resuspended contaminated dust or ash after the event. This prior iteration of the inhalation pathway calculations was based on the model used by the GENII-S V.1.4.8.5 computer code. Assumptions and inputs for calculation of inhalation exposure for the GENII-S model (BSC 2001a, Section 13.3.6) are identified in *Input Parameter Values for External and Inhalation Radiation Exposure Analysis* (CRWMS M&O 2000). For the SSPA analysis, distributions of mass loading were based on concentrations of TSP, rather than small particles (i.e., PM_{10}), to account for inhalation of resuspended particles (CRWMS M&O 2000, Section 6.1.1 and 6.1.2).

To determine TSP concentrations for the groundwater release scenario for the SSPA analyses, average annual outdoor distributions of PM_{10} from analogue arid farming communities were multiplied by the ratio of TSP to PM_{10} measured in an undisturbed area in northern Amargosa Valley to develop a distribution of mass loading representative of the reference biosphere farming community (CRWMS M&O 2000, Section 6.1.1). Because no measurements of air quality have been made at the farming area in Amargosa Valley, analogue measurements from arid, rural, agricultural sites elsewhere in the United States were selected. The measurements selected were high compared to those taken at Yucca Mountain and elsewhere in the United States; the average of the measurements was greater than 96 percent of over 10,000 other PM_{10} values reported for the United States between 1994 and 1999, and the maximum was greater than 99.7 percent of the other measurements. The selected PM_{10} measurements were multiplied by a factor of 2.5 to convert to TSP. That factor was based on 1,276 simultaneous measurements of PM_{10} and TSP taken at Yucca Mountain. The resulting mass loading probability function used was normally distributed with an average of 105 $\mu g/m^3$.

For the volcanic release scenario for the SSPA analyses, two distributions of mass loading were developed (CRWMS M&O 2000, Section 6.1.2). The first was intended to be applicable to deep ash deposits and described changes in annual average mass loading through a 10-year transition period. The transition period is characterized by an increased concentration of airborne particulates compared with pre-eruption conditions. This distribution was developed to bound uncertainties in mass loading for extreme ash depths. The second distribution described the relationship between ash depth and transition-period (i.e., 10-year) average mass loads, and was intended to account for uncertainties in mass loading caused by variations over all predicted ash depths. These distributions were based on assumptions about the maximum annual concentration during the first year following a volcanic eruption, changes in that concentration following an eruption, and the ratio of TSP to PM_{10} in resuspended volcanic ash.

The maximum annual average mass loading of small particles (PM_{10}) considered for inhalation was assumed to be no higher than 1,000 $\mu g/m^3$, based on the measurements taken following Mount St. Helens and Montserrat volcanic eruptions and the premise that people will modify their behavior to avoid respiratory distress caused by very high levels of PM_{10} (BSC 2001a,

Section 13.3.6). However, no activity budget analysis considering exposure levels (concentration and time) in different environments was documented in support of the selected values. Similarly, one average value for the ratio of TSP to PM_{10} in resuspended volcanic ash was chosen, although there is evidence that the TSP to PM_{10} ratios depend on the environment and human activity, and that they differ between static and disturbed conditions.

Based on these assumptions, mass loading concentrations experienced at the maximum ash depths were predicted to decrease exponentially, from an annual average of 3,000 $\mu g/m^3$ the first year following an eruption to 105 $\mu g/m^3$ within 10 years. The average value representing this 10-year period is 864 $\mu g/m^3$. This distribution was intended to represent the 10-year period following an eruption that deposits a large amount of ash at the location of the receptor population. The distribution of transition-period mass loading concentrations applicable to all ash depths was predicted to be exponential, with a maximum of 864 $\mu g/m^3$ (the average of the distribution for maximum ash depth). Predicted low values of ash depths are so small (10^{-5} to 10^{-2} cm) that they will cause no detectable change in mass loading; therefore, the minimum value for this distribution was the same as the average mass loading for a farming community (105 $\mu g/m^3$) (BSC 2001a, Section 13.3.6). This distribution was intended for modeling the effects of ash depths and for sampling mass loading values that cover the range of all predicted depths.

3.2 SAFETY/TECHNICAL BASIS FOR THE COMPLIANCE DEMONSTRATION

The DOE is modifying the approach used to calculate inhalation exposure contributions to BDCFs for both the groundwater and volcanic release exposure scenarios. For this new approach a time budget analysis will be conducted that takes into account various activity-related microenvironments and associated airborne particle concentration levels to which the RMEI may be subjected.

Scoping calculations presented at the Igneous Activity technical exchange in June 21-22, 2001 (Crump 2001) on this topic demonstrated that the anticipated exposure levels for the RMEI are controlled by a few outdoor activities that give rise to high concentrations of TSP. As a consequence, the uncertainties in inhalation exposure are governed by variability in the high dust levels and the exposure time for these levels. The corollary of this effect is that the variability and uncertainty in particle concentrations during activities where there are lower levels of dust have little effect on inhalation exposure. Therefore, to correctly represent the overall inhalation exposure and associated uncertainty levels it is essential to appropriately capture the contributions from the environments and activities associated with high airborne particle concentrations and the duration of these activities.

Distributions of airborne particle concentrations are being developed from measurements of TSP when possible, or by scaling measurements of smaller particles using ratios appropriately based on the dynamic or static conditions of associated behaviors. Specifics of the changes in approach for developing the mass loading parameters are discussed below.

A behavior/microenvironmental model is being used to calculate inhalation exposure. Exposure to contaminated particles within microenvironments is being calculated as a function of time spent in the environment, concentrations of TSP associated with behaviors to occur within that

microenvironment, and breathing rate associated with the behaviors. Microenvironments and associated behaviors included in the model are conducting outdoor, dust generating activities; outdoor sedentary activities; indoor activities; indoors asleep; and activities undertaken away from the contaminated environment.

Distributions of particle concentrations within each microenvironment are being developed directly from analog measurements of TSP when appropriate measurements are available. For example, information such as that reported in Buist et al. (1986), Nieuwenhuijsen et al. (1998), and Donham et al. (2000) is being used to develop a distribution of TSP for outdoor, dust-generating activities, and information from Buist et al. (1983, 1986), Thatcher and Layton (1995), and others may be used to develop TSP distributions for indoor conditions.

If sufficient measurements of TSP within a microenvironment are not available, distributions of airborne particulate concentrations will be developed from measurements of smaller particles and ratios of small to total particles. To ensure that differential resuspension and settling of small and large particles are properly accounted for in the distributions, ratios based on static or dynamic conditions are being selected that match the characteristics of dust-disturbing behaviors within each microenvironment. For example, a TSP:PM10 ratio of about 10:1 may be used, if necessary, for outdoor, dust-generating activities, based on measurements of TSP and PM_{10} reported in Nieuwenhuijsen et al. (1998), Donham et al. (2000), Buist et al. (1983, 1986), and others. A ratio of about 3:1 may be used for outdoor static conditions and indoor conditions, based on measurements taken at Yucca Mountain (e.g., Data Tracking Numbers MO98PSDALOG111.000, TM000000000001.079) and corroborating measurements such as those taken by Yano et al. (1990), Chow et al. (1994), Thatcher and Layton (1995), and Brook et al. (1997).

The results of analyses which use the above method and inputs will be available for NRC review in early 2003.

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10 CFR 2. Energy: Rules of Practice for Domestic Licensing Proceedings and Issuance of Orders. Readily available.

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

4.3 DATA CITED

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