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UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

DEC 12 1988

MEMORANDUM TO: HLWM Staff

FROM: Robert E. Browning, Director
Division of High-Level Waste Management

SUBJECT: ISSUANCE OF SCP REVIEW PLAN

Enclosed is the SCP Review Plan (SCPRP) for your use in reviewing DOE's SCP. The SCPRP was developed by revising the CDSCP review plans to incorporate both the lessons learned from the staff's CDSCP review and the required activities and products associated with reviewing the statutory SCP and preparing the Site Characterization Analysis (SCA). Staff interviews were conducted to obtain suggested revisions based on the staff's CDSCP reviews experience. The interviews provided many useful ideas for improving the plan and review process. All the suggestions were carefully considered and many were incorporated into the SCPRP. Following the interviews, a summary of the SCPRP was prepared to facilitate the development and management review of many key aspects of the SCPRP. The summary also provided the staff with early information about the SCPRP to assist them in their planning. Finally, the SCPRP can be revised if concerns are identified during the review that require correction.

If the SCP is released and delivered to NRC by DOE in late December, as is presently planned, a memo notifying the staff of the start of review will be issued early in the week of January 3, 1989, after receipt of the SCP copies and references. This memo will also contain the specific review schedule. Finally, an extended team meeting will be held on January 4, 1989, to answer questions about the SCPRP.

Robert E. Browning, Director
Division of High-Level Waste Management

Enclosure: As stated

cc: H. Thompson, Jr.
R. Bernero

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REVIEW PLAN FOR NRC STAFF REVIEW OF DOE'S SITE CHARACTERIZATION PLAN

DECEMBER 12, 1988

DIVISION OF HIGH-LEVEL WASTE MANAGEMENT
OFFICE OF NUCLEAR MATERIAL SAFETY AND SAFEGUARDS
U.S. NUCLEAR REGULATORY COMMISSION
WASHINGTON, DC 20555

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INTRODUCTION

The Nuclear Waste Policy Act of 1982 (NWPA) established a comprehensive national program under the direction of the Department of Energy (DOE) to construct geologic repositories for the permanent disposal of high-level nuclear waste. In accord with the requirements of the NWPA, DOE published Siting Guidelines on December 12, 1984 and on December 20, 1984 issued Draft Environmental Assessments (DEAs) for nine sites considered potentially suitable for location of the first repository. On May 28, 1986 DOE nominated five sites as potential repository locations suitable for characterization and published Final Environmental Assessments (FEAs) for those sites. On that same date the Secretary of Energy recommended three of those sites--Yucca Mountain, Nevada; Hanford, Washington; and Deaf Smith County, Texas--for site characterization, and the President approved that recommendation. Since that date, DOE has been in the site characterization state of its high-level waste (HLW) program. That stage, which in reality extends until such time as the Nuclear Regulatory Commission (NRC) may grant DOE a construction authorization, is when DOE is to conduct activities intended to collect the information necessary to support a License Application for a geologic repository. As the first major activity of that stage, DOE began developing site characterization plans (SCPs) for the three sites which describe the programs and investigations by which DOE is to obtain the needed information. The DOE announced in August 1987 that consultation draft SCPs (CDSCPs) would be issued for all three sites for the purpose of consultation with NRC, States, and Indian Tribes. Subsequently, however, the Nuclear Waste Policy Amendments Act (NWPAA) of 1987 focused all work on the Yucca Mountain Site in Nevada. Therefore, in accordance with NWPAA, on January 8, 1988, DOE issued a CDSCP only for the Yucca Mountain site. After issuance NRC prepared its concerns with the CDSCP in the form of draft point papers which were given to DOE in March 1988 and were the focus of workshops with DOE. Following the workshops the staff prepared final point papers and provided these to DOE in May 1988. DOE prepared the statutory SCP for the Yucca Mountain site with consideration to comments received and workshops discussions.

Under the NWPA, NRC has certain specific responsibilities--for example, concurrence on the DOE Siting Guidelines, which the NRC did on June 22, 1984--as well as a general consultative role during the pre-licensing portions of the DOE HLW program. The NRC's pre-licensing role is essentially to provide early identification and participation in resolution of concerns which could become potential licensing issues. This will help assure that DOE has recognized and attempted to resolve all such concerns so that they can submit a complete and high quality License Application. The NRC staff has been active in this role by means of various interactions with DOE staff including data reviews, technical meetings, quality assurance (QA) audits, site visits, and informal technical information exchanges. The NRC staff, although not required to do so by the NWPA, also reviewed and commented on the DEAs and FEAs as another way to identify potential licensing issues.

The SCP review is an important step in the pre-licensing consultation between NRC and DOE. However, despite its importance, it is but the first step in an extensive sequence of reviews that the NRC staff will perform throughout site characterization. There will be ample opportunities to comment upon the SCP progress reports that DOE is required to issue every six months after release of the SCP, as well as upon the study plans as they become available. (See Section 2.3 for the relationship of study plans to level of detail required in the SCP.) Furthermore, many other types of DOE reports and documents (e.g., study reports, topical reports, issue resolution reports, design drawings and specifications) will become available for review and comment.

The SCP Review Plan (SCPRP) provides the NRC staff with guidance for conducting the SCP review and preparing the Site Characterization Analysis (SCA). The SCPRP supersedes the March 1983 SCP Review Plan and the December 1988 draft Technical Review Plan (TRP) and Administrative Plan and Procedures (APP) used by the staff to review the Yucca Mountain site CDSCP. The SCPRP was prepared by combining both the TRP and APP into one plan with two parts. The TRP and APP were also revised based on the staff's CDSCP review experience. Few changes were made to the TRP in preparing Part A of the SCPRP. However, major revisions to the APP were necessary in preparing Part B of the SCPRP. These changes reflect the different activities and products needed to conduct an SCP review and prepare an SCA as required by 10 CFR Part 60.

The primary purpose of the Technical Review Plan in Part A is to provide technical guidance to the NRC staff and contractors for conducting the SCP review. Part A gives the purpose, objectives, and scope of the SCP review. It also provides both general and detailed review guides, each of which contain 1) background and review approach, 2) criteria, 3) applicable sections of 10 CFR Part 60, and 4) key documents for consideration during the review (e.g. Regulatory Guide 4.17, Generic Technical Positions, NRC/DOE meeting agreements, NRC EA comments, and NRC letters providing guidance or concerns). Part A will help assure the quality of the review. Developing Part A was also a mechanism for the staff to prepare for the review by 1) developing and documenting the collective staff views on important review considerations and 2) identifying the existing NRC documents which contain guidance or concerns relevant to the SCP, and focusing their use in the review. Finally, Part A documents the staff's review process so that DOE, States, Indian Tribes, and other interested parties can obtain an understanding of the staff review. Such documentation also may be used for future reference during the licensing process.

Part B contains the Work Plan and Procedures (WPP) which provides the administrative guidance needed to manage the review. The WPP identifies 1) review activities including state interactions, 2) general schedule of review activities, 3) organization and responsibilities, 4) resource allocations 5) description and preparation of products, 6) internal QA requirements, 7) records management, 8) open item tracking, and 9) review procedures.

PART A: TECHNICAL REVIEW PLAN

1.0 PURPOSE, OBJECTIVES AND SCOPE

1.1 Purpose

The NRC has a two-fold purpose for reviewing the SCP: (1) to fulfill its mandated responsibilities under NWPA and 10 CFR Part 60 to review the SCP and to provide comments to DOE (in the Site Characterization Analysis (SCA); (2) to continue the process since the passage of the NWPA of pre-license application review and consultation for early identification and resolution of potential licensing issues. The SCP contains DOE's identification of issues related to regulatory requirements and their plans for resolving them. The NRC staff's independent evaluation of DOE's program to resolve these issues will give guidance to DOE that is intended to result in DOE submitting a complete and high quality License Application. This in turn will help assure that the staff will be able to make a decision regarding construction authorization within the three-year statutory licensing time period.

The objections, comments, or questions and related recommendations that the staff presents in the SCA will be entered in an open item tracking system such that progress toward closure of those items with DOE can be readily followed. The SCA is intended to be the vehicle by which the NRC staff's concerns over the past several years (at the SCP level of detail), along with new concerns raised in the SCP review, are brought together into one trackable set of open items that DOE can respond to and resolve with the NRC staff during site characterization. Open items have been identified in the above manner so as to make maximum use of the staff resources by designing a process (SCP review) and product (the SCA) which will give DOE guidance on the site characterization program and give the staff the means to identify and track the resolution of concerns. (See Section 7.0 of the Work Plan in Part B for additional information).

1.2 Objectives

To accomplish the purpose of the NRC staff review of the SCP, the following specific objectives must be achieved:

Acceptance Review

1. Determine whether the SCP content and level of detail is substantively consistent with 10 CFR Part 60.17 requirements as well as NRC guidance and NRC-DOE agreements.

2. Determine whether DOE has substantively responded to the NRC CDSCP concerns.

3. Determine whether the review should continue and document the results of the acceptance review in a letter to DOE.

Technical Review

1. Identify concerns with DOE's program (consistent with the more general level of detail presented in the SCP) related to DOE obtaining the information needed for a complete and high quality License Application.

2. Identify concerns with any of the DOE program activities as presented in the SCP and references that might have significant, adverse effects on the waste isolation capabilities of the site.

3. Identify concerns with any of the DOE program activities as presented in the SCP and references that might have significant, irreversible, and unmitigatable effects on the ability to adequately characterize the site.

4. Determine whether any planned use of radioactive materials in testing is necessary for site characterization.

5. Review DOE's resolution of NRC's CDSCP concerns to either identify those that are adequately resolved (CDSCP open item closed) or identify those that are partially or completely unresolved (SCP open items).

6. Document the staffs concerns in a Site Characterization Analysis (SCA), including any comments by the Director of the Office of Nuclear Material Safety and Safeguards (NMSS) as required by 10 CFR Section 60.18(d).

1.3 Scope

The general and specific scope of the review for sections of the SCP are given below. Sections not within the scope below should not be reviewed.

1.3.1 General Scope

1. Only SCP sections and references related to 10 CFR Part 60 are in scope (see specific scope below).

2. SCP sections related to 10 CFR Part 960 (DOE's Siting Guidelines) are out of scope accept where they relate to 10 CFR Part 60.

3. Study plans and procedures other than the five related to Exploratory Shaft construction and testing during construction are out of the scope for the SCP review.

1.3.2 Specific Scope

1. Issues, information needs, and performance allocation

   - All SCP sections related to issues, information needs, and performance allocation including those related to CDSCP open items.

2. Site investigations and design and performance assessment activities

   - All SCP sections and references related to potential adverse effects on waste isolation, including those related to resolution of CDSCP objections.

   - All SCP sections and references related to potential irreversible and unmitigatable effects on site characterization, including those related to resolution of CDSCP objections.

   - All SCP sections and references related to use of radioactive materials in site characterization.

   - SCP sections and references related to resolution of CDSCP objections, comments, and questions.

   - SCP sections and references related to the key technical topics for the Yucca Mountain site given in the detailed review guides.

3. Exploratory Shaft Facility

   - All SCP sections and references including those related to CDSCP open items. Note that ESF related study plans and ES design acceptability analysis will also be reviewed concurrently with the SCP to support DOE's schedule for starting ESF construction.

4. Milestones and Schedules

   - All of SCP section 8.5.

   - SCP sections in 8.3 with milestone and schedule information related to the key technical topics for the Yucca Mountain site as defined in the detailed review guides.

5. Quality Assurance

   - All section 8.6 and references including those related to resolving the CDSCP open items.

6. Decontamination and Decommissioning

   - All of section 8.7 is out of scope since this information, which is related to site characterization facilities and activities, is not in NRC's area of licensing jurisdiction.

7. Site and design descriptions (Chapters 1-7) should be reviewed to support items 1-5 above.

1.3.3 Discussion

Aside from the need to address issues related to Part 60, the DOE is also required to address issues related to the DOE Siting Guidelines, 10 CFR Part 960 (hereafter Part 960). The adequacy of DOE's plans relative to Part 960 issues is not within the purview of the NRC and thus will not be evaluated by the staff. However, much of the material in sections of the SCP concerning such issues may relate as well to Part 60 issues; insofar as it does so, the staff will review that material in light of the Part 60 issues.

The NWPA and Part 60.17 require that the SCP contain information concerning the DOE's plans for mitigating any environmental impacts caused by site characterization activities in the event that a particular site is found unsuitable for a repository. In accord with Part 60, the staff will examine the SCP (section 8.7) to that information is in fact present as part of its acceptance review of the whole document. No additional review will occur since this material is not relevant to potential licensing issues or Part 60 concerns. Decontamination and decommissioning of site characterization facilities are not in themselves matters of concern to the staff inasmuch as the NRC only has licensing jurisdiction over repository facilities and not site characterization facilities or activities.

The DOE uses a hierarchy of terms to reflect the structure of their site characterization plans from the broadest down to the finest level of detail. Program used in a generic sense (e.g., site program) is the broadest level of detail; program used in a specific sense (e.g., geology program) is not as broad and encompasses two or more related investigations. An investigation is comprised of one study or a set of related studies, where study refers to a combination of tests and analyses (assessments of test results) which deal with a single or several related objectives within a given area. A test or analysis consists of a combination of procedures (detailed step-by-step processes specifying how a test will be conducted) that produces information about some parameter through one or more experiments.

As agreed by the NRC and the DOE in the SCP Level of Detail Meeting May 7-8, 1986, and documented in the meeting summary, the SCP will contain an extensive discussion of the programs and investigations to be conducted during site characterization, a summary discussion of studies, and a listing of tests, analyses, and technical procedures. Inasmuch as the SCP is intended to lay out the overall logic behind and structure for the DOE plans for characterizing the site rather than the details of how the needed information is to be obtained, extensive discussion of the site characterization programs down to the investigation level should be adequate for the NRC staff to evaluate whether there are serious concerns with the direction of the DOE plans. After the overall review, NRC will review DOE's proposed testing and analyses given in the study plans and technical procedures prior to the start of the activities described in the study plans.

2.0 ACCEPTANCE REVIEW

2.1 Background and Approach

NRC has provided guidance to DOE, on the format and content of the Site Characterization Plans, in the form of Regulatory Guide 4.17 (RG 4.17, "Standard Format and Content of Site Characterization Plans for High-Level Waste Geologic Repositories," Revision 1, March 1987). The purpose of this Regulatory Guide is to suggest the types of information to be provided in the SCPs in accordance with 10 CFR Part 60.17 and the NWPA. Additional guidance on SCP content has been developed from NRC/DOE meeting agreements on "Level of Detail in the SCP," "Performance Allocation," and "Quality Assurance." DOE has prepared an "Annotated Outline for Site Characterization Plans," based on NRC's Regulatory Guide 4.17, and has revised it to be consistent with the above mentioned meeting agreements. The NRC staff have reviewed the "Annotated Outline" and consider it to be a reasonable interpretation of, and consistent with, Regulatory Guide 4.17 and the meeting agreements.

The above discussion provides relevant background for understanding the acceptance review approach and criteria. Clearly, the basic approach is to determine if the SCPs are reasonably consistent with the guidance and agreements on the SCP content. The review will be more than a simple check to determine if items in the table of contents have been addressed; it will also be to determine if the material provided is substantive enough for meaningful staff review. No conclusion will be made, as part of the acceptance review, on the adequacy of the material. This will be done during the technical reviews. Therefore, the acceptance review is intended to: (1) identify omissions and areas severely lacking in substance; and (2) assess any inadequacies, as a whole, to determine if continuation of the review is a worthwhile expenditure of staff resources. A decision will be made with respect to continuing the review and a letter will be prepared and sent to DOE giving the results of the acceptance review.

2.2 Criteria

1. The SCP content and level of detail should be substantively consistent, as appropriate for the site, with:

   a. SCP content requirements of 10 CFR 60.17
   b. Regulatory Guide 4.17 (March 1987)
   c. DOE "Annotated Outline" (April 1987)

2. All SCP references should be provided at the time of SCP issuance. (Agreement in "Summary of the NRC-DOE Meeting on Level of Detail for Site Characterization Plans and Study Plans", May 7-8, 1986).

3. NRC CDSCP open items have been substantively addressed (Letter from Browning to Stein dated May 11, 1988, transmitting NRC's final CDSCP point papers).

4. DOE's Design Acceptability Analysis is available and is substantive enough for meaningful review.

5. Five study plans related to ESF construction and testing during construction are available and are substantive enough for meaningful review (Agreement in "Summary of the NRC-DOE Meeting on Level of Detail for Site Characterization Plans and Study Plans", May 7-8, 1986).

2.3 Applicable Section of 10 CFR Part 60

60.17

2.4 Key Documents to Consider

U.S. Nuclear Regulatory Commission, "Standard Format and Content of Site Characterization Plans for High-Level Waste Geologic Repositories," Regulatory Guide 4.17, Rev. 1, March 1987.

U.S. Department of Energy, Office of Civilian Radioactive Waste Management, "Annotated Outline for Site Characterization Plans," (OGR/B-5), April 1987.

Summary of the NRC/DOE meeting on the Level of Detail for Site Characterization Plans and Study Plans, May 8, 1986.

3.0 TECHNICAL REVIEW

3.1 Overall Approach

3.1.1 Organization

The technical review of the SCP will be conducted considering the scope in section 2.3 and the general and detailed review guides that follow in Sections 3.2 and 3.3.

The general review guides (Sections 3.2.1 through 3.2.8) have been developed to provide a broad coverage of the entire SCP, with the exception of SCP Section 8.7 on decontamination and decommissioning. NRC does not have licensing jurisdiction over site characterization facilities/activities, just over repository facilities, in this case. The general review guides are organized so that they basically parallel the SCP's structure. One section has been developed pertinent to the site and design descriptions in SCP Chapters 1-7. Subsequent sections have been developed pertinent to various sections of SCP Chapter 8 (i.e., issues and performance allocation (8.2); site investigations and design activities (8.3.1-8.3.4); performance assessment activities (8.3.5); exploratory shaft facility (8.4); milestones and schedules (8.5); and quality assurance program (8.6)). The general review guide for performance assessment activities has been subdivided into 11 separate guides for review of various topics such as scenario development and modeling. An additional review guide related to staff comments on the CDSCP has been included with the general review guides to ensure that review of the SCP has taken the NRC staff's previous CDSCP concerns adequately into consideration.

The criteria presented in the general guides are such that they may be applied by all technical disciplines. The exception is in the review of the quality assurance program which are reviewed by the quality assurance staff.

The general review guides are focused by the detailed review guides which address selected, important, SCP review topics. These have been developed to provide additional, more detailed criteria for reviewing parameter identification and investigations/activities related to key specific technical topics. Each detailed review guide presents site-generic criteria for examining a particular technical topic, as well as criteria for site-specific concerns related to the topic.

Both the general and detailed review guides have the same four-part structure: "Background and Approach"; "Criteria"; "Applicable Sections of Part 60"; and "Key Documents to Consider". The "Background and Approach" presents a discussion of a review topic's importance in the review process, and how the topic is to be reviewed. The "Criteria" are statements to use, as appropriate, in evaluating adequate treatment of a specific section or topic in the SCP and SCP references, and in developing open items (objections, comments, or questions). "Applicable Sections of 10 CFR Part 60" consists of a listing of Part 60 requirements related to the subject topic. "Key Documents to Consider" is a listing of important documents (e.g., GTPs; NUREGs; NRC letters to DOE;

NRC/DOE meeting summaries) that should be considered in the review of the particular topic, thereby bringing applicable previously-documented NRC open items and concerns to bear, as the review guides are applied to the various Portions of the SCP.

3.1.2 Review Approach

The reviewer should review the SCP considering the appropriate criteria in the general review guides. When the review centers upon a key technical area for which additional criteria have been developed, the appropriate detailed review guides should be consulted. Given the diversity of review responsibilities of the various technical disciplines, and the magnitude and format of the SCP itself, there can be no simple review process that all reviewers must follow. However, given below is a logical sequence of the major steps of the technical review, with reference to the appropriate guides of this review plan (see Section 2 of the Work Plan and Procedures (WPP) for all the activities and products associated with the technical review). These steps might be useful to follow in preparing their preliminary concerns.

1. Read SCP Section 8.2 and appropriate portions of 8.3, to obtain an overview of the issues, the performance allocations, and the performance assessment plans, as they relate to the reviewer's technical discipline responsibility (see Tables 4-6 of the WPP).

2. Review existing site and design information in Chapters 1-7 (as applicable to the reviewer's particular technical discipline), following the basic approach in Section 3.2.1 of the review plan. No review criteria are provided; any concerns noted in the review of existing information should be considered in addressing related aspects of site characterization activities presented in SCP Chapter 8.

3. Based on the information reviewed in Steps 1 and 2, make an <u>initial</u> assessment of the reasonableness and adequacy of the performance allocation and identified information needs/parameters. General criteria listed in the Review Guide for Issues, Information Needs and Performance Allocation (Section 3.2.2), and the information needs and documents to consider, provided in appropriate detailed review guides, should be used to aid this assessment.

4. Review the site investigations and design activities (SCP Sections 8.3.1-8.3.4) applicable to obtaining the information needs/ parameters related to the reviewer's technical area of responsibility. The general criteria of the Review Guide for Site and Design Investigations (Section 3.2.3) should be used, as well as criteria of the appropriate detailed review guides. The latter criteria identify specific information needs and/or methodology related items for the key technical topics on which the review is focused.

5. Review the appropriate technical aspects of the performance assessment activities (SCP section 8.3.5) and provide input to the staff's assessment of their adequacy. The technical reviewer should be conversant with the general criteria for performance assessment activities, provided in Section 3.2.4, so that the required input can be prepared. (Note: Review Steps 4 and 5 should be performed conjunctively or iteratively, rather than sequentially.)

6. Revisit the performance allocation sections to make a final assessment of whether the "pieces" of the issues resolution strategies are complete and reasonable, considering the general criteria in Section 3.2.2.

7. Review the overall site characterization schedule as presented in SCP Section 8.5, considering the general review criteria provided in the Review Guide for Milestones and Schedule (Section 4.2.6).

8. Based on the criteria presented in Section 4.2.8, assess the adequacy of the SCP's consideration of the NRC's CDSCP concerns.

3.2 General Review Guides

3.2.1 Review Guide for Site and Design Descriptions (Chapters 1-7)

Background and Approach

Chapters 1 through 7 of the SCP are intended to present currently available information about the site, and conceptual designs of the repository and waste package. This information establishes the basis for DOE's issue resolution strategies, performance allocations, identification of information needs, and plans for investigations and activities provided in Chapter 8 of the SCP. Likewise, this existing information should be reviewed using this Guide to form a basis on which to assess the completeness and relevancy of the proposed programs in Chapter 8. No criteria are provided for review of these chapters, since any concerns noted in this portion of the review should be addressed in the application of the criteria provided in the general and detailed review guides pertinent to review of Chapter 8.

Concerns arising from review of Chapters 1 through 7 may take two basic forms. One may stem from the SCP's lack of identification of pertinent existing data. The other may stem from the SCP's inadequate consideration of existing information gaps, or uncertainties regarding existing information. Such information might include reasonable ranges of parameter values, alternative analyses, interpretations, conceptual models, designs, etc. Staff concerns regarding missing pertinent information might arise from their knowledge of such existing information obtained either through previous interactions with DOE staff or through review of existing technical documents and data. Concerns over whether existing information gaps and uncertainties have been adequately considered would result from an assessment of information needs and associated investigations/activities, in view of what related existing information has been presented.

3.2.2 Review Guide for Issues, Information Needs, and Performance Allocation

3.2.2.1 Background and Approach

It is anticipated that Section 8.2 of the SCP will present the issues* to be resolved and the strategy for resolution of each issue. DOE has identified key issues, and issues that are applicable to all three sites, in its "Issues Hierarchy" (DOE, 1987). The key issues and issues are questions related to the regulatory requirements in both 10 CFR Part 60 and 10 CFR Part 960.

NRC staff have previously reviewed DOE's issues hierarchy and determined that, in general, the logic allows adequate consideration of any technical concerns related to the criteria of Subparts E and F of Part 60 (NRC-DOE Meeting, March 3-4, 1987). The SCP review of DOE's performance allocation and its implementation of the issues hierarchy provides a means to confirm that the site characterization program will address these concerns. The performance allocation process provides the rationale for establishing particular information needs considered necessary to resolve each of those DOE issues that are related to Part 60. The completeness and adequacy of the information needs relative to the detailed technical requirements of Part 60 will be assessed based on those information needs given in the detailed review guides.

As the NRC staff review the proposed performance allocation, they will recognize that "performance allocation" represents an early technical-management decision (guided by the performance criteria of Part 60) about: (a) the system elements to be relied on to resolve an issue; (b) the performance goals for the individual elements; and (c) the desired confidence in the goals. Performance goals are used for planning the site characterization program; they are not to be construed as performance criteria for licensing. It is understood that the initial setting of performance goals must be tentative. It is further understood that the tentative goals should be established conservatively. That means establishing sufficient margin to allow for anticipated uncertainties in showing compliance with Part 60 while at the same time not being unduly optimistic about potential performance of the site.

The performance allocation process calls for iterative steps of data collection, performance assessment, reevaluation of performance goals, and, as necessary, design of a revised set of activities during characterization. This process is continued until compliance with the requirements of 10 CFR Part 60 can be determined.

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*In the DOE's issues hierarchy, "issues" are broad level questions regarding compliance with regulatory requirements. They are not the same as the NRC "issues" in the Issue Oriented Technical Positions (ISTPs), nor the same as what we sometimes call the NRC comments on the EAs or CDSCP.

There are four general steps in the performance allocation process as applied to each individual issue of the issues hierarchy. Step 1 is a statement of the functions of the system elements (site features and engineered components) and processes to be relied on in resolving the issue. Step 2 is identification of a performance measure (variable that specifies the performance of a system element) for each function and, for each performance measure, identification of a performance goal (tentative value for performance measure) with an associated level of desired confidence in the goal. Step 3 is identification of performance and design parameters (variables needed to evaluate performance and design) to be measured, and, for each parameter, identification of a parameter goal and an associated level of desired confidence in the parameter goal. Step 4 is identification of characterization parameters (more directly measurable quantities that contribute to determining performance and design parameters), current estimates of their values, confidence in the current estimates, and the needed confidence in them. Step 1 for the set of issues, forms the basis for developing the plan for demonstrating compliance with regulatory requirements and may be called a "licensing strategy." Step 2 expresses the strategy in more specific terms. Step 3 provides the information needs in terms of parameters that define the performance measures. Step 4 provides the basis for investigations in terms of parameters linked to the performance allocation process. It is expected that there will be some variation in the way these four steps will be applied to performance and design issues as well as variations in the application to engineered components and natural components.

Criteria are provided below for reviewing each of the four general steps of the performance allocation process to be applied to each issue. It will probably be necessary for the reviewer to review the investigations and activities presented in Section 8.3 of the SCP, before drawing conclusions based on all these criteria. This general review guide is to be supplemented by the detailed review guides, which identify various specific information needs that should be identified in the SCP as appropriate for the site and are based on the performance allocation process.

3.2.2.2 Criteria

A. For resolution of each DOE issue related to Part 60, the initial Performance allocation should clearly state the system elements to be used, functions of the system elements, processes that affect their performance, and conceptual models and analyses to be used. This statement, taken together with statements for other issues, should show how each system or subsystem performance objective of Part 60 will be achieved through the performance of lower-level system elements.

   1. System elements should be identified in three categories: primary elements to be relied upon; reserve elements to be used if primary elements fail to meet the desired performance goal; and system elements and processes that could adversely affect performance.

a. The performance allocation should be complete in the sense that, taken together and considering adverse processes and events, primary elements of the system that are being relied upon should cover the functions necessary to meet performance objectives.

b. The subsystem performance allocation should provide functional redundancy among subsystems, relative to meeting the overall system performance objectives.

c. If system elements specified as reserve elements were to be needed in a subsequent revised performance allocation, completeness and redundancy should be preserved.

2. Pertinent scenarios, primary and alternative conceptual models, and relevant analyses or specific plans to develop scenarios, models and analyses should be presented for DOE's performance issues. (These will be reviewed according to Sections 4.2.4.1, 4.2.4.2, 4.2.4.3, and 4.2.4.4)

B. A performance measure should be identified for each function of a system element to be relied upon. A performance goal, and desired level of confidence, with supporting rationales, should be provided for each performance measure.

1. A performance measure that is appropriate to the designated function should be identified for each primary and reserve system element. The performance of system elements that could adversely affect performance of other system elements should be quantified.

a. The selected performance measure should be such that appropriate data can be obtained, or measurements or analyses can be accomplished to evaluate the performance measure.

b. The performance of system elements should be quantified to the extent necessary to determine deleterious effects on system elements being relied on or held in reserve.

2. A performance goal for each performance measure should be identified and supported by a stated rationale.

a. The performance goal should be consistent with regulatory performance objectives and requirements.

b. The performance goal should be physically reasonable and achievable.

c. The performance goal should be consistent with pertinent scenarios and conceptual models identified for the issue.

3. A level of desired confidence should be stated and justified for each performance goal.

   a. The level of desired confidence should reflect a level of uncertainty in the performance goal that provides a reasonable margin between predicted results and regulatory limits.

   b. The basis for the desired level of confidence, e.g., sensitivity analysis or expert judgment, should be provided. Qualitative terms such as "high," "medium," or "low" should be clearly defined.

4. Collectively, the performance goals and associated levels of desired confidence should provide a margin with respect to regulatory limits that allows for limitations and uncertainty in available technology.

C. The indicated performance measures should be completely described in terms of sets of performance or design parameters that meet the following criteria.

1. For each system element, a list of performance or design parameters should be given that will allow analysis of the performance of that element. Performance or design parameters describing the environment within which the element must perform should be included.

2. The desired confidence in each of the performance or design parameter values should be presented along with the basis for the desired confidence.

   a. Desired confidences should be consistent with the desired confidence for the performance goal with which the performance or design parameters are associated.

   b. Desired confidences should be consistent with the limitations and uncertainties of available testing methodologies.

3. Performance or design parameters associated with performance issues should be consistent with the scenarios and conceptual models that have been presented.

4. Performance or design parameters to measure deleterious interactions among system elements identified in the performance allocation should be included.

D. The information needs, as stated in terms of characterization parameters, should contain the information needed to resolve the performance or design issue with which they are associated. This determination should be based on the detailed review guides and the following criteria.

1. A rationale should be provided that relates the characterization parameters to be measured to the selected performance measures, goals and confidence levels.

2. The relationship between the characterization parameters needed and the properties to be measured should be described.

3. The presented ranges of characterization parameter values should be physically reasonable.

4. Processes and conditions that must be controlled when characterization parameter(s) are being measured should be clearly identified as such.

5. Interdependence among characterization parameters should be identified and the means for dealing with their interdependence should be presented.

6. Characterization parameters associated with performance issues should be consistent with scenarios and conceptual models presented. Characterization parameters derived from the issue resolution strategy should be supplemented, as required, by parameters needed to select among alternative conceptual models. DOE consideration of alternative conceptual models should be consistent with the specifics of the agreements reached at the Alternative Conceptual Model Workshops (April 1988).

7. Collectively, the information needs identified by the characterization parameters should be such that plans for obtaining them would adequately cover the detailed technical requirements of 10 CFR Part 60, Subparts E and F. This determination should be based on the detailed review guides that list information and parameter needs.

3.2.2.3 Applicable Sections of 10 CFR Part 60

Sections 60.112, 60.113, 60.133, 60.134, and 60.135

3.2.2.4 Key Documents to Consider

U.S. Nuclear Regulatory Commission, Regulatory Guide 4.17, "Standard Format and Content of Site Characterization Plans for High-Level Waste Repositories," Revision 1, March 1987. (See Section 6.7)

NRC-DOE agreements on performance allocation are documented in the meeting summaries of the following generic NRC/DOE meetings: (1) Performance Allocation, April 17, 1985, (2) Subsystem Performance Allocation, September 26-27, 1985, (3) Level of Detail in Site-Characterization Plans, May 7-8, 1986, (4) Issues Hierarchy and Performance Allocation, March 3-4, 1987, and (5) SCP Issues Hierarchy and Performance Allocation Briefing, October 8-9, 1987.

U.S. Department of Energy, "Issues Hierarchy for a Mined Geologic Disposal System," OGR/B-10, August 1987

U.S. Department of Energy, "Mission Plan for the Civilian Radioactive Waste Management Program," June 1985. (See Volume I, Part II, Section 2.6)

NRC-DOE Summary of Meeting on Alternative Conceptual Models, April 11-13, 1988.

3.2.3 Review Guide for Site Investigations and Design Activities

3.2.3.1 Background and Approach

It is anticipated that Sections 8.3.1 through 8.3.4 of the SCP will address the planned investigations and activities that are deemed necessary to fulfill the specific information needs of the "Issues Hierarchy" for the site program, repository program, seal system program, and waste package program, respectively. Section 8.3 of DOE's "Annotated Outline for Site Characterization Plans" establishes the basic content for description of these planned investigations and activities. It is based on guidance provided in NRC Regulatory Guide 4.17 and on DOE/NRC agreements made during a May 7-8, 1986 meeting on "Level of Detail for SCPs." The general criteria given below are consistent with the NRC guidance and meeting agreements. They are to be applied in the review of the investigations and activities regardless of site or technical discipline.

Additional criteria are provided in the detailed review guides in Sections 3.3.1 through 3.3.26 of this Review Plan. They are to be applied, as appropriate, for review of the investigations and activities related to specific key technical topics of the site, repository, seal system, and waste package programs.

3.2.3.2 Criteria

A. Those investigations related to the information/ parameter needs given in the detailed review guides, should adequately address (as appropriate) all the information on the objectives, rationale, description of studies, application of results, and scheduled milestones, as specified in the following reference and given in Appendix A to the SCPRP: "Summary of the NRC/DOE Meeting on the Level of Detail for Site Characterization Plans and Study Plans," May 7-8, 1986, Attachment 4, "DOE Content Requirements for Description of Investigations in Chapter 8.3 of the Site Characterization Plan." The rationale should include explicit demonstrations that the information needs/parameters are based on the performance allocation.

B. If any planned investigation requires the use of radioactive materials, this requirement should be identified and justified consistent with requirements in NWPA Section 113. The quantities to be used and any plans for retrieval should be adequately discussed.

C. Appropriate consideration should be given to the potential effects of the investigation on the capability of the site to isolate high-level waste. If potential effects exist, the SCP should include acceptable discussion of preventive/mitigative measures. (Note that such information may be given in 8.3 and 8.4 of the SCP.)

D. The investigation/activity should accurately reflect what is already known about the site/design, as presented in Chapters 1-7 of the SCP.

E. The description of the duration and sequencing of studies, tests and analyses associated with the planned investigation and other related investigations should be based on obtaining the information needs, and

developing adequate testing or analyses technology (if not already available) to reduce technical uncertainties, rather than on programmatic time constraints.

3.2.3.3 Applicable Sections of 10 CFR Part 60

60.15
60.17(1),(2)

3.2.3.4 Key Documents to Consider

"Summary of the NRC/DOE Meeting on the Level of Detail for Site Characterization Plans and Study Plans," May 7-8, 1986, Attachment 4.

U.S. Department of Energy, "Annotated Outline for Site Characterization Plans," OGR/B-5, April 1987, Section 8.3.

3.2.4 Review Guide for Performance Assessment Activities

Performance assessment is the process of quantitatively evaluating component and system behavior, relative to containment and isolation of radioactive waste, to support development of a high-level waste repository and to determine compliance with the numerical criteria associated with 10 CFR Part 60. Performance assessment will be a primary tool in both DOE's demonstration of and NRC's assessment of compliance with the numerical criteria of Part 60. It will also be used in directing site characterization activities, identifying important processes and parameters, and assisting in development of conceptual models.

In the performance allocation of Chapter 8, the SCP is anticipated to include the conceptual models and related mathematical models that DOE considers will be needed to resolve the performance issues. These models would be used in the performance allocation process to identify performance and characterization parameters. Section 8.3.5 of the SCP is anticipated to include preclosure and postclosure performance assessment strategies necessary for resolution of preclosure and postclosure performance issues. Section 8.3.5 of DOE's "Annotated Outline for Site Characterization Plan," based on guidance provided in NRC's Regulatory Guide 4.17, establishes the basic content for a description of the Performance Assessment Program.

The Performance Assessment Program, in demonstrating compliance with the Performance objectives of 10 CFR Part 60, is expected to address the following: scenario development and screening; determination of anticipated and unanticipated processes and events (for post-closure analyses); estimation of scenario probabilities; modeling; modeling uncertainty; data uncertainty; sensitivity analysis; and formal use of expert judgement. The following review guides address these topics. There are also review guides for the containment requirements of the EPA standards and for preclosure analyses under Section 60.111 that establish the specific relationship of these topical guides to the Part 60 performance objectives. Finally, performance confirmation is addressed in a review guide.

The following subsections provide general criteria for reviewers in the various technical disciplines to become conversant with, and to consider in reviewing performance allocation and applicable portions of the Performance Assessment Program in the SCP. These criteria apply to all quantitative analyses of repository performance. They are also partially applicable to the repository design process (detailed review criteria that address the repository design process are included in Section 3.3.23). As part of its SCP review, the staff will review the models used for performance allocation, and, at a comparable level of detail, will review models throughout the SCP. The staff will not review computer codes as part their SCP review.

The general criteria of this Section should be used in conjunction with other general review criteria for parameter identification in Section 3.2.2 and investigations in Section 3.2.3 to review activities related to performance assessment. Existing information in Chapters 1-7 relevant to the criteria given below and any staff concerns regarding this material should also be considered in the review of the performance assessment activities.

3.2.4.1 Review Guide for Scenario Development and Screening

3.2.4.1.1 Background and Approach

To conduct a performance assessment (either preclosure or postclosure) of a repository, it is necessary to hypothesize the future states that the disposal system may experience over the time period of interest. Scenario development addresses this issue. Scenarios are combinations of processes and events that could initiate or influence the release or migration of radionuclides from the waste to human beings. Scenario development includes systematic methods for the selection of scenarios, as well as an estimate of their likelihood of occurrence.

The scenarios used to evaluate a particular repository will depend on the design of the facility and the characteristics of the site. However, a general procedure can be used to identify scenarios for any given site and design. Such a procedure would generally include: (1) an initial comprehensive identification and classification of processes and events; (2) an initial screening to eliminate unimportant processes and events; (3) the formation of scenarios by taking specific combinations of the remaining processes and events; and (4) the screening of scenarios to select a final set for use in repository analysis. The classification in Step 1 includes natural phenomena that occur independently of the presence of the repository, phenomena resulting from human activity, and phenomena resulting from the presence of the repository. An additional classification to identify anticipated and unanticipated processes and events is also essential in assessing compliance with the postclosure requirements of 10 CFR Part 60. The screening of processes and events and scenarios is based on criteria such as (1) physical reasonableness (e.g., "not credible" processes and events as defined by the NRC); (2) probability; and (3) consequences.

The term "scenario" is not specifically used by the NRC in 10 CFR Part 60, or by the EPA in 40 CFR Part 191. However, the development of scenarios is clearly implied both in the definition of performance assessment provided in Section 191.12 of 40 CFR Part 191, and in the assessment of compliance with the EPA's containment requirement. This requirement is in Section 191.13 of 40 CFR Part 191, and implemented in Section 60.112 of 10 CFR Part 60. Scenario development is used to assess compliance with Sections 60.111, 60.113, and 60.134 of 10 CFR Part 60. Scenarios are also useful in demonstrating the completeness of performance assessment analyses and in directing site characterization efforts.

In addressing the topic of scenario development and screening, the SCP is expected to include: (1) a definitional statement of the term "scenario"; (2) a identification of the analyses in which the scenarios will be used; (3) a description of the methodology that has been or will be used to develop and screen scenarios; (4) supporting justification for the methodology, such as evidence that the methodology has been successfully used in the past; and (5) a discussion of how the issue of completeness will be addressed in scenario development. The staff will review the SCP to assess the adequacy of the scenario development and screening process. In these reviews the staff will

evaluate any preliminary identification and screening of scenarios and its justification.

3.2.4.1.2 Criteria

A. The SCP should provide a concise definition of a scenario and identify the methodology for scenario development and screening. This methodology should satisfy the following criteria:

1. Be systematic

   a. The steps of the methodology should be well-defined and orderly.

   b. The product of applying the methodology should be reproducible.

2. Provide assurance that all relevant events and processes will be considered in the development of scenarios, in the following ways:

   a. Compare the initial list of events and processes to other available lists (e.g., that published by the International Atomic Energy Agency); at a minimum, the SCPs should consider all of the siting criteria in Section 60.122 and the design criteria in Sections 60.131 through 60.134.

   b. Compare the events and processes on the initial list to the site description, to identify events and processes unique to a particular site that might not be on the list.

3. Contain explicit criteria, with justification for these criteria, for screening events, processes, and scenarios.

4. Ensure the compatibility of scenarios developed for the various components of an overall performance assessment (e.g., waste package, engineered barrier system, etc.).

5. Clearly identify the areas where formal use of expert judgement is applied. Such formal use of expert judgement should satisfy the criteria provided in Section 4.2.4.8.

