COMPLIANCE DETERMINATION STRATEGY
RRT 3.2.2.12 POTENTIALLY ADVERSE CONDITION: PERCHED WATER BODIES

APPLICABLE REGULATORY REQUIREMENTS:

10 CFR 60.122(c)(23)
10 CFR 60.21(c)(1)(ii)(B)
10 CFR 60.21(c)(1)(ii)(F)

TYPES OF REVIEW:

Acceptance Review (Type 1)
Safety Review (Type 3)
Detailed Safety Review Supported by Analysis (Type 4)
Detailed Safety Review Supported by Independent Tests, Analyses, or Other Investigations (Type 5)

RATIONALE FOR TYPES OF REVIEW:

Acceptance Review (Type 1) Rationale:

This regulatory requirement topic is considered to be license application-related because, as specified in the license application content requirements of 10 CFR 60.21(c) and regulatory guide "Format and Content for the License Application for the High-Level Waste repository (FCRG)", it must be addressed by the U.S. Department of Energy (DOE) in its license application. Therefore, the staff will conduct an Acceptance Review of the license application for this regulatory requirement topic.

Safety Review (Type 3) Rationale:

This regulatory requirement topic is related to containment and waste isolation. It is a requirement for which compliance is necessary to make a safety determination for construction authorization as defined in 10 CFR 60.31(a) (i.e., regulatory requirements in Subparts E, G, H, and I). Therefore, the staff will conduct a Safety Review of the license application to determine compliance with this regulatory requirement topic.

This regulatory requirement topic is a potentially adverse condition (PAC) and is concerned with the potential for existing or future perched water bodies to saturate portions of the underground facility, or to provide a faster flow path from an underground facility located in the unsaturated zone to the accessible environment. There are two concerns associated with this regulatory requirement topic. The first concern is related to the performance of the repository from the stand point of increased radionuclide releases. It is assumed that waste canisters in unsaturated rock will last longer than waste canisters in saturated rock. Perched groundwater is defined as an unconfined saturated zone separated from an underlying saturated zone (water table) by an unsaturated zone (USGS, 1981). Therefore, should perched water bodies form, that would subsequently saturate all or portions of the repository and the waste canister failure rate could increase. In turn, this would result in increased releases of radionuclides to the accessible environment. Alternatively, perched water bodies could form above the repository. This could result in the formation of vertical pathways of saturated rock that conduct water from the overlying perched zone into the repository and down to the water table. Such pathways would also increase the waste canister failure rate by creating saturated conditions around waste canisters intersected by the pathways.

The second concern is relevant to repository performance from the standpoint of increased radionuclide releases. One of the main benefits of a repository located in the unsaturated rock at Yucca Mountain is that slow groundwater velocities through the unsaturated rock matrix should greatly reduce the release of radionuclides from the repository to the accessible environment. However, as water contents in the rock increase, fracture flow could become the predominant mechanism for fluid flow. Fracture flow could then greatly increase groundwater flow velocities from the repository to the water table, and subsequently, to the accessible environment. Should perched water bodies saturate all or portions of the repository, vertical fracture flow pathways may form. This would result in faster flow velocities from the repository to the water table. Alternatively, perched water bodies could form above the repository. This in turn could result in the formation of vertical fracture flow pathways through the repository to the water table. Again, this would result in faster flow velocities from the repository to the water table. In addition, episodic wetting and drying of the repository caused by formation and drainage of perched water bodies could concentrate salt solutions near the waste container and increase the potential for corrosion.

Perched zones may form where there is a sharp contrast in rock permeability. Perched water bodies can be relatively permanent features, but are more likely to be intermittent, forming when the groundwater flux through the unsaturated zone increases and draining when the flux decreases. Therefore, should future climatic conditions cause increased groundwater flux, perched water bodies may be more likely to form.

In the vicinity of the repository, climatic changes may not be the only mechanism controlling groundwater flux. It has been hypothesized that rock drying by repository heat may cause the formation of perched water zones. This process involves the vaporization of water around the repository from waste canister heat. Water vaporized by waste canister heat moves away from the repository (any direction, laterally or vertically); until it reaches a location where the rock temperature is cool enough to cause condensation. If the condensed water encounters low permeability material, rock water saturations may increase and form a perched zone.

