COMPLIANCE DETERMINATION STRATEGY
RRT 3.2.3.4 POTENTIALLY ADVERSE CONDITION: GROUNDWATER CONDITIONS AND THE ENGINEERED BARRIER SYSTEM

APPLICABLE REGULATORY REQUIREMENTS:

10 CFR 60.122(c)(7)
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 considered to be 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). It concerns: (1) the effect of groundwater conditions on the effectiveness and performance of the engineered barrier system to contain radionuclides and prevent their release to the geologic medium surrounding the repository, and (2) the characterization of the Yucca Mountain site as it relates to groundwater conditions in the host rock that could enhance the solubility of waste constituents and/or the chemical reactivity of the engineered barrier system. Therefore, the staff will conduct a Safety Review of the license application to determine compliance with this regulatory requirement.

The engineered barrier system, as defined in 10 CFR Part 60, consists of the waste packages and the underground facility. The evolution of the chemical environment (i.e., groundwater and host rock chemistry) will have a considerable impact on the integrity of the engineered barrier system and its ability to prevent the release of radionuclides to the geologic medium surrounding the repository (Apted, 1989; Stephens et al., 1986; O'Connell et al., 1989; Sadeghi et al., 1990; O'Connell, 1990; Davis et al., 1990; Glassley, 1986; Walton et al., 1993). The groundwater and host-rock system at Yucca Mountain is fairly complex, and the conditions of this system are expected to evolve and change with time. These conditions

are expected to influence, directly and indirectly, the waste package failure mechanisms. One of the two major aspects affecting the useful lifetime of waste packages is the continuous degradation of the container material due to exposure to the geochemical, thermal, and radiation environment in the repository (Walton et al., 1993); the other aspect being waste package failure due to overload conditions caused by seismic effects. This CDS, however, does not consider seismic effects.

Given that the waste package is considered in some conceptual designs the principal engineered barrier at Yucca Mountain (Jardine, 1990), the demonstration of compliance with the performance objectives in 10 CFR 60.112 and 10 CFR 60.113(a)(1) requires a thorough understanding of the chemical and physical environment in the vicinity of the waste package. The estimation of corrosion rates for waste package containers will necessitate knowledge of the physical and chemical environment surrounding the packages (e.g., see Apted, 1989; Stephens et al., 1986; Davis et al., 1990; Manaktala and Interrante et al, 1990; Walton et al., 1993). Furthermore, the chemical and physical environment, in particular, the conditions of the groundwater will play a major role in: (1) the dissolution of radionuclides from the waste matrix; (2) the alteration of the matrix due to chemical reactions; and (3) the solubility and retardation of radionuclides within the engineered barrier system. The combination of high temperatures, high ionic strengths, changes in the groundwater's redox potential, and changes in pH could result in: (1) enhanced and faster degradation of waste packages; (2) decreased evaporation (thus increased presence of groundwater in the vicinity of the waste packages); and/or (3) enhanced dissolution of the waste matrix, among other effects (Stephens et al., 1986; Walton et al., 1993). As a result, changes, both temporally and spatially, in the groundwater conditions can contribute to diminishing the ability of the engineered barrier system to: (1) effectively isolate the waste from groundwater and (2) prevent radionuclide releases to the geologic medium surrounding the repository.

Determination of the existence of this Potentially Adverse Condition (PAC) will depend on two factors: (1) the mechanism by which, and the amount of, groundwater that can penetrate the engineered barrier system and come in contact with the waste package and (2) the evolution of the groundwater conditions near the waste packages during the regulatory period. Predicting both of these factors presents tremendous challenges. First, a number of plausible conceptual models exist and are being considered for the infiltration of groundwater into the repository (e.g., O'Connell, 1990; Sadeghi et al., 1990). Second, the successful prediction of waste package performance will require detailed knowledge regarding the chemical and physical environment around the waste package (Glassley, 1986). However, one key problem is the prediction of the evolution of this environment (O'Connell et al., 1989; Walton et al., 1993).

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

The staff considers that there may be a high potential risk of noncompliance with the applicable regulatory requirements because, for the Yucca Mountain site, there are the following Key Technical Uncertainties.

These Key Technical Uncertainties are considered to require a Type 4 review because there is a high risk of noncompliance with the performance objectives specified below. This concern of high risk of noncompliance 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.

