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STANDARD FORMAT AND CONTENT OF SITE CHARACTERIZATION REPORTS FOR HIGH-LEVEL-WASTE GEOLOGIC REPOSITORIES

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

INTRODUCTION

On February 25, 1981, the Nuclear Regulatory Commission (NRC) issued the licensing procedures for the disposal of high-level waste in 10 CFR Part 60, "Disposal of High-Level Radioactive Wastes in Geologic Repositories" (46 FR 13971). As part of the prelicensing procedures set forth in the final rule, the Department of Energy (DOE) is required to submit a site characterization report (SCR) to the NRC as early as possible after commencement of planning for a particular geologic repository operations area and prior to starting site characterization* (paragraph 60.11(a)).** This guide covers, in detail, the many technical and institutional aspects of licensing a high-level waste repository. However, the basic purpose of the SCR is simple: to provide a mechanism for identifying and delimiting the specific issues at a proposed repository site*** and to identify the plans for resolving those issues at an early time in order to avoid delays in the licensing process. The SCR as reflected in the logic sequence and organization of this Standard Format and Content of Site Characterization Reports for High-Level-Waste Geologic Repositories (hereinafter "Standard Format") should accomplish the following:

1. Establish what is known about a site from site exploration activities completed to date,

2. Describe the issues that DOE has identified at a site in light of the results of investigations to date, and

3. Describe the detailed plans to resolve the issues identified.

Objectives of Site Characterization

The site characterization program will include exploration and research, both in the laboratory and in the field, undertaken to establish the geologic conditions at a site and ranges of parameters that characterize the site.

The objectives of site characterization are:

1. To collect pertinent geological and other site characteristic information that will ultimately be needed for a license application, i.e., sufficient information about DOE's preferred site to support a finding, prior to

*As defined in 10 CFR Part 60, site characterization means the program of exploration and research, both in the laboratory and in the field, undertaken to establish the geologic conditions and the ranges of those parameters of a particular site relevant to the procedures under Part 60. Site characterization includes borings, surface excavations, excavation of exploratory shafts, limited subsurface lateral excavations and borings, and in situ testing at depth needed to determine the suitability of the site for a geologic repository, but does not include preliminary borings and geophysical testing needed to decide whether site characterization should be undertaken.

**On July 8, 1981, NRC published proposed technical criteria, and other conforming provisions, for incorporation into 10 CFR Part 60 (46 FR 35280). The adoption of these provisions as final rules was assumed for purposes of preparing this guide. The guide will be modified, as appropriate, to take into account any changes that may be made in the final technical criteria.

***Site and other terms appearing in this Standard Format have the meanings set forth in proposed § 60.2 of 10 CFR Part 60.

construction, of reasonable assurance that there is no unreasonable risk to public health and safety.

2. To collect necessary data from alternative sites and media to permit the NRC to make National Environmental Policy Act (NEPA) findings with respect to consideration of alternatives.

Objectives of Site Characterization Report

The purpose of the SCR is to generate a document in which DOE:

1. Summarizes (either in the SCR itself or incorporated by reference from an environmental impact statement):

   a. Screening work and criteria that led to selection of the candidate area and site to be characterized,

   b. The decision process by which the site was selected for characterization, and

   c. Plans for screening work and characterization of alternative sites in different geologic media.

2. Describes the site, conceptual design of a repository appropriate to the site, waste form, waste packages, emplacement environment, and performance analysis in sufficient detail so that the site screening and selection process and the planned site characterization program may be understood.

3. Identifies the uncertainties and limitations on site- and design-related information developed during site screening, including issues that need further investigation or for which additional assurance is needed.

4. Describes the detailed programs for additional work to resolve outstanding issues and to reduce uncertainties in the data.

The objective of the SCR is to expedite the licensing process by providing a vehicle for early NRC, State, Indian tribal, and public input on DOE's data-gathering and development work so as to avoid postponing issues to the point where modifications would involve major delays or disruptions in the program. Early review of DOE's site characterization plans, as presented in the SCR, will provide an opportunity for NRC to evaluate whether DOE's proposed program is likely to generate data suitable to support a license application.