B. Scenarios developed for the ultimate purpose of demonstrating compliance with the EPA's containment requirement (implemented by Section 60.112 of 10 CFR Part 60) should include all anticipated and unanticipated processes and events (see Section 4.2.4.2). This consideration should be included in any proposed method to develop such scenarios.

C. Scenarios developed for the ultimate purpose of showing compliance with engineered barrier system and waste package performance objectives should consist of the subset of scenarios that include anticipated processes and events (see Criterion B above).

3.2.4.1.3 Applicable Sections of 10 CFR Part 60

60.111
60.112
60.113
60.134

3.2.4.1.4 Key Documents to Consider

R.M. Cranwell, R.V. Guzowski, J.E. Campbell, and N.R. Ortiz, "Risk Methodology for Geologic Disposal of Radioactive Waste: Scenario Selection Procedure," USNRC Report NUREG/CR-1667, in press.

U.S. Nuclear Regulatory Commission, Regulatory Guide 4.17, "Standard Format and Content Guide of Site Characterization Plans for High-Level Waste Repositories," Revision 1, March 1987.

U.S. Department of Energy, "Annotated Outline for Site Characterization Plans," OGR/B-5, April 1987.

International Atomic Energy Agency "Performance Assessment for Underground Radioactive Waste Disposal System," Safety Series No. 68, IAEA, Vienna, 1985.

3.2.4.2 Review Guide for Anticipated Processes and Events and Unanticipated Processes and Events

3.2.4 2.1 Background and Approach

In the SCP, the programs of studies, investigation, analysis and performance assessment, especially in regard to the waste package and engineered barrier system, will need to consider anticipated processes and events and unanticipated processes and events. Within Section 60.113(a)(1), it is specified that the engineered barrier system be designed to meet the following conditions, assuming anticipated processes and events. (1) Containment of high level waste will be substantially complete during the period when radiation and thermal conditions within the engineer barrier system are dominated by fission Product decay. (2) Release of radionuclides from the engineered barrier system will be a gradual process. (3) Specific numerical performance objectives will be achieved. Therefore, without specifically stating the premise, the primary function of anticipated processes and events is to specify, in part, the design basis for the engineered barrier system and waste package, during the post-closure period.

In addition to the requirements specified in Section 60.113, anticipated processes and events must be considered, along with unanticipated processes and events, in evaluation of compliance with the overall containment requirements of the EPA standard, as specified in Section 60.112. Within the license application, the applicant must present an evaluation of the performance of the geologic repository, for the period after permanent closure, assuming anticipated processes and events and unanticipated processes and events (Section 60.21(c)(1)(ii)(C)). Based on these analyses, as is stated in Section 60.113(c), the NRC may specify additional requirements to satisfy the overall system performance requirements (Section 60.112), as they relate to unanticipated processes and events. The EPA standard has not been formally adopted by the NRC because of its rejection in court. However, if the final standard is similar to the vacated standard, it also will be necessary to consider anticipated processes and events, in the evaluation of compliance with the groundwater and individual protection standards.

The detailed criteria below should be used in conjunction with the general review criteria for parameter identification in Section 3.2.2, and investigations and activities in Section 3.2.3 and 3.2.4 to review appropriate portions of SCP Chapter 8. Existing information presented in Chapters 1-7 relevant to the criteria given below and any staff concerns regarding this material should also be considered in the review of Chapter 8.

3.2.4.2.2 Criteria

The plans presented in the SCP should show that the following criteria have been or will be considered.

1. An "anticipated event" and a natural "unanticipated event" should reflect the maximum event which has occurred within the geologic setting during the Quaternary. The "anticipated event" should be assumed to occur at the location(s) this event occurred during the Quaternary. An "unanticipated

event" should be assumed to occur at any credible location within the geologic setting, at which it could occur, to determine its effect on waste isolation.

2. An "anticipated process" should reflect a reasonable and conservative projection of the rate of the process which is occurring or which has occurred within the geologic setting during the Quaternary. The variation around the average rate of the process should be considered, with emphasis on the rate of this process during the late Quaternary. A natural "unanticipated process" should consider the maximum sustained rate of this process during the Quaternary. As with anticipated and unanticipated events, an anticipated process should be assumed to occur at the location where this process has occurred in the past. An unanticipated process should be assumed to occur at any credible location, within the geologic setting, to determine its effect on waste isolation.

3. Both the "anticipated" and "unanticipated" processes and events must reflect the potential modifications to such processes and events caused by past, ongoing or projected human-induced processes and events which will not be under DOE's control.

4. Human-induced processes and events which may occur on lands which will be under DOE's jurisdiction, either within or outside the controlled area, are considered unanticipated.

5. Natural processes and events which are normally handled as "random" processes and events will normally be considered as anticipated processes and events.

6. The processes and events used in the performance assessment and in design must reflect modifications to these processes and events which could occur due to the perturbations from the effects of waste emplacement and the uncertainty in the various projections.

7. Professional judgement must be exercised in evaluating the various natural processes and events which may affect the site during the post-closure period. The processes and events should not simply reflect average or maximum values, but should reflect the natural geologic variability including, but not limited to:

    a. the spatial and temporal variability of the processes and events; and
    b. the periodicity of the processes and events.

8. Although the Quaternary record for the region of the geologic setting, and especially the late Quaternary record, should be the main basis for providing the evidence for consideration of the various processes and events, the following information should also be considered:

    a. the pre-Quaternary record for those processes and events which have a cycle which may not be adequately reflected in the Quaternary record;

b. any changes in the processes and events which are evident in the Quaternary record. and
c. evidence from analogues in other geological settings, experimental data or the results of modeling and sensitivity exercises.

9. When evaluating the effect of human-induced processes and events, if it is assumed that potentially adverse condition of Section 60.122(c)(17) is not present, the guidance which had been presented in appendix B to 40 CFR 191 (subsequently vacated) on frequency and severity of inadvertent human intrusion should be followed.

10. When potentially adverse condition of Section 60.122(c)(17) is assumed to be present, the rationale for frequency and severity of inadvertent human intrusion should be based on a comparison of drilling histories of similar deposits in similar geologic settings.

11. The evaluations in 9 and 10 above should also consider the express assumptions contained in the definition of "unanticipated processes and events" in Section 60.2.

12. The use of the terms "anticipated processes and events" and "unanticipated processes and events" should be consistent with the regulatory definition of the terms, not the standard dictionary usage.

13. The conceptual design and analysis for the engineered barrier system and the waste package, as presented within the SCP, should consider anticipated processes and events in formulating the design and in performing the preliminary analysis.

14. The preliminary analysis for determining compliance with Section 60.112, the section of the rule which requires compliance with the EPA standard, should show consideration for both anticipated processes and events and unanticipated processes and events.

15. The investigations of the natural system must be sufficient to allow both a deterministic and a probabilistic evaluation of known and potential processes and events which could affect the geologic setting. The information stemming from these investigations must be sufficient to allow the potential events and processes to be characterized, evaluated and categorized into anticipated processes and events and unanticipated processes and events.

3.2.4.2.3 Applicable Sections of 10 CFR Part 60.

60.2
60.21(c)(1)(ii)(C)
60.112
60.113

3.2.4.2.4 Key Documents to Consider

U.S. Department of Energy, "Annotated Outline for Site Characterization Plans," USDOE Report OGR/B-5, April 1987.

U.S. Department of Energy and Geological Survey, U.S. Department of Interior, "Earth Science Technical Plan for Disposal of Radioactive Waste in a Mined Repository," USDOE Draft Report DOE/TIC-1033, April 1980.

U.S. Department of Energy, "NWTS Program Criteria for Mined Geologic Disposal of Nuclear Waste: Site Performance Criteria," USDOE Report DOE/NWTS-33/2, February 1981.

U.S. Department of Energy, "Major Geoscience Issues Associated with Siting a High Level Nuclear Waste Repository," prepared for DOE's Office of Civilian Radioactive Waste Management by R. F. Weston Consultants, June 15, 1984.

U.S. Department of Energy, "Issues Hierarchy for a Mined Geologic Disposal System (OGR/B-10)," USDOE Report DOE/RW-0101, Rev. 1, August 1987.

U.S. Department of Energy and U.S. Nuclear Regulatory Commission, "Summary of the NRC/DOE Meeting on the Level of Detail for Site Characterization Plans and Study Plans," May 7-8, 1986, 9pp. plus four attachments.

U.S. Nuclear Regulatory Commission, "Information Needs for Characterization of High-Level Waste Repository Sites in Six Geologic Media," USNRC Report NUREG/CR-2663, Vols. 1 and 2, May 1985.

U.S. Nuclear Regulatory Commission, Regulatory Guide 4.17, "Standard Format and Content of Site Characterization Plans for High-Level Waste Repositories," Revision 1, March 1987.

U.S. Nuclear Regulatory Commission, "Draft Issue-Oriented Site Technical Position (ISTP) for Nevada Waste Isolation Project (NNWSI)," September 1984.

U.S. Nuclear Regulatory Commission, "NRC Guidance on SCP Content," dated June 27-28, 1983.

U.S. Nuclear Regulatory Commission, "NRC Staff Comments on the DOE Final Environmental Assessments," Yucca Mountain Site comment numbers 1, 2, 3, 4, and 5; dated December 22, 1986.

U.S. Nuclear Regulatory Commission, "NRC Comments on DOE Draft Environmental Assessment for Yucca Mountains Site," March 20, 1985.

U.S. Department of Energy, "Environmental Assessment for Yucca Mountain Site, Nevada Research and Development Area, Nevada," DOE/RW-0073, Vols. 1-3, May 1986.

3.2.4.3 Review Guide for Estimating Scenario Probabilities

3.2.4.3.1 Background and Approach

There is a direct relationship between scenario development and screening and the estimation of scenario probabilities. Scenario probabilities generally are determined by combining the probabilities of the specific events and processes that comprise the scenario. As applied to assessing the performance of repositories, scenario probabilities are initially used as screening criteria for scenarios. They are ultimately used in combination with scenario release estimates in assessing release probabilities to show compliance with Section 60.112 of 10 CFR Part 60 (see Section 4.2.4.9). In addition, probabilities of events and processes can be used to direct data collection and other activities for events and processes that are at or near the "cut-off" probability.

The SCP is expected to include: (1) a statement of why probabilities are needed; (2) a description of what probabilities are needed (i.e., for which events and processes); (3) an explanation of how the probabilities are (will be) used; (4) a description of what technique(s) are (will be) used to estimate probabilities of events and processes; (5) the criteria required for the use of each technique; and (6) alternative approaches for estimating probabilities when little or no data are available. The staff will review the SCP to determine the adequacy of the approach for estimating probabilities of important events and processes and of scenarios. In their review, the staff will evaluate: (1) approaches associated with scenarios documented in the SCP; (2) proposed approaches associated with future scenario development; and (3) specific site characterization activities aimed at estimating probabilities of specific events and processes.

3.2.4.3.2 Criteria

The SCP should contain provisions that will clearly identify the technique used to estimate the probability of each event and process and state the justification for using the technique selected. The least subjective technique should be the most favored. However, the appropriate technique for a particular event or process will depend on the nature of the phenomenon; the level of understanding of the phenomenon; the quantity and quality of the available data; and the appropriateness of the data base for future projections. The nature of a particular event or process may suggest a specific technique, although the available data for a site or the time frame over which the event or process occurs may necessitate the use of another technique.

A. Criteria for the selection of four important probability techniques are:

1. Frequentist (the use of existing frequency data to estimate a probability density function directly)

   (a) Sufficient data exist so that the frequency of or cyclicity in the data can be recognized (see also Section 3.2.4.6).

(b) Projection of the frequency or cyclicity into the future is reasonable given the nature of the event or process and the time Period involved.

2. Modeling (the use of a model of the physical system and a sampling procedure to perform Monte-Carlo simulations to estimate a probability density function):

   (a) The physical system is understood well enough that a conceptual model can be developed that incorporates all or most of the available data (see also Sections 3.2.4.4 and 3.2.4.5).

   (b) Recognition of a need to provide computer code that can represent the events or process in the physical system (see also Section 3.2.4.4).

   (c) The available data are sufficient that sampling from the data and performing Monte-Carlo simulations using the data will produce a realistic probability density function (see also Section 3.2.4.6).

3. Axiomatic (the use of a probability model (e.g., Poisson)):

   (a) Sufficient data exist to determine that the event or process is random in space and/or time (see also Section 3.2.4.6).

   (b) The event or process is likely to remain random during the time period of interest.

4. Subjective (the formal use of expert judgment, see Section 3.2.4.8)

B. The proposed method should explain how time-dependent probabilities are (will be) assessed for scenarios that involve transient phenomena (e.g., volcanism: if the pressure in a magma chamber increases with time, the probability of renewed volcanism also increases).

3.2.4.3.3 Applicable Sections of 10 CFR Part 60

60.112

3.2.4.3.4 Key Documents to Consider

R M. Cranwell, R.V. Guzowski, J.E. Campbell, and N.R. Ortiz, "Risk Methodology for Geologic Disposal of Radioactive Waste: Scenario Selection Procedure," USNRC Report NUREG/CR-1667, in press.

U.S. Nuclear Regulatory Commission, Regulatory Guide 4.17, "Standard Format and Content Guide of Site Characterization Plans for High-Level Waste Repositories," Revision 1, March 1987. Copies are available from USNRC Division of Technical Information and Document Control, Washington, DC 20555.

U.S. Department of Energy, "Annotated Outline for Site Characterization Plans," OGR/B-5, April 1987.

3.2.4.4 Review Guide for Modeling

3.2.4.4.1 Background and Approach

Predictive modeling is a procedure for simulating the response of a system. For performance assessment, it is used for estimating the consequences of processes and events that are expected to occur in a repository system. The use of predictive modeling is necessary because it is not possible to ascertain, by direct observation, the consequences of all the physical processes relevant to the geologic disposal of high-level waste. Direct observation, either through field or laboratory experiments, is not possible for all processes because of both the spatial and temporal scales that must be considered in showing compliance with Sections 60.111, 60.112, 60.113, and 60.134 of 10 CFR Part 60. Although natural analog studies can provide insight on some of the relevant processes over large spatial and temporal scales, these studies are generally qualitative and cannot be used to resolve all of the pertinent issues. Predictive modeling used in conjunction with data from accelerated tests is expected to be used to help provide reasonable assurance that the performance objectives will be met (see Section 60.101(a)(2) of 10 CFR Part 60).

Predictive modeling may be divided into two major components: (1) conceptual models and (2) mathematical models. A conceptual model is composed of a set of hypotheses that delineates the behavior of a system. This set of hypotheses includes the identification of physical processes that affect the behavior of the system as well as the definition of the structure, geometry, initial and boundary conditions, and properties of the system. A mathematical model is the mathematical representation of the conceptual model. A mathematical model is normally composed of a set of coupled algebraic, differential, and/or integral equations with appropriate boundary conditions in a specified domain.

The SCP is expected to propose the use of predictive modeling to aid in repository design, to screen scenarios, and to assess the consequences of certain scenarios. It is also expected that modeling techniques will be applied for both data collection and reduction during site characterization. In many cases, it is necessary to use predictive models to transform observable data to a form that is useful in consequence analysis. For data collection activities, predictive modeling could be used for design of both field and laboratory experiments. Predictive modeling, when used in conjunction with sensitivity analysis (see Section 3.2.4.7), could also be used to guide the data collection activities of site characterization through the identification of important parameters. For these reasons, the SCP should include a description of the physical processes and domains modeled or to be modeled, and where any mathematical equations and boundary conditions are used, the analytical and numerical techniques used to solve the mathematical equations. The staff will focus its review on conceptual and mathematical models used to support the identification of parameters for performance issues developed in the performance allocation process. (See also the closely related review guide on model uncertainty, Section 3.2.4.5).

3.2.4.4.2 Criteria

A. Conceptual models.

1. Existing data and evidence from field and laboratory tests and natural analog studies should support the given conceptual model. Justification for neglecting any contradicting information or alternative interpretations should be clearly presented, or multiple conceptual models should be considered in the modeling uncertainty program (see Section 3.2.4.5).

2. Assumptions in conceptual models to be used for data reduction during site characterization should be consistent with those for use in consequence analysis.

3. The role of expert judgement in developing conceptual models should be documented (see Section 3.2.4.8).

B. Mathematical models.

1. Types and characteristics of mathematical models necessary to simulate the consequence of all significant scenarios should be identified. The use of these models to represent features, events, processes, or repository components or subsystems should be justified through a discussion of the assumptions, application(s), and limitations of the mathematical model. These should not contradict any of the hypotheses embedded in the corresponding conceptual model(s). If mathematical models of appropriate type or characteristics do not currently exist, activities to develop these should be identified.

2. Mathematical models should not be unnecessarily complex. All processes that could affect the model results should, however, be considered; decisions to omit certain processes should be technically justified.

3. The procedure to be used for implementing in the mathematical models for the investigations should be identified. The assumptions, application(s), and limitations of the procedures identified should be discussed.

4. The validation of mathematical models used in the SCP addressed. For those that have not been validated, the need to do so should be identified (see Section 3.2.4.5).

C. If a sequence of conceptual and/or mathematical models is used to represent a subsystem, a procedure to aggregate the results for the subsystem performance should be described that properly links the subsystem responses both spatially and temporally.

3.2.4.4.3 Applicable Sections of 10 CFR Part 60

60.101(a)(2)
60.111
60.112
60.113
60.134

3.2.4.4.4 Key Documents to Consider

U.S. Nuclear Regulatory Commission, Regulatory Guide 4.17, "Standard Format and Content Guide of Site Characterization Plans for High-Level Waste Repositories," Revision 1, March 1987. Copies are available from USNRC Division of Technical Information and Document Control, Washington, DC 20555.

U.S. Department of Energy, "Annotated Outline for Site Characterization Plans," OGR/B-5, April 1987.

3.2.4.5 Review Guide for Model Uncertainty

3.2.4.5.1 Background and Approach

Model uncertainty is the uncertainty introduced during the formulation of the conceptual models and the formulation and implementation of the mathematical models (see Section 3.2.4.4) that describe the behavior of the system, and its subsystems and components. Uncertainty is introduced during the formulation of a conceptual model by: (1) simplifying assumptions made about the behavior of the real system so that it may be represented by a tractable mathematical model; (2) insufficient data describing the real system or its various subsystems that force certain assumptions about their behavior; (3) all of the available data not supporting a single conceptual model; and (4) significant data describing the behavior of the real system being discarded because of preconceived notions about the system. Conceptual model uncertainty, which is uncertainty associated with the use and interpretation of the data, should not be confused with data uncertainty. The conceptual model includes implicit assumptions about the natural (spatial and temporal) variation of the data (see Section 4 2 4.6). Uncertainty can be introduced into the formulation and implementation of the mathematical model by: (1) uncertainty in the conceptual model carrying forward to the mathematical model; (2) difficulties that can be encountered in measuring the representative parameters required by the mathematical model; (3) the limited capability of mathematics to represent complex processes and their couplings; and (4) extrapolation into space and time of small-scale accelerated experimental results. If the mathematical model is implemented in a computer code, additional uncertainty may be introduced by: (1) coding errors; (2) computational limitations; (3) simplifying assumptions applied to the mathematical model to enhance computational efficiency; and (4) user error in the form of improper application of the computer codes and/or errors in the interpretation of the computational results.

The SCP is expected to address uncertainty associated with the formulation of conceptual models and the development and implementation of mathematical models. Site characterization activities are expected to be based largely on hypotheses regarding the behavior of the system (conceptual models) and the representation of the system mathematically (mathematical models). The identification of model uncertainties associated with both the data collection and data reduction activities of site characterization and the consequences analyses associated with performance assessment should be considered in the SCP.

The staff should review the SCP to determine whether or not modeling uncertainties have been addressed adequately. The review should emphasize the manner in which uncertainties in the formulation of conceptual models and the formulation and implementation of mathematical models are recognized and what their potential impact on site characterization and ultimately on performance assessment could be. Specifically, and as is brought out in more detail in the criteria below, the data and reasoning used to arrive at the conceptual and mathematical models should be examined to ensure that the stated conceptual model and mathematical models adequately address the full scope of physical processes in a consistent manner.

3.2.4.5.2 Criteria

Model uncertainty includes uncertainty in conceptual models and mathematical models. The SCP should address each of these areas and the plans should be reviewed with respect to the following criteria.

A. The SCP should identify or include provisions for identifying the areas of uncertainty in the development of conceptual models, accordingly:

   1. The simplifying assumptions should be addressed and shown to be consistent with the observed behavior of the real system.

   2. All of the available data should support the given conceptual model(s). If contradictory data or alternative interpretations exist, justification for neglecting these data or interpretations should be clearly stated or multiple conceptual models should be considered.

   3. The extrapolation and interpolation of data to address spatial distribution and gain insight on conditions not covered in experiments should be based on the use of well-established techniques (e.g., such as kriging for interpolation).

B. In each instance, the SCP should describe the potential effect of multiple conceptual models on estimated consequences and include a procedure for resolution of differences.

C. The SCP should identify or include provisions for identifying potential sources of uncertainty in the mathematical models.

   1. Assumptions embedded in the formulation and implementation of the mathematical model(s) should be consistent with the hypotheses embedded in the related conceptual model(s).

   2. Any simplifying assumptions should be a correct mathematical representation of the related physical process(es).

   3. The treatment of couplings between processes should represent the appropriate response of couplings in the real system.

   4. The treatment of the interdependence of parameters and temperature dependence of physical properties should be consistent with the responses observed in the real system.

D. At the performance issue level of detail, the SCP should describe the methodology used for addressing uncertainty in model results including quantifying and propagating uncertainties.

E. Investigations designed to validate key conceptual models should be given high priority.

3.2.4.5.3 Applicable Sections of 10 CFR 60

60.101
60.111
60.112
60.113
60.131
60.132
60.133
60.134
60.135

3.2.4.5.4 Key Documents to Consider

U.S. Department of Energy, "Annotated Outline for Site Characterization Plans," OGR/B-5, April 1987.

U.S. Nuclear Regulatory Commission, Regulatory Guide 4.17, "Standard Format and Content of Site Characterization Plans for High-Level Repositories," Revision 1, March 1987.

Summary of NRC/DOE Meeting on Level of Detail for Site Characterization Plans, May 8-9, 1986.

3.2.4.6 Review Plan for Analysis of Data Uncertainty

3.2.4.6.1 Background and Approach

Data uncertainty is the lack of assurance that the available data for a given site truly represents the conditions of the site. To a lesser degree, uncertainty will also exist in the data for the engineered components of the repository system. Data uncertainty arises from two sources. First there will be imprecision or error in the instruments and techniques used to obtain primary data (e.g., hydraulic head). Secondly, there may be errors in interpretation and analysis of the primary data, in arriving at coefficients and parameters used in describing the physical system (e.g., hydraulic conductivity). Data uncertainty is not to be confused with uncertainties arising from the use or interpretation of the data, such as spatial interpolation of the data (i.e., contouring or kriging the data) or assigning probability distributions to the data; these are conceptual model uncertainties. This section does not treat data uncertainty arising from naturally occurring variability which addressed under conceptual models (Sections 3.2.4.4. and 3.2.4.5.) The SCP is expected to include a description of the sources of data uncertainty along with consideration of the need to quantify and reduce this uncertainty in the site characterization investigations.

The quantification and reduction of uncertainty is important in the assessment of whether the plans proposed in the SCP will result in sufficient information to allow decisions to be made regarding compliance with the requirements of 10 CFR 60 at the time of licensing. These requirements pertain to the estimation (using models) of cumulative radionuclide releases, ground-water travel time, and radionuclide release rates from the engineered barrier system. Uncertainty in the collection and use of data in model development or as input to models and computer codes, is an important component of overall uncertainty.

The staff will review the SCP to determine whether or not the major sources of uncertainty in data have been identified and considered in the development of conceptual models as well as in its plans for investigations to determine parameters. Particularly, the review would emphasize the determination of the adequacy of approaches proposed to quantify uncertainty and reduce uncertainty in data.

3.2.4.6.2 Criteria

A. The sources of uncertainty in data used to develop conceptual models should be identified and addressed. The most important sources of data uncertainty that should be addressed in the plan are the following:

   1. Measurement errors caused by incorrect use of a given measuring technique statistical bias of the measurement

   2. An incomplete understanding of the spatial variability of data.

3. Misinterpretation of data caused by incorrectly assuming a priori the conditions of the system, and/or by using indirect observations to infer values of parameters.

4. Analysis and interpretation of data to obtain coefficient and Parameters such as hydraulic conductivity.

B. The SCP should describe the proposed use of techniques for analyzing and interpreting the data in investigations to determine parameters. Justification should be provided for the use as well as sufficient evidence that other more direct means of measuring given coefficient and parameters are not available.

C. The SCP should recognize the need for and propose developing approaches to reduce uncertainty in data.

3.2.4.6.3 Applicable sections of 10 CFR 60

60.101
60.111
60.112
60.113
60.122
60.130
60.131
60.132
60.133
60.134
60.135

3.2.4.6.4 Key Documents to Consider

U.S. Department of Energy, "Annotated Outline for Site Characterization Plans," OGR/B-5, April 1987.

U.S. Nuclear Regulatory Commission, Regulatory Guide 4.17, "Standard Format and Content of Site Characterization Plans for High-Level Repositories," Revision 1, March 1987.

Summary of NRC/DOE Meeting on Level of Detail for Site Characterization Plans, May 8-9, 1986.

3.2.4.7 Review Guide for Sensitivity Analysis

3.2.4.7.1 Background and Approach

Sensitivity analysis is a methodology for identifying and assessing the importance of the variables that affect the site performance parameters. Many variables can introduce uncertainty into the values of the performance and design parameter(s). However, all of these variables will not have the same impact. Sensitivity analysis can be used to identify the important variables that contribute to uncertainties. Sensitivity analysis should not be confused with uncertainty analysis. Uncertainty analysis involves the estimation of the probabilistic properties of the variables in the performance analyses. Sensitivity analysis involves determining the variables that influence performance parameters and their distribution.

In the SCP, it is not anticipated that sensitivity analyses will be a frequently used tool. However, at the investigation level, the SCP should present plans to identify and quantify important uncertainties that affect the performance parameters of a given site. This is necessary because reasonable assurance must be provided at the time of licensing that the engineered barrier system and the geologic setting conform with performance objectives and criteria.

This effort should be supported. where practicable, by appropriate sensitivity analyses. If a sensitivity analysis indicates that a certain performance parameter is important for resolving a performance issue and values for the parameter are not well known, the study(s) to determine the parameter will be essential. As addressed in more detail in the criteria stated below, the staff will review the SCP to determine the purpose, applicability, and completeness of the sensitivity analyses used or proposed, and the role it plays in the issue resolution strategy.

3.2.4.7.2 Criteria

In the SCP, sensitivity analyses should satisfy the following criteria:

A. The objective of the sensitivity analysis should be clearly stated. The sensitivity analysis should be used to identify important parameters so as to:

   1. Identify important sources of uncertainty in terms of parameters that most influence the results and the uncertainties associated with their values. (see Section 3.2.4.6)

   2. Identify influential parameters that must be considered for measurement and quantification during site characterization activities.

   3. Identify important parameters for model development.

B. The approach used for the sensitivity analysis in the SCP or proposed approaches to be used should be described. The description should include

the following, all of which should be applicable to the objective of the analysis.

1. Techniques used and the procedure to apply the techniques

2. The rationale for selecting the technique(s)

3. Inherent assumptions and limitations of the selected technique(s)

4. Method of presenting results of the sensitivity analysis

C. For sensitivity analyses to identify important parameters the following criteria should be met:

1. The criteria for deciding on the importance of parameters (i.e., ranking of parameters) should be such that no parameters are unnecessarily excluded.

2. The nature of the model used (i.e., complex vs. simple models; bounding models) should be appropriate for the purpose.

3. Validated models should be used to the extent practicable. If model(s) that have not yet been validated are used, the technical basis for using these models should be stated.

4. The ranges of values of parameters considered in the sensitivity analysis should be representative of expected repository conditions.

D. Sensitivity analysis used for or proposed for identifying important processes and the effect of modeling assumptions about these processes on performance assessment should be described.

1. Models used should be validated and for models not yet validated, the effect of using such models should be addressed.

2. The ranges of value of parameters governing these processes should be representative of expected repository conditions.

3.2.4.7.3 Applicable Sections of 10 CFR 60

60.101
60.111
60.112
60 113
60.122
60.130
60.131
60.132
60.133
60.134
60.135

3.2.4.7.4 Key Documents to Consider

U.S. Department of Energy, "Annotated Outline for Site Characterization Plans," OGR/B-5, April 1987.

U.S. Nuclear Regulatory Commission, Regulatory Guide 4.17, "Standard Format and Content of Site Characterization Plans for High-Level Repositories," Revision 1, March 1987.

Summary of NRC/DOE Meeting on Level of Detail for Site Characterization Plans, May 8-9, 1986.

R.L. Iman and W.J. Conover, "Sensitivity Analysis Techniques: Self-Teaching Curriculum," U.S. NRC Report, NUREG/CR-2350, 1983.

R.M Cranwell, J.E. Campbell, J.C. Helton, R.L. Iman, et al, "Risk Methodology for Geologic Disposal of Radioactive Waste: Final Report," U.S. NRC Report, NUREG/CR-2452, August, 1987.

R.L. Iman and J.C. Helton, "A Comparison of Uncertainty and Sensivity Analysis Techniques for Computer Models," U.S. NRC Report, NUREG/CR 3904, May 1985.

3.2.4.8 Review Guide for Formal Use of Expert Judgment

3.2.4.8.1 Background and Approach

The formal use of expert judgement is a systematic, documented technique for eliciting and reporting the opinions of panels of experts who have been selected and who have worked according to methods that are generally accepted in the scientific literature on subjective judgement. The formal use of expert judgement is highly structured and is intended to be a way of drawing inferences from sparse data and assessing the uncertainty of those inferences. It is not the same as the routine use of expert judgement that is part of any scientific or engineering investigation or design process. The formal use of expert judgement should also be distinguished from the formal use of peer review, another process in which expert panels are used (See Section 3.3.28). The formal use of expert judgement is directed toward drawing inferences where hard data and facts are few, whereas peer review is an independent critique of the way data and information are analyzed or of conclusions drawn from those analyses. Thus, a peer review of an application of formal use of expert judgement is possible and even likely in some instances. As with peer review, the formal solicitation and use of expert judgement should be a documented process.

The SCP is expected to include the formal use of expert judgement in the development of investigations. For example, formal use of expert judgement might have been applied to formulate hypotheses that are the basis for site characterization investigations such as screening scenarios. Also, formal use of expert judgement might be applied to estimate quantitative values of certain parameters or to draw qualitative conclusions when other approaches are unavailable.

Finally, formal use of expert judgement might play a major role in the interpretation of data (including the determination of distributions of parameters): assignment of probabilities of occurrence to scenarios; and the formulation and validation of conceptual and mathematical models.

During the licensing process, results of the formal use of expert judgement will not be accepted without question. Instead, the facts and reasoning used by experts to reach their conclusions will be examined independently. In reviewing the SCP, the staff will determine whether the formal use of expert judgement is proposed or was applied only when more objective approaches were found to be unavailable. Where such approaches are shown to be unavailable, the staff should determine whether formal use of expert judgement was applied or is proposed to be applied in a manner that will yield an adequate basis for NRC staff review of the license application.

3.2.4.8.2 Criteria

The formal use of expert judgement either in the SCP or proposed for use in the site characterization program should meet the following criteria.

A. In general, the formal use of expert judgement should be relied upon only when other sources of information such as experimental data, quantitative analyses, and historical data are not reasonably obtainable.

B. Problems addressed through the formal use of expert judgement should be identified.

   1. Problems to be addressed by experts should be explicitly identified. The importance of these issues should be stated.

   2. The reasons that particular problems were identified for formal use of expert judgement should be stated. The reasons that alternate approaches were not adopted should be presented to provide assurance that the formal use of expert judgement was not adopted when other approaches, such as data collection, were available.

C. The methodology used in the decomposition of problems should be described and should include:

   1. A description of the scope of the problem addressed by experts

   2. A technique to assure that the problem is well-formulated and tractable. Also, assurance should be provided that all important aspects of the problem have been included.

   3. A description of the approach to decomposing the problem into subproblems. Also, the procedures to integrate the answers from each subproblem to provide an answer for the overall problem should be documented.

D. The criteria for selecting experts that have a substantive knowledge of the problem should be described.

E. For evidence presented to experts, as a basis for developing opinions or recommendations, the nature of the data (quantitative vs. qualitative) and the source of the data (laboratory vs. field; actual site vs. generic site) should be identified.

F. The methodology for eliciting and applying expert judgment should be discussed. The approach should be logical and systematic.

   1. The approach to provide normative training (training in techniques for treating uncertainties and estimating probabilities) to experts should be addressed to assure that they can incorporate uncertainties in their estimates.

   2. The reasoning used by the experts to arrive at their estimates should be documented.

G. Whenever possible, the SCP should provide for the calibration of the estimates made by experts. Calibration techniques should include:

1. A feedback mechanism for the calibration of estimates by experts against data collected during site characterization.

2. The use of new data to refine estimates (test assumptions and reduce uncertainties) or to result in new estimates (provide for alternative interpretations).

H. Any problems to be addressed by the formal use of expert judgement as part of a site characterization investigation should be identified and described.

3.2.4.8.3 Applicable Sections of 10 CFR Part 60

60.101
60.111
60.112
60.113
60.122
60.130
60.131
60.132
60.133
60.134
60.135

3.2.4.8.4 Key Documents to Consider

U.S. Department of Energy, "Annotated Outline for Site Characterization Plans," OGR/B-5, April 1987.

U.S. Nuclear Regulatory Commission, Regulatory Guide 4.17, "Standard Format and Content of Site Characterization Plans for High-Level Repositories," Revision 1, March 1987.

U.S. Nuclear Regulation Commission/U.S. Department of Energy, Summary of NRC/DOE Meeting on Level of Detail for Site Characterization Plans, May 8-9, 1986.

A. Mosleh, V.M. Bier, and G. Apostolakis, "Methods for the Elicitation and Use of Expert Opinion in Risk Assessment, Phase 1," USNRC Report, NUREG/CR-4962, August 1987.

M.A. Meyer, and J.M. Booker, "Sources of Correlation Between Experts: Empirical Results of Two Extremes," USNRC Report, NUREG/CR-4814, April 1987.

U.S. Department of Energy, Summary of the Briefing on the DOE Issue Hierarchy and Issue Resolution Strategy. October 8 & 9, 1987.

3.2.4.9 Review Guide for Compliance Assessment with the EPA Containment Requirement

3.2.4.9.1 Background and Approach

The NRC's overall system performance objective for the repository after permanent closure (Section 60.112 of 10 CFR Part 60) is designed to implement the containment requirement of the EPA Standard* (Section 191.13 of 40 CFR Part 191). The requirement is that a repository protect the public from significant radiation doses by limiting the radioactivity released to the accessible environment for up to 10,000 years after repository closure. Compliance with the containment requirement is to be shown based upon a performance assessment that must include: (1) an identification of events and processes that might affect the disposal system; (2) an estimate of the likelihood of occurrence of these events and processes; (3) an examination of the effects of these events and processes on the performance of the disposal system; and (4) an estimate of the cumulative release of radionuclides, considering the associated uncertainties, caused by all significant events and processes. It is expected that the results of the performance assessment will be incorporated into an overall probability distribution of cumulative release, to the extent practicable. A commonly used type of distribution would indicate the probability of exceeding various levels of cumulative releases. The means of displaying such a probability distribution is called a complementary cumulative distribution function (CCDF), which is one (1) minus the integrated value of the probability density function.

It is expected that the SCP will address the containment requirement by discussing a probabilistic approach to compliance demonstration and identifying the information needs of this approach. This information is important in evaluating the acceptability of the proposed probabilistic approach in showing compliance with the containment requirement, and the sufficiency of the plan to provide site-specific data for use in compliance demonstration at the time of license application.

The staff will review the SCP to assess whether the plan will result in the information necessary to evaluate compliance with the containment requirement. The staff will review both the plans to use methodologies specified in the SCP and the plans to develop such methodologies. In addition, regardless of whether a CCDF or some alternate approach is identified in the SCP, the staff review should ascertain that an acceptable method of consolidating the results of performance assessment has been presented or proposed.

In June 1986, the Commission requested comment on proposed amendments to conform existing 10 CFR Part 60 with 40 CFR Part 191. Based on comments received, the Commission prepared final amendments; in July 1987, however, the U.S. Court of Appeals for the First Circuit vacated the EPA Standard and remanded it to the Agency for further consideration. Accordingly, the final amendments have not been issued. Lacking a final standard, this review guide is based on the existing standard.

3.2.4.9.2 Criteria

A. The SCP should present the approach for demonstrating compliance with the containment requirement. The following four steps should be included in the approach.

1. An identification of events and processes that might affect the disposal system. Events and processes can be combined to construct scenarios which may be analyzed if the scenario probability warrants this (see Section 3.2.4.1).

2. An estimate of the likelihood of occurrence of these events and processes (see Section 3.2.4.3).

3. An analysis of the effects of these events and processes on the performance of the disposal system (see Section 3.2.4 4). Effects of events and processes may be estimated by performing multiple deterministic calculations with computer codes or by using analytical solutions.

4. The consideration of uncertainties in the estimate of cumulative releases (see Sections 3.2.4.1, 3.2.4.5 and 3.2.4.6), and the relative significance of these uncertainties (see Section 3.2.4.7).

The following specific criteria are needed in the approach to develop a CCDF that is used to present the results of a performance assessment:

5. The scenarios used in generating the CCDF would be mutually exclusive. (See Section 3.2 4.1)

6. The sum of the probabilities of the scenarios would be less than or equal to unity.

7. The CCDF (or a family of CCDFs) would incorporate estimated uncertainties in the scenario probabilities.

3.2.4.9.3 Applicable Sections of 10 CFR Part 60

60.112
60.113(a)(1)

3.2.4.9.4 Key Documents to Consider

Sandia National Laboratories, Fuel Cycle Risk Analysis Division, "Technical Assistance for Regulatory Development: Review and Evaluation of the Draft EPA Standard 40 CFR 191 for Disposal of High-Level Waste," Vols. 1-6, USNRC Report NUREG/CR-3235, April 1983.

U S. Nuclear Regulatory Commission, Regulatory Guide 4.17, "Standard Format and Content Guide of Site Characterization Plans for High-Level Waste Repositories," Revision 1, March 1987.

U.S. Department of Energy, "Annotated Outline for Site Characterization Plans," OGR/B-5, April 1987.

3.2.4.10 Review Guide for Preclosure Analysis

3.2.4.10.1 Background and Approach

It is anticipated that the SCP will present procedures to develop information, models and data for both surface and subsurface facilities at the repository site to show compliance with the radiological criteria of 10 CFR Part 20, 40 DFR Part 191, Subpart A. These procedures should in turn provide reasonable assurance that applicable severity categories of 10 CFR Part 2 Appendix C will not be exceeded. Thus, at a broad level of detail the SCP is expected to describe a methodology for analyzing important scenarios* (sequences for both normal operation, anticipated operational occurrences, and accident conditions during pre-closure) and estimating their consequences. Alternatively, where there are gaps in the methodology, the need to complete the methodology would be described. These methodologies would be used in the SCP as a basis for identifying parameters (needed information) that will be determined during site characterization.

3.2.4.10.2 Criteria

The methodology for preclosure analysis to be used in preparing the SCP should meet the following criteria:

A. The scenarios for exposure to and release of radionuclides to both the restricted and unrestricted areas should follow criteria similar to the criteria identified in Section 3.2.4.1 on scenario development and screening, and Section 3.2.4.3 on estimating scenario probabilities. Methodology used to generate these scenarios should also meet the following criteria.

   1. Initiating events of accidents should include (as a minimum) those listed in 10 CFR Parts 60.131 through 60.133.

      a. Natural phenomena and environmental conditions (such as earthquakes, landslides, floods, and accidents caused by rain, sleet, snow, tornadoes, wind)

      b. Dynamic effects of equipment failure and similar events

      c. Fires and explosions

      d. Failure of utility services

      e. Failures leading to criticality

      f. Failures of instruments and controls

*In this guide, the word scenario, which is frequently referred to as an "accident sequence" in engineering reports' is used to provide consistency in terminology between this guide and other guides.

g. Failure of waste handling equipment (e.g. hoists, cranes, etc.)

h. Human (operator) error

i. Subsurface structure failure (loss of ground support, rockburst etc.)

j. Failure (including aging) of structures and equipment

k. Engineering and operational changes during the lifetime of the facility.

2. The selection of a comprehensive set of scenarios for the subsurface and surface facilities (emplacement, waste handling, etc) should:

   a. Consider possible mechanisms and timing for releases from the waste packages and the ventilation system. The SCP should contain a description of how the initial inventory and the source term will be determined. It should be stated whether some fixed fraction of the total inventory is assumed to be released or whether the accident is independently modeled to determine the released fraction

   b. Provide the basis for the determination of the quantity of release (taking into account deposition and containment mechanisms inside the GROA)

3. The identification of systems, structures, and components important to safety should satisfy the criteria identified in Section 3.3.30 on items and activities subject to QA procedures.

