January 15, 2003

Joseph D. Ziegler, Acting Assistant Manager
Office of Licensing and Regulatory Compliance
U.S. Department of Energy
Office of Repository Development
P.O. Box 364629
North Las Vegas, NV 89036-8629

SUBJECT: AGREEMENT UNSATURATED AND SATURATED FLOW UNDER ISOTHERMAL CONDITIONS (USFIC).5.09

Dear Mr. Ziegler:

In your letter dated September 26, 2002, the U.S. Department of Energy (DOE) enclosed a response to Agreement USFIC.5.09 that requested additional information on the site scale and regional flow models. Three reports were sent: Calibration of the Site-Scale Saturated Zone Flow Model Analysis/Model Report; *Three-Dimensional Numerical Model of Predevelopment Conditions in the Death Valley Regional Groundwater Flow System, Nevada and California* report; and *The Use of Death Valley Regional Flow System Results in the Site-Scale Flow and Transport Calculations* report. The U.S. Nuclear Regulatory Commission (NRC) staff has reviewed this information, with respect to Agreement USFIC.5.09, and the results of the staff's review are enclosed.

NRC staff has identified some specific issues that need to be elaborated beyond the information provided by DOE. However, this additional information need not be provided to complete this particular agreement. We understand that information addressing the specific issues described in the attached NRC staff review will be provided for other agreements (USFIC.5.01, USFIC. 5.02, and USFIC.5.12). The topics of these comments are groundwater specific discharge, horizontal hydrologic anisotropy, flow fields for future climate states, regional and site-scale fluxes comparison, and model validation of the site-scale saturated zone flow model.

The information to complete the agreement under review has been provided, and Agreement USFIC.5.09 is considered complete. If there are any questions regarding this letter, please contact Bill Dam at 301-415-6710 or by e-mail at wld@nrc.gov.

Sincerely,

/RA/

Janet R. Schlueter, Chief
High-Level Waste Branch
Division of Waste Management
Office of Nuclear Material Safety
and Safeguards

Attachment: NRC Review of DOE Documents Pertaining to Key Technical Issue Agreement USFIC.5.09

cc: See attached distribution list

Letter to J. Ziegler from J. Schlueter dated January 15, 2003

cc:

R. Loux, State of Nevada
S. Frishman, State of Nevada
M. Chu, DOE/Washington, DC
C. Einberg, DOE/Washington, DC
S. Gomberg, DOE/Washington, DC
N. Slater-Thompson, DOE/Washington, DC
C. Newbury, DOE/ORD
W. J. Arthur III, DOE/ORD
R. Dyer, DOE/ORD
J. Ziegler, DOE/ORD
D. Brown, DOE/OCRWM
S. Mellington, DOE/ORD
C. Hanlon, DOE/ORD
T. Gunter, DOE/ORD
K. Hess, BSC
D. Krisha, BSC
S. Cereghino, BSC
N. Williams, BSC
M. Voegele, BSC/SAIC
D. Beckman, BSC/B&A
M. Paslov Thomas, Nevada Legislative Counsel Bureau
W. Briggs, Ross, Dixon & Bell
I. Navis, Clark County, NV
E. von Tiesenhausen, Clark County, NV
A. Kalt, Churchill County, NV
G. McCorkell, Esmeralda County, NV
L. Fiorenzi, Eureka County, NV
A. Johnson, Eureka County, NV
M. Yarbro, Lander County, NV
R. Bahe, Benton Paiute Indian Tribe
R. Massey, Churchill/Lander County, NV
L. Stark, Lincoln County, NV
M. Baughman, Lincoln County, NV
L. Mathius, Mineral County, NV
L. Bradshaw, Nye County, NV
M. Murphy, Nye County, NV
D. Chavez, Nye County, NV
W. Boyle, DOE/ORD
M. Corradini, NWTRB
R. Holden, NCAI
R. Arnold, Pahrump Paiute Tribe
J. Larson, White Pine County
R. Clark, EPA
F. Marcinowski, EPA
R. Anderson, NEI
R. McCullum, NEI
S. Kraft, NEI
J. Kessler, EPRI
D. Duncan, USGS
R. Craig, USGS
W. Booth, Engineering Svcs, LTD
L. Lehman, T-REG, Inc
S. Echols, ECG
B.J. Gerber, NV Congressional Delegation
T. Story, NV Congressional Delegation
J. Reynoldson, NV Congressional Delegation
S. Joya, NV Congressional Delegation
J. Pegues, City of Las Vegas, NV
D. Hammermister, Nye County
A. Remus, Inyo County, CA