Following commencement of site characterization, DOE will provide the NRC Director of the Office of Nuclear Material Safety and Safeguards (NMSS) with semiannual reports (see Appendix A to this Standard Format) that will include the results of site characterization studies, including any new information that might affect the design assumptions concerning waste form and packaging and the planned repository itself. Semiannual reports will also include the identification of new issues, plans for additional studies to resolve these issues, the elimination of planned studies no longer necessary, and the identification of decision points reached and modifications to schedules, where appropriate.

Purpose, Applicability, and Use of This Standard Format

The purpose of this Standard Format is to suggest the types of information to be provided in the SCR in accordance with 10 CFR Part 60 and to establish a uniform format for presenting the information. Use of this format will help ensure the completeness of the information provided, will assist the NRC staff and others in locating the information, and will aid in shortening the time needed for the review process. This Standard Format represents a format that is acceptable to the NRC staff. However, conformance with the Standard Format is not required. SCRs with differing formats will be acceptable if they provide an adequate presentation of the information required by 10 CFR Part 60.

The Standard Format is divided into three parts:

1. Part A provides guidance on the presentation of information related to the criteria used to arrive at the candidate area, the method and decision process by which the site was selected for site characterization, the identification and location of alternative media, and the quality assurance program applied to data collection.

2. Part B provides guidance on the types of information needed to describe the site and the conceptual design (including the waste form and waste package and its emplacement environment) of a repository appropriate to the site. There is no threshold amount of data to be accumulated during the preliminary site exploration activities required prior to the submittal of an SCR. Rather, Part B provides guidance on how to submit information that is currently available.

3. Part C provides guidance on the presentation of the site characterization program, on the identification of unresolved issues, and on the plans to resolve these issues during site characterization.

In its review of Part C, the NRC will look for answers to the following questions:

a. Have the important information needs and unresolved issues been identified?

b. Does the SCR specifically address these information needs and present program plans to obtain the needed information?

c. Are the methods of testing and analysis proposed for the planned site characterization program appropriate?

d. Have alternative methods of testing and analysis been identified and evaluated, and has an adequate basis been provided for the selection of the methods to be used?

e. Will the data to be collected and the reliability of the collection methods and analyses be of adequate quality to support a future construction authorization application?

The SCR will be principally evaluated according to the completeness of Part C, its most critical part.

In developing Part C of the SCR, DOE should ensure that attention is focused on those aspects of siting, development of waste form and packaging, and the conceptual design of a repository appropriate to the site that may require the most effort in the site characterization program. While the SCR must be complete in developing the issues of site characterization, it is important--particularly in initial planning phases--that those issues considered critical or most important to licensing be identified and given highest priority in the site characterization plans.

NRC recognizes that the DOE program of site characterization will be a phased process. NRC expects that data included in the SCR may be better defined and more detailed for early phases of site characterization (e.g., testing in the exploratory shaft) and less detailed for later phases (e.g., testing in an underground facility with two shafts). As DOE completes plans for later phases of site characterization, additional data should be submitted to NRC in semiannual reports (see Appendix A to this Standard Format).

In any event, all site characterization plans for gathering the information needed to conduct the full 10 CFR Part 60 evaluation of site suitability and design acceptability that will accompany the license application should be addressed fully in the SCR for each site.

Supplemental Information

Detailed supplemental information not explicitly identified in this Standard Format may be provided in appendices to the SCR. Examples include:

1. Technical information in support of conceptual design features,
2. Reports furnished by consultants,
3. Summaries of how appropriate NRC regulations and guides were addressed, and
4. Portfolios of maps.

In cases where only representative data (e.g., selected geophysical data from selected borehole logs) are submitted, the original raw data should be accessible either at the site or other appropriate locations and should be readily available to NRC. Representative data should be of sufficient quality and quantity to permit an understanding of the nature and extent of the set of data actually available.

Style and Composition

Information should be presented clearly and concisely. Claims of adequacy of designs or design methods should be supported with technical bases.

Units of measurement (both fundamental and derived) should be given in the International System of Units (SI). If common industrial usage is in other units and the use of SI would be confusing, give the measurement in accepted units with SI units in parentheses.

The SCR should follow the numbering system and headings of the Standard Format at least down to the headings with three digits, e.g., 3.3.2 Tectonic History.

Avoid duplication of information. Similar or identical information may be requested in various sections of the Standard Format because it is appropriate to more than one portion of the SCR. In such cases, present the information in the principal section, and reference it appropriately in the other applicable sections.

