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U.S. DEPARTMENT OF ENERGY (DOE) RESPONSES TO U.S. NUCLEAR REGULATORY COMMISSION COMMENTS ON STUDY PLANS 8.3.1.2.3.3 (SITE SATURATED ZONE HYDROLOGIC SYSTEM SYNTHESIS AND MODELING); 8.3.1.2.2.8 (FLUID FLOW IN UNSATURATED FRACTURED ROCK); 8.3.1.2.2.9 (SITE UNSATURATED ZONE MODELING AND SYNTHESIS); 8.3.1.5.2.2 (CHARACTERIZATION OF FUTURE REGIONAL HYDROLOGY DUE TO CLIMATE CHANGE); 8.3.1.15.1.2 (LABORATORY THERMAL TESTING, REVISION 2); 8.3.1.15.1.5 (EXCAVATION INVESTIGATIONS, REVISION 1); 8.3.1.8.5.2 (CHARACTERIZATION OF IGNEOUS INTRUSIVE FEATURES, REVISION 1); AND 8.3.1.5.1.6 (CHARACTERIZATION OF FUTURE REGIONAL CLIMATE AND ENVIRONMENTS) (SCPB: 8.3.1.2.3.3, 8.3.1.2.2.8, 8.3.1.2.2.9, 8.3.1.5.2.2, 8.3.1.15.1.2, 8.3.1.15.1.5, 8.3.1.8.5.2, 8.3.1.5.1.6)

Reference: Ltr, Federline to Milner, dtd 10/18/94

Enclosed are DOE's responses to one comment and six questions on Study Plan 8.3.1.2.3.3, five questions on Study Plan 8.3.1.2.2.8, one comment and five questions on Study Plan 8.3.1.2.2.9, one comment and three questions on Study Plan 8.3.1.5.2.2, four questions on Study Plan 8.3.1.15.1.2, and one question on Study Plan 8.3.1.15.1.5. DOE's response to Question 2 on Study Plan 8.3.1.2.2.9 has been prepared to also address a similar question posed on Study Plan 8.3.1.2.2.4 (enclosure 3).

For comments on DOE-approved study plans, the Yucca Mountain Site Characterization Office asks the responsible participant organization and principal investigator to perform a review and assess the impact on the planned study. The assessment includes a determination as to whether or not a revision is warranted. If a revision is warranted, DOE's intention is stated in the responses. If a revision is not warranted, additional information is provided on how the concern is being addressed, why it is inappropriate, or where the concern is being addressed if another study plan is at issue.

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On October 18, 1994, the NRC asked for clarification with respect to a reference for Study Plan 8.3.1.5.1.6 (reference). DOE agrees to delete the reference to World Climate Program that is "in preparation" in the reference section for Study Plan 8.3.1.5.1.6 (Characterization of Future Regional Climate and Environments), in a future revision to the study plan, if a revision is required.

If you have any questions, please contact Thomas W. Bjerstedt at (702) 794-7590.

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Enclosures:
1. DOE Responses to Comments on Study Plan 8.3.1.2.3.3
2. DOE Responses to Comments on Study Plan 8.3.1.2.2.8
3. DOE Responses to Comments on Study Plan 8.3.1.2.2.9
4. DOE Responses to Comments on Study Plan 8.3.1.5.2.2
5. DOE Responses to Comments on Study Plan 8.3.1.15.1.2
6. DOE Responses to Comments on Study Plan 8.3.1.15.1.5
7. DOE Responses to Comments on Study Plan 8.3.1.8.5.2

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U.S. DEPARTMENT OF ENERGY RESPONSE TO
U.S. NUCLEAR REGULATORY COMMISSION COMMENTS ON
STUDY PLAN 8.3.1.2.3.3
(SITE SATURATED ZONE HYDROLOGIC SYSTEM SYNTHESIS AND MODELING)

ENCLOSURE 1

NRC QUESTION 1:

How will laboratory scale models and data be used to estimate model parameters in the corresponding site scale models?

DOE RESPONSE:

The purpose of a laboratory test is to provide measured parameters in a fairly constrained environment which will help increase the probability that the model will represent a larger scale. For example, in the Intact Fracture test, a direct comparison of flux predictions will be made, based on measured water potentials, air permeability, and fracture characteristics including hydraulic aperture and roughness, with known fluxes measured from controlled boundary conditions. As the tested sample becomes larger scale (e.g. Percolation block test, and even larger scale the Air Permeability test), less and less will be known of the matrix and fracture hydraulics, therefore a statistical distribution (becoming less constrained with increase in scale) will result for each of the parameters. The model input values for the hydraulic properties will be based on their corresponding statistical distributions. Methods to choose the appropriate parameter values that give the best match are: (1) use the mean value of the parameter with one output value for each input; (2) use different values chosen from the statistical distribution of the corresponding parameter, and the output will be a distribution of possibilities; and (3) use dimensionless quantities to scale parameters up, or down.