C. Anderson, Las Vegas Paiute Tribe

J. Birchim, Yomba Shoshone Tribe

L. Jackson, Timbisha Shoshone Tribe

C. Meyers, Moapa Paiute Indian Tribe

V. Miller, Fort Independence Indian Tribe

A. Bacock, Big Pine Paiute Tribe of the Owens Valley

R. Quintero, Inter-Tribal Council of Nevada (Chairman, Walker River Paiute Tribe)

M. Bengochia, Bishop Paiute Indian Tribe

J. Egan, Egan & Associates, PLLC

J. Leeds, Las Vegas Indian Center

K. Tilges, Shundahai Network

J. Triechel, Nuclear Waste Task Force

T. Kingham, GAO

D. Feehan, GAO

S. Lynch, State of Nevada

K. Kirkeby, NV Congressional Delegation

C. Bradley, Kaibab Band of Southern Paiutes

R. Joseph, Lone Pine Paiute-Shoshone Tribe

L. Tom, Paiute Indian Tribes of Utah

E. Smith, Chemehuevi Indian Tribe

J. Charles, Ely Shoshone Tribe

D. Crawford, Inter-Tribal Council of NV

H. Blackeye, Jr., Duckwater Shoshone Tribe

D. Eddy, Jr. Colorado River Indian Tribes

G. Runkle, DOE, Washington, DC

E. Hiruo, Platts Nuclear Publications

H. Jackson, Public Citizen

M. Smurr, BNFL, Inc.

P. Johnson, Citizen Alert

A. Gil, DOE/ORD

D. Williams, DOE/ORD

I. Zabarte, W. S. N. C.

January 15, 2003

Joseph D. Ziegler, Acting Assistant Manager
Office of Licensing and Regulatory Compliance
U.S. Department of Energy
Office of Repository Development
P.O. Box 364629
North Las Vegas, NV 89036-8629

SUBJECT: AGREEMENT UNSATURATED AND SATURATED FLOW UNDER ISOTHERMAL CONDITIONS (USFIC).5.09

Dear Mr. Ziegler:

In your letter dated September 26, 2002, the U.S. Department of Energy (DOE) enclosed a response to Agreement USFIC.5.09 that requested additional information on the site scale and regional flow models. Three reports were sent: Calibration of the Site-Scale Saturated Zone Flow Model Analysis/Model Report; *Three-Dimensional Numerical Model of Predevelopment Conditions in the Death Valley Regional Groundwater Flow System, Nevada and California* report; and *The Use of Death Valley Regional Flow System Results in the Site-Scale Flow and Transport Calculations* report. The U.S. Nuclear Regulatory Commission (NRC) staff has reviewed this information, with respect to Agreement USFIC.5.09, and the results of the staff's review are enclosed.

NRC staff has identified some specific issues that need to be elaborated beyond the information provided by DOE. However, this additional information need not be provided to complete this particular agreement. We understand that information addressing the specific issues described in the attached NRC staff review will be provided for other agreements (USFIC.5.01, USFIC. 5.02, and USFIC.5.12). The topics of these comments are groundwater specific discharge, horizontal hydrologic anisotropy, flow fields for future climate states, regional and site-scale fluxes comparison, and model validation of the site-scale saturated zone flow model.
The information to complete the agreement under review has been provided, and Agreement USFIC.5.09 is considered complete. If there are any questions regarding this letter, please contact Bill Dam at 301-415-6710 or by e-mail at wld@nrc.gov.