Where numerical values are stated, the number of significant figures given should reflect the accuracy or precision to which the number is known. Where appropriate, estimated limits of error or uncertainty should be provided.

Abbreviations should be consistent with generally accepted usage throughout the SCR. Any abbreviations, symbols, or special terms not in general use should be defined when they first appear in the SCR.

Graphic presentations such as drawings, maps, diagrams, sketches, and charts should be used where the information can be presented more adequately or conveniently by such means or when the interpretation of data can be clarified. All information presented in drawings should be legible, symbols defined, and drawings not reduced to the extent that visual aids are necessary to easily interpret pertinent items of information presented in the drawings. When a series of maps is submitted, a common scale should be used whenever possible.

Bibliography

Bibliographic listings of documents or reports discussed in the SCR should appear at the end of the chapter in which they are first mentioned. For each report or document (e.g., articles in professional journals) listed in the bibliography, include the author, the title, the report or document number, and the date of publication and/or of submittal to NRC. For any reports that have been withheld from public disclosure as proprietary documents, nonproprietary summary descriptions of the general content of such reports should also be included in the bibliography. In cases where proprietary documents were used to obtain information, provide a nonproprietary summary of the document. Bibliographic listings may include not only documents and reports but also data on file at the site or project office (e.g., drill logs, hydrologic test data).

Physical Specifications

1. Paper Size

   Text pages: 8-1/2 x 11 inches.

   Drawings and graphics: 8-1/2 x 11 inches preferred; however, a larger size is acceptable provided the bound side does not exceed 11 inches, except where required for legibility, and the finished copy when folded does not exceed 8-1/2 x 11 inches.

2. Paper Stock and Ink

   Suitable quality in substance, paper color, and ink density for handling and reproduction by microfilming or image-copying equipment.

3. Page Margins

A margin of no less than 1 inch should be maintained on the top, bottom, and binding side of all pages.

4. Printing

Composition: should be single-spaced text pages.

Type font and style: must be suitable for microfilming.

Reproduction: may be mechanically or photographically reproduced. Text pages should preferably be printed on two sides with the image printed head to head.

5. Binding

Pages should be punched for standard 3-hole loose-leaf binder.

6. Page Numbering

Pages should be numbered with the two digits corresponding to the chapter and first-level section numbers followed by a hyphen and a sequential number within the section, i.e., the third page in Section 4.1 of Chapter 4 should be numbered 4.1-3. Do not number the entire report sequentially. (Note that, because of the small number of pages in many chapters, this Standard Format is numbered sequentially throughout the document.)

PART A

STANDARD FORMAT AND CONTENT GUIDANCE FOR DESCRIBING THE CRITERIA AND DECISION PROCESS OF SELECTING CANDIDATE AREAS AND SITES

Part A of the Standard Format is designed to provide guidance on the following issues, as set forth in paragraph 60.11(a):

1. The types of information needed to evaluate the criteria used to arrive at the candidate area;

2. The method by which the site was selected for site characterization;

3. The identification and location of alternative media and sites at which DOE intends to conduct site characterization and for which DOE anticipates submitting subsequent SCRs;

4. A description of the decision process by which the site was selected for characterization; and

5. A description of the quality assurance program to be applied to data collection.

1. PROGRAM OVERVIEW

1.1 National Waste Terminal Storage Program

Briefly summarize how the site chosen for site characterization fits into the national waste terminal storage program for identifying alternative sites in different rock types.

1.2 Identification of Agents and Contractors

Identify the DOE project management organization. Describe the DOE technical projects and tasks. Prime agents or contractors for site investigations, design, waste form and packaging, and performance analysis should also be identified. All principal consultants, outside service organizations, and key research groups to be involved with site characterization should be listed. The division of responsibility and lines of communication among these various parties should be delineated.

1.3 Quality Assurance

Describe the quality assurance (QA) programs that have been applied during site exploration activities and that will be applied to data collection during the planned site characterization program. The QA methods should be presented in sufficient detail to allow NRC to make an independent evaluation of the precision, accuracy, reproducibility, analytic sensitivity, and limitation of data acquisition and analysis methods that were used during site exploration and will be used during site characterization.