4. Show that the applicable release and exposure criteria can be met for margins of safety selected.

B. Models for consequence analyses described in the SCP should permit assessment of compliance with the applicable exposure and concentration limits specified in 10 CFR 20, 40 CFR 191, Subpart A, and 10 CFR Part 2, Appendix C.

1. The SCP should recognize the need to identify and assess the impact of other site-specific factors that could significantly affect the performance of the GROA, such as features of the site, meteorology (see Section 3.3.18), and population density.

2. As applicable, the SCP should consider the transport of radionuclides from the GROA into the terrestrial, atmospheric and aquatic environments (resuspension and surface deposition should be included for the atmospheric pathway).

C. Models for consequence analyses (including accident scenarios) should satisfy the criteria given in Section 3.2.4.4 on modeling, Section 3.2.4.5 on model uncertainty, and Section 3.2.4.7 on sensitivity analysis.

3.2.4.10.3 Applicable Sections of 10 CFR 60

60.2
60.21(c)(1)
60.21(c)(1)(ii)(A)
60.21(c)(1)(ii)(E)
60.21(c)(1)(ii)(F)
60.21(c)(3)
60.21(c)(5)
60.101(a)(2)
60.111(a)
60.122(b)(6)

3.2.4.10.4 Key Documents to Consider

P.A. Harris, D.M. Ligon, and M.G. Stamatelatos, GA Technologies, Inc. "High-Level Waste Preclosure Systems Safety Analysis, Phase I, Final Report", USNRC Report NUREG/CR-4304, July 1985.

E M. Ligon, M.G. Stamatelatos, A.W. Barsell, and C.A. Bolig, GA Technologies, Inc., "High-Level Waste Preclosure Systems Safety Analysis, Phase 2, Final Report", USNRC Report NUREG/CR-4846, June 1987.

D.R. Gallup, D.W. Whitehead, and M.G. Vannoni, Sandia National Laboratories, "A Method for Using PRA to Establish Quality Assurance Program Applicability" USNRC Report NUREG/CR-4678, August 1986.

U.S. Nuclear Regulatory Commission, "PRA Procedures Guide", USNRC Report NUREG/CR-2300, Vols. 1-2, 1983.

D.L. Strenge, Battelle-Pacific Northwest Laboratory, "Models Selected for Calculation of Doses, Health Effects and Economic Costs Due to Accidental Radionuclide Releases from Nuclear Power Plants," USNRC Report NUREG/CR-1021, May 1980.

U.S. Nuclear Regulatory Commission, "Radiological Assessment, A Textbook on Environmental Dose Analysis," USNRC Report NUREG/CR-3332, September 1983.

U S. Nuclear Regulatory Commission, "Handbook of Reliability Analysis With Emphasis on Nuclear Power Plant Applications," USNRC Report NUREG/CR-1278, August 1983.

3.2.4.11 Review Plan for Performance Confirmation

3.2.4.11.1 Background and Approach

Performance confirmation is a program, of tests, experiments and analyses which is conducted to evaluate the accuracy and adequacy of the information used to determine, with reasonable assurance, that 60.112 and 60.113 will be met. It will include determining parameters, responses (e.g., rock mass, hydrologic), and conditions (disturbed or undisturbed) in order to compare the measured data with assumed or predicted behavior. Initially, performance confirmation is a subpart of site-characterization. It is meant to provide, for parameters and processes, baseline information that may be altered by further site characterization and/or construction and/or operation activities. Subsequent to construction authorization, the performance confirmation program is meant to monitor changes from the baseline condition of parameters that could affect repository performance. In so doing, it should provide confirmation of the conceptual and mathematical models used in licensing a repository.

Section 60.137 requires a performance confirmation program that meets the requirements set forth in Subpart F of Part 60. 60.140(b) explicitly states that performance confirmation should start during the site characterization phase and continue until permanent closure. The SCP should present a discussion on the performance confirmation program, and how the program intends to meet the requirements of Subpart F. A comparison of the performance confirmation data with the original design bases and assumptions will be useful in assessing whether the performance of the natural and engineered features are within design limits. Performance confirmation data will help detect any substantial deviations from expected (or assumed) performance. It is expected that the license amendment for permanent closure or a decision to retrieve will depend on the results of the performance confirmation program.

The staff will review the SCP to determine if the plan considers those aspects of the performance confirmation program that need to be implemented during site characterization and if the plan provides, as appropriate, for performance confirmation during construction and operation of the repository. Discussions in the SCP for the performance confirmation program during site characterization should be considerably more detailed than those for the program during construction and operation. Because of the long-term and first-of-a-kind nature of the performance confirmation program, the staff may find that the criteria below are insufficient to review the SCP and may need to supplement them during the course of the SCP review.

3.2.4.11.2 Criteria

Discussions in the SCP pertaining to performance confirmation should satisfy the following criteria:

A. The SCP should recognize a need to identify performance confirmation parameters. Performance confirmation parameters should include parameters needed for confirming and validating the conceptual and mathematical models proposed for use in the performance assessment program to show compliance with 60.112 and 60.113.

B. Parameters for which performance confirmation will be initiated during site characterization should be identified as such.

1. The parameters on which the repository design is based should be baselined during site characterization.

2. Parameters for long-term performance confirmation should be identified before exploratory shaft sinking and drifting.

3. Data to establish subsurface baseline conditions should be collected before repository construction.

4. Performance confirmation activities should not adversely affect the ability of the natural and engineered elements of the repository system to meet the performance objectives.

C. The SCP should address the relationship between the site characterization and construction and operation phases of the performance confirmation program.

3.2.4.11.3 Applicable Sections of 10 CFR Part 60

60.2
60.137
60.140
60.141
60.142
60.143

3.2.4.11.4 Key Documents to Consider

U.S. Nuclear Regulatory Commission, Generic Technical Position, "In Situ Testing During Site Characterization for High-Level Nuclear Waste Repositories."

U.S. Department of Energy, "Annotated Outline for Site Characterization Plans," OGR/B-5, April 1987.

U.S. Nuclear Regulatory Commission, Regulatory Guide 4.17, "Standard Format and Content Guide of Site Characterization Plans for High-Level Waste Repositories," Rev. 1, March 1987.

3.2.5 Review Guide for Exploratory Shaft Facility

3.2.5.1 Background and Approach

In the SCP, it is anticipated that the exploratory shaft facility details will include a description of the plans and procedures for the construction of exploratory shafts, underground test areas and exploratory drifts. It is expected that the details will also include facility location rationale, construction testing, and inspection plans; plans for gathering specific information related to site characterization; and shaft and seal design considerations. It is also expected that the SCP will provide an analysis of the effects of exploratory shaft facility construction and in situ testing on long-term performance of the geologic repository.

The NRC has raised concerns and questions with the DOE on information needs and performance related issues for the Exploratory Shafts in letters to the DOE, dated April 1983. The staff should review the SCP information on exploratory shaft facility design, construction, exploration testing, and performance with the following two broad concerns in mind: 1. The site characterization activities will not compromise subsequent long-term isolation and containment capabilities of the repository. 2. Plans for construction of the exploratory shaft facility will not preclude the acquisition of adequate information for site characterization.

The detailed criteria below should be used to review appropriate portions of SCP Chapter 8 and the design acceptability analysis, which will be provided separately from the SCP. Existing information presented in Chapters 1-7 relevant to the criteria given below and any staff concerns regarding this material should also be considered in the review of Chapter 8.

This review guide focuses on the design and construction testing aspects. The testing in the area of geology, hydrology etc., is considered in detailed review criteria for these disciplines. General considerations are provided in Criterion A. Considerations relative to key site-specific topics that should receive special attention are provided in Criterion B, and Criterion C identifies the considerations for the design acceptability analysis.

3.2.5.2 Criteria

A. The conceptual design description and program of activities related to exploratory shaft facility should provide an adequate consideration of the following items with consideration of the performance allocation for the topic:

   1. Rationale for the Exploratory Shaft Location, including:

      a. flooding potential through surface and other sources of water
      b. ability to obtain representative site characterization information
      c. adequate separation distance from other shaft(s)
      d. adequate separation from the long-term influence of the waste package heat source

2. The SCP should contain a technical rationale based on analyses to demonstrate that interferences and interactions among tests, construction, and operation have been factored into the design of the underground layout for site characterization testing. Alternative concepts should be considered in arriving at the final design of the access from surface to the underground test area, layout, and construction method that provides a clear advantage from the point of view of long-term waste isolation characteristics.

3. Construction Plans and Procedures

   a. techniques employed to inflict minimal damage (fracturing) to rock units and mitigative measures
   b. excavation experience in similar rock types under similar conditions
   c. stability of openings, support requirements

4. Construction Testing

   a. mechanical characteristics of the zone surrounding the opening
   b. effect of damaged zone on seal installation

5. Characterization of Rock Above and Below Repository Level

   a. important geologic. hydrologic and geochemical aspects of characteristics around shaft openings
   b. water inflow through discrete faults and fractures
   c. effects of shaft construction method on ability to collect information

6. Seal Design Considerations

   see Review Guide on "Borehole and Shaft Seals"

7. Performance Analysis

   a. preliminary performance assessment that accounts for appropriate degree of reliability of seal design and placement
   b. see also Review Guide for "Compliance Assessment with the EPA Containment Requirement"

8. Test Area Layout

   a. see Review Guide for "Geomechanics Testing"

9. Exploratory Drifts and Coreholes

   a. direction, length, and size of drifts, based on need for site characterization

b. investigation of specific target features of interest (such as adverse anomalies)
c. design of exploratory drilling (core drilling) from the exploratory drifts
d. see Review Guide for Geomechanics Testing

B. DOE's Design Acceptability Analysis should meet the appropriate quality assurance requirements of 88-9 and address items (1) and (2) below.

1. An analysis of 10 CFR Part 60 requirements which:

a. identifies all 10 CFR Part 60 requirements that are applicable to design and construction;
b. evaluates design interfaces; and
c. generates design criteria based on (a) and (b) or demonstrates how the current design criteria used for the Title I addresses (a) and (b).

2. An analysis of the current design against the design criteria generated under 1(c). This analysis should demonstrate that the ESF design and construction satisfy the three general objectives in 10 CFR Part 60. These are: (1) the long-term waste isolation capability of the site is not compromised; (2) the ability to characterize the site is not compromised; and (3) the ESF site characterization activities would provide representative data. This analysis should also address the appropriateness of the data used in the design and how the uncertainties were considered. The analysis is not intended to meet NUREG-1298, "Qualification of Existing Data for HLW Repositories," but will demonstrate the reasonableness of the data for the type of analyses being performed.

C. The ESF design description, identification of parameters, and program of activities should provide an adequate consideration of the following key site-specific topics:

1. Yucca Mountain Site

a. proposed exploratory shaft location at the edge of wash area (flooding concern)
b. interference from construction of nearby second shaft
c. alternate ESF design concepts and construction methods
d. representativeness of data from ESF and need for exploration of south side of repository block
e. investigations of the effects of natural and man-made vibrations on underground openings and seals (effects of seismotectonic events, underground nuclear explosions, etc.)
f. investigations of the effects of rock movements on underground openings, seals and waste packages

3.2.5.3 Applicable Sections of 10 CFR 60

10 CFR 60.2
10 CFR 60 15
10 CFR 60.16
10 CFR 60 17
10 CFR 60.18
10 CFR 60.112
10 CFR 60.113
10 CFR 60.134
10 CFR 60.137
10 CFR 60.140
10 CFR 60.142
10 CFR 60.151
10 CFR 60.152

3.2.5.4 Key Documents to Consider

U.S. Government Printing Office. Code of Federal Regulations. 10 CFR 60, "Radioactive Wastes in Geologic Repositories." Washington, DC: U.S. Government Printing Office, January 1987.

U.S. Nuclear Regulatory Commission, Regulatory Guide 4.17, "Standard Format and Content of Site Characterization Plans for High-Level Waste Geologic Repositories."

U.S. Department of Energy. "Annotated Outline for Site Characterization Plans," DOE Report DOE/RW-0142 (OGR/B-5), April 1987.

U.S. Nuclear Regulatory Commission. Draft Issue-Oriented Site Technical Position, "NNWSI Repository Design/Rock Mechanics."

U.S. Nuclear Regulatory Commission, "Generic Technical Position on Design Information Needs in Site Characterization Plans."

U.S. Nuclear Regulatory Commission, "Generic Technical Position on Borehole and Shaft Seals."

U.S. Nuclear Regulatory Commission, "Generic Technical Position on In-Situ Testing During Site Characterization."

U.S. Nuclear Regulatory Commission, "Draft Generic Technical Position on Interpretation and Identification of the Disturbed Zone."

U.S. Nuclear Regulatory Commission, "Draft Generic Technical Position on Items and Activities in the HLW Geologic Repository Program Subject to 10 CFR Part 60 Quality Assurance Requirements."

U.S. Nuclear Regulatory Commission, "Generic Technical Position on Qualification of Existing Data."

U.S. Nuclear Regulatory Commission, "Generic Technical Position on Peer Review."

U.S. Nuclear Regulatory Commission/U.S. Department of Energy, "Summary of the NRC/DOE Meeting on the Level of Detail for Site Characterization Plans and Study Plan," May 7-8, 1986.

U.S. Nuclear Regulatory Commission/NNWSI, "Summary of the NRC-NNWSI Project Exploratory Shaft Design/Construction Meeting," August 27-28, 1985.

U.S. Nuclear Regulatory Commission/NNWSI, "Summary of the NRC-NNWSI Project Meeting on Proposed Changes to the NNWSI Project Exploratory Shaft Facility," April 14-15, 1987.

Letters from NRC to DOE, Subject: Information Considered Necessary Regarding Exploratory Shaft Construction and Sealing (all sites), dated April 14, 1983.

U. S. Nuclear Regulatory Commission, "Draft Technical Position on Postclosure Seals in an Unsaturated Medium."

3.2.6 Review Guide for Milestones and Schedule

3.2.6.1 Background and Approach

Details of milestones and sequencing of tests and analyses that are presented for each investigation/activity in SCP Section 8.3 are reviewed in accordance with applicable criteria in Section 3.2.3 of this document. However, Section 8.5 of the SCP presents a compilation of the milestones and decision points established for the overall characterization program. The schedule presented in this section is reviewed on a broad programmatic level, in accordance with the following criteria.

3.2.6.2 Criteria

A. The overall schedule of characterization program activities should be such that it represents proper sequencing, considering the interrelationships and interferences among the activities.

B. The overall program duration should be realistic and should be based on a goal of adequately obtaining the information needs, so that they can be used at the time of license application.

C. The schedule should appropriately identify the key stages in the characterization program' when options would be assessed and decisions would be made as to how to proceed (hold points, readiness reviews, NRC consultation, etc.).

3.2.6.3 Applicable Sections of 10 CFR Part 60

N/A

3.2.6.4 Key Documents to Consider

U.S. Nuclear Regulatory Commission, Regulatory Guide 4.17, "Standard Format and Content of Site Characterization Plans for High-Level Waste Geologic Repositories, Rev. 1, March 1987, Sections 8.6, 8.7.

U.S. Department of Energy, "Annotated Outline for Site Characterization Plans," OGR/B-5, April 1987, Section 8.5.

3.2.7 Review Guide for QA Program

3.2.7.1 Background and Approach

In accordance with the requirements of 10 CFR Part 60, Subpart G - "Quality Assurance," DOE is required to implement a QA program, based on the criteria of Appendix B to 10 CFR Part 50, for its conduct of site characterization activities. For each of the criteria in Appendix B, the NRC staff positions and information that needs to be addressed have been identified in Appendix A of the NRC Review Plan, "QA Program for Site Characterization of High-Level Nuclear Waste Repositories." DOE has submitted specific QA plans to NRC for advance review. NRC staff have reviewed these plans, and resolution of significant outstanding issues should be completed before site characterization activities begin.

In light of this advance review, much of the review of the QA discussion in the SCP (Section 8.6), as required by the following criteria, will be to ensure consistency with the advance detailed QA plans. More specific criteria pertinent to review of the items and activities subject to QA requirements, qualification of existing data, peer review, and software QA procedures, are provided in Sections 3.3.27 through 3.3.30 of this document. Since discussion of specific QA measures to be applied to tests and analyses will be included at the study plan level, these specific aspects of the QA program will not be an item of the SCP review. They will be addressed as part of the NRC staff's review of study plans, when they are issued.

3.2.7.2 Criteria

A. The following information areas should be addressed in the SCP; should generally meet applicable criteria provided in Appendix A of the NRC's "Review Plan: QA Programs for Site Characterization of High-Level Nuclear Waste Repositories"; and should be reasonably consistent with the site-specific QA plan NRC staff previously evaluated:

   1. Listing of the HQ and site-specific QA plans of the participating organizations,

   2. General approach of how QA will be applied to site characterization,

   3. Summary of the regulatory requirements, regulatory guidance, DOE documents, and national standards on which the QA plan and criteria are based,

   4. Organizational charts and a description of the specific responsibility of the HQ and project participants, and

   5. Discussion of the administrative QA procedures to be applied to site characterization.

3.2.7.3 Applicable Sections of 10 CFR Part 60

60.150
60.151
60.152

3.2.7.4 Key Documents to Consider

10 CFR Part 50, Appendix B, "Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants."

U.S. Nuclear Regulatory Commission, "Review Plan: Quality Assurance Programs for Site Characterization of High-Level Nuclear Waste Repositories," June 1984.

QA Plan review correspondence

3.2.8 Review Guide for Consideration of CDSCP Final Point Papers

3.2.8.1 Background and Approach

The NRC staff reviewed the CDSCP for the Yucca Mountain site and provided concerns for consideration by the DOE in their development of the SCP. Therefore, this review guide addresses the staff's follow-up of these concerns to determine if they have been adequately addressed in the SCP. Based on the review of the related SCP contents in Chapter 8 performed in accordance with Sections 3.2.2 through 3.2.5 of this review plan, conclusions should be made with regard to how the NRC's CDSCP concerns are addressed in the SCP. It is anticipated that DOE will provide comment resolution sheets along with the SCP. These sheets will explain how DOE resolved in the SCP each of NRC's CDSCP concerns.

3.2.8.2 Criteria

A. The planned characterization programs should be such that the appropriate site-related concerns expressed in NRC's CDSCP Final Point Papers are adequately addressed in the SCP.

3.2.8.3 Applicable Sections of 10 CFR Part 60

N/A

3.2.8.4 Key Documents to Consider

U. S. Nuclear Regulatory Commission, "NRC Staff Review of the Department of Energy's January 8, 1988, Consultation Draft Site Characterization Plan for the Yucca Mountain Site, Final Point Papers," May 11, 1988.

3.3 Detailed Review Guides

3.3.1 Review Guide for Geomorphic, Physiographic, and Topographic Information and Investigations

3.3.1.1 Background and Approach

In the SCP, it is anticipated that the site program will include plans for investigations of the geomorphic, physiographic, and topographic features, as needed, for issues resolution and a basic understanding of the site. An understanding of geomorphic processes and events is necessary both for the siting of the preclosure facilities, and for projection of effects on the ability of the site to meet the performance objectives during the post closure. The physiographic and topographic features of the site and region can provide important clues as to the geology of the geologic setting, not only in the area of geomorphology, but as a means of evaluating the basic structure, stratigraphy and tectonic processes which are operating or may have operated in the geologic setting. These processes, events, and conditions are important considerations in developing site-specific scenarios, conceptual models, numerical models and designs.

The detailed criteria below should be used in conjunction with the general review criteria for parameter identification in Section 4.2.2 and investigations and activities in Sections 4.2.3 and 4.2.4, to review appropriate portions of SCP Chapter 8. Existing information presented in Chapters 1-7 relevant to the criteria given below and any staff concerns regarding this material should also be considered in the review of Chapter 8.

General considerations are provided in Criterion A, while considerations relative to key site-specific topics that should receive special attention in the review, are provided in Criterion B.

3.3.1.2. Criteria

A. The identification of parameters and program of investigations related to geomorphology, physiography and topography should provide an adequate consideration of the following items, with consideration of the performance allocation for the topic:

1. The physiographic provinces within a 200-mile radius including:

    a. aerial extent
    b. relationship to other provinces
    c. distinguishing characteristics
    d. major geologic activity(s) responsible for its formation
    e. major geologic activity modifying the present land forms

2. The geomorphic units and features within and abutting the controlled area, including:

    a. aerial extent
    b. relationship to other geomorphic units and features

c. distinguishing characteristics
d. major geologic activity(ies) responsible for the formation of the unit or feature
e. major geologic activity(ies) modifying the present landforms

3. The geomorphic processes which are acting or could be acting within the geologic setting, including information on the:

a. location of the processes
b. nature of the processes
c. rate of the processes
d frequency of the processes
e. cycle of the processes
f. controlling mechanism for the processes

4. The paleogeomorphic processes which have occurred, could have occurred, or could reoccur within the geologic setting, including such information as the:

a. location of the processes
b. nature of the processes
c. rate of the processes
d. frequency of the processes
e. cycle of the processes
f. controlling mechanism for the processes

5. The paleo conditions which can be deduced from the geomorphic studies, such as climatalogical variations and paleo surface and groundwater conditions.

6. The location, nature and extent of known or suspected geomorphic features within the geologic setting.

7. Reasonable assurance that areas studied are representative of physiographic, topographic, and geomorphic conditions throughout the site.

B. The identification of parameters and program of investigations should provide an adequate consideration of the following items (information/parameter needs and possible methodologies) for key site-specific topics (with consideration of performance allocation for the topic):

1. Yucca Mountain site:

a. erosion

(1) potential maximum rate of erosion in the vicinity of the exploratory shaft facility
(2) potential maximum rate of erosion in the area of the waste handling facilities

(3) potential maximum rate of erosion of repository overburden
(4) potential maximum rate of erosion in adjacent or overlying wash areas

b. features resulting from geomorphic processes

(1) locations and characteristics of paleo spring deposits
(2) locations and characteristics of landslide areas

c. paleoclimate

(1) pleistocene climatic variations
(2) effect of variations on
- effective precipitation,
- water table,
- springs
- carbonate deposition

3.3.1.3 Applicable sections of 10 CFR Part 60

Lead	Input
60.21(c)(1)	60.21(c)(2)
60.122(a)	60.21(c)(3)
60.122(b)(1)	60.21(b)(8)
60.122(b)(5)	60.21(c)(5)
60.122(c)(3)	60.21(c)(6)
60.122(c)(6)	60.21(c)(20)
60.122(c)(10)	60.21(c)(22)
60.122(c)(16)	60.111
	60.112
	60.113
	60.130-135

3.3.1.4 Key Documents to Consider

U.S. Department of Energy, "Annotated Outline for Site Characterization Plans," USDOE Report OGR/B-5, April 1987.

U.S. Department of Energy and Geological Survey, U.S. Department of Interior, "Earth Science Technical Plan for Disposal of Radioactive Waste in a Mined Repository," USDOE Draft Report DOE/TIC-1033, April 1980.

U.S. Department of Energy, "NWTS Program Criteria for Mined Geologic Disposal of Nuclear Waste: Site Performance Criteria," USDOE Report DOE/NWTS-33/2, February 1981.

U.S. Department of Energy, "Major Geoscience Issues Associated with Siting a High Level Nuclear Waste Repository," prepared for DOE's Office of Civilian Radioactive Waste Management by R.F. Weston Consultants, June 15, 1984.

U.S. Department of Energy, "Issues Hierarchy for a Mined Geologic Disposal System (OGR/B-10)," USDOE Report DOE/RW-0101 Revision 1, August 1987.

U.S. Department of Energy and U.S. Nuclear Regulatory Commission, "Summary of the NRC/DOE Meeting on the Level of Detail for Site Characterization Plans and Study Plans," May 7-8, 1986, 9pp. plus four attachments.

U.S. Nuclear Regulatory Commission, "Information Needs for Characterization of High-Level Waste Repository Sites in Six Geologic Media," USNRC Report NUREG/CR-2663, Vols. 1 and 2, May 1985.

U.S. Nuclear Regulatory Commission, Regulatory Guide 4.17, "Standard Format and Content of Site Characterization Plans for High-Level Waste Repositories," Revision 1, March 1987.

U.S. Nuclear Regulatory Commission, "Draft Issue-Oriented Site Technical Position (ISTP) for Nevada Waste Isolation Project (NNWSI)," September 1984.

U.S. Nuclear Regulatory Commission, "Repository Design, Exploratory Shaft, and In-Situ Testing," dated October 25-26, 1983.

U.S. Nuclear Regulatory Commission, "NRC Guidance on SCP Content," dated June 27-28, 1983.

U.S. Nuclear Regulatory Commission, "NRC Staff Comments on the DOE Final Environmental Assessments," Yucca Mountain Site comment numbers 1, 2. 3, 4, and 5; dated December 22, 1986.

U.S. Nuclear Regulatory Commission, "NRC Comments on DOE Draft Environmental Assessment for Yucca Mountains Site," March 20, 1985.

Letter Report from D.H. Chung, Lawrence Livermore National Laboratory, to M.E. Blackford, NRC, Subject: "C. Purcell Report on Potential Erosion at the Yucca Mountain Nuclear Waste Site", Purcell Letter Report, dated September 26, 1986.

Memorandum from T.L. Johnson, NRC, to R.J. Starmer, NRC, Subject: "Report of Site Visit to NNWSI Project", dated July 22, 1987.

U.S. Department of Energy, "Environmental Assessment Yucca Mountain Site, Nevada Research and Development Area, Nevada," DOE/RW-0073, Vols. 1-3, May 1986.

U.S. Nuclear Regulatory Commission, "Effects of Earthquakes on Underground Facilities: Literature Review and Discussion," USNRC Report, June 1986.

3.3.2 Review Guide for Stratigraphy and Lithology Information and Investigations

3.3.2.1 Background and Approach

In the SCP, it is anticipated that the site program will include plans for investigations of stratigraphy and lithology, as needed for issue resolution and a basic understanding of the site. Stratigraphic and lithologic studies are diverse and serve multiple purposes for the characterization of the region and the candidate area. Specific knowledge of the stratigraphy and lithology, as developed through Chapter 8 (Site Characterization Program) investigations, is required (1) for the development of a framework on which other geologic and hydrologic studies depend, such as structure, tectonics, and groundwater flow; (2) the identification of physical properties of the host rock that could influence repository design; and (3) for the identification of the isolation capabilities of the rock. These processes, events, and conditions associated with the stratigraphic and lithologic studies are important considerations in developing site-specific scenarios, conceptual models, numerical models and designs.

The detailed criteria below should be used in conjunction with the general review criteria for parameter identification in section 4.2.2, and investigations and activities in section 4.2 3 and 4.2.4, to review appropriate Portions of SCP Chapter 8. Existing information presented in Chapters 1-7 relevant to the criteria given below and any staff concerns regarding this material should also be considered in the review of Chapter 8.

General considerations are provided in Criterion A, while considerations relative to key site-specific topics that should receive special attention in the review, are provided in Criterion B.

3.3.2.2 Criteria

A. The identification of parameters and program of investigations related to stratigraphy and lithology should provide an adequate consideration of the following items, with consideration of performance allocation for the topic:

1. Description of the stratigraphic framework of the candidate area (minimum of 50-mile radius from the candidate site) including:

    a. surface and subsurface geology
    b. relationship between Quaternary and pre-Quaternary units
    c. relationship between surface rock units and subsurface rock units
    d. basis for stratigraphic boundaries
    e. genetic models for the origin and development of the rock sequences that will include:

        (1) general geologic history of the rock sequence through time
        (2) the processes that formed and altered the sequence including

- sedimentation
- tectonics
- source area
- depositional and diagenetic environments
- volcanism
- plutonism
- metamorphism

2. Description of the stratigraphy of the site, focusing, as a minimum, on the following topics:

   a. lithologic and mineralogical components
   b. diagnostic physical and paleontological characteristics useful for identification and correlation
   c. physical characteristics such as

      (1) bedding
      (2) mineralogy
      (3) intergranular filling
      (4) secondary mineralization

   d. geophysical characteristics or signatures such as

      (1) density
      (2) magnetic susceptibility
      (3) remanent magnetism
      (4) conductivity
      (5) velocity profiles

   e. vertical and lateral variation of composition and characteristics and comparison to surrounding rock units including

      (1) contacts
      (2) unconformities

   f. thickness and spatial extent
   g. age dating of the lithostratigraphic units, as well as that of secondary mineralization, when necessary
   h. genesis or origin of the unit, including

      (1) rock formation processes
      (2) models
      (3) rock alteration processes

   i. interrelationship with structure of site area (see Review Guides 4.3.4, 4.3.6)

   j. interrelationship with geochemistry
      (1) see Review Guide 4.3.11

   k. interrelationshiP with hydrology
      (1) see Review Guide 4.3.16

1. interrelationship with natural resources

(1) see Review Guide 4.3.5

3. Level of detail of exploratory shaft facility mapping should be sufficient to assure examination of a statistically significant sampling of stratigraphic features encountered.

B. The identification of parameters and program of investigations should Provide an adequate consideration of the following items (information/parameter needs and possible methodologies) for key site-specific topics (with consideration of performance allocation for the topic):

1. Yucca Mountain Site:

a. identification of stratigraphic features

(1) degree of welding
(2) lithophysae content
(3) content of lithic fragments
(4) thinning and thickening of repository horizon
(5) porosity and permeability

b. amount of offset of stratigraphic units by faulting

3.3.2.3 Applicable Sections of 10 CFR Part 60

Lead	Input
60.21(c)(1)	60.21(c)(2)
60.122(b)(1)	60.21(c)(3)
60.122(b)(4)	60.111
	60.112
	60.113
	60.122(b)(7)
	60.122(b)(8)
	60.122(c)(20)
	60.122(c)(21)
	60.122(c)(23)
	60.122(c)(24)
	60.130
	60.131
	60.132
	60.133
	60.134
	60.135

3.3.2.4 Key Documents to Consider

U.S. Bureau of Mines and U.S. Geological Survey, Principles of a Resource/Reserve Classification for Minerals, U.S. Geological Survey Circular 831, 1980.

U.S. Bureau of Mines, "Natural Resource Assessment Methodologies for Proposed High-Level Waste Repositories," USNRC draft report, 1987.

U.S. Department of Energy, "Annotated Outline for Site Characterization Plans," USDOE Report OGR/B-5, April 1987.

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U.S. Department of Energy, "NWTS Program Criteria for Mined Geologic Disposal of Nuclear Waste: Site Performance Criteria," USDOE Report DOE/NWTS-33/2, February 1981.

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U.S. Department of Energy and U.S. Nuclear Regulatory Commission, Letter from M. Bell, NRC, to C. Heath, DOE, "Trip Report, July 7-17, 1980," dated September 17, 1980.

U.S. Department of Energy and U.S. Nuclear Regulatory Commission, "DOE/NRC Workshop, Geology and Geologic Stability, April 11-15, 1983," dated June 2, 1983.

U.S. Department of Energy and U.S. Nuclear Regulatory Commission, "Summary of NRC/DOE Meeting on Seismic/Tectonic Investigations," December 4, 1985.

U.S. Department of Energy and U.S. Nuclear Regulatory Commission, "Summary of the NRC/DOE Meeting on the Level of Detail for Site Characterization Plans and Study Plans," May 7-8, 1986, 9pp. plus four attachments.

U.S. Nuclear Regulatory Commission, Memorandum from S. Brocoum, L. L. Lehman, and D. L. Siefken, NRC, "Notes of Meeting Held with U.S. Geological Survey, Tuesday, June 17, 1980," dated July 31, 1980.

U.S. Nuclear Regulatory Commission, "Information Needs for Characterization of High-Level Waste Repository Sites in Six Geologic Media," USNRC Report NUREG/CR-2663, Vols. 1 and 2, May 1985.

U.S. Nuclear Regulatory Commission, Regulatory Guide 4.17, "Standard Format and Content of Site Characterization Plans for High-Level Waste Repositories," Revision 1, March 1987.

U.S. Nuclear Regulatory Commission, "Draft Issue-Oriented Site Technical Position (ISTP) for Nevada Waste Isolation Project (NNWSI)," September 1984.

U.S. Nuclear Regulatory Commission, "Repository Design, Exploratory Shaft, and In-Situ Testing," dated October 25-26, 1983.

U.S. Nuclear Regulatory Commission, "NRC Guidance on SCP Content," dated June 27-28, 1983.

U.S. Nuclear Regulatory Commission, "NRC Staff Comments on the DOE Final Environmental Assessments," Yucca Mountain Site comment numbers 1, 2, 3, 4, and 5; dated December 22, 1986.

U.S. Nuclear Regulatory Commission, "Survey of Geophysical Techniques for Site Characterization in Basalt, Salt and Tuff," NUREG/CR-4957, July 1987.

U.S. Nuclear Regulatory Commission, "NRC Comments on DOE Draft Environmental Assessment for Yucca Mountain Site," March 20, 1985.

Letter Report from D. H. Chung, Lawrence Livermore National Laboratory, to M. E. Blackford, NRC; Subject: "C. Purcell Report on Potential Erosion at the Yucca Mountain Nuclear Waste Site," Purcell Letter Report, dated September 26, 1986.

Memorandum from T. L. Johnson, NRC, to R. J. Starmer, NRC; Subject: "Report of Site Visit to NNWSI Project," dated July 22, 1987.

U.S. Department of Energy, "Environmental Assessment Yucca Mountain Site, Nevada Research and Development Area, Nevada," DOE/RW-0073, Vols. 1-3, May 1986.

U.S. Nuclear Regulatory Commission, "Effects of Earthquakes on Underground Facilities: Literature Review and Discussion," USNRC Report, June 1986.

3.3.3 Review Guide for Seismological Information and Investigations.

3.3.3.1 Background and Approach

In the SCP it is anticipated that the site program will include plans for seismological investigations. Seismological investigations are important because they are needed to resolve issues that arise during the consideration of the applicable sections of 10 CFR 60 listed in Section 4.3.3.3 and to obtain a basic understanding of the site. Subsections 2.5.1, 2.5.4.6, 2.5.4.7, 2.5.4.8, 2.5.5.1 (Rev. 1, July 1981), 2.5.2.1, 2.5.2.2, 2.5.2.3, 2.5.2.4, 2.5.2.5, and 2.5.2.6 (Proposed Revision, September 1984) of the Office of Nuclear Reactor Regulation Standard Review Plan (NUREG-800) form the bases for the criteria set forth below. The criteria have been modified to reflect the requirements and terminology expressed in 10 CFR 60. However, the basic seismicity criteria required in NUREG-800 are considered applicable to both the permanent closure of a HLW Geologic Repository.

The detailed criteria below should be used in conjunction with the general review criteria for parameter identification in section 4.2.2, and investigations and activities in section 4.2.3 and 4.2.4 to review appropriate portions of SCP Chapter 8. Existing information presented in Chapters 1-7 relevant to the criteria given below and any staff concerns regarding this material should also be considered in the review of Chapter 8.

General considerations are provided in criterion A. Considerations relative to key site-specific topics that should receive special attention in the review are provided in criterion B.

3.3.3.2 Criteria

A. The identification of parameters and program of investigation related to seismology should provide an adequate consideration of the following items, with consideration of performance allocation for the topic:

1. Seismic history of the geologic setting and site region (within a radius of approximately 200 miles) including:

   a. all earthquakes having Modified Mercalli (MM) intensity greater than, or equal to, IV, or magnitude greater than, or equal to, 3.0, which have been reported, with consideration for:

      (1) epicenter coordinates
      (2) depth of focus
      (3) origin time
      (4) highest intensity
      (5) magnitude, such as m_b, M_L, M_S, etc.
      (6) seismic moment
      (7) source mechanism
      (8) source dimensions

(9) distance from the site
(10) any strong-motion recordings

b. all historical earthquakes located beyond 200 miles of the site, which nevertheless may have affected the site in a manner similar to those within the 200-mile criteria

c. any reported earthquake-induced geologic failure, such as liquefaction, landsliding, landspreading, and lurching, including the level of strong motion which induced failure and physical properties of the materials

2. The relationship of seismicity to geology and tectonic characteristics, including:

a. characteristics of all significant geologic structures within the region, with emphasis on potentially seismogenic faults
b. techtonic history of region
c. paleo and present stress regime
d. relationship between geologic structures and tectonic activity
e. relationship between geologic structues and seismic activity
f. earthquake-generating potential of various geologic structures
g. regions of uniform earthquake potential, with justification based on such things as:
(1) pattern and level of historic seismicity
(2) differences in geologic history, with emphasis on the Post Miocene and younger history
(3) development and characteristics of the current tectonic regime
(4) neotectonics
(5) alternative tectonic models

3. Earthquake-generating potential of geologic structures and seismo-tectonic zones within the geologic setting, including:

a. the maximum credible earthquake which could occur on each geologic structure, or within each region of uniform earthquake potential, based on such things as:
(1) the type of faulting
(2) fault length
(3) fault slip rate
(4) rupture length
(5) rupture area
(6) moment
(7) earthquake history

b. the maximum historic earthquake associated with each geologic structure or region of uniform earthquake potential
c. the earthquake which would produce the maximum vibratory ground motion at the site, considering such things as relationship of structure or region of uniform earthquake potential to the site

d. the vibratory ground motion due to the maximum credible earthquake associated with each geologic structure or region of uniform earthquake potential, based on such things as:
   (1) seismic wave transmission characteristics
   (2) frequency bands

4. Seismic wave transmission characteristics of the site, including:

   a. amplification and/or attenuation characteristics of the materials overlying bedrock at the site, as a function of the significant frequencies
   b. material properties for each stratum under the site, including:
      (1) seismic compressional and shear wave velocities
      (2) bulk densities
      (3) soil index properties and classification
      (4) shear modulus and damping variations with strain level
      (5) water table elevation and its variation
   c. free-field ground motion at the foundation level of each structure, system or component important to safety considering:
      (1) significant frequency bands
      (2) different seismic wave types
      (3) variations from each maximum credible event along each structure or in each region of uniform earthquake potential
   d. the effects of site conditions and material property variations upon wave propagation and frequency content
   e. one-dimensional equivalent-linear analysis, nonlinear analysis, or other appropriate analysis, of vertical and horizontally propagating shear waves, surface or compressional waves, which may produce the maximum ground motion
   f. comparison of site response characteristics determined from analytical procedures with historical and instrumental earthquake data

5. Vibratory ground motion at the site, including:

   a. free-field response spectrum for design basis and maximum credible earthquakes, considering:
      (1) site transmission effects
      (2) different frequency bands
   b. statistically developed horizontal and vertical-component site specific response spectra based on response spectra of recorded strong motion records selected to have similar source, propagation path and recording site properties as the controlling earthquake(s)
   c. important source properties, including:
      (1) magnitude, if possible
      (2) fault type
      (3) tectonic environment
   d. propagation path properties including:
      (1) distance
      (2) depth

(3) attenuation

e. relevant site properties including:
   (1) shear velocity profile
   (2) other factors which affect the amplitude of waves at different frequencies

f. development of site-specific spectra including, as appropriate:
   (1) direct estimates of spectral ordinates
   (2) corrections for site effects for site-specific response spectra not obtained under geologic conditions similar to those at site
   (3) scaling approximations, which represent the best estimate of source, propagation path and site properties, for limited ensembles of strong motion data
   (4) sensitivity studies of such scaling approximations
   (5) determination of site-specific peak ground acceleration velocity and displacement (if necessary) for appropriate magnitude, distance and foundation conditions
   (6) determination of response spectra by scaling the acceleration, velocity and displacement values with appropriate amplification factors
   (7) use of a peak acceleration as the high frequency asymptote to appropriate standardized response spectra
   (8) use of theoretical-empirical modelled ground motion, with thoroughly documented input parameters, at sites near potentially seismogenic faults

g. determination of peak ground motions for each controlling earthquake, including use of current relations between:
   (1) acceleration
   (2) velocity
   (3) displacement (if necessary)
   (4) earthquake size (magnitude or intensity)
   (5) source distance

h. determination of the design basis earthquake time history including:
   (1) time duration
   (2) number of cycles of strong ground motion
   (3) adequacy of the time history for structural analysis
   (4) compatibility with the seismological and geological conditions in the site vicinity
   (5) compatibility with the accepted design basis earthquake model
   (6) use of an ensemble of ground motion time histories from earthquakes with similar size, site-source characteristics, and spectral characteristics
   (7) use of results of a statistical analysis of such an ensemble

6. Earthquake-induced phenomena within the geologic setting that may affect the site, including:

   a. historic groundwater fluctuations during seismic events

b. effects of prior earthquakes on the soils and rocks in the vicinity of the site, including:
   (1) evidence of liquefaction
   (2) sand cone formation
c. dynamic tests, performed in the laboratory, on samples of the foundation soil and rock from the site of proposed surface facilities of the repository, to aid in determination of:
   (1) shear stresses induced in the soil by postulated earthquakes
   (2) liquefaction potential
d. consequences of induced soil stresses and strains on the proposed surface facilities
e. lateral and vertical variations in slope and foundation conditions
f. static and dynamic properties of the soil and rock

7. Potential for induced seismicity, including:

   a. potential effects of waterways, either natural or man-made
   b. effects of potential exploitation of natural resources, including:
      (1) hydrocarbons
      (2) water
      (3) injection and/or disposal
   c. effects of large-scale rock extraction
   d. effects of detonation of significant amounts of high-yield explosives in the region

8. Seismic risk evaluations, including:

   a. probabilistic estimates of seismic hazard emphasizing sources significant to the site
   b. calculated uniform hazard spectra over the frequency range of interest for 0.01, 0.001 and 0.0001 annual probabilities of exceedance at the site
   c. estimation and comparison of the probability of exceeding the design basis earthquake response spectra with results from other probabilistic studies

B. The identification of parameters and program of investigations should provide an adequate consideration of the following items (possible methodologies and information/parameter needs) for key site-specific topics (with consideration of performance allocation for the topic):

1. Yucca Mountain Site:
   a. historic seismicity, including:
      (1) representativeness of the historical pattern of seismicity in the vicinity of the site
      (2) reconciliation of focal mechanisms for microearthquakes in vicinity of the site with apparent nature of tectonic activity

b. relationship of seismicity to geologic and tectonic structures, including:
   (1) regions of uniform earthquake potential in the southern Great Basin including, but not limited to, regions encompassing:
      (a) the Walker Lane
      (b) Owens Valley
      (c) Death Valley
      (d) the Las Vegas Shear Zone
      (e) the Southern Nevada East-West Seismic Belt
   (2) potential for seismic activity on faults in the immediate vicinity of Yucca Mountain

c. earthquake generating potential of geologic structures and seismotectonic zones, including:
   (1) faults in the Yucca Mountain vicinity
   (2) maximum earthquake potentials

d. seismic wave transmission characteristics, including:
   (1) response at repository depth to nuclear tests and nearby natural earthquakes

e. vibratory ground motion including:
   (1) nature of vibratory motion at the site resulting from earthquakes on faults in the immediate vicinity of Yucca Mountain

f. seismically induced phenomena, including:
   (1) effect of earthquakes on ground water levels

3.3.3.3 Applicable Sections of 10 CFR 60

Lead	Input
60.21(c)(1)	60.21(c)(2)
60.122(a)	60.21(c)(3)
60.122(b)(1)	60.111
60.122(c)(12)	60.112
60.122(c)(13)	60.113
60.122(c)(14)	60.122(b)(2)
	60.122(b)(7)
	60.122(b)(8)
	60.122(c)(1)
	60.122(c)(2)
	60.122(c)(3)
	60.122(c)(4)
	60.122(c)(5)
	60.122(c)(11)
	60 122(c)(15)
	60.122(c)(20)
	60.122(c)(21)

Input (con't)
60.122(c)(22)
60.122(c)(23)
60.122(c)(24)
60.130
60.131
60 132
60.133
60.134
60.135

3.3.3.4 Key Documents to Consider

U.S. Department of Energy, "Annotated Outline for Site Characterization Plans," USDOE Report OGR/B-5, April 1987.