Sincerely,
/RA/
Janet R. Schlueter, Chief
High-Level Waste Branch
Division of Waste Management
Office of Nuclear Material Safety
and Safeguards

Attachment: NRC Review of DOE Documents Pertaining to Key Technical Issue Agreement USFIC.5.09

cc: See attached distribution list

DISTRIBUTION:

File Center	DWMr/f	HLWB r/f	EPAB r/f	Lcampbell	TmcCartin	Wdam
Harlt	Dhiggs	Jwinterle	CENTER	LSN	ACNW	
S:\DWM\HLWB\HDA\Agreement.USFIC.5.09.wpd				ML		

OFC	HLWB		HLWB		HLWB		DWM		HLWB	
NAME	WDam		HArlt		LCampbell		TMcCartin		JSchlueter	
DATE	1/2/03		1/2/03		1/3/03		1/8/03		1/15/03	

NRC Review of DOE Documents Pertaining to
Key Technical Issue Agreement USFIC.5.09

The U.S. Nuclear Regulatory Commission (NRC) goal of issue resolution during this interim pre-licensing period is to assure that the U.S. Department of Energy (DOE) has assembled enough information on a given issue for NRC to accept a licensing application for review. Resolution by the NRC staff during pre-licensing does not prevent anyone from raising any issue for NRC consideration during review of a license application. Just as important, resolution by the NRC staff during pre-licensing does not prejudge what the NRC staff evaluation of that issue will be after its licensing review. Issues are resolved by the NRC staff during pre-licensing when the staff has no further questions of comments about how DOE is addressing an issue. Pertinent new information could raise new questions or comments on a previously resolved issue.

This enclosure addresses agreement Unsaturated and Saturated Flow Under Isothermal Conditions (USFIC).5.09 which was reached between NRC and DOE during a technical exchange and management meeting.[1]

Wording of the Agreement: "Provide additional information in an updated AMR or other document for both the regional and site scale model (for example, grid construction, horizontal and vertical view of the model grid, boundary conditions, input data sets, model output, and the process of model calibration). The updated USGS Regional Groundwater Flow Model is a USGS product, not a Yucca Mountain Site Characterization product. It is anticipated that this document will be available in September 2001. The DOE believes that the requested information is now available in the current version of the *Calibration of the Site-Scale Zone Flow Model* AMR and will be carried forward in future AMR revisions."

NRC Review

Summary of Information Provided by DOE

Three reports were received from DOE to address this agreement:

1. *A Three-Dimensional Numerical Model of Predevelopment Conditions in the Death Valley Regional Groundwater Flow System, Nevada and California*, U.S. Geological Survey Water-Resources Investigations Report 02–4102. This report is a revision to the regional-scale flow model.

2. *Calibration of the Site-Scale Saturated Zone Flow Model,* MDL–NBS–HS–000011, Revision 00, ICN01. This report is an updated Analysis/Model Report documenting the calibration of the site-scale flow model.

3. *The Use of Death Valley Regional Flow System Results in the Site-Scale Flow and Transport Calculations.* This report provides a discussion of how the latest regional-scale model could be used in future site-scale flow model calculations.

[1]Reamer, C.W. "U.S. Nuclear Regulatory Commission/U.S. Department of Energy Technical Exchange and Management Meeting on Unsaturated and Saturated Flow Under Isothermal Conditions (October 31–November 2, 2000)." Letter (November 17, 2000) to S. Brocoum, DOE.

Background

The primary tool used in DOE's Total-System Performance Assessment (TSPA) to describe Saturated Zone (SZ) flow is a numerical model formulated in three dimensions. The three-dimensional SZ flow model has been developed specifically to determine the groundwater velocities (or groundwater travel times) and the flow paths from the potential repository footprint in the saturated zone to the southern boundary of the controlled area. The purpose of this site-scaled saturated zone flow model is to calculate a library of flow fields, essentially maps of groundwater specific discharge, with which SZ transport of radionuclides is calculated. The SZ transport subcomponent takes inputs in the form of radionuclides mass fluxes from the Unsaturated Zone (UZ) transport component and flow fields from the SZ flow subcomponent and produces outputs in the form of radionuclide mass fluxes for the Biosphere component. The *Calibration of the Site-Scale Saturated Zone Flow Model Analysis/Model Report* states, "it is one of the most important models developed in the Yucca Mountain project. This model will be a culmination of much of our knowledge of the SZ flow system".