Perched zones may also form where alluvial deposits underlie intermittent stream channels. When stream flow saturates the alluvial material, the alluvium may remain saturated long after the stream channel is dry at the surface. Even though these perched zones are located near the surface, water from these perched zones could eventually drain through fractures to the water table below. Perched zones in alluvial material at Yucca Mountain may make it difficult to demonstrate compliance with this regulatory requirement topic because they are more likely to form under present or future climate conditions. Like intermittent stream flow, they have the potential to form, drain, and form again.

Yucca Mountain neutron-access hole data indicates that the thickness of alluvium in channel bottoms ranges from 0 to 11.8 meters (DOE, 1991). Channel bottoms which are underlain by more than 3 meters of alluvial material are primarily located in the eastern part of the site. The topography over the rest of the site is too steep to accumulate much alluvial material. Therefore, the greatest potential for the formation of alluvial perched water bodies is in those areas that overlie (both within and outside) the eastern boundary of the perimeter drift.

Changes in rock permeability over time could also cause perched zones to form. Some conditions that could cause rock permeability changes are: (1) sealing of fractures; (2) geochemical alteration of the rock matrix; (3) intrusion of low permeability vertical or horizontal igneous rock; and (4) structural movements (faulting) that could cause the blockage of lateral flow.

Detailed Safety Review Supported by Analyses (Type 4) Rationale:

The staff considers that there may be a high potential risk of non-compliance with this regulatory requirement topic. The findings made under this requirement may be highly uncertain due to the following Key Technical Uncertainties:

1. Uncertainty in modeling groundwater flow through unsaturated fractured rock caused by the lack of codes tested against field and laboratory data.

2. Uncertainty in identifying which conceptual models adequately represent isothermal and nonisothermal liquid and vapor phase movement of water through unsaturated fractured rock at Yucca Mountain.

3. Uncertainties associated with determining characterization parameters.

These Key Technical Uncertainties require a Type 4 review because there is a high risk of non-compliance with performance objectives 10 CFR 60.112, 60.113(a)(1)(ii)(B), or 60.113(a)(2) for the case of pre-existing perched water zones. This concern of a high risk of non-compliance will necessitate analysis above and beyond that required for a Type 3 Safety Review in order to assure that the uncertainties and potential effects on performance have been minimized to the extent practical.

Key Technical Uncertainty Topic:

Uncertainty in modeling groundwater flow through unsaturated fractured rock caused by the lack of codes tested against field and laboratory data.

Description of Uncertainty:

Compliance demonstration of this regulatory requirement topic will require quantitative prediction of the potential for future perched water bodies to form or to provide a faster flow path from an underground facility to the accessible environment. Computational models will be the primary methods used to estimate the likelihood of perched water bodies forming in the unsaturated zone. This is because the conditions that trigger fracture flow and the rate of flow when it does occur have a big effect on the potential for perched water bodies to form.

There are currently three approaches to modeling unsaturated fractured rock flow. These approaches are the equivalent continuum model of Peters and Klavetter (Klavetter, 1986), the dual continuum approach, and models which directly incorporate discrete fractures. However, these approaches were theoretically developed and need to be tested against laboratory or field experiments to build confidence. There are not yet any experimental methods currently available which would allow the composite continuum model to be verified.

Performance Objectives at Risk :

10 CFR 60.112, 60.113(a)(1)(ii)(B), or 60.113(a)(2).

Explanation of Nature of Risk:

Modeling of groundwater flow through unsaturated fractured rock will play an important role in demonstrating compliance with this potentially adverse condition. Failure to demonstrate compliance with this potentially adverse condition would make it harder to demonstrate compliance with the overall system performance objective. This is because the formation of perched water could result in increased waste canister failure rates and faster radionuclide transport to the accessible environment. However, a determination of compliance or noncompliance may not be possible if it cannot be established that the unsaturated groundwater flow models are adequate representations.

Description of Resolution Difficulty:

This difficulty should be resolved by testing unsaturated fractured rock flow codes against physical experiments. Should it be determined that existing codes are inadequate, new codes may have to be developed and tested.