U.S. Department of Energy and Geological Survey, U.S. Department of Interior, "Earth Science Technical Plan for Disposal of Radioactive Waste in a Mined Repository," USDOE Draft Report DOE/TIC-1033, April 1980.

U.S. Department of Energy, "NWTS Program Criteria for Mined Geologic Disposal of Nuclear Waste: Site Performance Criteria," USDOE Report DOE/NWTS-33/2, February 1981.

U.S. Department of Energy, "Major Geoscience Issues Associated with Siting a High Level Nuclear Waste Repository," prepared for DOE's Office of Civilian Radioactive Waste Management by R. F. Weston Consultants, June 15, 1984.

U.S. Department of Energy, "Issues Hierarchy for a Mined Geologic Disposal System (OGR/B-10)," USDOE Report DOE/RW-0101, Rev. 1, August 1987.

U.S. Department of Energy, Nevada Operations Office, "Final Report on the Calcite and Opaline Silica Deposits Peer Review," dated November 10, 1987.

U.S. Department of Energy, Nevada Operations Office, "Final Summary of Workshop on Fault-Related Calcite-Silica Deposits Near Yucca Mountain Held on February 28, 1986," dated March 31, 1986.

U.S. Department of Energy, Nevada Operations Office, "Final Summary of Workshop on Fault-Related Calcite-Silica Deposits Near Yucca Mountain Held on April 28, 1986," dated June 26, 1986.

U.S. Department of Energy and U.S. Nuclear Regulatory Commission, Letter from M. Bell, NRC, to C. Heath, DOE; Subject: "Trip Report, July 7-17, 1980," dated September 17, 1980.

U.S. Department of Energy and U.S. Nuclear Regulatory Commission, "DOE/NRC Workshop, Geology and Geologic Stability, April 11-15, 1983," dated June 2, 1983.

U.S. Department of Energy and U.S. Nuclear Regulatory Commission, "Summary of NRC/DOE Meeting on Seismic/Tectonic Investigations," December 4, 1985.

U.S. Department of Energy and U.S. Nuclear Regulatory Commission, "Meeting Report of DOE/NRC Workshop of December 3-4, 1985, Exploratory Shaft Design," dated December 4, 1985.

U S. Department of Energy and U.S. Nuclear Regulatory Commission, "Summary of the NRC/DOE Meeting on the Level of Detail for Site Characterization Plans and Study Plans," May 7-8, 1986, 9pp. plus four attachments.

U.S. Nuclear Regulatory Commission, Memorandum from C. Abrams to K. Stablein, NRC; Subject: "Trip Report, 4-28-86, to SAIC Offices, Las Vegas, Nevada and Notes of Meeting on Calcite-Silica Deposits", dated June 3, 1986.

U.S. Nuclear Regulatory Commission, Memorandum from C. Abrams to K. Stablein, NRC; Subject: "Appendix 7: Attendance at DOE Peer Review Committee Meeting for Veins Deposits," dated June 30, 1987.

U.S. Nuclear Regulatory Commission, Memorandum from J. Trapp, NRC, to M. Knapp; Subject: "Trip Report: Appendix 7 Visit to NNSWI, September 17-19, 1985," dated October 3, 1985.

U.S. Nuclear Regulatory Commission, Memorandum from S. Brocoum, L. L. Lehman, and D. L. Siefken, NRC; Subject: "Notes of Meeting Held with U.S. Geological Survey, Tuesday, June 17, 1980," dated July 31, 1980.

U.S. Nuclear Regulatory Commission, Memorandum from C. Abrams, NRC, to P. Justus; Subject: "Trench 14 Calcite-Silica Vein Deposits, Observations and Implications," dated June 4, 1986.

U.S. Nuclear Regulatory Commission, "Information Needs for Characterization of High-Level Waste Repository Sites in Six Geologic Media," USNRC Report NUREG/CR-2663, Vols. 1 and 2, May 1985.

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U.S. Nuclear Regulatory Commission, "Draft Issue-Oriented Site Technical Position (ISTP) for Nevada Waste Isolation Project (NNWSI)," September 1984.

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Memorandum from T. L. Johnson, NRC, to R. J. Starmer, NRC; Subject: "Report of Site Visit to NNWSI Project," dated July 22, 1987.

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U.S. Nuclear Regulatory Commission, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants, LWR Edition," USNRC Report NUREG-0800, June 1987.

U.S. Department of Interior, "Reported Effects of Selected Earthquakes in the Western North American Intermontane Region, 1852-1983, on Underground Workings and Local and Regional Hydrology: A Summary," prepared by Russell G. Raney, USDOI Bureau of Mines, Western Field Operations Center, Spokane, WA for the USNRC Division of Waste Management, NMSS, under NRC FIND-1018, April 1988.

3.3.4. Review Guide for Structural Geology and Tectonic Information and Investigations

3.3.4.1. Background and Approach

In the SCP, it is anticipated that the site program will include plans for investigations of the structural and tectonic features as needed for issue resolution and a basic understanding of the site. An understanding of structural geology and tectonic processes and events is necessary both for the siting of the preclosure facilities and for projection of effects on the ability of the site to meet the performance objectives during post closure. The structural features of the site and region, in large part, define the geologic setting. They are important, therefore, not only in the area of tectonics, but also as a means of evaluating other processes that are operational now, or may have operated in the past, in the geologic setting. These processes, events and conditions are important considerations in developing site-specific scenarios, conceptual models, numerical models, and designs.

The detailed criteria below should be used in conjunction with the general review criteria for parameter identification in section 4.2.2, and investigations and activities in section 4.2.3 and 4 2.4, to review appropriate portions of SCP Chapter 8. Existing information presented in Chapters 1-7 relevant to the criteria given below and any staff concerns regarding this material, should also be considered in the review of Chapter 8.

General considerations are provided in Criterion A. Considerations relative to key site-specific topics that should receive special attention in the review are provided in Criterion B.

3.3.4.2. Criteria

A. The identification of parameters and program of investigations related to structure and tectonics should provide an adequate consideration of the following items with consideration of performance allocation for the topic:

1. Tectonic framework and tectonic history:

    a. primary and alternative tectonic models under consideration
    b. approach for establishing which model is the most accurate for predicting future events
    c. the style of deformation associated with the preferred model

2. Volcanic history in the vicinity of the site:

    a. age of the most recent volcanic event
    b. recurrence interval
    c. potential for associated volcanogenic economic mineral deposits
    d. likelihood of a volcanic event close to the repository.

e. interrelationship of volcanic processes and events, hydrology, and geochemistry
f. structural control of volcanism
9 hydrothermal processes and events
h. presence of magma bodies in the crust
i. natural analog studies
j. accuracy/precision of currently available radiometric dating techniques

3. Faulting history in the vicinity of the site:

a. location and length of faults with emphasis on "active" faults in the geologic setting
b. age of most recent movement
c. spacing of faults
d. fault segmentation
e. fault interaction
f. relationship between faults and seismicity
g. accuracy of tectonic model in accounting for faults
h. interrelationship of faults and hydrologic regime
i. type and style of faults/faulting present and predicted such as:

(1) detachment/decollement style faulting
(2) normal faults
(3) strike-slip

j. mechanism for low-angle faults
k. methodology for identifying detachment faults
l. orientation and aerial extent of faulting
m. reliability/accuracy of currently available radiometric dating techniques
n. amount of offset of stratigraphic units

4. Folding history in the Vicinity of the site:

a. styles of folding present
b. potential for coseismic folding
c. interrelationship with faults/faulting

5. Jointing history in the vicinity of the site:

a. location and characteristics of joints/jointing patterns
b. variation between and within units
c. origin of joint systems
d. relationship to faults/faulting

6. Active stress field in the vicinity of the site:

a. characteristics of local and regional stress fields
b. state of stress at repository depth
c. interrelationship of stress field with faulting, folding and hydrology
d. potential for movement along favorably oriented structures

7. Information sufficient to show that conditions in the areas of proposed tests are representative of geologic structures throughout the repository with consideration of:

    a. brecciation
    b. width and spacing of faults
    c. fracture spacing, aperture, filling, and density
    d. jointing

8. Level of detail of exploratory shaft facility mapping sufficient to assure that a representative sampling of structural features has been identified and examined.

B. The identification of parameters and program of investigations should provide an adequate consideration of the following items (information/parameter needs and possible methodologies) for key site-specific topics (with consideration of performance allocation for the topic) :

1. Yucca Mountain Site:

    a. tectonic framework and tectonic history

        (1) role of pure and/or oblique extension in tectonic model

    b. volcanic history in the vicinity of the site

        (1) volume of material associated with each cycle
        (2) duration and character of each cycle
        (3) interrelationships between faulting and volcanism

    c. faulting history in the vicinity of the site

        (1) amount of vertical versus oblique displacement
        (2) effect of detachment faults on site stability
        (3) relationship between strike-slip, normal, and detachment faults

    d. active stress field in the vicinity of the site

        (1) influence of nuclear tests on the state-of-stress
        (2) relationship to microseismicity

3.3.4.3. Applicable sections of 10 CFR Part 60

Lead	Input
60.21(c)(1)	60.21(c)(2)
60.122(a)	60.21(c)(3)
60.122(b)(1)	60.122(b)(2)
60.122(c)(11)	60.122(b)(7)
60.122(c)(15)	60.122(b)(8)
	60.122(c)(3)

Input (con't)
60.122(c)(4)
60.122(c)(5)
60.122(c)(12)
60.122(c)(13)
60 122(c)(20)
60.122(c)(21)
60.122(c)(22)
60.122(c)(23)
60.122(c)(24)
60.111
60.112
60.113
60.130-135

3.3.4.4. Key documents to consider

U.S. Department of Energy, "Annotated Outline for Site Characterization Plans," USDOE Report OGR/B-5, April 1987.

U.S. Department of Energy and Geological Survey, U.S. Department of Interior, "Earth Science Technical Plan for Disposal of Radioactive Waste in a Mined Repository," USDOE Draft Report DOE/TIC-1033, April 1980.

U.S. Department of Energy, "NWTS Program Criteria for Mined Geologic Disposal of Nuclear Waste: Site Performance Criteria," USDOE Report DOE/NWTS-33/2, February 1981.

U.S. Department of Energy, "Major Geoscience Issues Associated with Siting a High Level Nuclear Waste Repository," prepared for DOE's Office of Civilian Radioactive Waste Management by R. F. Weston Consultants, June 15, 1984.

U.S. Department of Energy, "Issues Hierarchy for a Mined Geologic Disposal System (OGR/B-10)," USDOE Report DOE/RW-0101 Revision 1, August 1987.

U.S. Department of Energy, Nevada Operations Office, "Final Report on the Calcite and Opaline Silica Deposits Peer Review," dated November 10, 1987.

U.S. Department of Energy, Nevada Operations Office, "Final Summary of Workshop on Fault-Related Calcite-Silica Deposits Near Yucca Mountain Held on February 28, 1986," dated March 31, 1986.

U.S. Department of Energy, Nevada Operations Office, "Final Summary of Workshop on Fault-Related Calcite-Silica Deposits Near Yucca Mountain Held on April 28, 1986," dated June 26, 1986.

U.S. Department of Energy and U.S. Nuclear Regulatory Commission, Letter from M. Bell, NRC, to C. Heath, DOE, "Trip Report, July 7-17, 1980," dated September 17, 1980.

U.S. Department of Energy and U.S. Nuclear Regulatory Commission, "DOE/NRC Workshop, Geology and Geologic Stability, April 11-15, 1983," dated June 2, 1983.

U.S. Department of Energy and U.S. Nuclear Regulatory Commission, "Summary of NRC/DOE Meeting on Seismic/Tectonic Investigations," December 4, 1985.

U.S. Department of Energy and U.S. Nuclear Regulatory Commission, "Meeting Report of DOE/NRC Workshop of December 3-4, 1985, Exploratory Shaft Design," dated December 4, 1985.

U.S. Department of Energy and U.S. Nuclear Regulatory Commission, "Summary of the NRC/DOE Meeting on the Level of Detail for Site Characterization Plans and Study Plans," May 7-8, 1986, 9pp. plus four attachments.

U.S. Nuclear Regulatory Commission, Memorandum from C. Abrams to K. Stablein, NRC; Subject: "Trip Report, 4-28-86, to SAIC Offices, Las Vegas, Nevada," Notes of Meeting on Calcite-Silica Deposits, dated June 3, 1986.

U.S. Nuclear Regulatory Commission, Memorandum from C. Abrams to K. Stablein, NRC; Subject: "Appendix 7: Attendance at DOE Peer Review Committee Meeting for Veins Deposits," dated June 30, 1987.

U.S. Nuclear Regulatory Commission, Memorandum from J. Trapp, NRC, to M. Knapp; Subject: "Trip Report: Appendix 7 Visit to NNSWI, September 17-19, 1985," dated October 3, 1985.

U.S. Nuclear Regulatory Commission, Memorandum from S. Brocoum, L. L Lehman, and D. L. Siefken, NRC; Subject: "Notes of Meeting Held with U.S. Geological Survey, Tuesday, June 17, 1980," dated July 31, 1980.

U.S. Nuclear Regulatory Commission, Memorandum from C. Abrams, NRC, to P. Justus; Subject: "Trench 14 Calcite-Silica Vein Deposits, Observations and Implications," dated June 4, 1986.

U.S. Nuclear Regulatory Commission, "Information Needs for Characterization of High-Level Waste Repository Sites in Six Geologic Media," USNRC Report NUREG/CR-2663, Vols. 1 and 2, May 1985.

U.S. Nuclear Regulatory Commission, Regulatory Guide 4.17, "Standard Format and Content of Site Characterization Plans for High-Level Waste Repositories," Revision 1, March 1987.

U.S Nuclear Regulatory Commission, "Draft Issue-Oriented Site Technical Position (ISTP) for Nevada Waste Isolation Project (NNWSI)," September 1984.

U.S. Nuclear Regulatory Commission, "Repository Design, Exploratory Shaft, and In-Situ Testing", dated October 25-26, 1983.

U.S. Nuclear Regulatory Commission, "NRC Staff Comments on the DOE Final Environmental Assessments," Yucca Mountain Site comment numbers 1, 2, 3, 4, and 5; dated December 22, 1986.

U.S. Nuclear Regulatory Commission, "Survey of Geophysical Techniques for Site Characterization in Basalt, Salt and Tuff," NUREG/CR-4957, July, 1987.

U.S. Nuclear Regulatory Commission, "NRC Comments on DOE Draft Environmental Assessment for Yucca Mountains site," March 20, 1985.

Letter Report from D. H. Chung, Lawrence Livermore National Laboratory, to M. E. Blackford, NRC; Subject: "C. Purcell Report on Potential Erosion at the Yucca Mountain Nuclear Waste Site," Purcell Letter Report, dated September 26, 1986.

U.S. Department of Energy, "Environmental Assessment, Yucca Mountain Site, Nevada Research and Development Area, Nevada," DOE/RW-0073, Vols. 1-3, May 1986.

U.S. Nuclear Regulatory Commission, "Effects of Earthquakes on Underground Facilities: Literature Review and Discussion," USNRC Report, June 1986.

3.3.5. Review Guide for Natural Resources Investigations

3.3.5.1. Background and Approach

In the SCP, it is anticipated that the site program will include plans for investigations of the natural resources potential as needed for issue resolution and a basic understanding of the site. An understanding of the natural resource potential is necessary to assure that the information on the topic of natural resources is sufficient to address the likelihood of human intrusion as a result of the presence and exploitation of natural resources of the candidate area.

The detailed criteria below should be used in conjunction with the general review criteria for parameter identification in section 4.2.2, and investigations and activities in section 4 2.3 and 4.2.4 to review appropriate portions of SCP Chapter 8. Existing information presented in Chapters 1-7 relevant to the criteria given below and any staff concerns regarding this material should also be considered in the review of Chapter 8.

General considerations are provided in Criterion A. Considerations relative to key site-specific topics that should receive special attention in the review are provided in Criterion B.

3.3.5.2. Criteria

A. The identification of parameters and program of investigations related to natural resources and the potential of human intrusion should provide an adequate consideration of the following items, with consideration of performance allocation for the topic:

1. Resource assessment of economic, marginally economic, and subeconomic identified resources, including:

    a. mineral
    b. hydrocarbon
    c. geothermal

2. Uses and net worth of mineral, hydrocarbon and geothermal resources in the candidate area

3. Commodities mined or prospected in the vicinity of the site

4. Locations of known mining activity in the vicinity of the site to, include:

    a. mines
    b. prospect pits
    c. shafts
    d. trenches
    e. exploratory drill holes

5. Economic assessment from literature, mapping, geochemical sampling, and comparison with working models of known:
   a. mines
   b. prospects
   c. exploratory drill holes

6. Lithologic and structural associations of mineral and hydrocarbon deposits mined or prospected in the candidate area

7. Comparison of the candidate area with areas of mineral and hydrocarbon deposits which have similar origins, host rocks, and structural regimes

8. Assessment of candidate area based on comparisions with known mineral resources and models

9. The location, nature, and extent of any known or suspected mineralization, hydrocarbons, or waters of elevated temperatures within the candidate area

B. The identification of parameters and program of investigations should provide an adequate consideration of the following items (information/parameter needs and possible methodologies) for key site-specific topics (with consideration of performance allocation for the topic):

1. Yucca Mountain Site:

   a. the presence of mineral deposits and their association with

      (1) stratigraphic units of volcanic origin
      (2) veining
      (3) fault zones
      (4) alteration zones
      (5) subsurface plutons

   b. the association of hydrocarbon resources with

      (1) Paleozoic stratigraphic units underlying the site
      (2) trap rocks

3.3.5.3. Applicable Sections of 10 CFR Part 60

Lead	Input
60.122 (a)	60.122 (c)(2)
60.122 (c)(17)	60.112
60.122 (c)(18)	60.113
60.122 (c)(19)	
60.21 (c)(13)	
60.121 (a)(2)	

3.3.5.4. Key Documents to Consider

U.S. Bureau of Mines and U.S. Geological Survey, Principles of a Resource/Reserve Classification for Minerals, U.S. Geological Survey Circular 831, 1980.

U.S. Bureau of Mines, "Natural Resource Assessment Methodologies for Proposed High-Level Waste Repositories," USNRC draft report, 1987.

U.S. Bureau of Mines, "Oil and Gas Drilling in Clark, Esmeralda, Lincoln, and Nye Counties, Nevada 1920 through 1986," USNRC Draft Report, February, 1987.

U.S. Department of Energy, "Annotated Outline for Site Characterization Plans," USDOE Report OGR/B-5, April 1987.

U.S. Department of Energy and Geological Survey, U.S. Department of Interior, "Earth Science Technical Plan for Disposal of Radioactive Waste in a Mined Repository," USDOE Draft Report DOE/TIC-1033, April 1980.

U.S. Department of Energy, "NWTS Program Criteria for Mined Geologic Disposal of Nuclear Waste: Site Performance Criteria," USDOE Report DOE/NWTS-33/2, February 1981.

U.S. Department of Energy, "Major Geoscience Issues Associated with Siting a High Level Nuclear Waste Repository," prepared for DOE's Office of Civilian Radioactive Waste Management by R. F. Weston Consultants, June 15, 1984.

U.S. Department of Energy, "Issues Hierarchy for a Mined Geologic Disposal System (OGR/B-10)," USDOE Report DOE/RW-0101 Revision 1, August 1987.

U.S. Department of Energy, Nevada Operations Office, "Final Report on the Calcite and Opaline Silica Deposits Peer Review," dated November 10, 1987.

U.S. Department of Energy and U.S. Nuclear Regulatory Commission, "DOE/NRC Workshop, Geology and Geologic Stability, April 11-15, 1983," dated June 2, 1983.

U.S. Department of Energy and U.S. Nuclear Regulatory Commission, "Summary of the NRC/DOE Meeting on the Level of Detail for Site Characterization Plans and Study Plans," May 7-8, 1986, 9pp. plus four attachments.

U.S. Nuclear Regulatory Commission, Memorandum from S. Brocoum, L. L. Lehman, and D. L. Siefken, NRC, Subject: "Notes of Meeting Held with U S. Geological Survey, Tuesday, June 17, 1980," dated July 31, 1980.

U.S. Nuclear Regulatory Commission, Memorandum from C. Abrams, NRC, to P. Justus, Subject: "Trench 14 Calcite-Silica Vein Deposits, Observations and Implications," dated June 4, 1986.

U.S. Nuclear Regulatory Commission, "Information Needs for Characterization of High-Level Waste Repository Sites in Six Geologic Media," USNRC Report NUREG/CR-2663, Vols. 1 and 2, May 1985.

U.S. Nuclear Regulatory Commission, Regulatory Guide 4.17, "Standard Format and Content of Site Characterization Plans for High-Level Waste Repositories," Revision 1, March 1987.

U.S. Nuclear Regulatory Commission, "Draft Issue-Oriented Site Technical Position (ISTP) for Nevada Waste Isolation Project (NNWSI)," September 1984.

U.S. Nuclear Regulatory Commission, "NRC Staff Comments on the DOE Final Environmental Assessments," Yucca Mountain Site comment numbers 1, 2, 3, 4, and 5; dated December 22, 1986.

U.S. Nuclear Regulatory Commission, "NRC Comments on DOE Draft Environmental Assessment for Yucca Mountain site," March 20, 1985.

U.S. Department of Energy, "Environmental Assessment Yucca Mountain Site, Nevada Research and Development Area, Nevada," DOE/RW-0073, Vols. 1-3, May 1986.

U.S. Bureau of Mines, "Ash-flow Sheets and Calderos: Their Relationship to Ore Deposits in Nevada, by E. H. McKee -- A Review of the Paper and Its Application in an Assessment of the Resource Potential at a Proposed High-Level Waste Repository, Yucca Mountain, Nye County, Nevada," U.S. NRC report, 1988.

U.S. Bureau of Mines, "Status of Lode-Quartz Claims on Yucca Mountain, Nye County, Nevada," U.S. NRC draft report, 1988.

3.3.6. Review Guide for Geophysical Information and Investigations.

3.3.6.1 Background and Approach

In the SCP, it is anticipated that the site program will include plans for geophysical investigations, as needed for issue resolution and a basic understanding of the site. Surface-based and borehole geophysical investigations are critical components of site characterization. They provide otherwise unattainable data from boreholes where no coring was performed, from areas where no boreholes exist, and from a relatively large area around the site through non destructive testing.

The detailed criteria below should be used in conjunction with the general review criteria for parameter identification in section 3.2.2 and investigations and activities in section 3.2.3 and 3.2.4, to review appropriate Portions of SCP Chapter 8. Existing information presented in Chapters 1-7 relevant to the criteria given below and any staff concerns regarding this material should also be considered in the review of Chapter 8. In addition, specific attention should be focused on the concerns and recommendations presented in NUREG/CR-4957.

General considerations are provided in Criterion A. Considerations relative to key site-specific topics that should receive special attention in the review are provided in Criterion B.

3.3.6.2. Criteria

A. The identification of parameters and program of investigations related to geophysics should provide an adequate consideration of the following items with consideration of performance allocation for the topic:

1. Use of the following surface-based and borehole geophysical methods to characterize the site:

    a. surface-based to include

        (1) seismic reflection
        (2) seismic refraction
        (3) gravity
        (4) magnetic
        (5) magnetotelluric

    b. borehole to include

        (1) nuclear logging (density, neutron, etc.)
        (2) natural gamma
        (3) acoustic (sonic, acoustic televiewer, etc.)
        (4) resistivity
        (5) spontaneous potential
        (6) downhole and crosshole seismic surveys
        (7) temperature

2. Surveying and processing techniques for each method

3. Resolution, penetration depths, limitations, and potential uncertainty associated with each method

4. Area of coverage, depths, and sampling density that should be used for each method used at the site

5. Previous and planned applications of specific geophysical methods:

    a. applications to stratigraphic studies
    b. applications to tectonic studies

        (1) fold characterization
        (2) fault characterization
        (3) fracture/joint characterization

    c. applications to hydrologic studies

        (1) identification of groundwater pathways to and from the repository

    d. applications to engineering parameter studies

        (1) determination of engineering parameters (Poisson's ratio, rigidity, density, etc.)

6. Integration of geophysical data with geologic, hydrologic, and engineering data

7. Modeling of synthetic data for comparison with empirical data

8. Rationale for rejecting geophysical methods that will not be used at the site

B. The identification of parameters and program of investigations should provide an adequate consideration and application of geophysical methods for the following key site-specific topics (with consideration of performance allocation for the topic):

1. Yucca Mountain Site;

    a. volcanism

        (1) potential magma chambers and magma sources

    b. structure

        (1) fault characteristics with emphasis on detachment surfaces, if present
        (2) fracture characteristics.

3.3.6.3. Applicable Sections of 10 CFR Part 60

Input
60.21(c)(1)
60.21(c)(2)
60.21(c)(3)
60.111
60.112
60.113
60.122(a)
60.122(b)(1)
60.122(b)(2)
60.122(b)(5)
60.122(b)(8)
60.122(c)(4)
60.122(c)(5)
60 122(c)(10)
60.122(c)(11)
60.122(c)(13)
60.122(c)(15)
60.122(c)(16)
60.122(c)(17)
60.122(c)(19)
60.122(c)(20)
60.122(c)(21)
60.122(c)(22)
60.122(c)(23)
60.122(c)(24)
60.130-135

3.3.6.4. Key Documents to Consider

U.S. Department of Energy, "Annotated Outline for Site Characterization Plans," USDOE Report OGR/B-5, April 1987.

U.S. Department of Energy and Geological Survey, U.S. Department of Interior, "Earth Science Technical Plan for Disposal of Radioactive Waste in a Mined Repository," USDOE Draft Report DOE/TIC-1033, April 1980.

U.S. Department of Energy, "NWTS Program Criteria for Mined Geologic Disposal of Nuclear Waste: Site Performance Criteria," USDOE Report DOE/NWTS-33/2, February 1981.

U.S. Department of Energy, "Major Geoscience Issues Associated with Siting a High Level Nuclear Waste Repository," prepared for DOE's Office of Civilian Radioactive Waste Management by R. F. Weston Consultants, June 15, 1984.

U.S. Department of Energy, "Issues Hierarchy for a Mined Geologic Disposal System (OGR/B-10)," USDOE Report DOE/RW-0101 Revision 1, August 1987.

U.S. Department of Energy and U.S. Nuclear Regulatory Commission, "DOE/NRC Workshop, Geology and Geologic Stability, April 11-15, 1983," dated June 2, 1983.

U.S. Department of Energy and U.S. Nuclear Regulatory Commission, "Summary of NRC/DOE Meeting on Seismic/Tectonic Investigations," December 4, 1985.

U.S. Department of Energy and U.S. Nuclear Regulatory Commission, "Summary of the NRC/DOE Meeting on the Level of Detail for Site Characterization Plans and Study Plans," May 7-8, 1986, 9pp. plus four attachments.

U.S. Nuclear Regulatory Commission, Memorandum from J. Trapp, NRC, to M. Knapp; Subject: "Trip Report: Appendix 7 Visit to NNSWI, September 17-19, 1985," dated October 3, 1985.

U.S. Nuclear Regulatory Commission, Memorandum from S. Brocoum, L. L. Lehman, and D. L. Siefken, NRC; Subject: "Notes of Meeting Held with U.S. Geological Survey, Tuesday, June 17, 1980," dated July 31, 1980.

U.S. Nuclear Regulatory Commission, Memorandum from H. E. Lefevre, K. McConnell, and J. Warner, NRC, to R. L. Ballard, NRC; Subject: "Report Describing Activities Associated with the August 2 Through 6, 1987 Yakima Fold Belt Field Trip in the Vicinity of the Hanford (BWIP) Site," dated September 11, 1987.

U.S. Nuclear Regulatory Commission, "Information Needs for Characterization of High-Level Waste Repository Sites in Six Geologic Media," USNRC Report NUREG/CR-2663, Vols. 1 and 2, May 1985.

U.S. Nuclear Regulatory Commission, Regulatory Guide 4.17, "Standard Format and Content of Site Characterization Plans for High-Level Waste Repositories," Revision 1, March 1987.

U.S. Nuclear Regulatory Commission, "Draft Issue-Oriented Site Technical Position (ISTP) for Nevada Waste Isolation Project (NNWSI)," September 1984.

U.S. Nuclear Regulatory Commission, "Repository Design, Exploratory Shaft, and In-Situ Testing", dated October 25-26, 1983.

U.S. Nuclear Regulatory Commission, "NRC Guidance on SCP Content," dated June 27-28, 1983.

U.S. Nuclear Regulatory Commission, "NRC Staff Comments on the DOE Final Environmental Assessments," Yucca Mountain Site comment numbers 1, 2, 3, 4, and 5; dated December 22, 1986.

U. S. Nuclear Regulatory Commission, "Survey of Geophysical Techniques for Site Characterization in Basalt, Salt and Tuff," NUREG/CR-4957, July 1987.

U.S. Nuclear Regulatory Commission, "NRC Comments on DOE Draft Environmental Assessment for Yucca Mountains Site," March 20, 1985.

Memorandum from T. L. Johnson, NRC, to R. J. Starmer, NRC; Subject: "Report of Site Visit to NNWSI Project," dated July 22, 1987.

U.S. Department of Energy, "Environmental Assessment, Yucca Mountain Site, Nevada Research and Development Area, Nevada," DOE/RW-0073, Vols. 1-3, May 1986.

U.S. Nuclear Regulatory Commission, "Effects of Earthquakes on Underground Facilities: Literature Review and Discussion," USNRC Report, June 1986.

3.3.7 Review Guide for Information and Investigations on Natural Analogs and Related Field Tests

3.3.7.1 Background and Approach

In the SCP, it is anticipated that the site program include plans for investigations which include the use of natural analogs and related field tests. Studies of geologic systems which are analogous to repository systems are needed to: (a) gain confidence in the models that will be applied to the repository; (b) to identify important processes that occur in geologic settings similar to proposed repositories; and (c) to assess the extrapolation of short-term laboratory experiments to long-term system performance. Data from field sites other than natural analog sites (e.g., below-ground nuclear weapons tests) can yield information relevant to the investigation of the migration of radionuclides, as well as in the evaluation of geochemical codes and performance assessment models. Natural analogs and related field tests may be used in the development of site-specific scenarios, conceptual models, numerical models, and designs.

The detailed criteria below should be used in conjunction with the general review criteria for parameter identification in Section 3 2.2, and investigations and activities in Sections 3.2.3 and 3.2.4 to review appropriate portions of SCP Chapter 8. Existing information presented in Chapters 1-7 relevant to the criteria given below and any staff concerns regarding this material should also be considered in the review of Chapter 8.

General considerations are provided in Criterion A. Considerations relative to key site-specific topics that should receive special attention in the review are provided in Criterion B.

3.3.7.2 Criteria

A. The identification of parameters and programs of investigations related to the use of information from natural analogs and related field tests should provide an adequate consideration of the following items with consideration of performance allocation for the topic:

1. Natural Analogs

   a. Similarities between the natural analog and the proposed repository site.
      should include a characterization of appropriate physical and chemical parameters of both the natural analog and the proposed repository site

   b. Description of the process of interest to an appropriate level of detail

   c. Discussion of the effects of differences in scale between the repository and the natural analog

d. Discussion of the effect of differences in time over which the natural and repository processes occur

e. Discussion of the constraints involved in characterizing a system in which the reaction of interest has already occurred, or where the system has already evolved.
specifically, in terms of chemical, physical, time, and transport parameters

f. Discussion of the effects of open versus closed systems

g. Discussion of the effects of varying hydrological conditions on site geochemistry in the analog environment

h. Alteration history of the analog system of interest including considerations of climatic shifts

2. Other Related Field Tests

a. Similarities between the field test and the expected conditions of the repository

b. Discussion of the process of interest to the appropriate level of detail

c. Discussion of the effects of differences in scale

d. Discussion of the effects of differences in the time over which the process has operated

e. Constraints involved in extrapolating field test data to repository conditions

f. Representativeness of the test area to the total repository environment

B. The identification of parameters and programs of investigations should also provide an adequate consideration of the following items (information/parameter needs and possible methodologies) for key site-specific topics with consideration of performance allocation for the topic:

1. Yucca Mountain Site

a. Natural Analogs
use of analogs in the investigation of zeolite stability and in interpretation of the origin of the calcite-silica vein deposits

b. Related Field Tests
use of data from the nuclear weapons tests at the Nevada Test Site for investigating radionuclide migration in tuff

3.3.7.3 Applicable Sections of 10 CFR Part 60

Lead	Input
	60.101(a)(2)
	60.112
	60.113(a)(1)
	60.113(a)(2)

3.3.7.4 Key Documents to Consider

U.S. Department of Energy, Office of Civilian Radioactive Waste Management, "Annotated Outline for Site Characterization Plans," OGR/B-5, April, 1987.

U.S. Nuclear Regulatory Commission, Regulatory Guide 4.17, "Standard Format and Content of Site Characterization Plans for High-Level Waste Geologic Repositories, Revision 1," March 1987.

U.S. Nuclear Regulatory Commission/U.S. Department of Energy, "Summary of the NRC/DOE Meeting on the Level of Detail for Site Characterization and Study Plans," May 7-8, 1986.

(Information/Data Needs Test Methods)" Draft Letter Report LR-287, Oak Ridge National Laboratory, 1987.

Jacobs, G.K., A.D. Kelmers, and K.L. Von Damm, "Geochemistry Issues for the Yucca Mountain Site Candidate High Level Waste Repository (Information/Data Needs Test Methods)," Draft Letter Report, LR-287, Oak Ridge National Laboratory, 1987.

3.3.8 Review Guide for Information and Investigations on the Effects of Post-Closure Changes on Site Geochemistry

3 3.8.1 Background and Approach

In the SCP, it is anticipated that the site program will include plans for investigations which assess the effects of post-closure changes in site conditions other than those produced directly from repository construction and operation on the geochemical environment of the site. These changes may be anthropogenic and/or natural changes, and include events such as resource recovery operations, climatic changes, or tectonic changes. These changes could affect the groundwater and rock geochemistry, the retardation properties, and the mineral stability of the site. The performance of the repository could be affected by these changes, and therefore, they should be fully assessed in the site characterization process. This assessment will be important in the development of site-specific scenarios, conceptual models, numerical models, and designs.

The detailed criteria below should be used in conjunction with the general review criteria for parameter identification in Section 3.2.2, and investigations and activities in Sections 3.2.3 and 3.2.4 to review appropriate portions of SCP Chapter 8. Existing information presented in Chapters 1-7 relevant to the criteria given below and any staff concerns regarding this material should also be considered in the review of Chapter 8.

General considerations are provided in Criterion A. Considerations relative to key site-specific topics that should receive special attention in the review are provided in Criterion B.

3.3.8.2 Criteria

A. The identification of parameters and programs of investigations related to the effects of post-closure changes on site geochemistry should provide an adequate consideration of the following items with consideration of performance allocation for the topic:

1. Natural Changes

   a. Tectonic Processes
      movement of rock units along fault planes and changes in the location of the water table, caused by tectonic processes, resulting in changes in mineralogy and water chemistry along flow paths

   b. Magmatic and Volcanic Processes
      thermal and chemical effects of magmatic intrusions on the geochemistry of the host rock and surrounding units

   c. Climatic Changes
      effects of changes in climate, such as the onset of a

pluvial period, on the location of the water table, the water chemistry, retardation, and mineral stability

d. Flooding
effects of flooding on the location of the water table and geochemical processes and conditions dependent upon water chemistry, such as radionuclide transport, retardation, and mineral stability

e. Hydrothermal Processes
hydrothermal systems could be produced by a heat source in the vicinity of the repository, and effect retardation properties and mineral stability

2. Anthropogenic Changes

a. Resource Recovery Activities
recovery of resources in the vicinity of the repository could introduce water into the host rock, or introduce air (and therefore oxygen) into the repository environment affecting site geochemical conditions

b. Groundwater Withdrawal
changes in the chemical conditions caused by the withdrawal of groundwater affecting the groundwater flow path and flow rate

B. The identification of parameters and programs of investigations should also provide an adequate consideration of the following items (information/parameter needs and possible methodologies) for key site-specific topics with consideration of performance allocation for the topic:

1. Yucca Mountain Site:

Natural Changes
climatic variations may affect the location of the unsaturated zone, and may result in changes in water chemistry and rock geochemistry

3.3.8.3 Applicable Sections of 10 CFR Part 60

Lead	Input
60.122(b)(1)	60.112
60.122(b)(3)	60.113(a)(1)
60.122(b)(4)	60.113(a)(2)
60.122(b)(8)	60.122(a)(2)
60.122(c)(7)	60.122(b)(1)
60.122(c)(8)	60.122(b)(2)
60.122(c)(9)	60.122(b)(5)
60.122(c)(10)	60.122(b)(7)

Input (con't)
60.122(c)(1)
60.122(c)(2)
60.122(c)(3)
60.122(c)(4)
60.122(c)(5)
60.122(c)(6)
60.122(c)(11)
60.122(c)(12)
60.122(c)(13)
60.122(c)(15)
60.122(c)(17)
60.122(c)(22)
60.122(c)(23)

3.3.8.4 Key Documents to Consider

U.S. Department of Energy, Office of Civilian Radioactive Waste Management, "Annotated Outline for Site Characterization Plans," OGR/B-5, April, 1987.

U.S. Nuclear Regulatory Commission, Regulatory Guide 4.17, "Standard Format and Content of Site Characterization Plans for High-Level Waste Geologic Repositories, Revision 1," March 1987.

U.S. Nuclear Regulatory Commission/U.S. Department of Energy, "Summary of the NRC/DOE Meeting on the Level of Detail for Site Characterization and Study Plans," May 7-8, 1986.

Jacobs, G.K., A.D. Kelmers, and K.L. Von Damm, "Geochemistry Issues for the Yucca Mountain Site Candidate High Level Waste Repository (Information/Data Needs Test Methods)," Draft Letter Report, LR-287, Oak Ridge National Laboratory, 1987.

3.3.9 Review Guide for Geochemical Concerns for Modeling

3.3.9.1 Background and Approach

In the SCP. it is anticipated that the site program will include plans for investigations which include the use of geochemical models. Geochemical models will be coupled with other models (e.g., hydrologic) to demonstrate the ability of the site to meet the performance objectives of 10 CFR Part 60. The verification and validation of these models is necessary to assure that these demonstrations are sound mathematically and are representative of site geochemical conditions. Geochemical models can be used to support predictions of waste package corrosion, waste form leaching, radionuclide migration in groundwater and radionuclide source term at the accessible environment and the engineered barrier system.

The detailed criteria below should be used in conjunction with the general review criteria for parameter identification in Section 3 2.2, and investigations and activities in Sections 3.2.3 and 3.2.4 to review appropriate portions of SCP Chapter 8. Existing information presented in Chapters 1-7 relevant to the criteria given below and any staff concerns regarding this material should also be considered in the review of Chapter 8.