The results from the USGS report *Three-Dimensional Numerical Model of Predevelopment Conditions in the Death Valley Regional Groundwater Flow System, Nevada and California* were not used in any significant manner to help develop the site-scaled saturated zone flow model, nor did the site-scale model boundary conditions derive from this updated regional model. The lateral boundaries in the site-scale model are derived from regional water levels and head data and used to assign specified head boundaries in the site-scale model. With fixed-head boundary conditions, the flux through the boundary is a function of the permeabilities assigned to the model grid. One example exists of information from the regional model being used as input in the site-scale model. Recharge in the caldera area in the northern part of the site-scale model used the extracted distributed recharge from the SZ regional-scale flow model input file. Discussions in the *Calibration of the Site-Scale Saturated Zone Flow Model Analysis/Model Report* on the sensitivity of estimated parameter values did not indicate recharge as being a sensitive parameter. As such, this review concentrated on evaluating the site-scale saturated-zone flow model due to it's greater importance.

Staff Comments:

NRC staff has identified some specific issues that need to be elaborated beyond the information provided by DOE. However, this additional information need not be provided to complete this particular agreement, but must be provided for those agreements to which the information is best suited. Those agreements for which this information must be provided are listed with the comments below.

1. Groundwater Specific Discharge

The transport time of radionuclides in the saturated zone is important to estimate potential repository performance. Uncertainty and variability of the groundwater flow system are accounted for in the DOE Total-System Performance Assessment through the probability distributions for three hydrologic input parameters: (i) groundwater specific discharge, (ii) effective porosity, and (iii) horizontal anisotropy. In 1997, DOE conducted formal expert elicitations (hereafter referred to as the Saturated Zone Flow and Transport Expert Elicitation) to better understand the state of

knowledge and uncertainties regarding these key input parameters to any Yucca Mountain Total-System Performance Assessment.

In the Total-System Performance Assessment currently supporting the DOE site recommendation (Total-System Performance Assessment–Site Recommendation), specific discharge in the **site-scale saturated zone flow model** is represented using one of three discrete cases: (i) high, (ii) medium, or (iii) low. Only the medium-specific discharge is calculated directly in the three-dimensional saturated zone model. The value for the low-specific discharge case was one-tenth the value for the medium-specific discharge case, and the value for the high-specific discharge case was 10 times that of the medium case. To arrive at these values, four Saturated Zone Flow and Transport Expert Elicitation panel members evaluated the uncertainty in hydraulic conductivity separately and subsequently propagated the results into a range of uncertainty for specific discharge.

For the *Supplemental Science and Performance Analyses* (a document identified by DOE as also supporting the Yucca Mountain site recommendation), rather than relying on the original Saturated Zone Flow and Transport Expert Elicitation estimates, DOE alternatively selected a factor of three above and below the medium-specific discharge case, such that specific discharge for the low-specific case is increased from one-tenth to one-third of the medium value, and is decreased for the high-specific case from 10 times to 3 times the medium value.

During the Saturated Zone Flow and Transport Expert Elicitation, it was recognized that, although the hydraulic gradient beneath Yucca Mountain is subject to uncertainty, its relative contribution to the uncertainty in specific discharge in the area of the C-Wells Complex is small. In general, the experts placed the heaviest reliance for hydraulic conductivity estimates on multiple-hole pumping tests at the C-Wells Complex. In most cases, the experts provided a range of hydraulic conductivity values wider than that obtained from the C-Well Complex studies, reflecting uncertainty in the range of hydraulic conductivities that might characterize the units at other locations within the region. The same data from the multiple-hole pumping tests at the C-Wells Complex are also used by DOE to decrease the range of values for specific discharge, arguing that the new reduced range better represents the data from the C-Wells Complex. Unlike the Saturated Zone Flow and Transport Expert Elicitation, the DOE excludes the uncertainty in the hydraulic conductivity for locations not influenced by pumping tests at the C-Wells Complex. DOE also argued that the scale effects do not cause single-hole tests to underestimate the hydraulic conductivity of unfaulted regions as was previously thought. Therefore, it was concluded that the single-hole hydraulic conductivities reflect the true hydraulic conductivities of the hydrologic units in unfaulted areas and can be used to represent the hydraulic conductivities of the hydrogeologic units in numerical models, provided the effects of faults are accounted for in the same manner. The recent work by Vesselinov, et al. (2001) at the Apache Leap test site is cited as support by DOE for its reduced range of groundwater specific discharge.