2. DECISION PROCESS FOR CHOOSING CANDIDATE AREA AND SITE

This chapter should describe the decision process through which a particular site was selected for site characterization. This description should define the criteria used to arrive at the selection of the candidate area, the method by which the site was selected for characterization, the identification of alternative sites, and a description of the decision mechanism used to evaluate the technical, environmental, legal, and institutional criteria.*

2.1 Technical Factors

In accordance with 10 CFR Part 60, discuss the application of the following types of technical criteria used in screening and selecting the site.

1. Geological,
2. Hydrological,
3. Meteorological,
4. Geochemical,
5. Geomechanical,
6. Geophysical,
7. Resource evaluation,
8. Human activity, and
9. Any other pertinent factors that affected the site selection process.

2.2 Environmental Factors

Describe how the following environmental factors influenced site selection.

1. Radiological,
2. Ecological,
3. Air quality,
4. Water quality,
5. Land resources and use,
6. Esthetics,
7. Historical, archeological, and cultural resources, and
8. Socioeconomics.

2.3 Legal and Institutional Factors

2.3.1 State, Indian Tribal, and Local Laws

Discuss the extent to which State, Indian tribal, and local laws and regulations have entered into the site selection process, including any specific State constitutional provisions, laws, regulations, or local ordinances that are relevant to site selection.

*To the extent that the information described in this chapter appears in an environmental impact statement prepared by DOE for site characterization at the named site, it may be incorporated into the SCR by reference.

2.3.2 Federal Legal Framework

To the extent that other Federal agencies have statutory responsibilities affecting repository site selection, discuss how these responsibilities have entered into the site selection process. Also, discuss any other Federal statutes, treaties, and administrative regulations that affect site selection.

2.3.3 Land Ownership

Discuss the manner in which land ownership and the ability to acquire jurisdiction and control affect site selection.

2.3.4 Public Involvement

2.3.4.1 State, Indian Tribal, and Local Government Participation in the Decisionmaking Process. Identify the government units affected by the proposed site, the methods used to accommodate their viewpoints, and the provisions made for their continuing involvement in the site selection process.

2.3.4.2 Public Participation. Identify the provisions made for public input into the site selection process, the nature of public involvement, and how public attitudes affected the site selection process.

2.4 Identification of Alternative Sites

Identify and describe all other sites and media for which DOE is conducting, or intends to conduct, site characterization. Indicate the current status of the site investigations, an outline of planned activity, and actual or estimated submittal dates for the SCRs.

2.5 Decisionmaking Analysis

For the selected candidate area and site, describe the method by which the site was evaluated against the criteria in Sections 2.1, 2.2, and 2.3. Include a discussion of any quantitative methods used, problems associated with the availability and reliability of data, any value judgments made, and an explicit identification of the tradeoffs made among the various criteria.

If the results of performance assessment were used in the decision process to (1) screen sites or (2) choose the site for the characterization program, these results, as well as the performance assessment techniques (including simplifying assumptions and boundary conditions) should be discussed. The discussion of the performance assessment should be presented in sufficient detail to permit an independent evaluation. In the discussion of the performance assessment, specific sections of other documents (e.g., user manuals and code documentations) may be incorporated by reference, provided these documents are either publicly available or, if proprietary, are readily available to NRC.

PART B

STANDARD FORMAT AND CONTENT GUIDANCE FOR DESCRIBING THE SITE, WASTE FORM AND PACKAGE, AND CONCEPTUAL DESIGN OF A REPOSITORY

Part B of the Standard Format is designed to provide guidance on the types of information needed to describe the site to be characterized (paragraph 60.11(a)(1)). The main purpose of describing the site and conceptual design of a repository appropriate to the site (including a description of the waste form and waste packaging and environment) will be to provide information to support the site screening and site selection process, provide information to allow issues to be identified, and provide information to support the site characterization program for resolving the issues. The descriptions should include the method of investigation used to obtain the information, the methods of evaluation used, and the limitations and uncertainties of either the method of investigation or the data used in the evaluation.

The NRC recognizes that, because of the generic nature of this Standard Format, some of the information requested in Chapters 3-8 (e.g., volcanic history) may not be appropriate to specific sites. The NRC also recognizes that the level of detail requested in some sections of Chapters 3-8 may not be available at the time the SCR for a particular site is submitted.