General considerations are provided in Criterion A. Considerations relative to key site-specific topics that should receive special attention in the review are provided in Criterion B.

3.3.9.2 Criteria

A. The identification of parameters and programs of investigations related to the use of geochemical models should provide an adequate consideration of the following items with consideration of performance allocation for the topic:

1. Thermodynamic Data Base
   the thermodynamic data base used in the model should be critically evaluated and internally consistent

2. Applicability of the Model
   The models selected should be applicable to geochemical processes expected in the repository. The appropriateness of geochemical assumptions and simplifications should be assessed. Specific areas of concern are: the validity of the local equilibrium assumption; the ability to model solid solutions; the method of activity coefficient calculation, the approach to representing sorption in the model; and the approach to modeling processes which have kinetic controls.

3. Model Sensitivity
   The investigations should consider the sensitivity of model results to the uncertainty of the geochemical input

parameters. The effects of the geochemical assumptions and simplifications should be assessed.
The effects of the coupling of geochemical models with models from other disciplines and the propagation of errors should be considered.

4. Model Validation
   a. models should be compared with experimental and field data
   b. natural analogs should be used to test the validity of the model

B. The identification of parameters and programs of investigations should also provide an adequate consideration of the following items (information and parameter needs and possible methodologies) for key site-specific topics with consideration of performance allocation for the topic:

1. Yucca Mountain Site:
   a. the ability of models chosen to predict chemical processes in the unsaturated zone
   b. the appropriateness of solid solution models used in calculating the thermodynamic parameters of zeolites

3.3.9.3 Applicable Sections of 10 CFR Part 60

Lead	Input
	60.111(a)
	60.111(b)
	60.112
	60.113(a)(1)
	60.113(a)(2)
	60.113(b)(4)

3.3.9.4 Key Documents to Consider

U.S. Nuclear Regulatory Commission, Regulatory Guide 4.17, "Standard Format and Content of Site Characterization Plans for High-Level Waste Geologic Repositories, Revision 1," March 1987.

U.S. Nuclear Regulatory Commission, Regulatory Guide 4.17, "Standard Format and Content of Site Characterization Plans for High-Level Waste Geologic Repositories, Revision 1," March 1987.

U.S. Nuclear Regulatory Commission/U.S. Department of Energy, "Summary of the NRC/DOE Meeting on the Level of Detail for Site Characterization and Study Plans," May 7-8, 1986.

INTERA Environmental Consultants, EQ3/EQ6: A Geochemical Speciation and Reaction Path Code Package Suitable for Nuclear Waste Performance Assessment, Technical Report, ONWI-472, May 1983.

U.S. Nuclear Regulatory Commission, "Conference on Application of Geochemical Models to High-Level Nuclear Waste Repository Assessment," NUREG/CP-0062, May 1985.

U.S. Nuclear Regulatory Commission, "The Symposium on Groundwater Flow and Transport Modeling for Performance Assessment of Deep Geologic Disposal of Radioactive Waste: A Critical Evaluation of State of the Art," NUREG/CP-0079, August 1986.

3.3.10 Review Guide for Information and Investigations on Geochemical Concerns for the Engineered Barrier System

3.3.10.1 Background and Approach

In the SCP, it is anticipated that the site program will include plans for investigations of the geochemical concerns for the engineered barrier system. The geochemical conditions of the geologic setting can affect the physical and chemical state of the engineered barrier system. Conversely, the engineered barrier system can affect the geochemical conditions in the near-field geologic setting. Both of these interactions may produce geochemical conditions which can affect the mobility of released radionuclides, and ultimately, the overall performance of the repository. The geochemical conditions and processes produced as a result of the interaction among engineered barrier materials, waste radionuclides, and the natural geochemical/geological setting must therefore be thoroughly assessed to determine what effects they will have on the ability of the site to attenuate radionuclide transport. This assessment will be important in developing site-specific scenarios, conceptual models, numerical models, and designs.

The detailed criteria below should be used in conjunction with the general review criteria for parameter identification in Section 3.2.2, and investigations and activities in Sections 3.2.3 and 3.2.4 to review appropriate portions of SCP Chapter 8. Existing information presented in Chapters 1-7 relevant to the criteria given below and any staff concerns regarding this material should also be considered in the review of Chapter 8.

General considerations are provided in Criterion A. Considerations relative to key site-specific topics that should receive special attention in the review are provided in Criterion B.

3.3.10.2 Criteria

A. The identification of parameters and programs of investigations related to the geochemical concerns for the engineered barrier system should provide an adequate consideration of the following items with consideration of performance allocation for the topic:

   1. Geochemistry of the Engineered Barrier System

      a. chemical composition of the waste

      b. identification of dissolution reactions, and rates of reactions

      c. solubility of the waste form under expected repository conditions

      d. chemical and mineralogical composition of engineered barriers under anticipated repository conditions

e. stability of engineered barriers under expected repository conditions

f. speciation, and changes in speciation of waste radionuclides crossing the engineered barrier/natural system interface

g. identification of key reactions between the engineered barrier system materials and the host rock and groundwater

h. proportions of phases involved in reactions

i. chemical buffering and poising of the engineered barrier system

j. hydrothermal alteration of the host rock

k. changes in groundwater chemistry due to the thermal pulse

l. changes in groundwater chemistry due to the radiation field

m. effects of changes in the host rock and groundwater on radionuclide migration

2. Geochemical Concerns with Regard to Leaching

a. Physico-chemical state of the waste form

b. Characterization of leaching mechanisms of key radionuclides under repository conditions, including the effects of the following:
(1) thermal pulse
(2) kinetics
(3) radiation field
(4) radiolytic products
(5) time
(6) groundwater flux
(7) stress/strain
(8) concentration gradients

c. Applicability of studies to repository conditions

3. Geochemical Concerns with Regard to Corrosion

a. Physico-chemical state of the waste package

b. Effects of repository conditions/site geochemistry on waste package corrosion, including a consideration of the following:
(1) thermal pulse
(2) radiation field
(3) radiolytic products
(4) groundwater flux

(5) concentration gradients
(6) stress/strain
(7) time
(8) kinetics

c. Applicability of studies to repository conditions

B. The identification of parameters and programs of investigations should also provide an adequate consideration of the following items (information/parameter needs and possible methodologies) for key site-specific topics with consideration of performance allocation for the topic:

1. Yucca Mountain Site:

a. Geochemical Concerns for Leaching
effects of successive wetting and drying cycles

b. Geochemical Concerns for Corrosion
effects of salt build-up, caused by the evaporation of infiltrating water

3.3.10.3 Applicable Sections of 10 CFR Part 60

Lead	Input
60.113(b)(3)	60.111(a)
60.122(c)(8)	60.112
	60.113(a)(1)
	60.113(a)(2)
	60.113(b)(1)
	60.113(b)(2)
	60.113(b)(4)
	60.122(b)(7)
	60.122(c)(20)

3.3.10.4 Key Documents to Consider

U.S. Department of Energy, Office of Civilian Radioactive Waste Management, "Annotated Outline for Site Characterization Plans," OGR/B-5, April, 1987.

U.S. Nuclear Regulatory Commission, Regulatory Guide 4.17, "Standard Format and Content of Site Characterization Plans for High-Level Waste Geologic Repositories, Revision 1," March 1987.

U.S. Nuclear Regulatory Commission/U.S. Department of Energy, "Summary of the NRC/DOE Meeting on the Level of Detail for Site Characterization and Study Plans," May 7-8, 1986.

Jacobs, G.K , A.D. Kelmers, and K.L. Von Damm, "Geochemistry Issues for the Yucca Mountain Site Candidate High Level Waste Repository (Information/Data Needs Test Methods)," Draft Letter Report, LR-287, Oak Ridge National Laboratory, 1987.

3.3.11 Review Guide for Information and Investigations on Geochemistry of the Host Rock

3.3.11.1 Background and Approach

In the SCP, it is anticipated that the site program will include plans for investigations of the geochemistry of the host rock. An understanding of the geochemistry of the host rock is necessary in order to assess the performance of a nuclear waste repository. Geochemical characterization of the rock will provide information on potential changes in water chemistry, sorption and other retardation mechanisms operating in the natural system, and physical stability of the host rock. A thorough assessment of the geochemistry of the host rock is therefore important in developing site-specific scenarios, conceptual models, numerical models and designs.

The detailed criteria below should be used in conjunction with the general review criteria for parameter identification in Section 3.2.2, and investigations in Sections 3.2 3 and 3.2.4 to review appropriate portions of SCP Chapter 8. Existing information presented in Chapters 1-7 relevant to the criteria given below and any staff concerns regarding this material should also be considered in the review of Chapter 8.

General considerations are provided in Criterion A. Considerations relative to key site-specific topics that should receive special attention in the review are provided in Criterion B.

3.3.11.2 Criteria

A. The identification of parameters and programs of investigations related to the geochemistry of the host rock, should provide an adequate consideration of the following items with consideration of performance allocation for the topic:

1. identification of minerals in the host rock and surrounding strata

2. petrology of the host rock and surrounding strata

3. chemistry of the minerals and rock

4. surface area/surface properties of minerals and rock

5. hydrodynamic properties of the host rock and the surrounding strata

6. effects of stress/strain on mineral dissolution and mineral stability

7. age determination
   to investigate the genesis and thermal history of the host rock and surrounding units

8. fluid inclusions
   to investigate the genesis of the host minerals and the characteristics of paleowaters at the repository

B. The identification of parameters and programs of investigations should also provide an adequate consideration of the following items (information/parameter needs and possible methodologies) for key site-specific topics with consideration of performance allocation for the topic:

1. Yucca Mountain Site:

   (a) petrology of the calcite-silica veins
      (1) use of stable isotopes to determine genesis
      (2) age determination
      (3) use of fluid inclusions and trace elements to determine temperature of formation

   (b) petrographic studies of geopetal structures to support geologic investigations of tectonism

   (c) formation and distribution of zeolites

3.3.11.3 Applicable Sections of 10 CFR Part 60

Lead	Input
60.113(b)(1)	60.111(b)(1)
60.113(b)(3)	60.111(b)(2)
60.113(b)(4)	60.112
60.113(c)	60.113(a)(1)
60.122(a)(1)	60.113(a)(2)
60.122(a)(2)	60.113(b)(1)
60.122(b)(1)	60.113(b)(3)
60.122(b)(3)(i)	60.113(b)(4)
60.122(b)(3)(ii)	60.113(c)
60.122(b)(3)(iii)	60.122(a)(1)
60.122(b)(4)	60.122(a)(2)
60.122(c)(8)	60.122(b)(1)
	60.122(b)(2)
	60.122(b)(5)
	60.122(b)(7)
	60.122(b)(8)
	60.122(c)(17)

3.3.11.4 Key Documents to Consider

U.S. Department of Energy, Office of Civilian Radioactive Waste Management, "Annotated Outline for Site Characterization Plans," OGR/B-5, April, 1987.

U.S. Nuclear Regulatory Commission, Regulatory Guide 4.17, "Standard Format and Content of Site Characterization Plans for High-Level Waste Geologic Repositories, Revision 1," March 1987.

U.S. Nuclear Regulatory Commission/U.S. Department of Energy, "Summary of the NRC/DOE Meeting on the Level of Detail for Site Characterization and Study Plans," May 7-8, 1986.

Jacobs, G.K., A.D. Kelmers, and K.L. Von Damm, "Geochemistry Issues for the Yucca Mountain Site Candidate High Level Waste Repository (Information/Data Needs Test Methods)," Draft Letter Report, LR-287, Oak Ridge National Laboratory, 1987.

Bernhard, M., et al, eds., The Importance of Chemical Speciation in Environmental Processes, Life Sciences Research Report #33, Dahlem Workshop, Berlin, West Germany, Springer Verlag, New York, 1984.

U.S. Nuclear Regulatory Commission, "NRC Nuclear Waste Geochemistry '83," Proceedings of U.S. NRC Workshop, August 30-31, 1983, NUREG/CP-0052, 1984.

U.S. Nuclear Regulatory Commission, "Critical Parameters for a High-Level Waste Repository," Volume 2: Tuff -NUREG/CR- TBD, (1985).

Apps, J.A., et al, "Status of Geochemical Problems Relating to the Burial of High-Level Radioactive Waste," NUREG/CR-3062, 1982.

Claiborne, H.C., et al, "Repository Environmental Parameters and Models/Methodologies Relevant to Assessing the Performance of High-Level Waste Packages in Basalt, Tuff, and Salt," NUREG/CR-4134/R1.

Trudinger, P.A., and Swane, D.J., eds., Studies in Environmental Science 3, "Biogeochemical Cycling of Mineral-Forming Elements," Elsevier Scientific Publishing Company, New York, 1979.

Cranwell, R. M., et al., "Risk Methodology for Geologic Disposal of Radioactive Waste," Final Report, NUREG/CR-2452, 1987.

National Research Council, Waste Isolation Systems Panel, Board on Radioactive Waste Management, "A Study of the Isolation System for Geologic Disposal of Radioactive Waste," National Academy Press, Washington, D.C., 1983.

American Physical Society Study Group on Fuel Cycle and Waste Management, "Report to the American Physical Society on Nuclear Fuel Cycles and Waste Management," Reviews of Modern Physics 50, No. 1, Part II, p. S1-S185, 1978.

Malbrain, C.M. and R.K. Lester, "An Improved Environmental Pathway Model for Assessing High-level Waste Repository Risks," Health Physics, Vol. 53, No. 5, pp. 473-486, 1987.

3.3.12 Review Guide for Information and Investigations on the Geochemistry of Groundwater

3.3.12.1 Background and Approach

In the SCP, it is anticipated that the site program will include plans for investigations of the geochemistry of groundwater. An understanding of the geochemistry of groundwater is a concern for both the siting of the repository and performance of a nuclear waste repository. The characterization of the geochemistry of groundwater will support predictions of the rates of waste package corrosion, waste form leaching, radionuclide migration and groundwater movement. A thorough assessment of the geochemistry of groundwater is therefore important in developing site-specific scenarios, conceptual models, numerical models and designs.

The detailed criteria below should be used in conjunction with the general review criteria for parameter identification in Section 3.2.2, and investigations in Sections 3.2.3 and 3.2.4 to review appropriate portions of SCP Chapter 8. Existing information presented in Chapters 1-7 relevant to the criteria given below and any staff concerns regarding this material should also be considered in the review of Chapter 8.

General considerations are provided in Criterion A. Considerations relative to key site-specific topics that should receive special attention in the review are provided in Criterion B.

3.3.12.2 Criteria

A. The identification of parameters and programs of investigations related to the geochemistry of the groundwater should provide an adequate consideration of the following items with consideration of performance allocation for the topic:

1. major elements in solution
2. minor elements in solution
3. trace elements in solution
4. speciation of ambient groundwaters
5. ionic strength
6. charge balance
7. pH
8. redox conditions
   Investigations should include consideration of uncertainties in redox measurement and calculations

9. ambient groundwater and rock temperature, and predicted post-closure temperatures

10. biogeochemical processes
    investigations should identify important macro- and micro-species, and identify the key biogeochemical reactions and cycles

11. identification of disequilibrium conditions

12. degree of saturation of groundwater with respect to key minerals

13. dissolved gas content and composition

14. stable isotopes
    can provide information on water/rock ratio

15. age of groundwater
    can provide information for groundwater travel time calculations

16. groundwater density

17. background concentrations of radioactive elements

18. size, nature, and amount of naturally-occurring colloids

19. size, nature and amount of naturally-occurring particulates

20. kinetic effects
    Investigations should include identification of the key kinetically controlled reactions and determine rate constants for these reactions

21. effects of radiolytic processes on groundwater chemistry

B. The identification of parameters and programs of investigations should also provide an adequate consideration of the following items (information/parameter needs and possible methodologies) for key site-specific topics with consideration of performance allocation for the topic:

1. Yucca Mountain Site:

   (a) evaluate the effect of water sample collection method on unsaturated zone water chemistry
   (b) presence and effect of colloidal or particle-bound radionuclides on matrix diffusion

3.3.12.3 Applicable Sections of 10 CFR Part 60

Lead	Input
60.113(b)(3)	60.18(e)
60.113(b)(4)	60.111(a)
60.122(b)(1)	60.112
60.122(b)(3)	60.113(a)(1)
60.122(c)(7)	60.113(a)(2)
60.122(c)(8)	60.113(b)(1)
60.122(b)(4)	60.113(b)(2)
60.122(c)(9)	60.122(c)(17)
60.122(c)(20)	
60.122(c)(24)	

3.3.12.4 Key Documents to Consider

U.S. Department of Energy, Office of Civilian Radioactive Waste Management, "Annotated Outline for Site Characterization Plans," OGR/B-5, April, 1987.

U.S. Nuclear Regulatory Commission, Regulatory Guide 4.17, "Standard Format and Content of Site Characterization Plans for High-Level Waste Geologic Repositories, Revision 1," March 1987.

U.S. Nuclear Regulatory Commission/U.S. Department of Energy, "Summary of the NRC/DOE Meeting on the Level of Detail for Site Characterization and Study Plans," May 7-8, 1986

Jacobs, G.K., A.D. Kelmers, and K.L. Von Damm, "Geochemistry Issues for the Yucca Mountain Site Candidate High Level Waste Repository (Information/Data Needs Test Methods)," Draft Letter Report, LR-287, Oak Ridge National Laboratory, 1987.

Bernhard, M., et al, eds., The Importance of Chemical Speciation in Environmental Processes, Life Sciences Research Report #33, Dahlem Workshop, Berlin, West Germany, Springer Verlag, New York. 1984.

U.S. Nuclear Regulatory Commission, NRC Staff Comments on the DOE Final Environmental Assessments, Comment Number 6, Redox Conditions, December, 1986.

U.S. Nuclear Regulatory Commission, "NRC Nuclear Waste Geochemistry '83," Proceedings of U.S. NRC Workshop, August 30-31, 1983, NUREG/CP-0052, 1984.

U.S. Nuclear Regulatory Commission, "Critical Parameters for a High-Level Waste Repository," Volume 2: Tuff -NUREG/CR- TBD, 1985.

Apps, J.A., et al, "Status of Geochemical Problems Relating to the Burial of High-Level Radioactive Waste," NUREG/CR-3062, 1982.

Claiborne, H.C., et al, "Repository Environmental Parameters and Models/Methodologies Relevant to Assessing the Performance of High-Level Waste Packages in Basalt, Tuff, and Salt," NUREG/CR-4134/R1.

Trudinger, P.A., and Swaine, D J., eds., Studies in Environmental Science 3, "Biogeochemical Cycling of Mineral-Forming Elements," Elsevier Scientific Publishing Company, New York, 1979.

U.S. Nuclear Regulatory Commission, Determination of Radionuclide Solubility in Groundwater for Assessment of High-level Waste Isolation, Technical Position, Geochemistry Section, Geotechnical Branch, Division of Waste Management, 1984.

National Research Council, Waste Isolation Systems Panel, Board on Radioactive Waste Management, "A Study of the Isolation System for Geologic Disposal of Radioactive Waste," National Academy Press, Washington, D.C., 1983.

American Physical Society Study Group on Fuel Cycle and Waste Management, Report to the American Physical Society on Nuclear Fuel Cycles and Waste Management, Reviews of Modern Physics 50, No. 1, Part II, p. S1-S185, 1978.

3.3.13 Review Guide for Information and Investigations on Mineral and Glass Stability

3.3.13.1 Background and Approach

In the SCP, it is anticipated that the site program will include plans for investigations of the mineral and glass stability. An understanding of the geochemistry of these processes and conditions is necessary in order to assess the performance of a nuclear waste repository. The assessment of mineral and glass stability will identify those phases which may change due to natural disequilibrium conditions, and in response to repository construction and operation. A thorough assessment of these geochemical processes and conditions is therefore important in developing site-specific scenarios, conceptual models, numerical models and designs.

The detailed criteria below should be used in conjunction with the general review criteria for parameter identification in Section 3.2.2 and investigations in Sections 3.2.3 and 3.2.4 to review appropriate portions of SCP Chapter 8. Existing information presented in Chapters 1-7 relevant to the criteria given below and any staff concerns regarding this material should also be considered in the review of Chapter 8.

General considerations are provided in Criterion A. Considerations relative to key site-specific topics that should receive special attention in the review are provided in Criterion B.

3.3.13.2 Criteria

A. The identification of parameters and programs of investigations related to mineral and glass stability should provide an adequate consideration of the following items with consideration of performance allocation for the topic:

   1. key mineral and glass reactions occurring under site-specific solid, liquid and vapor phase conditions

   2. effects of stress/strain on mineral and glass stability

   3. effects of the engineered barrier system materials on mineral and glass stability

   4. duration and rate of change of geochemical conditions

   5. kinetic controls on key mineral and glass reactions

   6. thermodynamic controls on key mineral and glass reactions

   7. effects of the radiation field and radiolytic reactions on mineral and glass stability

B. The identification of parameters and programs of investigations should also provide an adequate consideration of the following items (information/parameter needs and possible methodologies) for key site-specific topics with consideration of performance allocation for the topic:

1. Yucca Mountain Site:

effect of silica phase stability on zeolite stability

3.3.13.3 Applicable Sections of 10 CFR Part 60

Lead	Input
60.113(a)(1)	60.111(a)
60.113(b)(1)	60.113(a)(1)
60.113(b)(2)	60.113(a)(2)
60.113(b)(3)	60.113(b)(1)
60.113(b)(4)	60.113(b)(2)
60.122(c)(4)	60.113(b)(4)
60.122(c)(7)	60.122(c)(6)
60.122(c)(8)	60.122(c)(7)
60.122(c)(9)	60.122(c)(17)
60.122(c)(10)	
60.122(c)(15)	
60.122(c)(20)	

3.3.13.4 Key Documents to Consider

U.S. Department of Energy, Office of Civilian Radioactive Waste Management, "Annotated Outline for Site Characterization Plans," OGR/B-5, April, 1987.

U.S. Nuclear Regulatory Commission, Regulatory Guide 4.17, "Standard Format and Content of Site Characterization Plans for High-Level Waste Geologic Repositories, Revision 1," March 1987.

U.S. Nuclear Regulatory Commission/U.S. Department of Energy, "Summary of the NRC/DOE Meeting on the Level of Detail for Site Characterization and Study Plans," May 7-8, 1986.

Jacobs, G.K., A.D. Kelmers, and K.L. Von Damm, "Geochemistry Issues for the Yucca Mountain Site Candidate High Level Waste Repository (Information/Data Needs Test Methods)," Draft Letter Report, LR-287, Oak Ridge National Laboratory, 1987.

U.S. Nuclear Regulatory Commission, NRC Staff Comment on the DOE Final Environmental Assessments, Comment Number 6, Redox Conditions, December, 1986.

U.S. Nuclear Regulatory Commission, "NRC Nuclear Waste Geochemistry '83," Proceedings of U.S. NRC Workshop, August 30-31, 1983, NUREG/CP-0052, 1984.

U.S. Nuclear Regulatory Commission, "Critical Parameters for a High-Level Waste Repository," Volume 2: Tuff -NUREG/CR- TBD, 1985.

Apps, J.A., et al, "Status of Geochemical Problems Relating to the Burial of High-Level Radioactive Waste," NUREG/CR-3062, 1982.

Claiborne, H.C., et al, "Repository Environmental Parameters and Models/Methodologies Relevant to Assessing the Performance of High-Level Waste Packages in Basalt, Tuff, and Salt," NUREG/CR-4134/RI.

Trudinger, P.A., Swaine, D.J., eds., Studies in Environmental Science 3, "Biogeochemical Cycling of Mineral-Forming Elements," Elsevier Scientific Publishing Company, New York, 1979.

Cranwell, R. M., et al, "Risk Methodology for Geologic Disposal of Radioactive Waste," Final Report, NUREG/CR-2452, 1987.

National Research Council, Waste Isolation Systems Panel, Board on Radioactive Waste Management, "A Study of the Isolation System for Geologic Disposal of Radioactive Waste," National Academy Press, Washington, D.C., 1983.

3.3.14 Review Guide for Information and Investigations on Radionuclide Retardation

3.3.14.1 Background and Approach

In the SCP, it is anticipated that the site program will include plans for investigations of radionuclide retardation. An understanding of the geochemistry of these processes and conditions is necessary in order to assess the performance of a nuclear waste repository. Investigations of radionuclide retardation mechanisms such as sorption, precipitation, and matrix diffusion will provide valuable information on the ability of a site to isolate released radionuclides. A thorough assessment of these geochemical processes and conditions is therefore important in developing site-specific scenarios, conceptual models, numerical models and designs.

The detailed criteria below should be used in conjunction with the general review criteria for parameter identification in Section 3.2.2, and investigations and activities in Sections 3.2.3 and 3.2.4 to review appropriate Portions of SCP Chapter 8. Existing information presented in Chapters 1-7 relevant to the criteria given below and any staff concerns regarding this material should also be considered in the review of Chapter 8.

General considerations are provided in Criterion A. Considerations relative to key site-specific topics that should receive special attention in the review are provided in Criterion B.

3.3.14.2 Criteria

A. The identification of parameters and programs of investigations related to radionuclide retardation should provide an adequate consideration of the following items with consideration of performance allocation for the topic:

1. Key Radionuclides

   In assessing the transport of radionuclides, it is essential to identify those radionuclides which are likely to reach the accessible environment and pose the greatest potential radiological hazard. Investigations should be focused on these "key radionuclides," identified using the following criteria:

   (a) Physico-chemical form of the waste
   (b) Radionuclide inventory over time
   (c) NRC radionuclide release limit from the engineered barrier system
   (d) EPA standards for radionuclide release to the accessible environment, individual radiation protection, and groundwater protection
   (e) Annual Limits of Intake for radionuclides, as defined by the International Commission on Radiation Protection, ICRP-30

(f) Speciation
(g) Processes and conditions affecting radionuclide mobility

2. Sorption of key radionuclides

(a) assessment of the effects of the following conditions and processes on the sorption of radionuclides:
(1) geochemistry of the groundwater
(2) geochemistry of the host rock
(3) groundwater flow rate
(4) temperature
(5) redox conditions
(6) colloids and particulates
(7) biogeochemical processes
(8) radioactive decay
(9) radiolytic processes
(10) kinetics
(11) mineral stability
(12) speciation of radionuclides
(13) surface area of rocks and minerals along flow paths
(14) time
(15) scale

(b) rationale for the selection of phases and conditions to be used in sorption experiments

(c) assessment of the applicability of particular sorption tests to repository conditions

3. Solubility/precipitation of key radionuclides

(a) demonstration of approach to equilibrium

(b) consideration of supersaturation

(c) demonstration that the experimental reactants and conditions simulate those in the repository

(d) characterization of experimental reactants

(e) characterization of experimental products

4. Dispersion, diffusion, advection of key radionuclides

(a) fracture density and aperture size distribution

(b) velocity of groundwater through the fractures

(c) pore size distribution and geometry

(d) matrix porosity and permeability

(e) degree of matrix saturation

(f) pore and fracture mineralogy

(g) differences in physical and chemical conditions between fracture and pore

(h) characterization of the diffusing species, including colloids and particulates

(i) effective diffusion coefficients for species under consideration

(j) solute concentration gradients between fracture and matrix

(k) applicability of studies to repository conditions

(l) effects of anion exclusion

(m) effects of sorption

(n) hydrodynamic dispersion

(o) effects of channeling

5. Vapor-phase transport of key radionuclides

(a) chemical analysis of the vapor phase

(b) dating of the vapor phase

(c) characterization of the nature and chemistry of aerosols

(d) degree of saturation

(e) effective porosity

(f) gas permeability

(9) effect of the thermal gradient on vapor-phase transport

(h) partitioning of radionuclides among the gas, liquid, and solid phases under repository conditions

(i) inventory and release rates of gaseous radionuclides

(j) vapor flux

B. The identification of parameters and programs of investigations should also provide an adequate consideration of the following items (information/parameter needs and possible methodologies) for key

site-specific topics with consideration of performance allocation for the topic:

1. Yucca Mountain Site:

   (a) Sorption of key radionuclides
      (1) sorption of radionuclides on zeolites
      (2) effect of wetting/drying cycles on sorption
   (b) Solubility/precipitation of key radionuclides
      effects of successive wetting/drying cycles on radionuclide solubility
   (c) Dispersion, diffusion, advection of key radionuclides
      effects of unsaturated conditions
   (d) Vapor-phase transport
      consequences of vapor phase transport of gaseous radionuclides by-passing the unsaturated zone hydrologic barrier

3.3.14.3 Applicable Sections of 10 CFR Part 60

Lead	Input
Key radionuclides	
60.113(a)(1)(i)	60.112
60.113(a)(1)(ii)	60.113(a)(1)
60.113(a)(1)(iii)	60.113(b)(1)
60.113(b)(1)	60.113(b)(2)
60.113(b)(2)	60.113(b)(4)
60.113(b)(3)	60.111(a)
60.113(b)(4)	
60.122(b)(3)(i)	
60.122(b)(3)(ii)	
Sorption	
60.113(a)(1)(i)(A)	60.111(a)
60.113(a)(1)(i)(B)	60.111(b)(1)
60.113(a)(1)(ii)(B)	60.111(b)(2)
60.113(b)(4)	60.112
	60.113(a)(1)
	60.113(a)(2)
	60.113(b)(4)
Solubility/precipitation	
60.113(a)(1)(i)(A)	60.112
60.113(a)(1)(i)(B)	60.113(a)(1)
60.113(a)(1)(ii)(A)	60.113(a)(2)
60.113(a)(1)(ii)(B)	60.113(b)(1)
60.113(b)(1)	60.113(b)(2)
60.113(b)(2)	60.113(b)(4)
60.113(b)(3)	60.122(a)(1)

Lead (con't)	Input (con't)
60.113(b)(4)	60.122(a)(2)
60.122(a)(1)	60.122(b)(1)
60.122(a)(2)	
60.122(b)(1)	
60.122(b)(3)(i)	
60.122(b)(3)(ii)	
60.122(c)(7)	
60.122(c)(8)	
60.122(c)(9)	
Dispersion, diffusion, advection	
60.133(b)(1)	60.111(a)
60.133(b)(3)	60.122
60.133(b)(4)	60.133(a)(1)
60.133(a)(1)	60.133(b)(1)
60.122(b)(1)	60.133(b)(2)
60.122(b)(3)(iii)	60.133(b)(4)
60.122(b)(4)	60.122(a)(1)
	60.122(b)(1)
Vapor phase transport	
60.113(a)(1)(i)(A)	60.111(a)
60.113(a)(1)(i)(B)	60.113(a)(1)
60.113(a)(1)(ii)(A)	60.113(b)(1)
60.113(a)(1)(ii)(B)	60.113(b)(2)
60 113(b)(1)	60.113(b)(4)
60.113(b)(2)	60.113(c)
60.113(b)(3)	60.122(a)(2)
60.113(b)(4)	60.122(b)(1)
60.122(a)(2)	60.122(c)(10)
60.122(b)(1)	
60.122(b)(3)(i)	
60.122(b)(3)(ii)	
60.122(b)(8)	
60.122(c)(6)	
60.122(c)(24)	
60.122(c)(7)	
60.122(c)(8)	
60.122(c)(9)	

3.3.14.4 Key Documents to Consider

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U.S. Nuclear Regulatory Commission, Regulatory Guide 4.17, "Standard Format and Content of Site Characterization Plans for High-Level Waste Geologic Repositories, Revision 1," March 1987.

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Bernhard, M., et al, eds., The Importance of Chemical Speciation in Environmental Processes, Life Sciences Research Report #33, Dahlem Workshop, Berlin, West Germany, Springer Verlag, New York, 1984.

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U.S Nuclear Regulatory Commission, NRC Staff Comment on the DOE Final Environmental Assessments, Comment Number 7, Microbial/Organic Complexes and Radionuclide Retardation, December, 1986.

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American Physical Society Study Group on Fuel Cycle and Waste Management, Report to the American Physical Society on Nuclear Fuel Cycles and Waste Management, Reviews of Modern Physics 50, No. 1, Part II, p. S1-S185, 1978.

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3.3.15 Review Guide for Surface Water System Information and Investigations

3.3.15.1 Background and Approach

In the SCP, it is anticipated that the site program will include plans for investigation of surface water features for siting and design of surface facilities and issue resolution, primarily to determine the effects of flooding and erosion on the operational and post-closure performance of the repository. Surface water is a concern because of potential flooding and damage to surface facilities. This could possibly result in surface water transport of radionuclides; potentially cause flooding of surface access and underground facilities; potentially affect groundwater hydrology; and, as a result, potentially affect transport of radioactive waste from the repository. Such processes, events and, conditions are important considerations in developing site-specific scenarios, conceptual and numerical models, and designs.

The detailed criteria below should be used, in conjunction with the general review criteria for parameter identification in Section 3.2.2, and investigations and activities in Sections 3.2.3 and 3.2.4, to review appropriate portions of SCP Chapter 8. Existing information presented in Chapters 1-7 relevant to the criteria given below and any staff concerns regarding this material should also be considered in the review of Chapter 8.

General considerations are provided in Criterion A. Considerations relative to key site-specific topics that should receive special attention in the review are provided in Criterion B.

3.3.15.2 Criteria

A. The identification of parameters and program of investigations related to surface water systems, should consider the following items (with consideration of the performance allocation for the topic):

   1. description of all bodies of surface water and watercourses, both permanent and ephemeral, within the controlled area and in the immediate region, including:

      a. drainage areas

      b. soil types

      c. topographic features

      d. stream channel cross-sections sufficient to perform detailed flooding analyses for each stream identified

      e. identification of erosion processes which may affect flooding analyses, including effects of scour, sedimentation and other phenomena associated with flooding

2. previous floods and high water levels, both from the historic and prehistoric record, including the date, level and peak discharge for major floods associated with nearby watercourses, or associated with dam failures, ice jams, or landslides

3. potential for future flooding of the site, including:

   a. description of all types of flooding that potentially could affect the site

   b. discussion of the extent and potential effects of floods as severe as the Probable Maximum Flood (PMF), including:
      (1) peak water levels, velocities, and flood magnitude
      (2) potential for erosion and/or inundation of surface facilities
      (3) maximum scour depths and sediment/debris deposition
      (4) potential for geomorphic changes to affect site flood protection features

   c. discussion of procedures used to derive estimates of flood magnitude, water levels, velocities, recurrence intervals and erosion/sedimentation potential

4. flooding protection designs and requirements, including:

   a. erosion protection measures provided to protect both natural and engineered features at the site from flooding and erosion

   b. analyses used to determine magnitude, extent and feasibility of flood protection measures

   c. description of flooding scenarios that could affect infiltration and recharge and subsequent transport of radionuclides to the accessible environment

5. points of surface-water use

6. projected surface-water use

7. chemical composition of adjacent watercourses

B. The identification of parameters and program of investigations should consider the following key site-specific topics (with consideration of the Performance allocation for the topic):

1. Yucca Mountain

   a. potential for flooding of surface locations of shafts and ramps during the preoperational, operational and post-closure periods for floods up to and including the PMF

   b. estimates of the potential for debris blockage of site ephemeral streams resulting in flooding

c. estimate of recharge to the unsaturated zone from potential flooding of surface openings or ponding in the vicinity of surface access location

d. discussion of geomorphic changes which could affect drainage configurations

e. measurements necessary for water balance estimates
   (1) meteorological parameters; e.g., solar radiation, wind speed, rainfall, air temperature, potential evapotranspiration

   (2) characterization of infiltration potential, e.g., infiltrometers, rainfall simulators, direct rainfall/runoff measurements in channels.

f. discussions of designs to preclude or minimize infiltration to the underground facility, particularly at shafts and ramps

3.3.15.3 Applicable Sections of 10 CFR 60 Subparts E, F and G

Lead Responsibility

60.122 (c)(1)

Input Responsibility	To
60.111 (a)	Compliance Demonstration
60.112 (a)(1)*,(2)*	Compliance Demonstration
60.112 (b)*	Compliance Demonstration
60.113 (a)(1)(i)(A),(B);(ii)(A),(B)	Materials Engineering
60 122 (a)(2)(i);(ii);(iii)(A),(B),(C)	Compliance Demonstration
60.122 (b)(1)	Compliance Demonstration
60.122 (c)(2),(3),(6)	Hydrology (Groundwater Flow)
60.131 (b)(1)	Design/Rock Mechanics
60.132 (c)(1),(2)	Design/Rock Mechanics
60.132 (e)	Design/Rock Mechanics
60.133 (a)(1),(2)	Design/Rock Mechanics
60.133 (c)	Design/Rock Mechanics
60.133 (d)	Design/Rock Mechanics
60.133 (f)	Design/Rock Mechanics
60.134 (a)	Design/Rock Mechanics
60.134 (b)(2)	Design/Rock Mechanics
60.135 (a)(1)	Materials Engineering

* Based on proposed rule change (51FR22288, June 19, 1986)

3.3.15.4 Key Documents to Consider

U.S. Nuclear Regulatory Commission, Regulatory Guide 4.17, "Standard Format and Content of Site Characterization Plans for High-Level Waste Geologic Repositories," Rev. 1, March 1987.

U.S. Nuclear Regulatory Commission and U. S. Department of Energy, "Summary of NRC/DOE Meeting on Level of Detail for Site Characterization Plans and Study Plans," May 8-9, 1986.

Johnson, T.L., Subject: Memorandum to J. Starmer, "NNWSI site visit, flooding and erosion comments, shaft and ramp locations," July 22, 1987.

Johnson, T.L., "Review of flooding analyses, Exploratory Shaft Performance Analysis Studies, NNWSI," April 21, 1986.

American Nuclear Society, ANS 2.8/ANSI N170-1976, "Standards for Determination of Design Basis Floods at Power Reactor Sites," 1976.

3.3.16 Review Guide for Groundwater Flow System Information and Investigations

3.3.16.1 Background and Approach

In the SCP, it is anticipated that the site program will include plans for investigations of the groundwater flow system as needed for issue resolution and a basic understanding of the site. Saturated and unsaturated groundwater flow is the primary way for radionuclides to be transported from a geologic, high-level waste repository. Thus, an understanding of the groundwater flow system is necessary for evaluating performance during preclosure operation and for providing assurance on the ability of the repository to meet the performance objectives after closure. For example, the potential for inflow of groundwater into the underground facility during the operational phase is a consideration in evaluating repository design and design criteria. In the context of long-term performance, groundwater flow into and/or through the underground facility is a consideration in evaluating waste package performance and radionuclide releases to the accessible environment. Finally, characterization of the groundwater flow system is needed to evaluate the pre-waste-emplacement groundwater travel time along the fastest path of likely radionuclide transport.

The detailed criteria below should be used, in conjunction with the general review criteria for parameter identification in Section 3.2.2, and investigations and activities in Sections 3.2.3 and 3.2.4, to review appropriate portions of SCP Chapter 8. Existing information presented in Chapters 1-7 relevant to the criteria given below and any staff concerns regarding this material should also be considered in the review of Chapter 8.

General considerations are provided in Criterion A. Considerations relative to key site-specific topics that should receive special attention in the review are provided in Criterion B.