DOE is not required to strictly adhere to the recommendations of elicitation it sponsors. Where DOE departs from those recommendations, however, it should document any additional data, analyses, or other information not considered by the expert panel that factored into its departure decision. The Saturated Zone Flow and Transport Expert Elicitation established the uncertainty range to include hydraulic conductivity uncertainty for locations not influenced by pumping tests at the C-Well Complex. No new data or analyses have been presented that

would replace the technical basis for establishing the uncertainty range. The only new information cited (Section 12.3.1.4.1, *Supplemental Science and Performance Analyses*) is a reference to an analysis by Vesselinov, et al. (2001) published in proceedings of a conference on fractured rock in Canada. It is not clear however, that the conclusions reached by Vesselinov, et al. (2001) have gained general acceptance within the broader technical/scientific community. It is also not clear that the conclusions, which were reached for air injection tests in a relatively small area at the Apache Leap site, are applicable for groundwater pumping testing in a much larger scale at Yucca Mountain.

Air permeability tests are used as an additional line of evidence by DOE showing permeability can be enhanced near fault zones. The logic is then extended to argue that the cross-hole tests at the C-Wells Complex indicate higher permeability because faults are included in the relatively large scale of the aquifer tested. It is, therefore, reasoned that, because the DOE saturated zone flow model explicitly includes major faults, the permeability assigned to the hydrostratigraphic layer properties should reflect unfaulted (but still fractured) rock, which is reflected in the smaller-scale results of single-hole tests. Because the range in variability from the population of single-hole tests alone is less than the variability among both single and cross-hole tests, DOE reasons that the range of uncertainty considered for TSPA need only consider the range of permeability from the single-hole tests. This logic may be sound as it applies to data uncertainty, but fails to consider and propagate model uncertainty into the TSPA.

To illustrate this point, it is helpful to look at the plot of permeability data shown in Figure 14 of the *Calibration of the Site-Scale Saturated Zone Flow Model Analysis/Model Report*. Within any of the relatively permeable units, the range of permeability estimates from single-hole tests spans approximately one order of magnitude. This range can be considered data uncertainty, and a factor of three above or below the mean (as DOE proposes for TSPA uncertainty) adequately captures this data uncertainty. In several instances (i.e., for the Prow, Bullfrog, and Tram Tuffs), however, the final calibrated permeabilities for the saturated zone flow model are more than one order of magnitude outside the range of permeabilities measured in the single-hole tests. The difference between the calibrated permeability and the single-hole test permeability can be considered model uncertainty because the reason for the discrepancy is not clear. To account for the additional model uncertainty, a larger range of saturated zone-specific discharges should be considered in the TSPA analyses. The factor of 10 above and below the calibrated model permeability that was previously used would account for the additional model uncertainty.

Results of the “unquantified” uncertainty analysis were documented in the *Supplemental Science and Performance Analyses* for the first time. Consequently, the NRC staff will wait for DOE to choose which of the two alternative methods is to be applied in the TSPA for a license application. If DOE decides to incorporate the SZ Flow and Transport Expert Elicitation in the License Application, but departs from the original panel’s recommendations, DOE will need to provide the technical bases for this change in order to complete the Agreement USFIC.5.02.

2. Horizontal Hydrologic Anisotropy

Agreement USFIC.5.01 states that DOE will provide results of an analysis of horizontal anisotropy for the C wells in the C-wells report. The *Saturated Zone C-Wells Hydraulic and Tracer Testing* report has been released by the DOE and no discussion was presented on horizontal hydrologic anisotropy. In the *Calibration of the Site-Scale Saturated Zone Flow Model Analysis/Model*

Report, the horizontal hydrologic anisotropy was investigated by running the site-scale model with a north-south to east-west permeability ratio of 5:1. The *Technical Update Impact Letter Report* states that pathlines leaving the potential repository would have a more north-south trajectory than the original model and are, thus, likely to encounter less alluvium than the original representation of no horizontal permeability anisotropy. In addition, it states that the 5:1 ratio is likely to be changed once the current analysis of the C-wells data is completed. In order to complete Agreement USFIC.5.01, DOE needs to provide the results of the horizontal hydrologic anisotropy analyses, and will need to carry the results forward to the site-scale saturated zone flow model as appropriate.