Key Technical Uncertainty Topic:

Uncertainty in identifying which conceptual models adequately represent isothermal and nonisothermal liquid and vapor phase movement of water through unsaturated fractured rock at Yucca Mountain.

Description of Uncertainty:

To address this regulatory requirement topic, predictions will be made through the use of computational models which are based on conceptual and mathematical models of the dominant physical-chemical mechanisms. These conceptual models will also be used to decide what site characterization parameters should be obtained, to design the characterization program, to interpret data from the tests, to interpret the distribution of site characterization parameters, to assign model inputs, and to interpret model results. Any uncertainty in the appropriateness of the conceptual models will, therefore, reduce the reliability of model predictions as well as the adequacy of that portion of the site characterization program designed to address this regulatory requirement.

Performance Objectives at Risk :

10 CFR 60.112, 60.113(a)(1)(ii)(B), or 60.113(a)(2).

Explanation of Nature of Risk:

Failure to demonstrate compliance with this regulatory requirement would make it more difficult to demonstrate compliance with the overall system performance objective. The formation of perched water could result in increased waste canister failure rates and faster radionuclide transport to the accessible environment, a result that may affect the overall performance of the repository. Conceptual models will be used in all phases of demonstrating compliance with this regulatory requirement topic. Not knowing which conceptual models are appropriate representations of the site will increase the uncertainty associated with demonstrating compliance with this regulatory requirement topic.

<u>Description of Resolution Difficulty:</u>

Uncertainty in the conceptual models of isothermal and non-isothermal liquid and vapor phase transport of water in unsaturated rock may be reduced by performing appropriate laboratory and field experiments for model validation. In addition, resolution of this difficulty will probably require the collection of model specific characterization data, and the elicitation of the opinions of experts.

<u>Key Technical Uncertainty Topic:</u>

Uncertainties associated with determining characterization parameters.

<u>Description of Uncertainty</u>:

To address this regulatory requirement topic, predictions will be made which are based on the values of numerous characterization parameters. These parameters will contain uncertainties due to experimental and measurement error, errors in test interpretation, conceptual model errors, and errors from incorrectly defined parameter ranges and distributions.

<u>Performance Objectives at Risk</u>:

10 CFR 60.112, 60.113(a)(1)(ii)(B), or 60.113(a)(2).

<u>Explanation of Nature of Risk</u>:

Characterization parameters will be used in all phases of demonstrating compliance with this regulatory requirement topic. The inability to determine appropriate site parameters will increase the uncertainty of being able to demonstrate compliance with this regulatory requirement topic. Failure to demonstrate compliance with this regulatory requirement topic would make it more difficult to demonstrate compliance with the overall system performance objective. This is because the formation of perched water could result in increased waste canister failure rates and faster radionuclide transport to the accessible environment.

<u>Description of Resolution Difficulty</u>:

Resolution of this difficulty will probably require prototype testing, the collection of site characterization data, and appropriate use of expert opinion.

Detailed Safety Review Supported by Independent Tests, Analyses, or Other Investigations (Type 5) Rationale:

The staff considers that there may be the highest potential risk of non-compliance with this regulatory requirement topic because, for the Yucca Mountain site, the following Key Technical Uncertainties are the most difficult to resolve. They are:

1. Uncertainty caused by the lack of experimental confirmation of the basic physical concepts of groundwater flow through unsaturated fractured rock.

2. Uncertainty caused by the lack of established data collection and interpretation techniques required to model groundwater flow through unsaturated fractured rock.

3. Uncertainty in modeling the formation of perched zones by thermally driven flow.

Non-compliance with this Regulatory requirement topic could result in non-compliance with performance objectives 10 CFR 60.112, 60.113 (a)(1)(ii)(B), or 60.113(a)(2) because of increased waste canister failure rates and faster radionuclide transport to the accessible environment. Therefore, there might be a high residual risk of non-compliance with this performance objective, because very little can be done to reduce the risk, or compensate for the risk using, for example, favorable site conditions or engineered features.

Some of the following key technical uncertainties could be considered subsets of Type 4 Key Technical Uncertainties dealing with the general topics of hypotheses and parameter uncertainty. These key technical uncertainties are identified here, because of their high potential for non-compliance and because they would require laboratory or field investigations to reduce the uncertainty.