3. GEOLOGIC DESCRIPTION OF CANDIDATE AREA AND SITE

A description of the geology of the candidate area and site should be provided in this chapter. This information is needed to understand the selection of the site for characterization, the relationship of the conceptual design of a repository appropriate to the specific site, and the rationale for the proposed site characterization program.

Where geophysical techniques such as gravity, heat flow, and magnetic surveys have been conducted in support of geologic studies (e.g., subsurface stratigraphy or structure), this fact should be noted in the appropriate sections of this chapter. When geologic information has been obtained from the literature, the sources should be referenced.

3.1 Geomorphology

Describe the physiography, topography, geomorphic units, and geomorphic processes for the candidate area and site. Discuss the application of geomorphology to site screening and selection for characterization.

3.1.1 Physiography and Topography

Describe the physiographic province(s) in which the candidate area and site are located. This should include the description province name(s), areal extent, relationships to surrounding province(s), distinguishing characteristics (e.g., elevation, relief), and major active processes modifying the present-day topography. This information should be provided by means of topographic maps of the candidate area and site using appropriate scales and contour intervals needed to support other studies associated with this site. When available, representative ground-level photographs, vertical and oblique aerial photographs, and satellite imagery should be included. Sources of information used to obtain the above descriptions should be listed.

3.1.2 Geomorphic Units

Describe each geomorphic unit by giving its name, areal extent, distinguishing characteristics, and other pertinent information. All units should be shown on a topographic map. Geomorphic units should be defined using a combination of factors influencing geomorphic processes such as near-surface geology and soil, relief, landform morphology, and biota.

3.1.3 Geomorphic Processes

Describe any geomorphic process that could affect the ability of the site to isolate radioactive waste. Each process should be discussed from the perspective of past, present, and estimated future activity. Emphasis should be placed on present and Quaternary processes since these may be the most useful for estimating future activity. However, information on older processes should also be given where it is useful for understanding present ground-water systems or predicting future changes (e.g., salt dissolution or collapse breccias) or where it can contribute to estimating the potential occurrence of future processes.

Each geomorphic process should be described, including (1) rate of activity, (2) frequency of occurrence and cycles, and (3) controlling mechanisms or factors.

3.2 Stratigraphy

Using available information, describe the stratigraphic framework of the candidate area and site, including both surface and subsurface geology. Distinguish between Quaternary and pre-Quaternary stratigraphic units.

Descriptions and illustrations (e.g., maps, columns, cross sections) should be given in sufficient detail, legibility, style, and quality to permit their evaluation by independent reviewers.

Uncertainties associated with stratigraphic extrapolations should be discussed.

3.2.1 Surface Geology

Provide a map of the surface geology and, where the information is available, relate surface rock units to those in the subsurface. Where feasible, nationally recognized geologic symbols should be used.*

3.2.2 Stratigraphic Framework of Candidate Area

Provide a framework for the stratigraphy of the candidate area in the following manner:

1. Present a map of the candidate area. State the technical bases (e.g., sedimentary basin) for the boundary of the candidate area, and include all areas relevant to studies supported by stratigraphy.

2. Illustrate the stratigraphy and lithology of the candidate area using such materials as geologic maps, representative lithostratigraphic columns, and cross sections. Lithostratigraphic sequences should be characterized in three dimensions in sufficient detail to give clear orientation and order to the detailed descriptions of rock units in the candidate area. For each lithostratigraphic sequence, list major unconformities, the age, range of thickness, spatial extent, major rock units, and vertical and lateral variations. Present an overall geologic time sequence (periods, epochs, and ages) for the rock units of the candidate area.

3. Present a genetic model for the origins and development of the rock sequences that includes a general geologic history through time of the rock sequence and the processes that formed and altered the sequence. Include subjects such as sedimentary tectonics, source area, depositional and diagenetic environments, volcanism, plutonism, and metamorphism.

*See Data Sheet Numbers 1-4, American Geological Institute, 5205 Leesburg Pike, Falls Church, Virginia 22041.

3.2.3 Stratigraphic Framework of Site

Describe the stratigraphy of the site, using surface and subsurface information when available. This information can be obtained from the literature or from the results of preliminary site exploration activities. Provide representative photographs and geophysical logs for the lithostratigraphic units when available. For wells that have been cored, representative driller logs, lithologic and geophysical logs, and core photographs should be provided.