A basic assumption is still required to justify a Type 4 or higher review. That is that groundwater chemistry conditions at Yucca Mountain are capable of having such a broad range of values that the use

of an easily justified bounding value is not practical. Otherwise, an easily justified bounding value would not require the in-depth reviews specified in this CDS.

Key Technical Uncertainty Topic: Understanding the Effect of Groundwater Conditions on Mode and Rate of Waste Package Corrosion

Description of Uncertainty: There is consensus within the technical community that groundwater conditions will have a major impact on the corrosion of waste packages. For example, Stahl and Miller (1986) present and discuss the potential corrosion modes enhanced by the geochemical conditions of the groundwater. Stephens et al. (1986) state that knowledge of the environmental conditions (e.g., temperature, chemical composition, redox potential, pH, etc.) will be needed in order to determine waste package corrosion. Similar arguments are offered by Glassley (1986), Apted (1989), Davis et al. (1990), O'Connell et al. (1989), and Walton et al. (1993), to name a few.

While there is little controversy regarding the need to know the groundwater conditions to estimate waste package corrosion, there seems to be considerable uncertainty regarding the specific corrosion modes affected or enhanced. The belief is that the presence of groundwater will enhance localized corrosion (pitting corrosion, crevice corrosion, and stress corrosion cracking) as opposed to uniform corrosion (Apted, 1989; Stahl and Miller, 1986; Stephens et al., 1986; O'Connell, 1990; Walton et al., 1993). However, the manner in which the changing groundwater conditions will affect corrosion over the length of the regulatory period is largely unknown. If a corrosion model is based on average or typical groundwater chemistry for the repository region, there is the risk that the effect of specific and potentially significant corrosion modes could be underestimated or overlooked (Staehle et al. 1993). Therefore, there is uncertainty associated with the effect that groundwater conditions will have on waste-package corrosion.

Performance Objective at Risk: 10 CFR 60.113(a)(1)(ii)(A).

Explanation of Risk: It is generally understood that the presence of groundwater within the repository will enhance waste package corrosion either by accelerating known corrosion modes or perhaps by introducing new ones. In addition, the interactions between the waste packages and the groundwater could change the latter's conditions in a manner that will augment its corrosive action (e.g., salt formation and dissolution, radiolitic effects, etc.). Such synergistic effects could lead to more severely adverse effects than if considered individually (Manaktala and Interrante, 1990).

Therefore, elucidating the effects that groundwater conditions could have on waste package corrosion will not be straightforward. Consequently, it could be difficult to demonstrate reasonable assurance that the ability of the waste package to withstand corrosion has not been compromised.

Description of Resolution Difficulty: Obtaining a sufficiently comprehensive data base from which to elucidate the effect of groundwater conditions on waste package corrosion is imperative. While the DOE's Site Characterization Program for Yucca Mountain should generate data to address this PAC, it is difficult to ascertain a priori whether or not the data will cover the range of conditions representative of the repository environment over the length of the regulatory period. One area of particular concern is the ability of the DOE to extrapolate short-term data to represent conditions far into the future and to demonstrate the validity and reliability of such extrapolation (CDS 5.2). Finally, it is difficult to envisage that the DOE will be able to consider all the complex interactions among the processes and phenomena as well as the synergistic effects expected to govern the manner in which the groundwater conditions will

impact waste package corrosion. Hence, it will be necessary for NRC to independently evaluate this key technical uncertainty through research and/or technical assistance on groundwater effects on mode and rate of corrosion.

Key Technical Uncertainty Topic: Understanding/Predicting the effect of Groundwater Conditions on Dissolution of Waste Form

Description of Uncertainty: Groundwater conditions, particularly chemical conditions, will play a major role on the dissolution of the waste form for both HLW and spent fuel (Stephens et al., 1986; Apted, 1989; Sadeghi et al., 1990; O'Connell, 1990). Releases of radionuclides from the waste form will be limited by the dissolution rate. However, the specific mechanisms by which groundwater conditions affect waste-form dissolution seem to be highly speculative (Apted, 1989).

For HLW, the chemistry of the groundwater in contact with the waste form is believed to be governed by the dissolution and/or precipitation of various primary and secondary solid phases that can form during the course of reaction (Apted, 1989). Some calculations suggest that formation of alteration phases in the waste matrix change the groundwater chemistry sufficiently to, in turn, change the solubility limits of the radionuclides (Apted, 1989).