<u>Key Technical Uncertainty Topic:</u>

Experimental confirmation of the basic physical concepts of groundwater flow through unsaturated fractured rock is needed.

<u>Description of Uncertainty</u>:

To address this regulatory requirement topic, predictions will use models of groundwater flow through unsaturated fractured rock. The conditions that trigger fracture flow and the rate of flow when it occurs, has a significant effect on the potential for perched water bodies to form.

All models are simplifications of basic governing physical laws of the process being modeled. If the basic concepts are incorrect, computational models based on these concepts may be inaccurate. To date, few experiments have been identified that rigorously test the concepts of unsaturated flow in fractured rock. This is supported by the Site Characterization Plan for Yucca Mountain, which states that "Theoretical models for liquid-water flow in single fractures have been developed (Montazer and Harold, 1985; Wang and Narasimhan, 1985) but have not been field and laboratory tested" (US DOE, 1988, p. 3-171). Therefore, models of groundwater flow through unsaturated rock may be inaccurate.

<u>Performance Objectives at Risk</u>:

10 CFR 60.112, 60.113 (a)(1)(ii)(B), or 60.113(a)(2).

<u>Explanation of Nature of Risk</u>:

Modeling of groundwater flow through unsaturated fractured rock will play an important role in demonstrating compliance with this regulatory requirement topic. However, a determination of compliance or noncompliance may not be possible if it cannot be established that the models are based on sound physical concepts. Failure to demonstrate compliance with this potentially adverse condition would make it harder to demonstrate compliance with the overall system performance objectives. This is because the formation of perched water could result in increased waste canister failure rates and faster radionuclide transport to the accessible environment.

Description of Resolution Difficulty:

Resolution of this Key Technical Uncertainty would require the use of physical experiments to confirm the basic physical concepts of groundwater flow through unsaturated fractured rock.

Key Technical Uncertainty Topic:

The development of new data collection and interpretation techniques are required for codes which model groundwater flow through unsaturated fractured rock.

Description of Uncertainty:

Modeling groundwater flow through unsaturated fractured rock will be an important part of addressing this regulatory requirement topic. However, if appropriate methods to collect data for unsaturated fractured rock flow codes do not exist, it will not be possible to adequately characterize the site or to calibrate the models used to predict groundwater flow through the unsaturated zone.

Currently, unsaturated fractured rock flow models designed for use at Yucca Mountain require either individual or bulk fracture properties. Furthermore, these codes require data on how the hydraulic properties of the fractures change as a function of changing moisture contents. However, appropriate measurement techniques for collecting unsaturated fracture hydraulic property data have neither been developed nor identified. Particular computer codes may use unique parameters which require different data collection or parameter estimation techniques. For example, dual continuum approaches to modeling unsaturated groundwater flow consist of one continuum for the porous matrix and one continuum for the fractures. The continua are connected by a fracture matrix transfer term that simulates flow between the fracture and the matrix. However, the fracture-matrix transfer term is a parameter that cannot be measured in the field or laboratory at this time.

Performance Objectives at Risk:

10 CFR 60.112, 60.113 (a)(1)(ii)(B), or 60.113(a)(2).

Explanation of Nature of Risk:

The modeling of groundwater movement through unsaturated fractured rock will be an important aspect of demonstrating compliance with this regulatory requirement topic. If appropriate methods are not available to collect data for unsaturated fractured rock flow codes, it will be difficult to adequately characterize the site or to model groundwater flow through the unsaturated zone. Failure to demonstrate compliance with this regulatory requirement topic would thus make it more difficult to demonstrate compliance with the overall system performance objective. This is because the formation of perched water could result in increased waste canister failure rates and faster radionuclide transport to the accessible environment.

Description of Resolution Difficulty:

Resolution of this Key Technical Uncertainty would require research to develop the appropriate testing techniques to collect the data and/or derive the code input parameters to model groundwater flow through unsaturated fractured rock.

Key Technical Uncertainty Topic:

Uncertainty in modeling the formation of perched zones by thermally driven flow.