3.3.16.2 Criteria

A. The identification of parameters and program of investigations related to the groundwater flow system should provide an adequate consideration of the following items (with consideration of the performance allocation for the topic):

1. hydrostratigraphic units within the region and at the site, including:

   a. lithology

   b. hydraulic characteristics
      (1) vertical and horizontal saturated hydraulic conductivity
      (3) transmissivity
      (4) intrinsic permeability
      (5) total and effective porosity
      (6) storage coefficient

(7) saturated thickness
(8) flow conditions

c. hydraulic characteristics of unsaturated zone
(1) unsaturated hydraulic conductivity
(2) moisture content
(3) temporal and spatial extent of unsaturated zone
(4) modes and amounts of infiltration and percolation (recharge)
(5) existence of perch water, flow rates and directions
(6) matrix vs. fracture flow
(7) flux rates
(8) potential for vapor transport

2. hydraulic head relationships between hydrostratigraphic units within the region and at the site, including:

a. potentiometric levels

b. hydraulic gradients

c. flow directions

d. seepage fluxes

3. regional and site hydrochemistry, including:

a. hydrochemical facies

b. isotopic ages of groundwater

c. major ions

d. trace constituents

e. dissolved gases

f. temperatures

g. density of fluids

h. temporal and spatial variations in groundwater quality

4. location, nature and extent of recharge and discharge areas for the region and site

5. groundwater velocity and travel time, including:

a. identification of credible pathways

b. methods for determining average interstitial velocities for darcian flow

c. maximum velocities for fractured flow

d. expected range of advective travel times

6. groundwater levels during the Quaternary

7. potential for changes in hydrologic conditions from foreseeable human activities, natural phenomena creating large-scale surface water impoundments, structural deformation or foreseeable climatic changes, including:

   a. hydraulic gradient

   b. average interstitial velocity

   c. storage coefficient

   d. hydraulic conductivity

   e. natural recharge

   f. potentiometric levels

   g. discharge points

8. baseline groundwater monitoring program for the site, including:

   a. monitor well construction, development and completion techniques

   b. monitor well locations

   c. screen depths

   d. types and locations of seals

   e. materials

   f. mode of drilling

   g. schedules of development

   h. monitoring and sampling methods
      (1) geophysical techniques
      (2) water sampling
      (3) head measurements
      (4) pressure testing

B. Identification of parameters and programs of investigations related to the groundwater flow system should consider the following items (information and parameter needs, and possible methodologies) for key site-specific topics (with consideration of the performance allocation for the topic):

1. Yucca Mountain

   a. possible methodologies for characterizing flow in unsaturated, fractured tuff formations, including:
      (1) thermocouple psychrometer tests
      (2) tensiometer tests
      (3) soil moisture block tests
      (4) neutron log tests
      (5) permeameter tests
      (6) fractured rock infiltrometer tests
      (7) packer tests of fracture permeability
      (8) pore water extraction by core squeezing
      (9) pore water extraction by centrifuge and displacement
      (10) pore water samples by lysimeter
      (11) vacuum collection of vapor-phase isotopes

3.3.16.3 Applicable Sections of 10 CFR Part 60, Subparts E, F and G

Lead Responsibility
60.113 (a)(2)
60.122 (b)(2)(i),(ii),(iii)
60.122 (b)(7)
60.122 (b)(8)(i),(ii),(iii),(iv)
60.122 (c)(2),(3),(4),(5),(6),(23)*,(24)*

Input Responsibility	To
60.111 (a)	Compliance Demonstration
60.111 (b)(1)	Design/Rock Mechanics
60.112 (a)(1)*,(2)*	Compliance Demonstration
60.112 (b)*	Compliance Demonstration
60.112 (c)(1)*,(2)*	Compliance Demonstration
60.113 (a)(1)(i)(A),(B);(ii)(A),(B)	Materials Engineering
60.122 (a)(2)(i);(ii);(iii)(A),(B),(C)	Compliance Demonstration
60.122 (b)(1)	Compliance Demonstration
60.122 (c)(21)*	Design/Rock Mechanics
60.122 (c)(25)*	Geochemistry
60.131 (b)(1)	Design/Rock Mechanics
60.132 (c)(1),(2)	Design/Rock Mechanics
60.132 (e)	Design/Rock Mechanics
60 133 (d)	Design/Rock Mechanics
60.133 (e)(1)	Design/Rock Mechanics
60.133 (f)	Design/Rock Mechanics
60.134 (a)	Design/Rock Mechanics
60.134 (b)(1),(2)	Design/Rock Mechanics
60 135 (a)(1)	Materials Engineering
60.140 (d)(1),(2),(3)	Compliance Demonstration

* Based on proposed rule change (51FR22288, June 19, 1986)

3.3.16.4 Key Documents to Consider

Davis S. N., and Murphy, E., University of Arizona, "Dating Ground Water and the Evaluation of Repositories for Radioactive Waste," USNRC Report NUREG/CR-4912, April 1987.

Rasmussen, T. C., and Evans, D. D., University of Arizona, "Unsaturated Flow and Transport through Fractured Rock Related to High-Level Waste Repositories," NUREG/CR-4655, May 1987.

Schrauf, T. W., and Evans, D. D., University of Arizona, "Relationship Between the Gas Conductivity and Geometry of a Natural Fracture," USNRC Report NUREG/CR-3680, April 1984.

Evans, D. D., University of Arizona, "Unsaturated Flow and Transport through Fractured Rock - Related to High-Level Waste Repositories," USNRC Report NUREG/CR-3206, March 1983.

U.S. Nuclear Regulatory Commission, "Final Technical Position on Documentation of Computer Codes for High-Level Waste Management," USNRC NUREG-0856, June 1983.

U.S. Nuclear Regulatory Commission, "Draft Issue-Oriented Site Technical Position (ISTP) for Nevada Nuclear Waste Storage Investigations (NNWSI)," Draft Report, September 1984.

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U.S. Nuclear Regulatory Commission, "Generic Technical Position on In-Situ Testing During Site Characterization," Final Report, December 1985.

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U.S. Department of Energy, "Annotated Outline for Site Characterization Plans," USDOE Report OGR/B-5, April 1987.

Hsieh, P. A., Neuman, S. P., and Simpson, E. S., University of Arizona, "Pressure Testing of Fractured Rocks; A Methodology Employing Three-Dimensional Cross-Hole Tests," USNRC Report NUREG/CR-3213, July 1983.

Winters, C. L., Neuman, S. P., and Newman, S. M., University of Arizona, "Prediction of Far-Field Subsurface Radionuclide Dispersion Coefficients from Hydraulic Conductivity Measurements: A multidimensional Stochastic Theory with Application to Fractured Rocks," USNRC Report NUREG/CR-3612, March 1984.

U.S. Department of Energy and U.S. Nuclear Regulatory Commission, "Summary of NRC/DOE Meeting on the Level of Detail for Site Characterization Plans and Study Plans," May 7-8, 1986.

U.S. Department of Energy and U.S. Nuclear Regulatory Commission, "Summary of NRC/DOE Meeting on the Geohydrology Testing Program before Construction of the Exploratory Shaft," April 9, 1987.

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Reeves, M., and Cranwell, R. M., Sandia National Laboratories, "Users Manual for the Sandia Waste-Isolation Flow and Transport Model (SWIFT) Release 4.81," USNRC Report NUREG/CR-2324, November 1981.

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Reeves, M., Ward, D. S., Johns, N. D., and Cranwell, R. M., Sandia National Laboratory, "Theory and Implementation for SWIFT II," USNRC Report NUREG/CR-3328, August 1986.

Duda, L. E., Sandia National Laboratory, "Verification of the Network Flow and Transport/Distribution Velocity (NWFT/DVM) Computer Code," USNRC Report NUREG/CR-3378, June 1984.

Cranwell, R. M , and Cambell, J. E., Sandia National Laboratory, "DNET Self-Teaching Curriculum," USNRC report NUREG/CR-2391, March 1983.

Reeves, M., Ward, D. S., and Johns, N. D., Sandia National Laboratory, "Data Input Guide for SWIFT II; the Sandia Waste-Isolation Flow and Transport Model for Fractured Media Release 4.84," USNRC Report NUREG/CR-3162, April 1986.

3.3.17 Review Guide for Water Resources Information and Investigations

3.3.17.1 Background and Approach

In the SCP, it is anticipated that the site program will include plans for studying the water resources of the site and surrounding area for resolution of issues related to repository performance, groundwater protection, radiological doses, and land ownership and control. Estimates of present and future water resource development, including use of injection wells, are important to understanding the overall groundwater flow system and for assessing the potential for human activity to adversely affect repository performance. Water resource investigations are needed for determining the presence of "significant" and "special sources" of groundwater in making total pathway radiological dose estimates and for assuring that invaluable groundwater is adequately protected from radiological contamination. Lastly, water resource investigations are needed for determining water rights in relation to the requirements for land ownership and control.

The detailed criteria below should be used, in conjunction with the general review criteria for parameter identification in Section 3.2.2, and investigations and activities in Sections 3.2.3 and 3.2.4 to review appropriate portions of SCP Chapter 8. Existing information presented in Chapters 1-7 relevant to the criteria given below and any staff concerns regarding this material should also be considered in the review of Chapter 8.

General considerations are provided in Criterion A. There are no site-specific topics identified for water resources that are not covered under Criterion A.

3.3.17.2 Criteria

A. Identification of parameters and program of investigations related to water resource potential should consider the following items (with consideration of the performance allocation for the topic):

   1. identification of methods to detect whether (1) "significant" sources of groundwater exist at the sites; (2) "special" sources of groundwater exist within controlled areas, or in areas less than five km beyond controlled areas

   2. presentation of data on groundwater quality and aquifer productivity (i.e., groundwater resource evaluation)

   3. identification of users of regional and local groundwater resources and projections of future human activities related to water resources, including irrigation, subsurface fluid injection, groundwater withdrawals, military activities, and dam construction

   4. data needed to determine what water rights may have to be acquired

   5. defensibility of planned studies in view of present knowledge of water resources

6. effects of water quality on use of groundwater resources

3.3.17.3 Applicable Sections of 10CFR Part 60

Lead Responsibility:
None

Input Responsibility:	To:
60.112 (b)*,(c)*	Hydrology (Groundwater Flow)
60.121 (c)(1),(c)(2)	Compliance Demonstration
60.122 (c)(2)	Hydrology (Groundwater Flow)
60.122 (c)(17),(c)(18)*,(c)(20)*	Geology

* Based on proposed rule change (51FR22288, June 19, 1986)

3.3.17.4 Key Documents to Consider

U. S. Nuclear Regulatory Commission, Regulatory Guide 4.17, "Standard Format and Content of Site Characterization Plans for High-Level Waste Geologic Repositories," Rev. 1, March 1987.

U. S. Nuclear Regulatory Commission, "10 CFR Part 60: Proposed Rule," Federal Register, Vol. 51, No. 118, June 19, 1986.

U. S. Department of Energy, "Annotated Outline for Site Characterization Plans," USDOE Report OGR/B-5, April 1987.

3.3.18 Review Guide for Climatology and Meteorology Information and Investigations

3.3.18.1 Background and Approach

In the SCP, it is anticipated that the site program will include plans for investigations of climatology and meteorology as needed for issue resolution and a basic understanding of the site. An understanding of both current climatological and meteorological conditions and future changes in those conditions is necessary, both for the siting of the preclosure facilities, and for projection of effects on the ability of the site to meet the performance objectives during the post closure.

Issues that need to be addressed during site characterization pertaining to meteorology include possible atmospheric pathways that might result in contamination of the accessible environment. The atmospheric transport, diffusion, deposition and resuspension of contaminants should be addressed.

The detailed criteria below should be used, in conjunction with the general review criteria for parameter identification in Section 3.2.2, and investigations and activities in Sections 3.2.3 and 3.2.4, to review appropriate portions of SCP Chapter 8. Existing information presented in Chapters 1-7 relevant to the criteria given below and any staff concerns regarding this material should also be considered in the review of Chapter 8.

General considerations are provided in Criterion A. There are no site-specific topics for climatology and meteorology that are not covered under Criterion A.

3.3.18.2 Criteria

A. The identification of parameters and program of investigations related to climatology and meteorology should provide a consideration of the following items (with consideration of the performance allocation for the topic):

1. an analysis of the the Quaternary paleoclimatology of the candidate area and site in the context of determining the magnitude of past climatic change and rates at which the changes occurred, including:

   a. atmospheric information, including:
      (1) air temperature
      (2) wind flow patterns
      (3) precipitation regimes, including relationships between windflow patterns, air temperatures and regional precipitation
      (4) potential evaporation/transpiration (evapotranspiration)

   b. hydrospheric information (i.e., existence of paleolakes, streams or other surface water bodies), including:
      (1) levels, areal extent and proximity to the site area
      (2) accumulation, evaporation and flow rates

c. cryospheric information (i.e., existence of ice sheets and glaciers), including:

(1) areal extent and thickness

(2) proximity to the candidate area

(3) accumulation and ablation

(4) estimated time of onset

(5) length and severity of glacial regimes in candidate site area

d. consideration of a complete climatic cycle from maximum glacial to maximum interglacial

2. description of conceptual models and information utilized in the paleoclimatic and future climate analyses, and evidence to support the results of the analyses, including:

a. geological and geomorphological data

b. biological data

c. ecological data

3. discussion of the potential impact of future climatic change on:

a. precipitation patterns

b. windflow regimes

c. the cryosphere

d. sea levels

e. fluctuations in lake and stream levels

f. potential for glaciation

4. long-term estimates of climatic conditions based on paleo and current climate information and models, including:

a. potential maximum and minimum changes and rates of change in precipitation

b. potential maximum and minimum and rates of change in air temperature

c. potential regional windflow and precipitation patterns that may evolve as a result of climatic and geologic changes

d. future fluctuations in sea levels and the cryosphere

5. a description of the general climate in the site area based on data sufficient in detail to indicate impacts on the conceptual design and operation of a repository, including:

   a. types of air masses, synoptic features and frontal systems

   b. general airflow patterns

   c. precipitation

   d. evaporation

   e. transpiration potentials

   f. relationships between synoptic-scale atmospheric processes and local (site) meteorological conditions

   g. climatological characteristics attributable to the terrain

6. procedures for obtaining meteorological information to characterize site atmospheric dispersion processes, including:

   a. airflow trajectories (local)

   b. atmospheric stability conditions

   c. depletion and deposition characteristics

   d. resuspension

   e. precipitation

7. description of models to be used to characterize atmospheric transport, diffusion, deposition and resuspension of contaminants, including:

   a. relationships between topography, release points and effluent characteristics

   b. model uncertainties and potential sources of error

   c. any plans to modify existing models or develop new modeling approaches

8. description of the planed site meteorological measurement program, including:

   a. measurements to be made

   b. locations and elevations of measurements

   c. description of instruments

d. instrument performance specifications

e. calibration and maintenance

f. data analyses procedures

3.3.18.3 Applicable Sections of 10 CFR Part 60, Subparts E, F and G

Lead Responsibility

60.122(b)(8)(v)

Input Responsibility	To
60.111(a)	Compliance Demonstration
60.112(a)(1)*,(2)*	Hydrology (Groundwater Flow)
60.112(b)*	Compliance Demonstration
60.112(c)(1)*,(2)*	Compliance Demonstration
60.113(a)(1)(i)(A),(B);(ii),(A)(B)	Materials Engineering
60.113(a)(2)	Hydrology (Groundwater Flow)
60.122(a)(2);(i);(ii);(iii)(A),(B),(C)	Compliance Demonstration
60.122(b)(1)	Compliance Demonstration
60.122(b)(7)	Hydrology (Groundwater Flow)
60.122(b)(8) (i),(iii),(iv)	Hydrology (Groundwater Flow)
60.122(c)(5),(6),(23)*,(24)*	Hydrology (Groundwater Flow)
60.131(a)	Compliance Demonstration
60.131(b)(1)	Design/Rock Mechanics
60.132(a),(b);(c)(1),(2)	Design/Rock Mechanics
60.133(g)(1)	Design/Rock Mechanics
60 134(a)	Design/Rock Mechanics
60.135(a)(1)	Hydrology (Groundwater Flow)

* Based on proposed rule change (51FR22288, June 19, 1986)

3.3.18.4 Key Documents to Consider

U.S. Department of Energy, "Annotated Outline for Site Characterization Plans," USDOE Report OGR/B-5, April 1987.

U.S. Nuclear Regulatory Commission, Regulatory Guide 4.17, "Standard Format and Content of Site Characterization Plans for High-Level Waste geologic Repositories, Rev. 1, March 1987.

U.S. Nuclear Regulatory Commission, Regulatory Guide 3.63 (Task ES 401-4), "Onsite Meteorological Measurement Program for Uranium Recovery Facilities - Data Acquisition and Reporting," December 1987.

U.S. Nuclear Regulatory Commission, Regulatory Guide 1.101, "Emergency Planning and Preparedness for Nuclear Power Reactors," Rev. 2, October 1981.

U.S. Environmental Protection Agency, "Ambient Monitoring Guidelines for Prevention of Significant Deterioration (PDS)", USEPA Report EPA-450/4-8-012, November 1980.

U.S. Environmental Protection Agency, "Guideline on Air Quality Models", USEPA Report EPA-450/2-78-027R, Rev., July 1986.

Culkowski, W. M., National Oceanographic and Atmospheric Administration, "An Initial Review of Several Models Suitable for Low-Level Waste Disposal Facilities," USNRC Report NUREG/CR-3838, June 1984.

Culkowski, W. M. and Patterson, M. R., "A Comprehensive Atmospheric Transport and Diffusion Model," ORNL/NSF/EATC-17, April 1976.

Howe, S. E., Webb, T., et al, Brown University, "Climatic Calibration of Pollen Data," USNRC Report NUREG/CR-3847, June 1984.

3.3.19 Review Guide for the Disturbed Zone Information and Investigations

3.3.19.1 Background and Approach

In the SCP, it is anticipated that the site program will include plans for establishing the disturbed zone, as needed, for issue resolution. To meet the siting criterion 60.122 and the performance objective 60.113 of pre-waste emplacement groundwater travel time-the computation of which starts from the edge of the disturbed zone- the extent of the disturbed zone needs to be established.

The NRC has provided guidance on the disturbed zone to the DOE, in the form of a generic technical position entitled: "Interpretation and Identification of the Extent of the Disturbed Zone."

The detailed criteria below should be used in conjunction with the general review criteria for parameter identification in Section 3.2.2, and investigations and activities in Sections 3.2.3 and 3.2.4, to review appropriate portions of SCP Chapter 8. Existing information presented in Chapters 1 - 7 relevant to the criteria given below and any staff concerns regarding this material should be addressed in the review of Chapter 8.

General considerations are provided in Criterion A. Considerations relative to the key site-specific topics that should receive special attention are provided in Criterion B.

3.3.19.2 Criteria

A. The identifcation of parameters and the program of investigations related to the disturbed zone should provide an adequate consideration of the following items with consideration of the performance allocation for the pre-emplacement groundwater travel time:

1. The extent of change in host rock-water system properties, chemical and/or physical resulting from repository construction and waste emplacement. Mechanical, thermomechanical, thermogeochemical and thermohydrologic effects of the repository construction and heat from the emplaced waste on rock-water system should be assessed by DOE.

2. Significance of these changes in the rock-water system on pre-emplacement groundwater travel time should be assessed.

3. The extent of the changes in the rock-water system that has significant effects on pre-emplacement groundwater travel time should be considered in assessing the disturbed zone.

B. The identification of parameters and program of investigations should provide an adequate consideration of the following key site-specific topics:

1. Yucca Mountain Site

   a. vibratory ground motion (underground nuclear explosions and earthquakes)
   b. thermal decomposition of zeolites

3.3.19.3 Applicable Sections of 10 CFR 60

LEAD

10 CFR 60.2
10 CFR 60.15
10 CFR 60.16
10 CFR 60.17
10 CFR 60.18
10 CFR 60.112
10 CFR 60.113
10 CFR 60.122
10 CFR 60.133
10 CFR 60.134

3.3.19.4 Key documents to Consider

U.S. Department of Energy, "Annotated Outline for Site Chacterization Plans," April 1985.

U.S. Nuclear Regulatory Commission, "Draft Generic Technical Position on Interpretation and Identification of the Extent of the Disturbed Zone," June 1986.

U.S. Nuclear Regulatory Commission, "Draft Issue-oriented Site Technical Positions for Design/Rock Mechanics NNWSI Repositories," September 1984.

R. Codell and N. Tanious, "Disturbed Zone and Groundwater Travel Time in the High Level Waste Rule (10CFR60), Waste Management 1986 Conference, Tucson, Arizona, 1986.

3.3.20 Review Guide for Geomechanics Testing Information and Investigations

3.3.20.1 Background and Approach

In the SCP, it is anticipated that the site program will include plans for the geomechanics testing needed for issue resolution and a basic understanding of the engineering properties of the host rock. An understanding of the site and the conceptual design of the repository is necessary for conducting a review of an investigation program consisting of surface-based and/or at-depth testing. Furthermore, an adequate understanding of the range of parameter values likely to be measured during site characterization, the analytical/numerical techniques used in the eyaluation of test data and their application to repository design and performance analyses, is necessary for the review of investigations that will be proposed in the SCP.

NRC has provided guidance on in situ testing to the DOE in the form of a generic technical position (GTP) entitled, "In Situ Testing During Site Characterization for High-Level Nuclear waste Repositories." Golder Associates, 1982 contains a complete listing of the geomechanics data needs and the tests required to collect the data.

The detailed criteria below should be used in conjunction with the general review criteria for parameter identification in Section 3.2.2 and investigations and activities in Section 3.2.3 and 3.2.4 to review appropriate portions of SCP Chapter 8. Existing information presented in Chapter 1-7 relevant to the criteria given below and any staff concerns regarding this material should also be considered in the review of Chapter 8.

General considerations are provided in Criterion A. Considerations relative to key site-specific topics that should receive special attention are provided in Criterion B.

3.3.20.2 Criteria

A. The identification of parameters and the program of investigations related to geomechanics testing should provide an adequate consideration of the following items, with consideration of the performance allocation for the topic:

   1. Rationale for geomechanics testing program, including:

      a. identification of unique and/or non-standard investigations which must be conducted to collect the needed information

      b. justification of the extent of the underground facility required to assess host rock variability for repository design input

         (1) plans for achieving minimum levels of uncertainty in geomechanics parameter ranges

      c. adequacy of the extent of the underground facility required to evaluate response characteristics of the host rock

(1) shape, size and orientation of excavations
(2) principal in situ stress directions
(3) location of tests
(4) scale of tests

d. justification for major test locations and references to analyses that substantiate the adequacy of test-to-test spacing from the point of view of physical, operational, and thermal interferences.

e. justification of the basis for scale and duration for large scale geomechanics tests

f. provisions for coupled thermal-hydrological-mechanical-chemical testing or justification for not conducting coupled testing

g. plans for determining sufficiency of testing

h. plans for integration of small-scale laboratory geomechanics test results with surface-based and at-depth test results

2. Identification of analyses to be applied to geomechanics test data

3. Identification of geomechanical parameters, including:

a. intact rock mechanical properties

(1) modulus
(2) poisson's ratio
(3) density
(4) compressive strength
(5) cohesion
(6) friction
(7) dilation
(8) others (e.g., Hoek-Brown empirical criterion)

b. thermal properties

(1) rock temperature
(2) thermal conductivity
(3) coefficient of thermal expansion
(4) diffusivity

c. rock mass properties

(1) large scale modulus
(2) density
(3) joint cohension
(4) joint friction

4. identification of rock response characteristics including:

a. determination of stress-strain behavior

(1) intact rock

(a) ambient temperature
(b) thermal load

(2) rock mass

(a) ambient temperature
(b) thermal load

b. failure criteria

B. The identification of parameters and programs of investigations should provide an adequate consideration of the following key site-specific topics:

1. Yucca Mountain Site

a. geomechanics characteristics of lithophysal zone
b. feasibility testing of long horizontal emplacement technology

(a) salt rock
(b) salt/mudstone rock units

3.3.20.3 Applicable Sections of 10 CFR Part 60

LEAD	INPUT
60.15	60.151
60.16	60.152
60.17 60.18 60.111 60.112	

3.3.20.4 Key Documents To Consider

Golder Associates, for U.S. NRC, "In Situ Test Program Related to Design and Construction of High-Level Nuclear Waste (HLW) Deep Geologic Repositories," NUREG/CR-3065, 1982.

U.S. Department of Energy, "Annotated Outline for Site Characterization Plans", OGR/B-5, April 1987.

U.S. Nuclear Regulatory Commission, "Generic Technical Position on In Situ Testing During Site Characterization for High-Level Nuclear Waste Repositories," December 1985.

3.3.21 Review Guide for Borehole and Shaft Seals

3.3.21.1 Background and Approach

In the SCP, it is anticipated that the Seal Program will include a description of the activities required to develop designs and demonstrate performance of seals to be placed in shafts, ramps, drifts and boreholes. The seals are to be designed and emplaced so that following permanent closure, they do not become pathways that compromise the geologic repository's ability to meet the performance objectives.

Information on borehole and shaft seals should be in sufficient detail for the NRC staff to make the necessary assessment about the adequacy of the borehole and shaft seal development program. The staff has provided guidance on the needed information for this assessment in the generic technical position on "Borehole and Shaft Seals," and draft technical position on post-closure seals in an unsaturated medium. The information, plans and procedures should be basically consistent with the NRC staff positions described in these technical positions.

The detailed criteria below should be used in conjunction with the general review criteria for parameter identification in Section 3.2.2 and investigations and activities in Sections 3.2.3 and 3.2.4 to review appropriate Portions of SCP Chapter 8. Existing information presented in Chapters 1-7 relevant to the criteria given below and any staff concerns regarding this material should also be considered in the review of Chapter 8.

General considerations are provided in Criterion A. Considerations relative to key site-specific topics that should receive special attention are provided in Criterion B.

3.3.21.2 Criteria

A. The conceptual design description and program of activities related to borehole and shaft seals should provide an adequate consideration of the following items, with consideration of the performance allocation for the topic:

   1. The excavation and drilling techniques including:

      a. selection to inflict minimal damage (fracturing) to rock units
      b. excavation experience in similar rock types

   2. The insitu investigations to measure excavation-induced damaged zones including:

      a. mechanical characteristics of the zone surrounding the openings
      b. effect of damaged zone on seal installation

   3. The important geologic, hydrologic and geochemical aspects of seal environment, including:

a. potential for future changes
b. flow through discrete faults and fractures

4. The proposed treatment of the damaged section of rock around openings and sealing methods for water-bearing strata, including:

   a. design measures to control groundwater
   b. design of seals in damaged zone
   c. effect of seal failure on repository performance

5. The use of operational seals for post-closure including:

   a. effect of liners and casings on ability to seal

6. The compatibility of materials for boreholes and shaft seals with host rock, including:

   a. planned field and laboratory investigations (see Review Guide for "Geomechanics Testing Information and Investigation")
   b. considerations for seal materials selection

7. The adequacy of installation of borehole and shaft seals, including:

   a. effectiveness of emplaced seals
   b. investigations to develop required procedures

8. The preliminary performance assessment that accounts for appropriate degree of reliability of seal design and placement (see Review Guide on "Compliance Assessment with the EPA Containment Requirement")

9. The long-term stability of seals, including:

   a. impact of thermal loading
   b. physical and chemical compatibility of seals to host rock
   c. accelerated testing of sealing materials

10. The performance confirmation program investigation plan, including:

    a. early initiation of seal tests
    b. plans for test sections in the exploratory shaft facility
    c. plans for long-term monitoring

B. The borehole and shaft sealing portion of the conceptual design description, identification of parameters and program of activities should provide an adequate consideration of the following key site-specific topics:

1. Yucca Mountain

   a. Sealing-design strategy

      (1) free drainage strategy

(a) reliability of free drainage for 10,000 years
(b) site characterization investigations for free drainage

(2) seal performance in unsaturated medium (geochemical)

b. Sealing of major faults
c. Sealing of excavation below the repository horizon

3.3.21.3 Applicable Sections of 10 CFR 60

10 CFR 60.2
10 CFR 60.15
10 CFR 60.16
10 CFR 60.17
10 CFR 60.18
10 CFR 60.112
10 CFR 60.113
10 CFR 60.134
10 CFR 60.137
10 CFR 60.140
10 CFR 60.142

3.3.21.4 Key Documents to Consider

U.S. Government Printing Office. Code of Federal Regulations, 10 CFR 60, "Radioactive Wastes in Geologic Repositories." Washington, DC: U.S. Government Printing Office, January 1987.

U.S. Nuclear Regulatory Commission, Regulatory Guide 4.17, "Standard Format and Content of Site Characterization Plans for High-Level Waste Geologic Repositories."

U.S. Department of Energy. "Annotated Outline for Site Characterization Plans," DOE Report DOE/RW-0142 (OGR/B-5), April 1987.

U.S. Nuclear Regulatory Commission. Draft Issue-oriented Site Technical Position, "NNWSI Repository Design/Rock Mechanics."

U.S. Nuclear Regulatory Commission, "Generic Technical Position on Design Information Needs in Site Characterization Plans."

U.S. Nuclear Regulatory Commission, "Generic Technical Position on Borehole and Shaft Seals."

U.S. Nuclear Regulatory Commission, "Generic Technical Position on In-Situ Testing during Site Characterization."

U.S. Nuclear Regulatory Commission, "Draft Technical Position on Postclosure Seals in an Unsaturated Medium."

U.S. Nuclear Regulatory Commission, "Draft Generic Technical Position on Interpretation and Identification of the Disturbed Zone."

U.S. Nuclear Regulatory Commission, "Draft Generic Technical Position on Items and Activities in the HLW Geologic Repository Program Subject to 10 CFR Part 60 Quality Assurance Requirements."

U S. Nuclear Regulatory Commission, "Generic Technical Position on Qualification of Existing Data."

U.S. Nuclear Regulatory Commission, "Generic Technical Position on Peer Review."

U.S. Nuclear Regulatory Commission/U.S. Department of Energy, "Summary of the NRC/DOE Meeting on the Level of Detail for Site Characterization Plans and Study Plans," May 7-8, 1986.

U.S. Nuclear Regulatory Commission/NNWSI, "Summary of the NRC-NNWSI Project Exploratory Shaft Design/Construction Meeting," August 27-28, 1985.

U.S. Nuclear Regulatory Commission/NNWSI, "Summary of the NRC-NNWSI Project Meeting on Proposed Changes to the NNWSI Project Exploratory Shaft Facility," April 14-15, 1985.

Letters from NRC to DOE, Subject: Information Considered Necessary Regarding Exploratory Shaft Construction and Sealing (all sites), dated April 14, 1983.

3.3.22 Review Guide for Retrievability Information and Investigations

3.3.22.1 Background and Approach

In the SCP, it is anticipated that the conceptual design program will include plans for investigations that pertain to or affect retrieval. It is expected that the SCP will contain descriptions of the following items: the waste emplacement mode; the expected temperatures in the emplacement entries during retrieval; stability of openings during retrieval; use of backfill in the emplacement rooms before the time of permanent closure; ventilation air temperature; the reliability of retrieval machinery; and likelihood of radionuclide release into the ventilation circuits. Therefore, the conceptual design should be reviewed to examine how the retrievability requirement has been incorporated into the overall scheme of the repository design, operation and construction.

The overall objective of the SCP conceptual design review should be to determine if all of the design elements provide reasonable assurance that the retrieval option, which is a pre-closure performance objective, is not precluded. Retrieval, in general, is not likely to be a simple reversal of the waste emplacement operation, because of thermal effects and the resulting deterioration of rock and the underground environment.

The detailed criteria below should be used in conjunction with the general review criteria for parameter identification in Section 3.2.2, and investigations and activities in Sections 3.2.3 and 3.2.4, to review appropriate portions of SCP Chapter 8. Existing information presented in Chapters 1-7 relevant to the criteria given below and any staff concerns regarding this material, should also be considered in the review of Chapter 8.

General considerations are provided in Criterion A. Considerations relative to key site-specific topics that should receive special attention are provided in Criterion B.

3.3.22.2 Criteria

A. The conceptual design description and program of activities related to retrievability should provide an adequate consideration of the following items with consideration of the performance allocation for the topic:

   1. Waste emplacement configuration and its effects on retrieval operations:

      a. horizontal, vertical, or other configurations
      b. feasibility of excavation and emplacement
      c. retrieval under normal and potentially adverse conditions

   2. Analyses of thermal environment in emplacement drifts and holes during retrieval:

a. Input design assumptions:

(1) waste type and age
(2) quantity of waste per package
(3) areal waste density
(4) host rock thermal characteristics
(5) ventilation
(6) use of backfill

3. Stability analyses of openings (emplacement drifts/holes) during retrieval:

a. state of stress in the host rock around openings
b. reduction in rock strength with thermal load or time
c. performance of the rock-support system, or emplacement hole liner

4. Identification of proof-of-principle and mockup demonstrations:

a. status of mockups or equipment testing
b. plans for demonstrations
c. alternative design concepts

B. The retrievability portion of the conceptual design and program of activities to perform any testing or analyses should provide an adequate consideration of the following key site-specific topics:

1. Yucca Mountain Site

a. long horizontal holes emplacement option

3.3.22.3 Applicable Sections of 10 CFR Part 60

LEAD

10 CFR 60.2
10 CFR 60.15
10 CFR 60.16
10 CFR 60.17
10 CFR 60.18
10 CFR 60.21
10 CFR 60.111
10 CFR 60.112
10 CFR 60.130
10 CFR 60.132
10 CFR 60.133
10 CFR 60.140
10 CFR 60.142
10 CFR 60.151
10 CFR 60.152

3.3.22.4 Key Documents to Consider

U.S. Code of Federal Regulations 10 CFR 60, 1987.

U.S. Department of Energy, "Annotated Outline for Site Characterization Plans," April 1985.

U.S. Nuclear Regulatory Commission, "Generic Technical Position on Design Information Needs in Site Characterization Plans," December 1985.

U.S. Nuclear Regulatory Commission, "Generic Technical Position on In-Situ Testing During Site Characterization," December 1985.

U.S. Nuclear Regulatory Commission, "Generic Technical Position on Items and Activities in the HLW Geologic Repository Program Subject to 10 CFR 60 Quality Assurance Requirements," 1986.

Summary of the U.S. Nuclear Regulatory Commission/U.S. Department of Energy Meeting on the Level of Detail for Site Characterization Plans and Study Plans, May 7-8, 1986.

NUREG/CR-3489, "Assessment of Retrieval for the Geologic Disposal of Nuclear Waste," 1984.

NUREG-0804, "Staff Analysis of Public Comments on Proposed Rule 10 CFR Part 60: Disposal of High-Level Radioactive Wastes in Geologic Repositories, 1983.

U.S. Department of Energy, "Draft Generic Position on Retrievability and Retrieval for a Geologic Repository," June 18, 1985.

Letter from Hubert J. Miller to Ralph Stein on review of DOE Draft Generic Technical Position on Retrievability and Retrieval, August 30, 1985.

N.S. Tanious, M.S. Nataraja, and J.K. Daemen, "Retrievability of High-Level Nuclear Waste from Geologic Repositories - Regulatory and Rock Mechanics/Design Considerations," 28th Symposium on Rock Mechanics, Tucson, AZ, June 1987.

3.3.23 Review Guide for Conceptual Design of the Repository

3.3.23.1 Background and Approach

In the SCP, it is anticipated that a conceptual design will be presented that takes into account likely site-specific conditions. An understanding of the site and the conceptual design of the repository is necessary for conducting a review of the design. Information on the conceptual repository design submitted in the SCP is expected to be of sufficient detail for NRC to determine the completeness and adequacy of the site characterization program.

NRC has provided guidance to the DOE in the form of a Generic Technical Position entitled "Design Information Needs in the Site Characterization Plans." In addition, NRC and DOE had a meeting on this topic in April 1985. For this meeting, the DOE submitted to NRC a draft annotated outline (AO) for the SCP Conceptual Design Report (CDR).

The review approach that will be taken for the repository conceptual design will be based on the NRC GTP and the AO of the CDR that was agreed upon by NRC and DOE. The detailed criteria below should be used in conjunction with the general review criteria for investigations and design activities in 3.2.3 to review appropriate portions of SCP Chapter 8. Existing information presented in Chapters 1-7 (predominantly Chapter 6) relevant to the criteria given below and any staff concerns regarding this material should also be considered in the review of Chapter 8. While review items such as Q-List, retrieval, seals, quality assurance and the engineered barrier system are included under repository design, separate review guides have been prepared for these items.

General considerations are provided in Criterion A. Considerations relative to key site-specific topics that should receive special attention are provided in Criterion B.

3.3.23.2 Criteria

A. The conceptual repository design description in Chapter 6 and programs of activities related to the repository design should provide an adequate consideration of the following items with consideration of the performance allocation of the topic:

   1. The design bases, including:

      a. the technical requirements and assumptions that form the bases of the design
      b. the site constraints that affect the design or the approach to the design
      c. the reference geological and geotechnical data used to support the design

   2. Radiological protection:

      a. see Preclosure Analyses Review Guide (4.2.4.10)

3. Structures, systems or components of the repository important to safety:

   a. see items and activities subject to "QA Procedures" Review Guide (3.3.30)

4. Surface waste-handling facilities, including:

   a. layout of surface facilities
   b. procedure for handling and retrieval of waste

5. Underground facility design element, including:

   a. location of shafts
   b. depth to host rock
   c. geometry and orientation of underground openings
   d. spatial relationship of the test facility and the repository
   e. general description and layout of the design

6. Engineered Barrier System (EBS) design

   a. see Waste Package Design and EBS Release Rates Review Guides (3.3.25 and 3.3.26)

7. Identification of possible disruptive events and their possible effects on the integrity of the repository.

   a. See review guide on "Anticipated and Unanticipated Processes and Events" (3.2.4.2)

8. Design elements, including:

   a. retrieval of waste (see Retrievability Review Guide, 3.3.22)
   b. control of water and gas
   c. stability of underground openings
   d. rock-support systems
   e. rock-excavation techniques
   f. underground-facility ventilation
   g. thermal loads

9. Borehole and shaft seal design

   a. see review guide on "Borehole and Shaft Seals" (3.3.21)

10. A description of barriers important to waste isolation.

    a. see review guide on "Compliance Assessment with the EPA Containment Requirement" (3.2.4.9)

11. Alternative design concepts which take into account:

a. uncertainties and variability of site parameters
b. local unacceptable conditions
c. flexibility to make trade-offs between subsystem components
d. interrelationship between system/components

12. Descriptions of the computer codes that have been used in the design:

    a. see review guide for "Software QA Procedures" (3.3.29)

13. QA program for the design

    a. see review guide for "Items and Activities Subject to QA Procedures" (3.3.30)

B. The conceptual repository design description, identification of parameters and the program of activities should provide an adequate consideration of the following items for key-specific topics:

1. Yucca Mountain Site:

    a. limits on vertical and lateral flexibility imposed by:

        (1) faulting
        (2) thickness of target horizon
        (3) heterogeneities such as lithophysae
        (4) overburden requirement

    b. defense-related activities

        (1) effects of proximity to bombing range on surface facilities
        (2) effect of underground nuclear explosions on the repository
        (3) potential for aircraft crashes on surface facilities

    c. long horizontal emplacement holes

        (1) retrieval (see "Retrievability" Review Guide 3.3.22)
        (2) deleterious rock movements
        (3) construction equipment technology

3.3.23.3 Applicable Sections of 10 CFR part 60:

Lead	Input
10 CFR 60 11	10 CFR 60.112-113
10 CFR 60.130-134	10 CFR 60.135
10 CFR 60 141	10 CFR 60.140,142-143
	10 CFR 60.150-152

3.3.23.4 Key Documents to Consider:

U.S. Department of Energy, "Annotated outline for SCP CDR," April 1985.

U.S. Nuclear Regulatory Commission, Regulatory Guide 4.17, "Standard format and content guide for SCP's, March 1987.

Nuclear Waste Policy Act, 1982.

U.S. Nuclear Regulatory Commission, "Draft Technical Position on Postclosure Seals in an Unsaturated Medium."

U.S. Nuclear Regulatory Commission, "GTP on Design Information Needs," December 1985.

U.S. Nuclear Regulatory Commission, "GTP on Borehole and Shaft Seals," December 1985.

U.S. Nuclear Regulatory Commission "GTP on In Situ Testing," December 1985.

U.S. Nuclear Regulatory Commission, "GTP on Items and Activities in the HLW Geologic Repository Program Subject to 10 CFR 60 Quality Assurance Requirements," 1986.

U.S. Nuclear Regulatory Commission/U.S. Department of Energy, "Summary of NRC/DOE meeting on SCP Repository Design Information," April 1985.

U.S. Nuclear Regulatory Commission, "Parameters and Variables Appearing in Radiological Assessment Codes," NUREG/CR-3160 June 1983.

ITASCA Consulting Group "A Review of Thermomechanical Analysis Methodologies for NNWSI, BWIP and SRP," March 1987.

ITASCA Consulting Group, "Major Underground System Design Components for NNWSI," 1987.

3.3.24 Review Guide for Substantially Complete Containment

3.3.24.1 Background and Approach

In the SCP, the waste package program is expected to include plans for investigations related to demonstrating that containment of the waste within the waste package during the containment period (300 to 1,000 years) will be substantially complete, consistent with the Commission's regulations (10 CFR 60.113).

Substantially complete containment of the waste within the waste package during the containment period is the only performance objective specified for the waste package per se. The completeness and accuracy of the data base to demonstrate substantially complete containment of the waste within the waste package for a period of 300 to 1000 years, therefore, is a major concern. Specifically, data that can be used to predict the rate of degradation of the waste package component(s) designed to contain the waste in an environment representative of the repository will govern whether NRC can make a positive finding for this performance objective in a licensing proceeding.

The detailed criteria below should be used in conjunction with the general review criteria for parameter identification in Section 3.2.2 and investigations and activities in Section 3.2.4 to review appropriate portions of SCP Chapter 8. These criteria should also be used to review Chapter 7.

General considerations are provided in Criterion A. Considerations relative to key site-specific topics that should receive special attention are provided in Criterion B.