For spent fuel, the situation seems to be more complex because spent fuel is composed of several different sources of radionuclides (e.g., UO_2 matrix, the cladding, the gap region between the fuel matrix and the cladding, and the grain boundaries), and each of these sources contains a different radionuclide inventory. Also, each of these sources of radionuclides is believed to react differently with groundwater (Apted et al., 1989). For some sources, the radionuclides will be highly soluble and the waste-form dissolution rate will be inventory-limited (e.g., cesium, iodine, and technetium), while for others, the radionuclides will not be readily soluble and the dissolution rate will be solubility-limited (e.g., actinides) (Apted, 1989; Sadeghi et al., 1990). In either case, the groundwater conditions will largely govern the dissolution rate. Two different dissolution mechanisms have been postulated for the UO_2 matrix (Apted, 1989): (1) solubility limit for reducing conditions and (2) kinetic-controlled dissolution for oxidizing conditions as a result of the electrochemical nature of the dissolution reactions that largely dictated by the chemical composition of the groundwater.

Results of laboratory studies suggest that reaction of the waste matrix with groundwater will result in an alteration of the matrix, and that such alteration will impact the rate of dissolution of the radionuclides (Sadeghi et al., 1990; O'Connell, 1990). For example, conversion of UO_2 in spent fuel to U_3O_8 due to reactions with groundwater can lead to the increased release of both actinides and fission products (Sadeghi et al., 1990). The reaction rates are highly dependent on the redox potential of the groundwater (Shoesmith and Sunder, 1992).

Performance Objectives at Risk: 10 CFR 60.112 and 10 CFR 60.113(a)(1)(ii)(B).

Explanation of Risk: Failure to understand the effect of groundwater conditions on the dissolution of the waste form can lead to gross underestimation of the release rates of radionuclides. The likelihood of gross underestimation could cast serious doubts on the validity and reliability of the predicted release rates. This could be particularly problematic insofar as compliance with 10 CFR 60.113(a)(1)(ii)(B) is concerned because, as the system evolves in time, groundwater conditions will change and the release rate from the engineered barrier system will change as well. Thus, release estimates based on either pre-waste-emplacement conditions or early post-closure conditions may not be representative at longer times.

Demonstration of reasonable assurance that the aforementioned performance objectives can be met may be in jeopardy.

Description of Resolution Difficulty: The dissolution of the waste form and, hence, the release rate of radionuclides, by and large, will depend on the solubility limits. These limits are typically estimated using geochemical codes such as EQ3/EQ6. However, there are problems associated with estimating the solubilities due to: (1) limitations in the data base; (2) uncertainties in interpreting measured steady-state concentrations of radionuclides; and (3) uncertainties in the formation of precipitates that govern the concentration of solutes (Sadeghi et al., 1990). Comparisons between predicted solubilities and experimental values have cast doubt on the validity of the calculated values (Sadeghi et al., 1990), thus rendering the estimation of release rates unreliable. Most data for solubility limits are obtained at ~25°C. The usefulness of these data is questionable when temperatures near the waste package are expected to be well above 100°C (e.g., ~300°C at time of closure and ~100°C at ~300 years) (Interrante et al., 1990).

The DOE's Site Characterization Program is expected to generate data to address the effect of groundwater conditions on the dissolution of the waste form. However, it is difficult to ascertain, a priori, whether or not the data will cover the range of conditions representative of the repository environment over the length of the regulatory period. Finally, it is difficult to envisage that the DOE will be able to consider all the interactions among the attendant processes and phenomena as well as the synergistic effects expected to influence the manner in which groundwater conditions will impact the dissolution of the waste form.

Therefore, it will be necessary for NRC to independently evaluate this key technical uncertainty through research and/or technical assistance in the area of waste form dissolution.

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 noncompliance with this Regulatory Requirement topic because, for the Yucca Mountain site, the following Key Technical Uncertainty is most difficult to resolve. Therefore, there might be a high residual risk of noncompliance with the performance objectives specified below because very little can be done to reduce the risk, or compensate for the risk using, for example, favorable site conditions or engineered features.

The potential for high residual risk of noncompliance in light of this Key Technical Uncertainty is sufficient that a detailed safety review supported by independent tests, analyses, or other investigations is justified.