Description of Uncertainty:

It has been hypothesized that rock drying by heat generated by radioactive decay of the spent fuel may cause the formation of perched water zones. In this process water near waste canisters is vaporized and driven away from the repository (any direction, laterally or vertically), until it reaches an area where the rock temperature is cool enough to cause condensation. If the condensed water encounters a low permeability material, rock water saturations may increase and form a perched zone. Modeling nonisothermal liquid and vapor phase movement of water through unsaturated fractured rock is still an area of active research and therefore standard approaches have not been established.

Performance Objectives at Risk:

This key technical uncertainty may lead to unwarranted conclusions concerning compliance with performance objectives 10 CFR 60.112, 60.113 (a)(1)(ii)(B).

Explanation of Nature of Risk:

Modeling of nonisothermal water movement as liquid or vapor through unsaturated fractured rock flow may play an important role in demonstrating compliance with this regulatory requirement topic. However, if it cannot be established that the models are adequate or inadequate representations, a determination of compliance or noncompliance would be very difficult. Failure to demonstrate compliance with this regulatory requirement topic would make it more difficult to demonstrate compliance with the overall system performance objective. This is because the formation of perched water could result in increased waste canister failure rates and faster radionuclide transport to the accessible environment.

Description of Resolution Difficulty:

Resolution of this difficulty could require research into the concepts and physics of modeling the flow of water as vapor and liquid under nonisothermal conditions in fractured rock. Resolution may also require (1) the development of field data collection techniques and (2) the design and testing of codes to do this type of modeling.

Summary:

It has been assumed that numerical models of groundwater flow through unsaturated fractured rock will be used to reach a determination regarding compliance with this regulatory requirement topic. However, it is also possible that formal expert elicitation may also be used by the DOE instead of numerical modeling to make this determination. If expert opinion elicitation is used, the rationale for this strategy would change. There may no longer be a need to test computer codes as discussed in the Type 4 rationale, or to develop new data collection and interpretation techniques to determine model parameters (Type 5), or for improved approaches to model the formation of perched zones by heat-driven two phase flow (Type 5). However, the Key Technical Uncertainty arising from the need to identify adequate conceptual models of isothermal and nonisothermal liquid and vapor movement of water through fractured rock (Type 4) would still be relevant. Also the Key Technical Uncertainty that identifies the need to determine characterization parameters would still be relevant (Type 4). In addition, the Key Technical Uncertainty concerned with the need for experimental confirmation of basic physical concepts of groundwater flow through unsaturated fractured rock would still be relevant. Unless these uncertainties are reduced, predictions made through the use of formal expert elicitation methods would not be credible. Therefore, there would still be a need for a Detailed Safety Review Supported by Analyses (Type 4) and a Detailed Safety Review Supported by Independent Tests, Analyses, or Other Investigations (Type 5).

REVIEW STRATEGY:

Acceptance Review:

In conducting the Acceptance Review of the potentially adverse condition concerning the formation of perched water bodies, the reviewer should determine if the content of the license application and its references is complete in technical breadth and depth with respect to the information requested by Section 3.2.2.12 of regulatory guide "Format and Content of the License Application for the High-Level Waste Repository (FCRG)". The reviewer should determine that all appropriate information necessary for the staff to review this potentially adverse condition is presented such that the assessments required by the Review Plans associated with total system and subsystem performance objectives can be performed.

The information presented in the license application should be presented in such a way that the assumptions, data, and logic lead to a clear demonstration of compliance with the requirements. The reviewer should not be required to conduct extensive analyses or literature searches. The reviewer should also determine whether an appropriate range of alternative interpretations and models has been described.

Finally, the reviewer shall determine if the DOE has either resolved all the NRC staff objections that apply to the applicable regulatory requirements or provided all the information requested in Section 1.6.2 of the FCRG, for unresolved objections. The reviewer will evaluate the effects of any unresolved objections, both individually and in combination with others, on: (1) the reviewer's ability to conduct a meaningful and timely review; and (2) the Commission's ability to make a decision regarding construction authorization within the three-year statutory period.