NRC QUESTION 2:

Why have particular modeling strategies been assigned to address particular technical issues?

DOE RESPONSE:

The "issues" are part of developing a conceptual model to understand how flow occurs in partly saturated fractured rock. As stated in Section 3.1.4, page 3.13, last paragraph, the intent is for models to test or examine the issues or concepts. The concepts will be initially examined with a model but the examination is not necessarily limited to a particular model. Several modeling strategies may be used to examine a number of concepts. The codes of the models listed, corresponding to an issue in Table 3.1.1, are best suited as a first iteration and first attempt to examine an issue. Several models may be needed to thoroughly examine one issue, and vice versa. Sensitivity analysis for each issue may help guide the examination toward use of a different model.

NRC QUESTION 3:

Is the method used by Cacas et al for the determination of fracture network hydraulic aperture distributions, applicable for unsaturated flow?

DOE RESPONSE:

The method of Cacas (1990) is a straightforward application of the "black box" approach to model calibration. By providing a sufficient number of sensitive model parameters, she was able to adjust parameters to obtain a calibrated match to observed hydraulic and tracer response. In Cacas' case, the parameters are pipe conductivity and flow path area distributions.

The key to the success of this type of approach is in having enough model parameters to obtain a reasonable match, while having sufficiently few parameters to obtain a relatively unique match. This effort is aided by *in situ* conditions which provide a relatively complex response, since a complex response provides a more unique solution to the inverse problem.

The three parameters being derived for partly saturated flow conditions in Section 3.1.7.2 and the fracture intrinsic conductance distribution (as hydraulic aperture), the storativity distribution, and the transport aperture distribution. All of these are functions of pressure, saturation, and temperature, and also of flow rate for non-laminar flow. In addition, correlations exist between many of these parameters (e.g. between intrinsic conductance "hydraulic aperture" and transport aperture), and between these parameters and other model parameters (such as fracture orientation, set, and size). There is a potentially large number of calibration parameters to fit, and should, therefore, be able to match the observed response.

Beyond matching the observed response, however, the model must consist of physically meaningful parameters, and the calibrated values must be within the reasonable range. The approach which will be adopted for partly saturated flow conditions will therefore be to: (1) calibrate models with as simple as possible physics, and as few as possible parameters; (2) compare model results to measurements; and (3) increase the complexity of structural models, physical processes, and correlations as necessary to match observations.

The cubic law is only one of the possible correlations, which can be utilized between transmissivity, storativity, and transport aperture. As the NRC stated, this relationship has been demonstrated to be inadequate particularly for partly saturated flow and at small apertures. However, a large number of alternative relations are documented in the literature. The complexity of the correlations implemented will be adjusted to the level necessary to explain observed responses.

NRC QUESTION 4:

How can one build confidence in conceptual models if every time a conceptual model is refuted by experimental data, the experiment is redesigned as inappropriate or not sensitive enough to capture the essence of the model?

DOE RESPONSE:

DOE agrees that conceptual models and experiments should be made and designed in concert with one another. The intent of Section 2.1.3 was to present a worst-case scenario and not standard practice of this activity. However, because this project has extremely complicated structural geology, hydrogeology, and hydraulics, developing a conceptual model and testing the model can be a difficult task. The difficulty is compounded by the fact that framework data is often not available or not collected when conceptualization needs to be formulated. This activity has made every effort to do as the NRC suggests; that is, make the models under testing clearly defined. So far we have had to make only minor adjustments to our tests to satisfy testing completeness, not to adjust to a model.

NRC QUESTION 5:

What modeling strategies will be used to address technical issues one, two, and five?

DOE RESPONSE:

The discrepancies between Tables 3.1-1 and 3.2-1 are oversights. There should not have been a difference in strategies. Modeling strategies of Table 3.1-1 are correct.

DOE RESPONSES TO NRC COMMENTS ON STUDY PLAN 8.3.1.2.2.9 (SITE UNSATURATED-ZONE MODELING AND SYNTHESIS)

ENCLOSURE 3