3.3.24.2 Criteria

A. The waste package design description in Chapter 7 and programs of activities in Chapter 8 related to demonstrating substantially complete containment should provide an adequate consideration of the following items:

   1. Waste package design basis including:

      a. the design goals or performance allocated to each waste package component in meeting the overall waste package performance objective of substantially complete containment

      b. the reliability goal for each component as it relates to performance allocation

   2. Waste package design descriptions including the proposed design(s) and materials specifications for:

      a. the waste form, including the radioactive waste and any associated encapsulation or stabilization media

b. the canister, including the major sealing enclosure system for the waste form.

c. the overpacks, which consist of any additional vessel receptacle, structure, or shielding which are both within and an integral part of the proposed waste package and which provide additional containment of the waste

d. the packing material, which may control the flow of groundwater, modify the groundwater chemistry, or retard the transport of radionuclides from the waste form after breach of the container

3. Design rationale/performance analysis including:

a. justification for the design basis or rationale

b. an analysis, including preliminary performance estimates of the waste package system, aimed at providing reasonable assurance that the proposed waste package designs will meet the substantially complete containment performance objective of 10 CFR Part 60 (see GTP on Waste Package Reliability Analysis)

c. estimates for rates of waste package degradation and the bases for these estimates

d. the most likely failure modes

e. input data required for the models used to calculate or estimate waste package performance

f. scenarios and processes for waste package degradation

4. Planned investigations and tests including:

a. the temperature profile of the waste package

b. solubility of the waste form

c. the radiation profile of the waste package

d. the pressure and stress fields of the waste package

e. synergistic effects including effects of waste package degradation products on the rates of degradation of other waste packages

f. the rates of propagation of stress corrosion cracks in the waste package container

g. the rates of formation and propagation of pits in the waste package container

h. the rates of formation and propagation of crevice corrosion in the waste package container

i. the rate of uniform corrosion of the waste package container

j. interactions of waste package components and host rock

k. radionuclide retardation in packing material

l. leaching of radionuclides from the waste form

B. The identification of parameters and program of investigations should Provide an adequate consideration of the following key site-specific topics:

1. Yucca Mountain Site

a. the consequences of uncertainties on the analyses of waste package lifetime and radionuclide release rate

b. assumptions regarding waste package failure modes and the uncertainties associated with these assumptions

c. the susceptibility of the austenitic stainless steels to stress-assisted cracking in chloride/oxygen/water (steam) environments

3.3.24.3 Applicable Sections of 10 CFR Part 60.

Lead	Input
60.113(a)(1) 60.113(b)	60.135

3.3.24.4 Key Documents to Consider

U.S. Nuclear Regulatory Commission, Regulatory Guide 4.17, "Standard Format and Content of Site Characterization Plans for High-Level Waste Geologic Repositories."

U.S. Department of Energy, Office of Civilian Radioactive Waste Management, "Annotated Outline for Site Characterization Plans" (OGR/B-5), April 1987.

U.S. Nuclear Regulatory Commission Generic Technical Position, "Waste Package Reliability Analysis for High-Level Nuclear Waste Repositories."

U.S. Nuclear Regulatory Commission/U.S. Department of Energy, "Meeting Summary, NNWSI Waste Package Workshop," July 23-25, 1985.

U.S. Nuclear Regulatory Commission, "Draft Issue-Oriented Site Technical Position (ISTP) for Nevada Nuclear Waste Storage Investigations (NNWSI)," September 1984.

U.S. Nuclear Regulatory Commission/U.S. Department of Energy, "Summary of the NRC/DOE Meeting on the Level of Detail for Site Characterization Plans and Study Plans," May 7-8, 1986.

3.3.25 Review Guide for Waste Package Design

3.3.25.1 Background and Approach

In the SCP, the waste package program is expected to include plans for investigations related to the design basis and criteria for the repository waste package. The repository waste package must be designed to satisfy a number of functional requirements. These requirements include provisions for handling, package identification and chemical stability of the contained waste form, among others. Additionally, the design and characteristics of the waste package will directly determine the ability of the waste package and engineered barrier system to meet the performance objectives of 10 CFR 60.113. The chemical, physical, and nuclear properties of the waste package and its interaction with the emplacement environment must be such that all functional requirements are satisfied without adversely affecting the performance of the underground facility or the geologic setting. The Commission's regulations (10 CFR 60.135) specify minimum design criteria for the waste package to address identified functional requirements that are important to its intended use. Accordingly, the staff's review will focus on investigations planned by the DOE to demonstrate compliance with the Commissions design criteria for the waste package.

The detailed criteria below should be used in conjunction with the general review criteria for parameter identification in Section 3.2.2 and investigations and activities in 3.2.3 to review appropriate portions of SCP Chapter 8. These criteria should also be used to review Chapter 7.

General considerations are provided in Criterion A. Considerations relative to key site-specific topics are not applicable for this review guide.

3.3.25.2 Criteria

A. The waste package design description in Chapter 7 and programs of activities in Chapter 8 related to waste package design should provide an adequate consideration of the following items.

1. General waste package design including:

   a in situ chemical, physical and nuclear properties of the waste package.

   b. waste package interactions with the emplacement environment and consideration of solubility, oxidation/reduction reactions, corrosion, hydriding, gas generation, thermal effects, mechanical strength, mechanical stress, radiolysis, radiation damage, radionuclide retardation, leaching, fire and explosion hazards, thermal loads, and synergistic interactions.

2. Specific waste package design criteria including:

   a. potential for explosive, pyrophoric and chemically reactive material in the waste package.

b. potential for adverse impacts resulting from liquids within the waste package.

c. handling of the waste package during transportation, emplacement, and retrieval.

d. means of identification for the waste package.

3. Specific waste form design criteria including:

a. solidification of radioactive wastes and placement in sealed containers.
b. consolidation of particulate waste.
c. consideration of potential adverse impacts of combustible radioactive waste.

B. Site Specific Criteria: None

3.3.25.3 Applicable Sections of 10 CFR Part 60

lead	input
60.135	none

3.3.25.4 Key Documents to Consider

H.C. Claiborne and others, "Repository Environmental Parameters and Models Relevant to Assess the Performance of High-Level Waste Packages (Basalt, Tuff and Salt)," NUREG/CR-4134, ORNL/TM-9522, Rev. 1, 1987.

C. Interrante and Others, "Evaluation and Compilation of DOE Waste Package Test Data," NUREG/CR-4735, Vols. 1 and 2, October 1987.

P. Soo, Ed., "Review of Waste Package Verification Tests," NUREG/CR-3091.

U.S. Nuclear Regulatory Commission, "Draft Issue-Oriented Site Technical Position (ISTP) for NNWSI," September 1984.

U.S. Nuclear Regulatory Commission, "Summary, NNWSI Waste Package Meeting, July 23-25, 1985."

U.S. Nuclear Regulatory Commission, Regulatory Guide 4.17, "Standard Format and Content of Site Characterization Plan for High-Level Waste Geologic Repositories."

U.S. Nuclear Regulatory Commission, "Draft Annotated Outline for the SCP Conceptual Design Report," April 8, 1985.

U.S. Nuclear Regulatory Commission, "NRC Staff Comments on the DOE Final Environmental Assessments," December 22, 1986. Comment 10 for NNWSI.

3.3.26 Review Guide for Engineered Barrier System Release Rates

3.3.26.1 Background and Approach

The Commission's regulations (10 CFR 60.113) include objectives for the performance of the engineered barrier system (EBS) following permanent closure of the geologic repository. Specifically, these objectives specify that the release rate of any radionuclide from the engineered barrier system following the containment period (i.e., 300 to 1000 years after permanent closure) shall not exceed one part in 100,000 per year of the inventory of that radionuclide calculated to be present at 1000 years following permanent closure. In the SCP, the site characterization program is anticipated to include plans for investigations necessary to support the DOE's demonstration of compliance with the Commission's performance objectives for the EBS.

The engineered barrier system is defined as the waste package and the underground facility. The waste package is expected to consist of a complex system of multiple barriers including the waste form, an outer canister, and combinations of one or more overpacks and backfill or packing. An understanding of the possible time-dependent processes, modes and mechanisms of waste package degradation in the repository environment is necessary to determine DOE's ability to demonstrate compliance with the Commission's postclosure performance objectives.

The detailed criteria below should be used in conjunction with the general review criteria for parameter identification in Section 3.2.2, and investigations and activities in Sections 3.2.3 and 3.2.4 to review appropriate portions of SCP Chapter 8. Existing information presented in Chapters 1-7 relevant to the criteria given below and any staff concerns regarding this material should also be considered in the review of Chapter 8.

General considerations are provided in Criterion A, while considerations relative to key site-specific topics that should receive special attention are provided in Criterion B.

3.3.26.2 Criteria

A. The conceptual design descriptions of the engineered barrier system in Chapter 7 and of the program of investigations related to engineered barrier system release rates should provide an adequate consideration of the following items:

   1. Design features and characteristics of all waste package components including:

      a. material properties of the waste form and waste package components
      b. geometry of all waste package components
      c. waste loading (i.e., radionuclide inventory)

d. mechanical strengths of waste package components

2. Design features and characteristics of the underground facility including:

   a. waste package configuration
   b. radiation profile in the EBS
   c. thermal profile in the EBS
   d. electrochemical potentials of the waste package/aqueous media/host rock system

3. Processes and scenarios for waste package degradation including:

   a. solubility of the waste form
   b. oxidation reduction reactions
   c. corrosion reactions and interactions of waste package components and host rock
   d. gas generation and hydriding
   e. thermal loads and effects
   f. mechanical stress effects
   g. radiolysis and radiation damage
   h. radionuclide retardation and leaching
   i. synergistic interactions

4. Rates of reactions or interactions for the various processes listed in Item 3 above

5. Process and scenario modeling, including methods proposed for extra-Polation of short-term data collected for investigations related to the processes listed in Item 3 above

B. See Review Guide for Substantially Complete Containment for site-specific criteria.

3.3.26.3 Applicable Sections of 10 CFR Part 60

Lead	Input
60.113(a)	60.101(a)(2)
60.113(b)	60.135

3.3.26.4 Key Documents to Consider

U.S. Department of Energy, Office of Civilian Radioactive Waste Management, "Annotated Outline for Site Characterization Plans (OGR/B-5)", DOE/RW-0142, April 1987.

U.S. Department of Energy, Office of Civilian Radioactive Waste Management, Office of Geologic Repositories, "Issues Hierarchy for a Mined Geologic Disposal System (OGR/B-10)", DOE/RW-0101, Rev. 1, August 1987.

DOE/NRC Meeting, U.S. Nuclear Regulatory Commission/U.S. Department of Energy, "Issues Hierarchy/Performance Allocation", September 29-30, 1987.

U.S. Nuclear Regulatory Commission, Regulatory Guide 4.17, "Standard Format and Content of Site Characterization Plans for High-Level Waste Repositories", July 1982.

U.S. Nuclear Regulatory Commission/U.S. Department of Energy, "Summary of NRC/DOE Meeting on Level of Detail for Site Characterization and Study Plans", May 8-9, 1986.

3.3.27 Review Guide for Qualification of Existing Data

3.3.27.1 Background and Approach

To obtain a license to operate a high-level nuclear waste repository, DOE must be able to demonstrate, in a license application, that the applicable health, safety, and environmental regulations in 10 CFR 60 have been fulfilled. Confidence in the adequacy of data, data analyses, construction activities, and other items and activities associated with the license application is obtained through a quality assurance (QA) program. Subpart G of 10 CFR 60 specifies a QA program for items and activities important to safety and waste isolation. DOE should have a QA program in place, consistent with 10 CFR 60, Subpart G and any applicable regulatory guidance, before the start of site characterization activities.

The staff expects that some data, which have not been initially generated under a QA program meeting the requirements of 10 CFR 60, Subpart G, will be needed to support DOE's license application to construct and operate a geologic repository for high-level nuclear waste. It is anticipated that the SCP will indicate generally in Section 8.6 and more specifically in appropriate sections of Chapters 1-7, the existing data that will be confirmed by testing during site characterization, and the existing data that are expected to be qualified for use in licensing by other qualification methods. The SCP and/or the QA plans referenced in the SCP are expected to describe the data qualification program. The NRC staff has developed the "Generic Technical Position on Qualification of Existing Data for High-Level Nuclear Waste Repositories." This Generic Technical Position (GTP) provides guidance to DOE on the use and qualification of data that have not been initially collected under a 10 CFR 60, Subpart, G QA program. It will be the basis by which the NRC staff evaluates DOE's data qualification program described in the SCP.

3.3.27.2 Criteria

A. DOE's data qualification program described in the SCP, and/or the QA plans referenced in the SCP, should be consistent with the definitions and staff positions described in NRC's "Generic Technical Position on Qualification of Existing Data for High-Level Nuclear Waste Repositories."

B. For existing data that will not be confirmed by additional testing during site characterization but will be relied on for licensing, the SCP should discuss the plans for its qualification.

C. If described in the SCP, plans for qualification of existing data pertinent to the following site-specific topics should meet the criteria in the "Qualification of Existing Data" GTP:

   1. Yucca Mountain Site

      a. Core obtained from drilling at the site (collection and handling procedures).

      b. Seismic monitoring

3.3.27.3 Applicable Sections of 10 CFR Part 60

60.150
60.151
60.152

3.3.27.4 Key Documents to Consider

Appendix B, 10 CFR Part 50

U.S. Nuclear Regulatory Commission, "NRC Review Plan: Quality Assurance for Site Characterization of High-Level Nuclear Waste Repositories," June 1984.

Site-Specific QA Plans

U.S. Nuclear Regulatory Commission, "Generic Technical Position on Peer Review for High-Level Nuclear Waste Repositories," Federal Register, Vol. 52, No. 131, July 9, 1987, 25932-25933.

3.3.28 Review Guide for Peer Review

3.3.28.1 Background and Approach

To obtain a license to operate a high-level nuclear waste repository, DOE must be able to demonstrate, in a license application, that the applicable health, safety, and environment regulations in 10 CFR 60 have been fulfilled. Confidence in the adequacy of the data, data analyses, construction activities, and other items and activities associated with the license application is obtained through a quality assurance (QA) program. Subpart G of 10 CFR 60 specifies a QA program for items and activities important to safety and waste isolation. DOE should have a QA program in place, consistent with 10 CFR 60, Subpart G and any applicable regulatory guidance, before the start of site characterization activities.

Peer reviews may be employed as part of the QA actions necessary to provide adequate confidence in the work under review, where the work may be design, a plan, a test procedure, a research report, a materials choice, or a site exploration. Because of the potential uncertainty in most geotechnical data, lack of unanimity among experts, and the first-of-a-kind nature of geologic repository technical issues, expert judgment will need to be used in assessing the adequacy of work. Peer reviews are a mechanism by which these judgments may be made.

The staff's "Generic Technical Position on Peer Review for High-Level Nuclear Waste Repositories" provides guidance on the definition of peer reviews, the areas where a peer review is appropriate, the acceptability of peers, and the conduct and documentation of a peer review. It will be the basis by which the NRC staff evaluates DOE's peer review process described in the SCP.

3.3.28.2 Criteria

A. DOE's peer review process, as described in the SCP and/or QA plans referenced in the SCP, should be consistent with the definitions and staff positions described in the NRC's "Generic Technical Position on Peer Review for High-Level Nuclear Waste Repositories."

B. The use of peer review for the following site-specific topics should be addressed in the SCPs:

   1. Yucca Mountain Site

      (a) The origin of the silica-carbonate veins

3.3.28.3 Applicable Sections of 10 CFR Part 60

60.150
60.151
60.152

3.3.28.4 Key Documents to Consider

Appendix B, 10 CFR Part 50

Site-Specific QA Plans

U.S Nuclear Regulatory Commission, "NRC Review Plan: Quality Assurance Programs for Site Characterization of High-Level Nuclear Waste Repositories," June 1984.

3.3.29 Review Guide for Software QA Procedures

3.3.29.1 Background and Approach

It is anticipated that Section 8.6 of the SCP, or the QA plans that it references, will discuss and describe how the development, verification, validation, operations, configuration management, and documentation of software codes are controlled. The quality assurance staff will review the adequacy of these procedures, using the criteria listed below.

3.3.29.2 Criteria

A. The software QA procedures should include the following information and should meet the criteria in NUREG-0856, "Final Technical Position on Documentation of Computer Codes for High-Level Waste Management":

1. Description of the Software QA Plan

   a. management organization
   b. responsibilities
   c. reviews, audits, and controls
   d. configuration management
   e. verification and validation
   f. control of software procurement
   g. software development procedures

2. Code Documentation Requirements

   a. user's manuals
   b. self-teaching curricula
   c. verification and validation documents
   d. sample problems

3. Internal Code Documentation

   a. code name
   b. version or completion data
   c. short description
   d. language(s)
   e. hardware that code was developed for
   f. required external libraries or routines
   g. code evolution
   h. contacts and/or author(s)
   i. references to all associated d@cumentation

3.3.29.3 Applicable Sections of 10 CFR Part 60

60.150
60.151

3.3.29.4 Key Documents to Consider

U.S. Nuclear Regulatory Commission, "Final Technical Position on Documentation of Computer Codes for High-Level Waste Management," USNRC Report NUREG-0856, June 1983.

Wilkinson, G.G., Runkle G.E., Sandia National Laboratories, "Quality Assurance (QA) Plan for Computer Software Supporting the US Nuclear Regulatory Commission's High-Level Waste Management Program," USNRC Report NUREG/CR-4369, January 1986.

Bryant J.L., Wilburn N.P., Pacific Northwest Laboratory, "Handbook of Software Quality Assurance Techniques Applicable to the Nuclear Industry," USNRC Report NUREG/CR-4640, August 1987.

U.S. Nuclear Regulatory Commission, "NRC Review Plan: Quality Assurance Programs for Site Characterization of High Level Nuclear Waste Repositories," June 1984.

3.3.30 Review Guide for Items and Activities Subject to QA Requirements

3.3.30.1 Background and Approach

Information on the items and activities to be controlled by the QA program during site characterization is anticipated to be summarized in Section 8.6.4.2 of the SCP, and discussed in greater detail in Sections 6.1.4 and 6.1.5 of the SCP. The staff will review this information in conjunction with "Generic Technical Position on Items and Activities in the High-Level Waste Geologic Repository Program Subject to Quality Assurance Requirements" (Q-List GTP).

3.3.30.2 Criteria

A. The following areas should be addressed in the SCP and should be consistent with the Q-List GTP:

1. A preliminary list of items and activities important to safety and/or waste isolation (Q-List)

2. A general description of the process by which the preliminary Q-List was developed and will be revised, including the following:

a. The preclosure accident dose limit and a justification for its use
b. A listing of the design basis accidents in preclosure
c. The probability cutoff for preclosure accidents and justification for its use
d. The method which was used to analyze preclosure accidents (e.g., Probable risk assessment). The method should:

(1) Identify credible events and scenarios, both external and internal

(2) Analyze response of safety systems

(3) Calculate offsite dose consequences

(4) Include all items relied on for accident mitigation on the Q-List

(5) Identify and justify accident source terms

e. Justification used for determining that various items will not fail during an accident

f. The allocation of performance among the various isolation components to determine which items are included on the Q-List

g. The basis for determining which site characterization activities are on the Q-List

h. The impact that the potential for retrieval has on the Q-List

3.3.30.3 Applicable Sections of 10 CFR Part 60.

60.2
60.111
60.112
60.113
60.131
60.151

3.3.30.4 Key Documents to Consider

U.S. Nuclear Regulatory Commission, "Draft Generic Technical Position on Items and Activities in the High-Level Waste Geologic Repository Program Subject to Quality Assurance Requirements" (Q-List GTP), Federal Register, Vol. 51, No. 147, July 31, 1986, 27447.

PART B: WORK PLAN

1.0 SCHEDULE FOR MAJOR REVIEW ACTIVITIES

The NRC review of the SCP will be completed within 30 weeks from the notification of start of review which includes making available copies of the SCP and references to the reviewers. The review period for the Acceptance Review is four weeks; the Technical Review and Integration is 14 weeks and begins concurrent with the Acceptance Review; the Internal Quality Assurance (IQA) and Management review is eight weeks, The Advisory Committee on Nuclear Waste (ACNW) review is four weeks, the Commission Review two weeks, and printing and issuance two weeks. The schedule for these major activities is shown in Figure 1. The detailed activities under each major activity are listed in Table 1. The review schedule for the detailed activities will be provided with the start of review notification.

2.0 RESOURCE ALLOCATION

It is anticipated that most of the SCP review will be done by the staff with specific additional research staff and contractor support in areas of specific expertise. Contractor involvement could range from technical review of portions of the SCP to IQA reviews. Resource allocations for the SCP review are limited to about 8.5 FTE and about $500K for contractor support. A detailed allocation will be provided early in the review to give limits on expenditures. Any significant deviations from the limits should be discussed with the Project Manager (PM) and Project Director (PD) before expenditure.

All SCP review activities including reviews of DOE's design acceptability analysis should be charged to the following numbers:

411412 - SCP Review (technical reviewer activities)
411412 L64100 - CNWRA Program Element Management Activities - SCP Review
411412 L64101 - Project Management - SCP Review
411412 L64102 - Design Acceptability Analysis Review

3.0 ORGANIZATION AND GENERAL RESPONSIBILITIES

3.1 Organization

The general organization shown in Figure 2 for the SCP review reflects the team approach which has been used for previous reviews such as the DOE Environmental Assessments (EAs) and CDSCP.

3.2 General Responsibilities

This section describes the general responsibilities of the staff involved with the reviews. Section 4.0 gives specific responsibilities for each review activity and Section 6.0 gives IQA responsibilities.

In the broadest sense, all staff, management, and technical assistance (TA) contractors assigned to this review are responsible for conducting their portions of the review and following all the elements of the SCPRP,

In short, this consists of 1) conducting an Acceptance Review; 2) conducting the Technical Review and Integration and preparing the SCA; 3) checking the quality of the SCA in the areas of assigned responsibility, and 4) checking the quality of the overall review. Assignments of various responsibilities for this review are given below.

The Repository Licensing and Quality Assurance Project Directorate (HLPD) is responsible for overall project management. The PM is responsible for conducting the Acceptance Review in consultation with the project team; for project managing the Technical Review and Integration; for coordinating the overall development of the SCA; and for IQA implementation, including coordinating the preparation of the IQA records.

The Geoscience-Systems Performance (GP) and Engineering (EN) Branches are responsible for conducing the technical review of designated portions of the SCP within schedules established by RLPD. The Section Leaders (SLs) of GP, EN, and the Quality Assurance (QA), and Special Analysis (SA) Sections of HLPD are responsible for managing the technical work of their staff consistent with the SCPRP and the guidance provided by the PM; managing staff resources consistent with resource allocations, managing activities consistent with established schedules; and conducting an IQA review for technical quality and integration (including resolution of all significant comments on SCA drafts by team members, the PM, and management.

The Lead Technical Reviewers assigned by the SL's to the project team, are responsbile for using the SCPRP, conducting the acceptance and technical review of the sections of the SCPs for which they have lead responsibilities; developing the SCA in the areas of responsibility; and resolving review comments on the draft SCA together with their SL. Lead technical reviewers are also responsible for identifying to appropriate reviewers potential major concerns in other technical areas that they become aware of during their review. The technical reviewers may be supplemented, as necessary, in specific technical areas, by supporting technical reviewers and/or contractors as necessary. The lead technical reviewer is responsible for coordinating with the supporting reviewers and contractors the review inputs for the areas that they have lead responsibility. Lead technical reviewers should meet early in the review with supporting technical reviewers both in their section and other sections and agree on what input appears to be needed from supporting technical reviewers.

The IQA Coordinator is responsible for verifying that the internal QA procedures are understood, implemented, and the IQA records are prepared.

The Production Coordinator is responsible for developing the editorial and format requirements of the product, coordinating production, editing, printing, and issuance of the products.

Specific responsibilities are defined in a number of tables. Table 2 lists the HLWM staff on the SCP review team. Research staff and contractor staff will be identified as necessary to support the HLWM staff. Table 3 gives the lead section responsible for DOE issues and related 10 CFR Part 60 requirements. Table 4 lists the lead and support responsibilities for

reviewing Chapter 8 of the SCP. Table 5 lists the lead section responsibilities for preparing SCA sections. Finally, Table 6 lists the lead section for reviewing DOE's resolution of CDSCP concerns (i.e., open items).

4.0 REVIEW ACTIVITIES AND SPECIFIC RESPONSIBILITIES

Table 1 lists the review activities. Descriptions and specific responsibilities for each activity are given below.

4.1 Review Preparation

4.1.1 Activities

The following activities should be conducted to meet the specific needs in a given technical area. Note that many of these activities, i.e., Nos. 1-3, have been conducted during the staff's CDSCP review and other ongoing reviews of DOE's program.

1. Obtain understanding of organization and content of SCP (general structure and content), in areas of responsibility.

2. Obtain understanding of key documents to consider in the reviews (as identified in Part A).

3. Obtain familiarity with the concerns of the State of Nevada in areas of responsibility.

4. Obtain understanding of the SCPRP through reading the summary and plan, training workshops, and discussions with SLs and PM. This includes an understanding of the review criteria, as described in Part A, in the reviewer's technical discipline, and an understanding of the general review criteria.

4.1.2 Responsibilities

All technical reviewers, SLs, and PM are responsible for completing Review Preparation Activities Nos. 1-4.

4.2 Notification of SCP Receipt and Start of Staff Reviews

4.2.1 Activities

Notification will consist of the following detailed activities.

1. Coordinate the receipt of SCP copies and references from DOE.

2. Make a copy of the SCP available in the Public Document Room.

3. Notify the staff in a memorandum of the start of the review, provide copies of SCPs to review team members and arrange for references to be available for review team.

4. Prepare a Federal Register notice of SCP receipt and start of staff review.

5. Prepare letters to the State of Nevada Governor and Legislature; Nye, Clark, and Lincoln Counties, and Indian Tribes.

4.2.2 Responsibilities

The PM is responsible for preparing the notifications in Nos. 3, 4, and 5 in consultation with GPA for Nos. 4 and 5. The PM assisted by the Production Coordinator is responsible for Nos. 1 and 2.

4.3 Acceptance Review

4.3.1 Activities

The staff acceptance review will use the Acceptance Review Criteria in Section 2.0 of Part A. This acceptance review will consist of the following activities:

1. Familiarization with and review of SCP by review team using the review guide for acceptance review.

2. Briefing by the review team of the PM and SLs on the review results. Briefing of Branch Chiefs (BCs) and Division Directors (DDs) on the review team and PM recommendation for continuation of review.

3. Decision by PD, DDs, and Office Directors (ODs) regarding continuation of review.

4. Preparation of letter from NMSS OD to the DOE/OCRWM Director with the results of the Acceptance Review and copies to the State of Nevada Governor, Legislature, Indian Tribes, and counties.

4.3.2 Responsibilities

The PM is responsible for Acceptance Review Activity No. 1, in consultation with the project team members, as well as activities Nos. 2 and 4. The PD, DDs, and ODs are responsible for No. 3 and concurrence on No. 4.

4.4 Technical Review and Integration

4.4.1 Activities

The Technical Review and Integration will use the general review guides and the detailed review guides in Part A. The technical review will consist of the activities listed below.

1. Follow the eight steps listed in Section 3.1.2 Review Approach of Part A and discuss preliminary concerns in project team meetings after steps 3 and 5 or after other steps, as necessary. Lead technical reviewers and support reviewers should discuss what inputs the lead needs from support reviewers.

2. Reviewers prepare preliminary discipline concerns and inputs for other disciplines.

3. SL's review preliminary discipline concerns and inputs.

4. Reviewers revise discipline concerns, summary and inputs based on SL comments and distribute to all team members.

5. Conduct formal integration review of discipline concerns, summary, and inputs focusing on performance allocation, performance assessment, discipline interfaces and discipline consistency. (Specific meetings and other interactions to enhance integrations will be identified prior to this step of the review.)

6. Reviewers prepare Reviewer Draft of concerns and summary based on the integration review.

4.4.2 Responsibilities

Technical review activities nos. 1-6 are the responsibility of the technical reviewers and their SLs in each technical discipline, with extensive consultation and communication with the other technical reviewers, SLs, and the PM.

The Technical Review will be conducted using the general and detailed review guides in Part A. The technical reviewers should review their own product and be satisfied that they have met the IQA criteria in Section 6.1. In addition, informal review meetings and discussions will be held, as appropriate with and among SCP technical reviewers, SLs, and PM. These interactions are intended to provide early feedback to assist the technical reviewers in producing a high quality draft and should minimize iterations.

4.5 IQA and Management Reviews

4.5.1 Activities

The IQA and Management Review for the SCA will consist of the activities listed below. Section 6.0 provides detailed information on IQA and criteria for the SCA.

1. SLs conduct IQA reviews of the Reviewer Draft using the criteria in Section 6.1 to assure the technical quality and integration of the draft and that the significant comments have been resolved.

2. Reviewers resolve SL IQA review comments and prepare Section Draft of concerns and summary.

3. BCs conduct reviews of Section Draft checking that section IQA reviews were conducted and that there are either no unresolved comments or a differing professional opinion (DPO) prepared (NRC Manual Chapter 41.25)

4. Reviewers resolve BC comments and prepare Branch Draft.

5. PM prepares Directors comments and transmittal letter.

6. PM, PD, and DDs conduct review of Branch Draft of concerns and summary, Directors comments and transmittal letter. Editors formally edit Branch Draft.

7. BCs review Directors comments and transmittal letter.

8. Reviewers resolve PM, PD, and DDs comments and PM resolves comments on Directors comments and transmittal letter. Division Draft of total SCA and transmittal letter is prepared.

9. ODs and Office of General Counsel (OGC) review Division Draft of SCA and transmittal letter.

10. Reviewers and PM resolve ODs and OGC comments and prepare Office Draft.

4.5.2 Responsibilities

The SL IQA review of the Reviewer Draft and the PM review of the Branch Draft will consist of a complete reading of all comments and selected checks or audits to various levels of detail (e.g., of calculations, comments accurately representing CDSCP information, etc.) to determine if the SCA meets the defined IQA criteria in Section 6.1. All IQA criteria should be reviewed under the SL IQA review. Although the PM review may cover all review criteria, its main responsibility is in C, D, G, H, I, and K. An editorial review of the Branch Draft will also be conducted by the editors of the production and editorial team and will focus only on review criteria H, I, and J.

SL IQA reviewers should be limited to their areas of responsibility. SLs and BCs should not feel responsible for reviewing and commenting on subjects outside of their lead and supporting areas of responsibility. If differences of opinion cannot be resolved at the reviewer or SL level, they should be escalated to the BC, PD, or DDs level. Project views will generally prevail on project issues, and functional views will generally prevail on functional issues. However, any staff member who has a disagreement with the final product is obliged to bring his views to the BC's attention and document them, as appropriate, in a DPO.

For SL IQA reviews, SLs can designate either staff or contractors to support them in performing their IQA reviews, where either additional resources are needed, or specific technical expertise is needed. Those supporting the SL IQA review should have: (1) technical expertise in the technical area being checked; (2) familiarity with the HLW program; (3) read applicable sections of the SCP; (4) read the SCPRP; (5) not contributed to the portion of the specific product being reviewed.

4.6 State, Indian Tribe, and County Interactions

4.6.1 Activities

The opportunity for the State of Nevada, Indian Tribe, and county interactions will be provided in the activities listed below:

1. Upon completion of the Reviewer Draft the State of Nevada, Indian Tribes, and counties will be provided the opportunity to have a conference call with the NRC staff to exchange views on preliminary concerns with the SCP.

2. Upon completion of the Branch Draft, the State of Nevada, Indian Tribes, and counties will be given the opportunity to meet with the staff to exchange views on the SCP, read the Branch Draft, and give the staff observations on the Branch Draft.

3. Other consultations may be possible pursuant to 10 CFR Part 60, Subpart C. Furthermore, while the above informal interactions might occur before the issuance of the SCA, it is important to note that, pursuant to 10 CFR Part 60, the SCA will be transmitted to the State of Nevada (also Indian Tribes, and counties) and comments will be invited. This formal mechanism gives the State of Nevada as well as other parties the opportunity to document their views on the staff's SCA.

4.6.2 Responsibilities

The PM is responsible for arranging activities nos. 1 and 2 with the appropriate state officials and NRC team members.

4.7 ACNW Review

4.7.1 Activities

The formal ACNW review will be initiated upon completion of the Office Draft of the SCA. The details of this review and related activities are still being developed and when completed will be issued as a revision to the SCPRP.

4.8 Commission Review

The following activities will be conducted:

1. The Commission will be given the SCA Commission paper for a negative consent decision.

2. The Commissioner's Assistants may choose to attend ACNW meetings or request meetings with the staff.

3. The staff plans on briefing the Commission.

4.9 Printing and Issuance

The following activities will be conducted:

1. The PM and Lead Technical Reviewers will prepare the Final SCA by revising, as needed, the Draft Final SCA and transmittal letter in response to Commission requests.

2. The appropriate number of SCA copies will be printed.

3. The SCA will be transmitted to DOE in a letter from the NMSS OD to the DOE/OCRWM Director.

4. The SCA will be transmitted to the State of Nevada Governor and Legislature, Indian Tribes, and counties to invite comments within 90 days.

5. A Federal Register notice will be prepared to notice SCA availability and request comments within 90 days.

6. The SCA and transmittal letters will be placed in the Public Document Room.

7. Soon after SCA issuance the IQA Record for the SCP review will be prepared and placed in the NRC Transitional Licensing Support System (TLSS).

5.0 DESCRIPTION AND PREPARATION OF PRODUCTS

Each major review activity will result in products as listed in Table 7. Descriptions of these products are given below.

5.1 Notifications of SCP Receipt

NWPA and 10 CFR Part 60 require a Federal Register notice of SCP receipt and start of the staff's review. The notice includes the site to be characterized and the NRC staff members to be consulted for further information.

NWPA and 10 CFR Part 60 also require NRC to notify the Governor and Legislature of the State where the candidate site is located. The letters listed in Table 7 will be prepared. These letters will also address interactions during the SCP review.

5.2 Acceptance Review Decision Letter

A letter from the NRC/NMSS OD to the DOE/OCRWM Director will be prepared to inform DOE of the staff's SCP acceptance decision and justification. Copies of the DOE letter will be sent to the State of Nevada, Governor, Legislature, Indian Tribes, and counties.

5.3 Site Characterization Analysis (SCA)

5.3.1 SCA Outline

The SCA is required by NWPA and 10 CFR Part 60. It is required by 10 CFR Part 60 to include:

1. Director's comments and recommendations including statements of either no objection or objection as appropriate.

2. Staff's analysis.

3. Determination of whether the Commission concurs that any proposed use of radioactive materials in testing is necessary.

The SCA will be prepared through a series of drafts listed in Table 7 and the final SCA will be a NUREG. Table 5 gives a preliminary SCA outline to guide the initial preparation of the drafts. This outline can change if necessary to accommodate the results of the review. A general description of the content is given below and open items are defined in 5.3.2.

1.0 Introduction

2.0 Director's Comments and Recommendations
- General conclusions and recommendations
- Statements of objection or no objection for each specific program

3.0 Summary of SCP Concerns
- One page summary of concerns for each specific program in SCP Chapter 8.
- Summary table of number and type of concern (i.e. objection, comment, question) for each specific program.
- Summary table giving resolution status of CDSCP concerns (open items).
- Summaries do not include additional concerns but only summarize concerns in section 4.0. Note that broad concerns which integrate specific concerns should also be prepared as separate concerns.

4.0 SCP Concerns with the Site Characterization Program
- Contains unresolved CDSCP concerns and new concerns
- Concerns consist of objections, comments, and questions as defined in section 5.3.2.
- Concerns are written in "point paper" format as was done for the CDSCP. The basis contains evaluations of how the CDSCP concern was addressed in the SCP.
- Concerns are organized first by objection, comment, and question and second by Chapter 8 section number as was done in the CDSCP point papers.

Appendix A: Resolved CDSCP Concerns
- Contains staff evaluations of resolved CDSCP concerns.
- Each evaluation is written in "point paper" format and should include:
  1. CDSCP Number
  2. Statement of Original concern (as given in the final CDSCP point papers)
  3. Evaluation of DOE Resolution (conclusion that concern is resolved, summary of DOE's resolution, and staff's evaluation)

Appendix B-?: Optional analyses supporting staff concerns or resolved concerns as necessary.

5.3.2 Description of Open Items Identified in SCA

Objections: a concern with the DOE program as presented in the SCP related to either: 1) potential adverse effects on repository performance; 2) potential significant and irreversible/unmitigatable effects on characterization that would physically preclude obtaining information necessary for licensing; 3) potential significant disruption to characterization schedules or sequencing of studies that would substantially reduce the ability of DOE to obtain information necessary for licensing; or 4) inadequacies in the QA program which must be resolved before work begins. Objections are reserved primarily for concerns with activities which, if started, could cause significant and irreparable adverse effects on the site, the site characterization program, or the eventual usability of the data for licensing (programmatic fatal flaws). Due to this irreparable nature of objections, NRC would recommend that DOE not start work until the objections are satisfactorily resolved.

Comments: a concern with the DOE program as presented in the SCP that would result in a significant adverse effect on licensing if not resolved, but would not cause irreparable damage if site characterization started before resolution. The DOE program could be modified in the future, with some risk to not having the necessary information for licensing; the adverse effects would be primarily related to the program schedule. Therefore, for these concerns, DOE could start work at its own risk before resolving such concerns with NRC. NRC would recommend timely resolution of comments. If resolution is not achieved in a timely manner, comments might evolve into the third category of objections described above (i.e., potential significant disruption of schedules).

Questions: a major concern with the presentation of the DOE program in the SCP, such as missing information that should be in the SCP, level of detail, contradictions, and ambiguities which preclude understanding a part of DOE's program, thereby preventing the staff from being able to comment. Questions related to level of detail should be screened carefully, so that the resulting questions are consistent with NRC/DOE agreements on level of detail in the SCP. NRC would recommend DOE clarify such questions. If a question is related to a potential

objection, satisfactory resolution should be accomplished before work begins. If the question is not related to an objection, then DOE could choose to proceed with work at its own risk, and resolve the questions in future reports. Questions should be reserved for major items; minor inconsistencies, etc., should not be included.

Each objection, comment or question should state briefly and concisely the objection, comment or question supported by the basis and significance to the program. Recommendations for DOE's consideration should also be given, where practicable. The CDSCP final point papers are examples of the format for objections, comments or questions. The Review Guides that were used should not be listed.

5.3.3 SCA Commission Paper

In response to a Commission request, the staff will prepare a Commission paper for negative consent as the mechanism to forward the Draft Final SCA to the Commission. This Commission paper will: 1) summarize the NMSS Director's Comments; 2) enclose the Draft Final SCA; 3) summarize and enclose the ACNW comments on the Office Draft of the SCA; 4) summarize how the staff resolved the ACNW comments; and 5) recommend release and transmittal of the SCA to DOE.

5.4 SCA Transmittal Letters and Federal Register Notice

A letter transmitting the SCA to DOE will be prepared. In addition, letters transmitting the SCA to and inviting comments from the State of Nevada Governor, Legislative, Indian Tribes, and Counties. A Federal Register notice will also be prepared noticing the SCA's availability and requesting comments.

5.5 SCA Editorial and Format Guidance

This section gives the necessary editorial and typing format guidance for the SCA. This guidance should be used by technical reviewers in writing their sections, editors who will edit the SCA, and secretaries who will be typing the SCA sections.

5.5.1 Typing Format Guidance

The typing format for the SCA should be as shown in Procedure No. 1. Each draft of the SCA up through and including the Branch Draft should be doubled spaced. The Division, Office Draft, and the Draft Final should be single spaced.

5.5.2 Editorial Guidance

The product should be consistent, to the extent possible with NRC's "Technical Writing Style Guide," NUREG-0650, which includes, for example, guidance on format for references, nomenclature, and preferred usage. The Production Coordinator and each SCP lead branch secretary should have a copy of NUREG-0650 for reference.

Also, listed below are some preferred usages unique to the SCA.
Use:

...CDSCP...
...SCP...
...the NRC staff...
...(see section No. __)...for reference to another NRC open item
...et al. (not ...et. al.)
Do not use ...the DOE... or ...DOE..., rather use "in the SCP." This usage will depersonalize the SCA.

5.6 SCA Production Guidance

This section provides the general production guidance for the SCA. Production team responsibilities, instructions for creating/revising documents on the IBM 5520, archiving, and merging are given. This guidance should be used by the production team members in typing, revising, controlling, and merging documents on the IBM 5520 system. Specific guidance on production team responsibilities and IBM 5520 procedures is provided in Procedure No. 1.

The production/editorial team will consist of the following members:

Production Coordinator
Branch Secretaries
IBM 5520 Coordinator

Secretaries for each branch will type the SCA sections written by the technical reviewers in their branch. This typing will be coordinated by each branch secretary. Secretarial overtime work may be needed, to supplement typing during normal working hours, and will be coordinated by the Production Coordinator.

The general responsibilities of the production team members are as follows:

1. Production Coordinator

   The Production Coordinator is responsible for all aspects of the mechanical production of the SCA. This includes such activities as typing procedures, tracking production progress, coordinating overtime, distribution of packages and formal editing by NRC editors.

2. Branch Secretary (HLPD, HLEN, HLGP)

   The branch secretaries are responsible for the coordination of the typing in appropriate format and following schedules requested by the technical reviewers.

3. IBM 5520 Coordinator

   The IBM 5520 coordinator is responsible for systems maintenance and trouble-shooting.

6.0 INTERNAL QUALITY ASSURANCE REQUIREMENTS

This section describes the IQA requirements and activities which have been developed in response to the IQA plan for the Division of High-Level Waste Management.