Safety Review:

This regulatory requirement is limited to consideration of perched water bodies. It is not concerned with the potential for a rise in the water table. This potentially adverse condition will be covered under review plans 3.2.2.9 (Potentially Adverse Conditions: Changes in Hydrologic Conditions) and 3.2.2.11 (Potentially Adverse Conditions: Potential for the Water Table to Rise and Inundate a Repository) of the license application and its attendant plan sections. The first step in the NRC review will be to evaluate the DOE analysis to determine if it has been correctly assumed that numerical models of groundwater flow through unsaturated fractured rock will be used to reach a determination regarding compliance with this regulatory requirement.

In conducting the Safety Review, the reviewer will, at a minimum, determine the adequacy of data and analyses presented in the license application to support the DOE's demonstrations regarding 10 CFR 60.122(c). Specifically, DOE will need to: (1) provide information to determine whether and to what degree the PAC is present; (2) provide information to determine to what degree evidence of this PAC is present, but undetected; (3) assure the sufficiency of the lateral and vertical extent of the data collection; and (4) evaluate the information presented in support of Items (1) and (2), with assumptions and analysis methods that adequately describe the presence (or absence) of the PAC and ranges of relevant parameters. The specific aspects of the license application on which the reviewer will focus are described below, and the Acceptance Criteria are identified in Section 3.0 of this review plan.

In conducting the aforementioned evaluations, the reviewer should determine that the DOE uses: (1) analyses that are sensitive to evidence of the PAC; and (2) assumptions which are not likely to underestimate its effects. Examples of the specific review activities that will be required of the staff include confirmation that DOE has fully considered the climatological, structural, and hydrologic data that are appropriate for the aforementioned analysis. Analyses and models that will be used to predict future conditions and changes in the geologic setting shall be supported by using an appropriate combination of such methods as field tests, laboratory tests, monitoring data, and natural analog studies. The reviewer will rely on staff expertise and independently acquired knowledge, information, and data such as the results of research activities being conducted by the NRC's Office of Nuclear Regulatory Research, in addition to that provided by DOE in its license application. The reviewer must have acquired a body of knowledge regarding these and other critical considerations in anticipation of conducting the review to assure that the DOE's program is sufficient in scope and depth to provide the information necessary for resolution of the concerns.

It should be noted that the information contained in Section 3.2.2.12 of the license application will be reviewed in parallel with the Safety Reviews of the information described in Table 3.2.2.12-1. If it is determined that the conclusions reached by the Safety Reviews described in Table 3.2.2.12-1 are inadequate to support the Safety Review called for in this section of the license application, additional information will be requested from the DOE as part of this review.

Detailed Safety Review Supported by Analysis:

A Detailed Safety Review supported by analysis will be needed to evaluate the following Key Technical Uncertainties concerning: (1) laboratory or field tested computer codes that are needed to model groundwater flow through unsaturated fractured rock, (2) uncertainty in identifying which conceptual models adequately represent isothermal and nonisothermal groundwater and vapor movement through unsaturated fractured rock at Yucca Mountain, and (3) uncertainties associated with deriving characterization parameters. This will ensure that the DOE has adequately demonstrated Items (1)-(4) listed in the section on "Safety Review."

When reviewing these Key Technical Uncertainties, the reviewer should determine if the approaches used to model fracture flow through unsaturated fractured rock have been adequately tested using laboratory and field data. Furthermore, the reviewer should review the site data to determine that the conceptual models adequately represent isothermal and nonisothermal liquid and vapor phase water movement through fractured rock at Yucca Mountain and that adequate test procedures and parameter values and their associated distributions have been developed. Finally, the reviewer should use the conclusions and tools successfully developed in addressing these uncertainties to conduct the Safety Review.

Detailed Safety Review Supported by Independent Tests, Analyses, or Investigations:

A Detailed Safety Review, independent modeling and the use of the results of staff investigations will be needed for the following Key Technical Uncertainties concerning: (1) the need for experimental confirmation of the basic physical concepts of groundwater flow through unsaturated fractured rock; (2) the development of new data collection and interpretation techniques required for codes which model groundwater flow through unsaturated fractured rock; and (3) uncertainty in modeling the formation of perched zones by repository heat. This will ensure that the DOE has adequately demonstrated Items (1)-(4) listed in the section on "Safety Review."