Key Technical Uncertainty Topic: Prediction of the Evolution of Groundwater Conditions near and within the Engineered Barrier System

Description of the Uncertainty: There is a suite of phenomena and processes that can directly and indirectly affect and cause changes to the chemical and physical conditions of the groundwater at Yucca Mountain. For example, radiolysis, temperature, and chemical reactions with the host rock and the waste form could alter the concentration of chemical and ionic species, the pH, and the redox potential (Eh) of the groundwater. Also, the cyclic evaporation/condensation of groundwater in the vicinity of the waste package could affect the concentration of salts in that region (Interrante et al., 1990; Walton et al., 1993).

For example, one concept is that the concentration of salts, such as Na_2CO_3, NaCl, $NaNO_3$, and $CaCl_2$, might increase to the point where the vapor pressure of water in the film of liquid on the wall of the waste package is lowered sufficiently to reduce the rate of evaporation of the water (Walton et al., 1993). As the rate of evaporation of water decreases, more water is available to come in contact with the waste package, thus increasing the likelihood of corrosion. However, the manner in which these phenomena and processes interact, and the temporal and spatial scales over which they occur are not known (Davis et al., 1990). Furthermore, establishing the scale at which the phenomena and processes take place relative to the scale of the engineered barrier system as well as the spatial variability is not readily possible (Glassley, 1986). Prediction of the evolution of the geochemical environment, in general, and the groundwater conditions, in particular, in the vicinity of the waste package would be difficult (O'Connell et al., 1989; Walton et al., 1993).

Performance Objectives at Risk: 10 CFR 60.112, 10 CFR 60.113(a)(1)

Explanation of Risk: The waste package is considered to be the principal engineered barrier in at least one conceptual design at Yucca Mountain (Jardine, 1990). If groundwater comes in contact with the waste packages -- a scenario that cannot be discarded -- corrosion is expected to be the major failure mechanism of the waste package container (Apted, 1989; Stephens et al., 1986; Davis et al., 1990; Walton et al., 1993). The chemical composition and ionic speciation of the constituents dissolved in the groundwater could have significant effect on the latter's corrosive action (Glassley, 1986). The specific mode of corrosion (e.g., uniform corrosion, pitting corrosion, crevice corrosion, stress corrosion cracking, or hydrogen embrittlement) will depend to a large extent on the geochemistry of the groundwater (Stahl and Miller, 1986). In particular, localized corrosion (pitting corrosion, crevice corrosion, stress corrosion cracking) is expected to be difficult to predict (Walton et al., 1993), yet is a subject of great concern (O'Connell et al., 1989).

Once the waste package container has failed, the groundwater conditions will largely dictate the rate of dissolution of the waste form and the sorption of radionuclides in other components of the engineered barrier system separating the waste form from the geologic medium surrounding the repository (Apted, 1989; Stephens et al., 1986; Davis et al., 1990; Sadeghi et al., 1990). Most of the radionuclides expected to be contained in HLW and spent fuel are solubility-limited, and there are large uncertainties associated with the prediction of the radionuclide-specific solubility limits (Sadeghi et al., 1990). Uncertainties in the solubility limits will directly introduce uncertainties in the dissolution rates from the waste form and the transport rates of radionuclides. In addition, redox conditions tend to promote oxidation which causes waste-form alterations, and these changes, in turn, lead to increased release of fission products and actinides from the waste form into the groundwater (Sadeghi et al., 1990).

Thus, the evolution of the groundwater chemical and physical conditions could lead to accelerated failure of the waste package container, increased release of radionuclides from the waste form and the engineered facility, and enhanced transport of the radionuclides from the repository to the accessible environment. Therefore, this Key Technical Uncertainty could put in jeopardy the demonstration of compliance with the aforementioned performance objectives.

Description of Resolution Difficulty: One of the most difficult problems that needs resolution is the prediction of the chemical behavior of the waste form/container/groundwater/host rock system within the temporally and spatially varying thermal/radiation/hydrologic environment within the engineered barrier system (O'Connell et al., 1989). These processes are highly coupled (Davis et al., 1990) and there is the potential for significant synergistic effects (Manaktala and Interrante, 1990). If groundwater conditions

are instrumental in enhancing the failure of a specific number of waste packages, it is believed that, due to thermal and radiation effects, changes in the groundwater conditions will be accelerated, which in turn will enhance the failure of other waste packages. Prediction of these synergistic effects seems to be in its infancy (O'Connell et al., 1989). Finally, groundwater conditions impact HLW packages differently than they impact spent fuel (Apted et al., 1989).