3. Flow Fields for Future Climate States

Uncertainty in present-day flow fields is considered only with regards to horizontal hydrologic anisotropy in DOE's site-scale saturated zone flow model. No uncertainty or variability in climate-change time or magnitude is considered. When a climate change does occur, no uncertainty or variability in flow paths or water table elevation is considered. This is especially important considering that present-day flow fields only represent 6% of the entire compliance period. Greater recharge can be expected during the following climate states with an expected rise of the water table. Future conditions of the groundwater flow system at Yucca Mountain are unknown, but estimates from past changes in climate and observation of paleosprings deposits have indicated 80 to 120 m higher water-table elevations. Contaminants traveling near the surface of the saturated zone during future climate states would be in different hydrostrigraphic units at different locations. Transport modeling results could be affected. In addition, present-day flow paths may diverge for the monsoon and glacial-transition climates, and travel times altered. DOE has discussed at various public meetings plans to change the current method for determining flow fields for future climates. These changes need to be documented, or the justification for not making any changes need to be shown, in order to complete the Agreement USFIC.5.02.

4. Regional and Site-Scale Fluxes Comparison

Section 3.4 of *The Use of Death Valley Regional Flow System Results in the Site-Scale Flow and Transport Calculations* report provides a preliminary analysis of the groundwater flux estimates from the 2001 Death Valley Regional Flow System model. The regional flux estimates are compared with the site-scale saturated zone flow model boundary fluxes. The report concludes that the 2001 Death Valley Regional Flow System model produced a flux for the northern boundary that is 161 percent of the flux value calculated from the calibrated site-scale model and a flux for the eastern boundary that is 40 percent of the flux value calculated from the calibrated site-scale model. The southern boundary is 59 percent, and the western boundary is 4170 percent, of the site-scale model. No discussion of this discrepancy is provided. In order to complete the Agreement USFIC.5.02, justification needs to be documented which demonstrates why this rather large discrepancy in flux estimates is acceptable.

5. Model Validation of the Site-Scale Saturated Zone Flow Model

Model validation provides assurance that a model is a correct representation of the process or system for which it is intended. It is often difficult to validate a model because usually only one set of field data is available. The DOE's site-scaled saturated zone flow model can not be considered validated at this time, and in Agreement USFIC.5.12, DOE agrees that site-scale model can only be considered "partially validated". However, the updated *Calibration of the Site-Scale Saturated Zone Flow Model Analysis/Model Report* has not documented any new criteria to demonstrate that this model is validated. The following criteria were given as justification for the validation of the model:

i) The criteria used for comparison on the simulated and inferred fluid pathways was one of visual inspection.
ii) The criteria used to evaluate the saturated zone flow model's ability to support the upward gradient was simply that the gradient near well UE#25p-1 be in the upward direction.
iii) The criteria used fro the permeability was that the calibrated permeability for the middle volcanic units (Bullfrog, Tram, Prow Pass) be within one order of magnitude of the multi-well test results.

These are confidence building measures to test a model for robustness, but not criteria for model validation. A calibrated robust model can still be used to make predictions as long as careful sensitivity analyses are performed and evaluated.

Additional confidence building activities need to be documented in a subsequent update of the *Calibration of the Site-Scale Saturated Zone Flow Model Analysis/Model Report* in order to complete the Agreement USFIC.5.12.

Additional information needs:

None.

Status of Agreement:

The DOE has provided the *Three-Dimensional Numerical Model of Predevelopment Conditions in the Death Valley Regional Groundwater Flow System, Nevada and California* report and the *Calibration of the Site-Scale Saturated Zone Flow Model Analysis/Model Report*. Agreement USFIC.5.09 is considered complete.

References

Vesselinov, V.V., W. Illman, Y. Hyun, S.P. Neuman, V. Di Federico, and D.M. Taratakovsky. "2001, Observation and Analysis of a Pronounced Permeability and Porosity Scale-Effect in Unsaturated Fractured Tuff." *Fractured Rock*. Toronto, Canada: Queens University. 2001.