When reviewing against these Key Technical Uncertainties the reviewer should confirm that physical experiments have been successfully performed that confirm the basic physical concepts of groundwater flow through unsaturated fractured rock so that the conditions under which fracture flow occurs are adequately known. In addition, the reviewer should confirm that adequate research has been completed to develop appropriate testing techniques to collect the data and/or derive the code input parameters to model the flow of water on liquid and vapor through fractured rock. The reviewer should also confirm that research into the concepts and physics of modeling vapor and liquid phase water flow under nonisothermal conditions in fractured rock has developed adequate field data collection techniques and appropriate codes. Finally, the reviewer should use the conclusions and tools successfully developed in addressing these uncertainties to conduct the Safety Review.

Contributing Analysts:

NRC: W. Ford

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Date of Analysis: 06/02/93

RATIONALE FOR REVIEW STRATEGY:

To support the Detailed Safety Review Supported by Analyses (Type 4) the staff should use methods developed by DOE or other parties that have been reviewed and found acceptable by NRC staff. To support the Detailed Safety Review Supported by Independent Tests, Analyses, or Other Investigations (Type 5) the staff should use methods developed by DOE or other parties that have been reviewed and found acceptable by NRC staff, as well as, methods and results from their own investigations. Specifically NRC research should be conducted to assure that the staff has a good understanding of the conditions under which fracture flow can occur in the unsaturated zone, the staff can determine if appropriate characterization techniques have been used to characterize unsaturated fractured rock hydrology, and that the staff has a good understanding of which models are adequate representations of nonisothermal multiphase flow through unsaturated fractured rock.

APPLICABLE REGULATORY REQUIREMENTS FOR EACH TYPE OF REVIEW:

Type 1:
10 CFR 60.21(c)(1)(ii)(B)
10 CFR 60.21(c)(1)(ii)(F)

<u>Type 3</u>:
10 CFR 60.122(c)(23)

<u>Type 4</u>:
10 CFR 60.122(c)(23)

<u>Type 5</u>:
10 CFR 60.122(c)(23)

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U. S. Nuclear Regulatory Commission, 1989 "NRC Staff Site Characterization Analysis of the Department of Energy's Site Characterization Plan, Yucca Mountain Site, Nevada," Office of Nuclear Material Safety and Safeguards, NUREG-1347.

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Wang, J.S.Y., and Narasimhan, T.N., 1985, "Hydrologic Mechanisms Governing Fluid Flow in Partially Saturated, Fractured, Porous Tuff at Yucca Mountain," SAND84-7202, Sandia National Laboratories, Albuquerque, NM.

TABLE 3.2.2.12-1 Sections of the License Application Which May Provide Input To The Potentially Adverse Condition: Perched Water Bodies

License Application Section	*Section Title*
Geologic Setting	
3.1.1	Geologic System
3.1.2	Hydrologic System
3.1.3	Geochemical System
3.1.4	Climatological and Meteorological Systems
3.1.5	Integrated Natural System Response to the Maximum Design Thermal Loading
Siting Criteria (Favorable Conditions)	
3.2.1.1	Favorable Conditions: Nature and Rates of Physical Processes
3.2.2.1	Favorable Conditions: Nature and Rate of Hydrogeologic Processes
3.2.2.4	Favorable Conditions: Unsaturated Zone Hydrogeologic Conditions
3.2.3.1	Favorable Conditions: Nature and Rates of Geochemical Processes
(Potentially Adverse Conditions)	
3.2.1.5	Potentially Adverse Conditions: Structural Deformation
3.2.1.6	Potentially Adverse Conditions: Historic Earthquakes
3.2.1.7	Potentially Adverse Conditions: Correlation of Earthquakes with Tectonic Processes
3.2.2.5	Potentially Adverse Conditions: Flooding
3.2.2.7	Potentially Adverse Conditions: Surface Water Impoundments
3.2.2.8	Potentially Adverse Conditions: Structural Deformation and Groundwater
3.2.2.9	Potentially Adverse Conditions: Changes in Hydrologic Conditions
3.2.2.11	Potentially Adverse Conditions: Potential for the Water Table to Rise and Inundate a Repository
3.2.4.2	Potentially Adverse Condition: Changes to Hydrologic System from Climate