Therefore, NRC will have to independently evaluate this key technical uncertainty through research and/or technical assistance in the evolution of groundwater conditions near and within the engineered barrier system.

REVIEW STRATEGY:

Acceptance Review:

In conducting the acceptance review of the potentially adverse condition concerning the effect of groundwater on the performance of the engineered barrier system, the reviewer should determine if the information presented in the license application and its references for determining compliance with the applicable regulatory requirements is complete in technical breadth and depth as identified in the Format and Content for the License Application for the High-Level Waste Repository. The reviewer should determine that all appropriate information necessary for the staff to review the effect of groundwater conditions on the performance of the engineered barrier system is presented such that the assessments required by the regulatory requirements associated with total system and subsystem performance objectives or other technical criteria can be performed.

The reviewer should determine whether the information presented in the license application is presented in such a manner that the assumptions, data, and logic leading to a demonstration of compliance with the requirement are clear and do not require the reviewer to conduct extensive analyses or literature searches. The reviewer should also determine that controversial information and appropriate alternative interpretations and models have been adequately described and considered.

Finally, the reviewer should determine if the U.S. Department of Energy (DOE) has either resolved all the NRC staff objections that apply to this requirement or provided all the information requested in Section 1.6.2 of the FCRG, for unresolved objections. The reviewer should evaluate the effects of any unresolved objections, both individually and in combinations 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 topic is limited to consideration of the effects of groundwater conditions on the performance of the engineered barrier system. It is not concerned with other PACs arising from geochemical processes and not-reducing groundwater conditions, these subjects are covered in other sections of the license application review plan. Furthermore, this review plan is not concerned with other phenomena and processes that could affect the performance of the engineered barrier system such as thermomechanical effects, criticality, and characteristics of waste package failure modes because these topics are covered in Chapter 5.0 of the license application review plan.

In conducting the Safety Review the reviewer should determine if the information presented in the license application and its references is an acceptable demonstration of compliance with the applicable regulatory requirements. At a minimum, the reviewer should determine the adequacy of the data and analyses presented in the license application to support DOE's demonstrations regarding 10 CFR 60.122(c)(7). Specifically, DOE will need to: (1) provide information to determine whether or not, and to what degree, the PAC exists; (2) provide information to determine to what degree the PAC is present, but undetected; (3) assure the sufficiency of the lateral and vertical extent of the data collection; and (4) evaluate information presented under items (1) and (2) above, with assumptions and analysis methods that adequately describe the presence of the PAC and the ranges of relevant parameters. For purposes of determining the presence of the PAC, investigations should include examination of the groundwater conditions in the host rock, including chemical composition, high ionic strength, and ranges of pH and Eh, that could increase the solubility and/or chemical reactivity of the different components of the engineered barrier system.

In conducting the aforementioned evaluations, the reviewer should determine that DOE uses: (1) analyses that are sensitive to evidence of the Potentially Adverse Condition and (2) assumptions which are not likely to underestimate the effects. In general, the reviewer will assess the adequacy of DOE's investigations for evidence of the potentially adverse condition, within the controlled area, as necessary, in the manner outlined in Section 60.21(c)(1)(ii)(B). The specific aspects of the license application on which the reviewer will focus are discussed below and the Acceptance Criteria will be identified in Section 3.0 of this Review Plan.

In order to conduct an effective review, 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 the DOE in its license application. For example, research activities aimed at elucidating the different waste package corrosion mechanisms, the penetration of groundwater into the repository, the evolution of the environment within the repository and near the boundary of the repository and the surrounding geologic medium, and the effect of that environment on waste form dissolution and alteration should be considered. The reviewer should focus on additional data which can refine knowledge of the PAC, and should perform, as necessary, additional analyses to confirm the resolution capabilities of the methodologies. It is incumbent upon the reviewer to have acquired a body of knowledge regarding these and other critical considerations in anticipation of conducting the review to assure that the DOE's research activities on the evolution of the groundwater conditions and their effect on the performance of the engineered barrier system are sufficient in scope and depth to provide the information necessary to resolve the concerns.

After reviewing the groundwater chemistry conditions and ranges of conditions, keeping in mind changes over the repository performance period, the reviewer should determine whether the use of an easily justified bounding value is practical. If not, the reviewer should continue with the additional compliance reviews discussed below. If so, the reviewer should reduce the scope of the review appropriately.