6.1 IQA Requirements for SCP Review

The IQA requirements for reviewing the SCP consists of the following:

1. Conduct the SCP review and develop the SCA consistent with the SCPRP.

2. Conduct IQA reviews of the SCA using the following review criteria:

   A. Technically defensible

   B. Accurately represents SCP information (i.e., SCP has been correctly quoted/represented, including recognizing what is said on a given topic in all chapters and the references of the SCP)

   C. Reflect that the review was conducted with an understanding of the general and detailed review guides in the SCPRP

   D. Consistent with the SCA format, including the definition of objections, comments, and questions. Careful review is needed for consistency with NRC/DOE agreements on level of detail in the SCP (i.e., comments or questions should not be made for items beyond the SCP level of detail)

   E. Technically consistent within a discipline

   F. Technically consistent across different disciplines

   G. Consistent with 10 CFR Part 60

   H. Written in a clear, concise, complete, and specific manner, with clear and adequate support given for concerns

   I. Written in an objective and factual tone

   J. Written grammatically and editorially consistent with NUREG style

   K. SCA reflects resolution of significant internal review comments

3. Assure that the quality review of the SCA was satisfactorily conducted.

4. Document by way of concurrence that the requirements in 1-3 above have been satisfactorily completed.

5. Prepare and retain the IQA record.

7.0 RECORDS MANAGEMENT

7.1 IQA Records

7.1.1 Nature and Content of the IQA Record

A large number of presently existing NRC documents are related in some manner to the SCP review. This document collection is and will continue to be stored and managed by Records Management (RM).

A specific set of documents, including some from the above collection will be compiled into an IQA record which directly supports the staff's SCA.

Specifically the IQA record will consist of:

1. SCPRP and all revisions

2. All products listed on Table 7 including listed drafts.

3. Other supporting records (examples below)

   a. Calculations supporting open items

   b. Notes from other team members, only as needed to support an open item (not all notes)

   c. Records documenting IQA reviews

It is recognized that the types and number of supporting records will vary, depending on the technical area. The lead technical reviewer, in conjunction with his respective SL and PM should discuss the specific supporting records retained. The above list gives examples to assist the reviewer in compiling the record judged appropriate to support his review. Please note that copies of all existing staff memos and letters directly related to the SCA must be referenced in the IQA record. Since the IQA record contains those documents judged appropriate to retain, this record should be the only record to document the SCP Review. Therefore, all other documents not identified as an IQA record are unnecessary to retain and should be discarded. Examples of documents which are not IQA records and therefore should not be kept include:

1. Early technical reviewer drafts leading up to the retained Reviewer Draft

2. Various drafts between the retained drafts

3. Mark-ups of drafts

4. Notes to other team members used to prepare open items unless necessary to support open item

5. Personal notes

6. Contractor inputs used to prepare open items. Contractor inputs should not be given to the staff in letter form which automatically goes into the system. Inputs should be verbal or in notes.

7.1.2 Rationale for One IQA Record

The primary reasons for compiling and retaining one totally self-contained IQA record are the following:

1. Provides one clearly defined record which will facilitate rapid search, retrieval, and response to future requests for copies of all or portions of the record (e.g., staff, Congressional or Freedom of Information Act (FOIA) requests).

2. Removes ambiguity over what records the staff should keep and who is responsible for officially retaining/controlling records.

3. Eliminates unnecessary documents and reduces duplicate copies of the IQA record to the minimum necessary to support staff work. Staff can rely on the TLSS and not their own limited file space to retain complete records.

7.2 Preparation, Retention, and Retrieval of Records

The SCPRP and products will be compiled by the Production Coordinator. No input is needed from Technical Reviewers.

Lead Technical Reviewers should provide the Production Coordinator with their supporting records, together with a list of their records, after discussing the contents with their respective SLs and the PM. The Production Coordinator will be responsible for organizing these records, combining them with the SCPRP and products and preparing a complete IQA record and listing.

The Production Coordinator will give the complete IQA record to RM for entering into the TLSS. One paper copy of this IQA record will be kept by the PM. This copy is for day-to-day use and making copies upon request. The IQA Coordinator will verify completion and retention of the IQA record.

8.0 SCP OPEN ITEM IDENTIFICATION AND TRACKING

8.1 Identification of Open Item

As defined in Section 5.3, SCP open items can be either objections, comments, or questions. The staff will also identify open items in it's review of other DOE documents or activities such as the SCP progress

reports, study plans, topical reports and issue resolution reports, on-site reviews, and technical meetings. Collectively, these open items are called DOE open items since they are NRC concerns with DOE's program that DOE should resolve.

The SCP review and the SCA provide an opportunity for organizing and systematically identifying DOE open items. As part of the SCP review, the staff will be familiar with and will consider past comments and open items that have been made by the NRC staff, State of Nevada and other parties, that bear upon the current DOE program described in the SCP. Therefore, the SCA serves as a preliminary recalibration point for identifying those open items related to the level of detail presented in the SCP.

8.2 Tracking DOE's Resolution of Open Items

Following up on DOE's resolution of CDSCP open items and identifying open items through the SCP review and SCA preparation process is being done in a way to facilitate tracking DOE's progress toward resolving or closing out each open item. The DOE SCP semi-annual progress reports and NRC's analysis of them provide the primary opportunity to regularly track the progress toward resolution. DOE can address SCP open items and then, by NRC review and comment, open items can be completely or partially closed out with the supporting bases documented. In addition, new material given in the semi-annual progress reports and study plans has the potential for leading to additional open items. Hence, the DOE semi-annual progress reports and study plans, and NRC's comments on those documents, can facilitate open item tracking by providing a trackable record, developed by a systematic process, on at least a semi-annual basis.

8.3 Comments on Open Item Resolution by the State of Nevada and Other Parties

As required by 10 CFR Part 60, the staff will issue the SCA and invite comments from the State of Nevada and others. This formal mechanism provides an opportunity for any party to express their views on the staff's evaluations including open items that have been closed out or not as well as new open items that have been identified. Other parties might also recommend additional concerns. These comments from other parties will be considered by the staff in it's review of DOE's semi-annual progress reports and other documents as appropriate.

9.0 PROCEDURES

This section contains the procedures referred to in the WPP, as follows:

10.1 SCA Production Guidance
10.2 Revising the SCPRP

Procedure No. 1
Production Guidance

1. Production Coordinator

Gives guidance in typing/production procedures

Tracks branch/team production progress throughout SCP review period, identifies production problems and recommends solutions

Directs the merging of individual documents into the SCA

Coordinates needed overtime typing

Coordinates the editing and editorial guidance to the reviewers and secretaries.

The editorial review should begin with the Section Draft and be completed in the Division Draft. The review will focus only on the following product IQA requirements:

- Written in a clear, concise, complete, and specific manner
- Written in an objective and factual tone
- Written grammatically and editorially consistent with NUREG style.

Assists the PM in distributing SCA drafts internally to staff.

Assists the PM in issuing the SCA, notifications, and placing the SCA in the Public Document Room

Assists the PM and IQA Coordinator in preparing the IQA Record.

2. Lead Branch Secretary (HLPD, HLEN, HLGP)

Coordinates branch typing of SCA up through and including the Branch Draft

Assures correct format is used

Tracks progress of branch typing and identifies any problems and need for additional typing to Production Manager and Branch Chief

HLPD secretary responsible for archiving SCA weekly

3. IBM 5520 Coordinator

Assures someone is available to solve any IBM 5520 or printer problems

Assists with weekly archiving of SCA

Instructions for creating/revising/controlling documents on the IBM 5520

The following guidance should be followed up to, but not including, merging.

1. Use FORMAT SCP, which has been created for this project.

2. Each concern (open item) and summary should be typed as a separate document, with the author's name and date of the latest revision at the end.

3. Do not make any page or line format changes.

4. Do not use the split page instruction.

5. The Header Margin Text should contain the correct document call-up name and page number at the top of each page.

6. In the document profile, the Document Charge Number should be "9999" so all documents can be accessed by whatever secretary is available to do revisions. (See attached)

7. The following naming conventions MUST be used:

SCP/Yucca/Author's initials/OBJ/# of Author's Objections
SCP/Yucca/Author's initials/COM/# of Author's Comments
SCP/Yucca/Author's initials/QUES/# of Author's Questions
SCP/Yucca/Author's initials/SUM
SCP/Yucca/Author's initials/DIRCOM

Archiving

All documents will be archived once a week. The only way we can made sure that documents are archived is by using the above naming conventions.

Merging and subsequent revision

After the BC review, the separate documents will be merged into one document, the Branch Draft. After this point, all revisions will be coordinated through the PM and Production/Editorial Coordinator. The Production/Editorial coordinator will decide if and when the merged comment package should be split up temporarily, to handle the typing load.

Procedure No. 2
Revising the SCPRP

1. Suggested concerns with or revisions to the SCPRP should be first discussed with the PM for the SCP Review to determine the significance to the ongoing review.

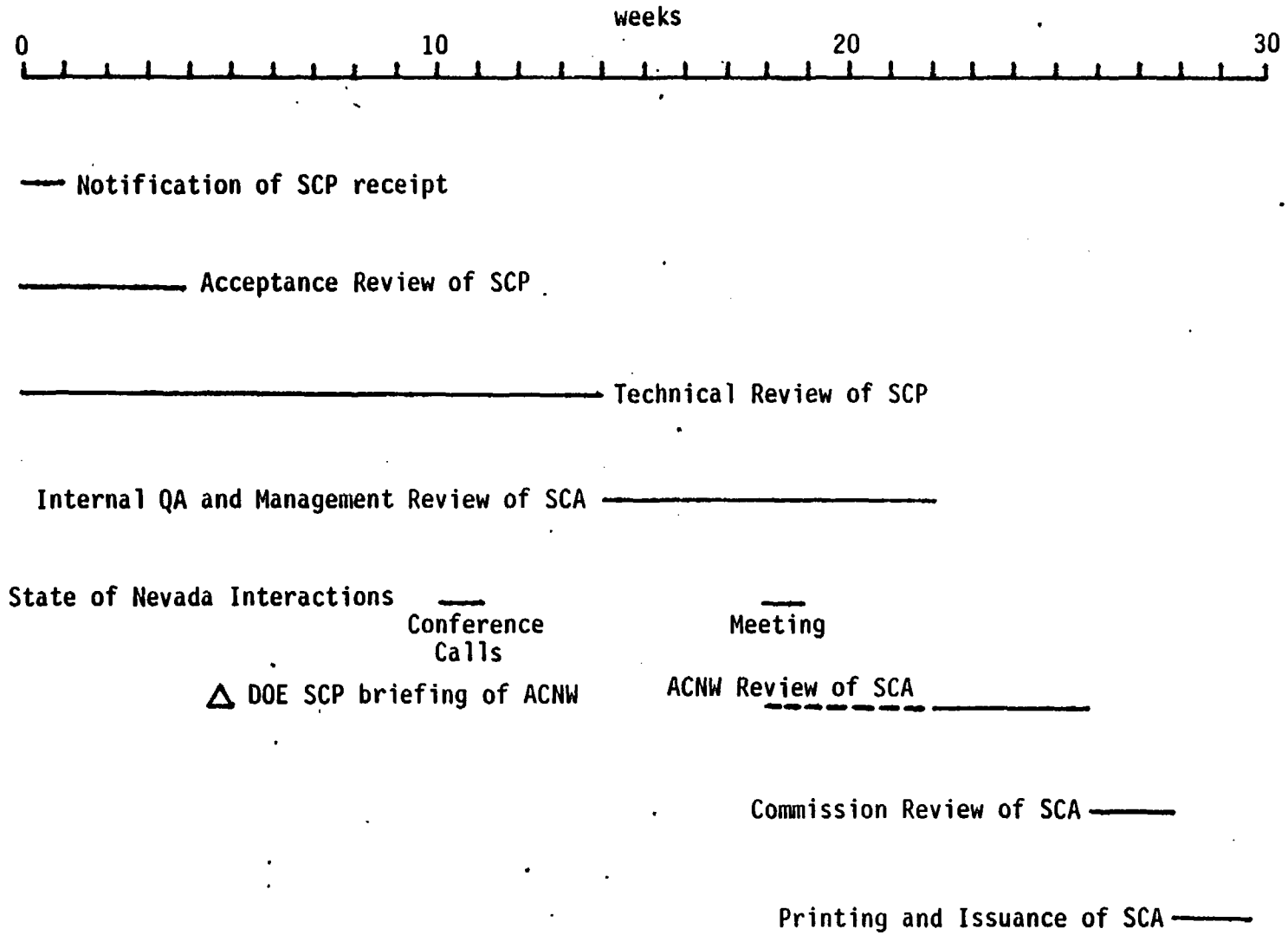
2. Suggestions agreed to by the PM for the SCP review will be discussed with the PD and the PM for Review Plans to determine what revision is needed and when it should be completed.

3. The PM for Review Plans will revise the SCPRP as agreed and coordinate the revision with the BCs, PD and DDs. The revised pages will be identified with the appropriate Revision No. and the areas revised identified by a line in the margin.

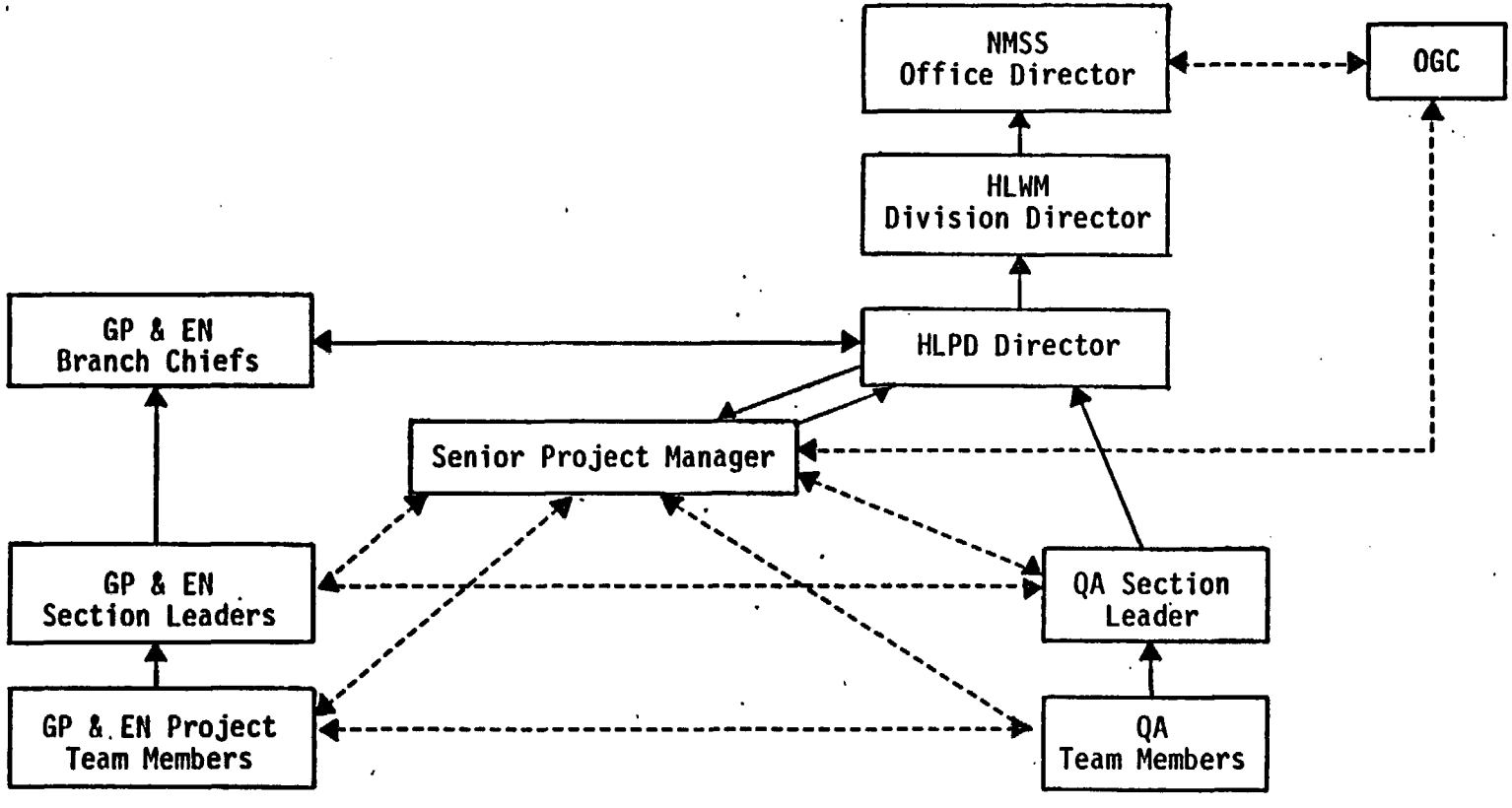
4. The revision to the SCPRP will be issued by the DD to all the HLWM staff.

5. The Lead Technical Reviewer should provide the revision to any support contractors or Research staff if the revision is relevant to the supporting contractor or staff work.

FIGURE 1 - SCHEDULE OF MAJOR SCP REVIEW ACTIVITIES*



*Based on a 7 month or 30 week review period from the receipt of an SCP and references accepted for review. If receipt of references (e.g. Design Acceptability Analysis) is delayed, there will be a corresponding delay in the review and SCA issuance.



——— Formal lines of responsibility and authority

- - - - - Informal lines of communication

FIGURE 2 - SCP REVIEW ORGANIZATION

Table 1 SCP Review Activities

Notification of SCP Receipt and Start of Staff Review

Receive SCP copies and references
Make a copy of the SCP available in the Public Document Room
Notify staff of start of review and provide SCP and references
Notification in Federal Register
Notification to Nevada Governor and Legislature, Indian Tribes, and counties

Acceptance Review

Acceptance review
Acceptance review briefing
Acceptance decision
Acceptance decision letter to DOE

Technical Review and Integration

Discipline review following eight steps given in Section 3.1.2 of Part A and prepare preliminary discipline concerns and inputs for other disciplines
Section Leader review of preliminary concerns and inputs and prepare discipline concerns, summary, and inputs for integration review
Formal integration review of all discipline concerns and inputs focusing on performance allocation, performance assessment, discipline interfaces, and discipline consistency. Prepare Reviewer Draft of concerns and summary.

(Other activities might include interactions with DOE on the ESF and observing DOE's public hearings on the SCP by the on-site representatives.)

IQA and Management Review

SL IQA review of Reviewer Draft and prepare Section Draft of concerns and summary
BC review of Section Draft and prepare Branch Draft of concerns and summary
PM, PD, and DDs review of Branch Draft and prepare Division Draft of SCA (Directors comments, summary, and concerns) and transmittal letter (includes BC review of Directors comments).
ODs and OGC review of Division Draft and prepare Office Draft of SCA and transmittal letter

State and Indian Tribe Interactions

Potential conference calls based on Reviewer Draft
Potential meeting based on Branch Draft
(Other consultation pursuant to 10 CFR Part 60, Subpart C)

ACNW Review

Arrange for DOE to brief ACNW on SCP Content
Provide ACNW Branch and Division Drafts of SCA to involve them earlier

Table 1 SCP Review Activities (Continued)

ACNW briefing and review of Office Draft of SCA and transmittal letter
Prepare negative consent Commission Paper with final SCA, transmittal letter, and concurrence

Commission Review

Commission briefing if requested
Commission negative consent decision to release SCA

Printing and Issuance

Print SCA
Issue SCA to DOE
Issue SCA to State of Nevada Governor and Legislature, Indian Tribes, and counties to invite comments
Federal Register notice of SCA availability and request for comment
Place SCA into the Public Document Room
Prepare IQA record and place into the TLSS

Table 2 SCP Review Team

Project Manager	K. Stablein
Production Coordinator	E. Tana
Internal QA Coordinator	T. Verma
OGC Representative	J. Wolf

Technical Reviewers and IQA Reviewers	Lead Technical Reviewers	Supporting Technical Reviewers	IQA Reviewers
Geology-Geophysics	C. Abrams	M. Blackford (Seismology) K. McConnel (Tectonics) A. Ibrahim (Geophysics) J. Trapp (Geoscience input to perf. assess., concept. models) T. Cardone (Shaft wall mapping, core, sample handling)) H. Lefevre (Natural res., erosion) C. Abrams (Volcanism, Natural res., hydrogenic dep.)	P. Justus
Hydrologic Transport	J. Pohle	B. Ford (Hydrology) F. Ross (Hydrology) N. Coleman (Hydrology) J. Bradbury (Geochemistry) T. Mo (Geochemistry)	D. Chery D. Brooks
Systems Performance	N. Eisenberg (Post-closure) J. Trapp (Pre-closure)	P. Brooks B. Neel (Health Physics) J. Pearring (Engineering)	S. Coplan
Engineering	D. Gupta (Geotechnical) K. Chang (Materials)	J. Peshel C. Peterson	R. Weller/ M. Nataraja
Quality Assurance	B. Belke		J. Kennedy
Special Analysis	J. Corrado		R. MacDougall

Table 3 Lead Responsibilities for DOE Issues* and Related 10 CFR Part 60 Requirements

DOE Issues (related 10 CFR Part 60 Requirement) *	Lead Section and Discipline**	Support Section and Discipline*
Key Issue 1 - Post-closure Performance		
1.1 Releases to Accessible Environment (60.112)	SP	HT,GG,EM,EG
1.2 Individual Protection	SP	
1.3 Groundwater Protection	HT	GG,HT
1.4 Waste Package Containment (60.113)	EM	HT,GG,SP
1.5 EBS Release Rate (60.113)	EM	HT,EG,SP,GG
1.6 Groundwater Travel Time (60.113)	HT	GG,HT,SP
1.7 Performance Confirmation (60.137)	SP	GG,HT,EM,EG
1.8 NRC Siting Criteria (60.122)	SP	GG,HT,EM,EG
1.9 DOE Guideline Findings	X	X
1.10 Waste Package Design (60.135)	EM	GG,HT,EG
1.11 Repository Design (60.133)	EG	GG,HT
1.12 Seals Design (60.134)	EG	GG,HT
Key Issue 2 - Pre-closure Radiological Safety		
2.1 Public Safety During Normal Operation (60.111)	SP	GG,EG
2.2 Worker Safety (60.111)	SP	GG,HT,EG
2.3 Public Safety During Accidents	SP	
2.4 Retrievability (60.111)	EG	GG
2.5 DOE Guideline Findings	X	X
2.6 Waste Package Design (60.135)	EM	EG
2.7 Repository Design (60.131, 132, 133)	EG	GG

* Key issues and issues from DOE's Issues Heirarchy. Only key issues 1 and 2 are related to 10 CFR Part 60.

** Geology-Geophysics (GG), Hydrologic Transmport (HT), Systems Performance (SP), Engineering-Geotechnical (EG), Engineering-Materials (EM), Quality Assurance (QA), Project Management (PM), Special Analysis (SA), X not NRC review responsibility

Table 4 Responsibilities for Reviewing Chapter 8 of the SCP

Section Number and Title	Lead Section (Discipline)*	Support Section (Discipline) *
8.1 Rationale for Site Char. Prog.	SP	GG,HT,EG,EM
8.2 Issue Resolution, Info. Req.	SP	GG,HT,EG,EM
8.3 Planned Tests, Analysis, Studies		
8.3.1 Site Program		
8.3.1.1 Overview	GG,HT,EG,EM	
8.3.1.2 Geohydrology	HT	GG,EG
8.3.1.3 Geochemistry	HT	GG
8.3.1.4 Rock Characteristics	EG,GG	HT,EM
8.3.1.5 Climate	HT,GG	
8.3.1.6 Erosion	GG	
8.3.1.7 Rock Dissolution	HT	GG
8.3.1.8 Post-closure Tectonics	GG	HT,EG
8.3.1.9 Human Interference	GG	SA
8.3.1.10 Population	SA	
8.3.1.11 Land Ownership	SA	GG,OGC
8.3.1.12 Meterology	HT	
8.3.1.13 Offsite Installations and Operations	SA	GG,EG
8.3.1.14 Surface Characteristics	GG	EG
8.3.1.15 Thermal and Mechanical Rock Prop.	EG	GG,HT
8.3.1.16 Pre-closure Hydrology	HT	GG,EG
8.3.1.17 Pre-closure Tectonics	GG	EG
8.3.2 Repository Program		
8.3.2.1 Overview	EG	
8.3.2.2 Post-closure Repository Design IRS	EG	GG,HT,EM,SP
8.3.2.3 Pre-closure Repository Design IRS	EG	GG,SP
8.3.2.4 Non-radiological Health, Safety IRS	X	X
8.3.2.5 Adequate Technology IRS	EG	
8.3.3 Seal Program		
8.3.3.1 Overview	EG	
8.3.3.2 Post-Closure Shaft, Borehole Seals IRS	EG	GG,HT,SP

Geology-Geophysics (GG), Hydrologic Transport (HT), Systems Performance (SP), Engineering-Geotechnical (EG), Engineering-Materials (EM), Quality Assurance (QA), Project Management (PM), Special Analysis (SA), X not NRC review responsibility

Table 4 Responsibilities for Reviewing Chapter 8 of the SCP (Continued)

Section Number and Title	Lead Section (Discipline)	Support Section (Discipline)
8.3.4 Waste Package Program		
8.3.4.1 Overview	EM	
8.3.4.2 Post-closure Waste Package Design IRS	EM	GG,HT,EG,SP
8.3.4.3 Pre-closure Waste Package Design IRS	EM	GG,EG,SP
8.3.4.4 Adequate Technology IRS	EG	
8.3.5 Performance Assessment Program		
8.3.5.1 Strategy for Preclosure Performance Assessment	SP	GG,HT,EG,EM,SA
8.3.5.2 Retrievability IRS	EG	GG,EM
8.3.5.3 Public Safety From Normal Operations IRS	SP	GG,EM,EG
8.3.5.4 Worker Radiological Safety IRS	SP	GG,HT,EM,EG
8.3.5.5 Public Safety from Credible Accidents IRS	SP	GG,HT,EM,EG
8.3.5.6 960 Findings	X	X
8.3.5.7 960 Findings	X	X
8.3.5.8 Strategy for Post-closure Performance Assessment	SP	GG,HT,EG,EM
8.3.5.9 Waste Package Containment IRS	EM	GG,HT,EG,SP
8.3.5.10 EBS Release Rates IRS	EM	GG,HT,EG,SP
8.3.5.11 Seal System Perf. IRS	EG	SP
8.3.5.12 Groundwater Travel Time IRS	HT	GG,HT,SP
8.3.5.13 Release to Access. Envir. IRS	SP	GG,HT,EM,EG
8.3.5.14 Individual Protection IRS	SP	GG,HT,EM,EG
8.3.5.15 Groundwater Protection IRS	HT	GG
8.3.5.16 Performance Confirmation IRS	SP	GG,HT,EM,EG
8.3.5.17 NRC Siting Criteria IRS	SP	GG,HT,EM,EG
8.3.5.18 960 Findings	X	X
8.3.5.19 Sub. Complete Anal. Tech.	SP	GG,HT,EM,EG
8.3.5.20 Anal. Tech-Sign. Devel.	SP	GG,HT,EM,EG
8.4 Potential Impacts of Site Char. Act.		
8.4.1 Introduction		
8.4.2 Description, Location of SC Operations	EG	GG,HT
8.4.2.1 Rationale for Testing	SP	GG,HT,EG,EM
8.4.2.2 Surface-based Activities	GG	GG,HT
8.4.2.3 Subsurface-based Activities (ESF)	EG	GG,HT,EM
8.4.3 Potential Impacts on Performance	SP	GG,HT,EG,EM

Table 4 Responsibilities for Reviewing Chapter 8 of the SCP (Continued)

Section Number and Title	Lead Section (Discipline)	Support Section (Discipline)
8.5 Milestones, Decision Pts., Schedule	SA	SP,GG,HT,EG,EM,QA
8.6 Quality Assurance Program	QA	SP,GG,HT,EG,EM
8.7 Decontamination, Decommissioning	X	X

Table 5 Lead Responsibilities for Preparing SCA Sections

SCA Sections	Lead Section* (Discipline)
1.0 Introduction	PM
2.0 Director's Comments and Recommendatins	PM
2.1 Issue Resolution Process	
2.2 Site Program	
2.3 Repository Program	
2.4 Seal Program	
2.5 Waste Package Program	
2.6 Performance Assessment Program	
2.7 Exploratory Shaft Facility Impacts	
2.8 Quality Assurance Program	
2.9 Schedules	
2.10 Use of Radioactive Materials	
2.11 Resolution of CDSCP Concerns	
2.12 Other (topics based on concerns such as integration, conservatism)	
3.0 Summary of SCP Concerns	
3.1 Issue Resolution Process	SP
3.2 Site Program	
3.2.1 Geohydrology and Preclosure Hydrology Programs	HT
3.2.2 Geochemistry and Rock Dissolution Programs	HT
3.2.3 Rock Characterisitcs and Thermal Rock Properties Programs	EG/GG
3.2.4 Climate and Meterology Programs	HT/GG
3.2.5 Erosion and Surface Characteristics Programs	GG
3.2.6 Post-closure and Pre-closure Tectonics Programs	GG
3.2.7 Human Interference and Land Ownership-Mineral Rights Programs	GG/SA
3.2.8 Population and Offsite Installations, Operations Programs	SA
3.3 Repository Program	
3.3.1 Post-closure Repository Design	EG
3.3.2 Pre-closure Repository Design	EG
3.4 Seal Program	EG

*Geology-Geophysics (GG), Hydrologic Transport (HT), Systems Performance (SP), Engineering-Geotechnical (EG), Engineering-Materials (EM), Quality Assurance (QA), Project Management (PM), Special Analysis (SA)

Table 5 Lead Responsibilities for Preparing SCA Sections (Continued)

SCA Sections	Lead Section* (Discipline)
3.5 Waste Package Program	
3.5.1 Post-closure Waste Package Design	EM
3.5.2 Pre-closure Waste Package Design	EM
3.6 Performance Assessment Program	
3.6.1 Post-closure Performance Assessment	SP
3.6.2 Pre-closure Performance Assessment	SP
3.7 Potential Impacts of Site Characterization Activities on Waste Isolation	
3.7.1 Exploratory Shaft Facility and Impacts	EG
3.7.2 Surface-based Activities and Impacts	SP
3.8 Quality Assurance Program	QA
3.9 Schedules	SA
4.0 SCP Concerns with the Site Characterization Program	All
4.1 Objections	
4.2 Comments	
4.3 Questions	
Appendix A: Resolved CDSCP Concerns	All
1.0 Objections	
2.0 Comments	
3.0 Questions	

Table 6 Lead Responsibilities for Reviewing CDSCP Open Items

Section (Discipline)

HYDROLOGIC TRANSPORT:

Comments 5; 6; 7; 8; 9; 10; 11; 12; 13; 14; 15; 16; 17; 18; 19; 20; 21; 22; 23; 24; 25; 31; 32; 33; 40; 41; 71; 86; 87; 88; 89; 96.
Questions 3; 4; 5; 6; 7; 8; 9; 10; 11; 24; 28; 47.

GEOLOGY/GEOPHYSICS:

Comments 26; 28; 34; 35; 36; 37; 38; 39; 49; 50; 51; 52; 53; 62; 69; 95.
Questions 13; 15; 18; 19; 20; 21; 22; 23 (deleted); 29; 30 (deleted); 31; 32; 33.

SYSTEMS PERFORMANCE:

Objection 1.
Comments 2; 4; 90; 91; 92; 93; 94.
Questions 2; 43; 44; 46; 52.

QUALITY ASSURANCE:

Objection 5.
Comments 104; 105; 106; 107; 108.

ENGINEERING (GEOTECHNICAL):

Objections 2; 3; 4.
Comments 1; 27; 29; 30; 42; 43; 44; 45; 46; 47; 48; 54; 55; 56; 57; 58; 59; 60; 61; 63; 64; 65; 66; 67; 68; 70; 72; 97; 98; 99; 100; 101; 102; 103.
Questions 12; 14; 16; 17; 25; 26; 27; 34; 35; 36; 37; 38; 40; 41; 42; 48; 49; 50; 51.

ENGINEERING (MATERIALS):

Comments 3; 73; 74; 75; 76; 78; 77; 79; 80; 81; 82; 83; 84; 85; 109; 110.
Questions 1; 45.

Table 7 SCP Review Products

SCP Review Activity and Product

Notification of SCP Receipt

Federal Register notice of SCP receipt and start of staff review
Letters to State of Nevada Governor and Legislature noticing SCP receipt
Letters to Indian Tribes noticing SCP receipt
Letters to Nye, Clark, and Lincoln Counties noticing SCP receipt
Letter to Director, State of Nevada Nuclear Waste Project Office (NWPO) noticing SCP receipt

Acceptance Review

Letter to DOE with the SCP acceptance review decision and a copy to NWPO

Technical Review and Integration

Reviewer Draft of concerns and summary

Internal QA and Management Review

Section Draft of concerns and summary
Branch Draft of concerns and summary
Division Draft of SCA and transmittal letter
Office Draft of SCA and transmittal letter

ACNW Review

Commission Paper with Draft Final SCA and transmittal letter

Commission Review and Printing and Issuance

Final SCA and transmittal letter

Appendix A: Information related to NRC/DOE Agreements on the Level of Detail in the SCP

Attachment C

DOE CONTENT REQUIREMENTS FOR DESCRIPTIONS OF INVESTIGATIONS IN CHAPTER 8.3 OF THE SITE CHARACTERIZATION PLANS

The test program presented in Chapter 8.3 of the Site Characterization Plans (SCPs) will be subdivided into a hierarchy of increasing detail. The SCP test program hierarchy will include (in increasing detail): generic program; specific program; investigation; study; and test and analysis. Generic programs, specific programs, and investigations will be described in Chapter 8.3 of the SCP. Details for studies, tests, and analyses will be presented in study plans separate from the SCP (see Attachment B).

The following outline describes the content requirements for ivestigations that will be presented in Chapter 8.3 of the SCP. An investigation may involve a single study or a set of studies, as appropriate.

I. Purpose and Objectives of Investigations:

- Describe the information that will be obtained in this investigation. Briefly discuss how this information will be used; and

- Provide the rationale and justification for the information to be obtained by the investigation. It can be justified by: 1.) a performance goal and a confidence level in that goal (developed via the performance allocation process and results that will be described elsewhere in the SCP); 2.) a design goal and a confidence level in that goal (design goals beyond those related to performance issues); 3.) a direct Federal, State, and other regulatory requirements for specific studies. Where relevant performance or design goals actually apply at a higher level than the investigation (e.g. where the goals apply to a group of investigations), describe the relationship between this investigation and that higher level goal.

II. Rationale for Selected Investigation:

- Provide the rationale and technical basis for why the investigation will be conducted. Identify relevant technical issues;

- Describe the constraints that exist for the investigation, explain how these constraints affect selection of studies, include a summary of the interrelationships involving significant interference among studies and investigations

and how plans have been designed or sequenced to address such interferences, and include a summary of the interrelationships involving significant interferences among studies and exploratory shaft facility design and construction (refer to NRC Observation 4); and

- Discuss the strategy, including how the planned studies, tests and analyses will be collectively used, for resolving the relevant technical issues.

III. Description of Studies:

- Since investigations are comprised of one or more studies, for each study:

  - State the objectives of the study, incorporating the tests and analyses that make up the study;

  - Indicate if the study is to provide information for the development of conceptual models (e.g., the collection of water level data will provide input to the development of the conceptual and numerical ground-water flow models);

  - Indicate if the study is being performed to guide the development of subsequent characterization, performance assessment and/or design activities (e.g., simulations with ground-water flow models will be performed to determine where additional drilling will be required);

  - List the tests, the test methods to be used, the data/parameters that are to be collected and/or evaluated for each test, the locations, numbers, and duration of tests and the technical procedures that will be used for the test. Reference the study plans, as appropriate; and

  - For each analysis that the study will support, list the method of analysis and the information that will result from the analysis.

IV. Application of Results:

- Briefly discuss where the results from the investigation will be used for the support of other investigations (performance assessment, design, and characterization investigations);

- For performance assessment uses, refer to specific performance assessment studies (described in Section 8.3.5 of the SCP) which will use the information produced from the studies described above, and refer to any use of the results

for model validation;

- For design uses, refer to, or describe, where the information from the studies described above will be used in construction equipment design and development and engineering system design and development (e.g., waste package, repository engineered barriers, and shafts and borehole seals); and

- For characterization uses, refer to, or describe, where the information from the studies described above will be used in planning other characterization activities.

V. Schedule and Milestones:

- List in tabular form, major milestones which will result from the studies that comprise the investigation. Proposed titles, expected delivery dates, and milestones are to be included;

- Present the schedule for the studies supporting the investigation, providing beginning and end dates for tests and analyses, or groups thereof; and

- Show the interrelationships and sequencing of the tests, analyses, or groups, with particular attention to those that will affect or be affected by the scheduled completion of other activities. Dependencies on data derived from other investigations also should be indicated on the schedule as well as the major milestones and decision points associated with the studies. A simple PERT chart should be used to illustrate these relationships.

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June 16, 1986
RFW-SD-DEL-01188/86

Dr. Donald H. Alexander
Chief, Technology Branch
Office of Geologic Repositories
U.S. Department of Energy
RW-24 (Forrestal) Room 8F-094
Washington, D.C. 20585

Subject: Revisions to Content Requirements Correlation Table from NRC-DOE Meeting, May 7-8, 1986. TDD #3002-24-09-1002

Dear Dr. Alexander:

Enclosed please find a copy of a correlation table entitled "Comparison of DOE Content Requirements for Descriptions of Study Plans and Investigations", which is a revised version of Attachment D included in the May 7-8, 1986 NRC-DOE advance meeting materials. Attachment D was revised to be consistent with Attachments B and C to Attachment 4 of NRC/DOE meeting summary. This revision to Attachment D satisfies NRC-DOE agreement number 2 from the meeting summary and should be forwarded to the NRC and the Project Offices.

If you have any questions please call me at 330-3761.

Sincerely,

ROY F. WESTON, INC.

Jeffrey W. Nelson,
SCP Task Manager
Siting Department

Approved by:

William W. Hewitt
Program Manager

cc: W. Purcell
T. Isaacs
R. Stein
J. Knight
H. Brandt
J. Fiore
R. Blaney
A. Jelacic
J. Frei
C. Head
S. Echols
C. Borgstrom
C. Hanlon
S. Grodin
R. Jackson
L. Skoblar

Comparison of DOE Content Requirements for Descriptions of Study Plans and Investigations

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	Study Plans	Investigations
I. Purpose and Objectives	• Describe the information to be obtained in the study • Provide the rationale for information to be be obtained	• Describe the information to be obtained in the investigation • Provide the rationale for the information to be obtained
II. Rationale for Study/Investigation	• Provide the rationale for tests and analyses, indicating alternatives considered and options, advantages and limitations • Provide the rationale for number, location, duration, and timing of tests, considering uncertainties, and identify obvious alternatives • Describe the constraints for the study, considering: - potential site impacts - need to simulate repository conditions - required accuracy and precision - limits of analytical methods - capability of analytical methods - time required vs. time available - scale of phenomena and parameters - interference among tests - interference between tests and exploratory shaft	• Provide the rationale for investigations, identifying relevant issues • Describe the constraints for the investigation affecting selection of studies, including interferences among studies and between studies and the exploratory shaft • Discuss the strategy for resolving issues
III. Description of Tests and Analyses/Studies	For each type of test: • Describe general approach that will be used in test • Describe key parameters that will be measured in test and experimental conditions under which test will be conducted	For each study: • State objectives of study • Indicate if the study is to provide information for development of conceptual models • Indicate if study is being performed to guide characterization activities • List tests, test methods, data/parameters, locations, numbers, technical procedures and duration of tests • Reference study plans

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Comparison of DOE Content Requirements for Descriptions of Study Plans and Investigations (Continued)

	Studies	Investigations
III. Description of Tests and Analyses/Studies (continued)	• Indicate number of tests and locations • Summarize test methods; if non-standard procedure, summarize steps of test, how it will be modified, and reference technical procedure • Indicate level of QA and provide rationale for any tests not QA Level 1 • Reference the applicable specific QA requirements applied to test. • Specify tolerance, accuracy, and precision required in test • Indicate range of expected results and basis for those results • List equipment requirements, describing briefly special equipment • Describe techniques to be used for data reduction and analysis • Discuss representativeness of test, indicating limitations and uncertainties that apply to use of results • Provide illustrations of test locations • Discuss relationship of test to set performance goals and confidence levels	
	For each type of analysis: • State purpose of analysis, indicate conditions to be evaluated and describe any uncertainty analysis	For each analysis: • List method of analysis and information that will result from analysis

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Comparison of DOE Content Requirements for Descriptions of Study Plans and Investigations (Continued)

	Studies	Investigations
III. Description of Tests and Analyses/Studies (continued)	• Describe methods of analysis, including analytical expressions and numerical models to be used • Reference the technical procedures document that will be followed during analysis • Indicate levels of QA applied • Identify data input requirements • Describe expected output and accuracy • Describe representativeness of analytical approach, indicating limitations and uncertainties that apply to results	
IV. Application of Results	• Briefly discuss where results from study will be used for support of other studies • Refer to specific performance assessment analyses • Describe where information from study will be used in construction equipment and engineering system, design and development • Describe where information from study will be used in planning other characterization activities	• Briefly discuss where results from investigation will be used for support of other investigations • Refer to specific performance assessment studies • Indicate where information from studies will be used in construction equipment and engineering system, design and development • Describe where information from studies will be used in planning other characterization activities
V. Schedule and Milestones	• Provide durations of and interrelationships among principal activities associated with conducting the study • List key milestones including decision points associated with study activities • Describe timing of study relative to other studies and other program activities • Provide dates for activities for the study plans; reference Sec. 8.5 in SCP	• Show interrelationships and sequencing of (groups of) tests and analyses; use PERT chart to illustrate • List major milestones which will result from studies • Present schedule for studies supporting the investigation, providing beginning and end dates

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