Detailed Safety Review Supported by Analysis:

A Detailed Safety Review and analysis will be needed for evaluation of the Key Technical Uncertainties regarding: (1) the effect of the groundwater conditions on the mode and rate of waste package corrosion and (2) to ensure that DOE has adequately demonstrated Items (1) - (3), listed in the previous section (see Safety Review, second paragraph). Activities performed in this Detailed Safety Review will help to assure

that DOE has adequately addressed and resolved this Key Technical Uncertainty so that it does not lead to noncompliance with the performance objectives in 10 CFR 60.112 and 10 CFR 60.113(a)(1).

For the Key Technical Uncertainty concerning the effect of the groundwater conditions on the mode and rate of waste package corrosion, the staff's Detailed Safety Review will also include (1) review and analysis of the effect of the changing groundwater conditions on the different modes of waste package corrosion and (2) sensitivity analysis to identify key assumptions and parameters that could lead to noncompliance with these performance objectives.

For the Key Technical Uncertainty regarding the effect of the groundwater conditions on the dissolution and alteration through chemical reactions of the waste form, the staff's Detailed Safety Review with specific review activities that will be required include: (1) review and analysis of the effect of the changing groundwater conditions on the dissolution and possible alteration of the waste form and (2) sensitivity analysis to identify key assumptions and parameters that could lead to noncompliance with these performance objectives.

For both Key Technical Uncertainties, it may also be appropriate to assess the quality and traceability of data and information by also utilizing staff with expertise in review of quality assurance programs.

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

A Detailed Safety Review, independent modeling, and use of the results of staff investigations, will be needed for the Key Technical Uncertainty associated with predicting the evolution of the groundwater conditions near and within the engineered barrier system. This will ensure that DOE has adequately demonstrated Items (1) - (3) listed in the section on Safety Review (see section 2.2.1 second paragraph).

For the Key Technical Uncertainty concerning the evolution of the groundwater conditions, the staff's Detailed Review will be supported by analyses and other research activities that consider the interactions between the thermal, hydrological, chemical and radiolitic processes that could affect the host rock and/or the groundwater in such a manner as to considerably alter the latter's conditions. Sensitivity analyses should be conducted to identify key relevant assumptions and parameters. Of particular interest should be the range of conditions covered in any analyses or experiments conducted to establish that the PAC is not present, and the representativeness of those conditions of the long-term evolution of the repository system (e.g., extrapolation of short-term data). In conducting this review, the staff must evaluate, for example, not only experimental results presented by DOE, but also the development and application of conceptual models, mathematical models, and associated computer codes for the estimation of radionuclide solubilities and the simulation of coupled thermal/hydrological/chemical processes. The data base used to generate input for the analyses performed by the DOE should be subjected to careful scrutiny to evaluate its completeness. The staff should also evaluate the use of, and reliance on, subjective expert judgments to supplement data.

The detailed safety review of the Key technical Uncertainty should be supported by the results of staff investigations that may include the development of appropriate models to conduct uncertainty analyses and sensitivity analyses as well as the conduct of experiments to investigate the effect of couple processes on the groundwater conditions. It is anticipated that these results will allow the staff to gain important insights regarding the presence of this PAC and the assumptions and parameters that dominate it.

For the Key Technical Uncertainty, it may also be appropriate to assess the quality and traceability of data and information by also utilizing staff with expertise in review of quality assurance programs.

RATIONALE FOR REVIEW STRATEGY:

In view of the complexity of the Key Technical Uncertainties addressed above, it is appropriate that the NRC conduct the independent activities described in order to: (1) develop the licensing tools and technical basis necessary to judge the adequacy of DOE's license application; (2) assure sufficient independent understanding of the basic physical and chemical processes taking place at the geologic repository; and (3) maintain an independent but limited confirmatory research capability under NRC auspices.

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APPLICABLE REGULATORY REQUIREMENTS FOR EACH TYPE OF REVIEW:

Type 1:

10 CFR 60.122(c)(7)
10 CFR 60.21(c)(1)(ii)(B)
10 CFR 60.21(c)(1)(ii)(F)

Type 3:

10 CFR 60.122(c)(7)

Type 4:

10 CFR 60.122(c)(7)

Type 5:

10 CFR 60.122(c)(7)

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