Lithostratigraphic units can be formal (groups, formations, or members) or informal (sequences or lithofacies) and should represent the degree of subdivision of the rock mass necessary to permit an evaluation of the planned site characterization program.

Each lithostratigraphic unit should be described.* Descriptions should include but not be limited to:

1. The name, using established nomenclature,

2. Lithologic and mineralogic composition,

3. Diagnostic physical and paleontological characteristics useful for identification and correlation (e.g., color, sedimentary structures, texture, fabric, trace elements content, fossil content),

4. Physical characteristics significant to isolation of radioactive waste such as bedding, mineralogy, grain size, intergranular fillings, cement, and secondary mineralization,

5. Geophysical characteristics or signatures (surface and subsurface, including downhole),

6. Vertical and lateral variation of composition and characteristics and comparison to surrounding units (lithofacies maps),

7. Thickness and spatial extent (isopach maps, geologic columns, cross sections, fence or block diagrams),

8. Structure (specific attitude measurements or inferred structure from geophysical data) and its variation (reference other sections of the SCR as needed for detail),

9. Vertical and lateral relationships to surrounding rock units (contacts and unconformities),

10. Age, and

11. Genesis or origin of the unit, including rock formation processes and models (deposition, intrusion, extrusion) and rock alteration processes and models (metamorphism and diagenesis).

*See "Code of Stratigraphic Nomenclature," in the Bulletin of the American Association of Petroleum Geologists, Vol. 45, pp 645-665, 1961, and subsequent revisions.

3.3 Structural Geology and Tectonics of Candidate Area and Site

Define the tectonic elements of the candidate area and site, and describe any pre-Quaternary and Quaternary structures present. If known, structural features that may create pathways from the depths of the conceptual design of a repository appropriate to the site to the accessible environment* should be described regardless of age. Structural features that provide information about the tectonic stability of the site should be described. In addition, structural features occurring in active areas of strain release that have constituted major tectonic boundaries in their geologic history or that may be reactivated to create tectonic instability should also be described.

3.3.1 Tectonic Framework

Discuss the tectonic framework of the candidate area and site. Identify those tectonic processes that have been active since the start of the Quaternary. Maps and cross sections that show all major tectonic features, including crystalline shields, sedimentary basins, uplifts, orogenic and fold belts, volcanics, major faults, and major joint sets, should be provided when available.

3.3.2 Tectonic History

Describe the tectonic history of the candidate area and site from the earliest recognizable tectonic elements through the end of the Pliocene. The tectonic history should include the age and sequence of development of all major crystalline shields, sedimentary basins, uplifts, orogenic and fold belts, volcanics, major faults, and major joint sets.

3.3.2.1 Volcanic History. The volcanic history should be described when applicable to a particular site or candidate area. Maps of the candidate area and site showing the distribution of extrusive and intrusive rocks should be provided.

If there is more than one period of volcanic activity in the candidate area or if there has been repeated volcanism during the Quaternary, a table listing the volcanic episodes should be included. The table should describe the type of extrusive or intrusive rock, composition of the volcanics, age, geometric relationship to other volcanics, and the stratigraphy of the surrounding rocks. A description of each major period of volcanism should be presented for each volcanic episode listed on the table.

The mineralogy and geochemistry of each volcanic unit should be presented in this section and referenced in other appropriate chapters of the SCR. Alteration, contact metamorphism, and mineralization of country rocks surrounding the flows should be discussed as well as any weathering and alteration of the volcanic rocks themselves. Fracturing and faulting associated with volcanism, including attitude, spacing and size of fractures, and cross-cutting relationships among fractures in country and volcanic rocks, should be described.

*For a definition of the term accessible environment, refer to proposed § 60.2 of 10 CFR Part 60.

The effects of the volcanism on the interstitial and secondary porosity and permeabilities of the country rocks and the effect of volcanism on the regional hydrogeology should be described. If this information is not currently available, present plans in Part C for obtaining it during site characterization.

Based on the Quaternary volcanic history, predict the potential for future volcanic activity in the candidate area with emphasis on the next 10,000 years.

3.3.2.2 Faulting History. The faulting history of the candidate area and site should be described. The description should include the distribution, characteristics, attitude, spacing, length, strike direction, dip of the fault plane, and width and nature of the fault zone of the faults. This should be accompanied by a map showing the location, strike, and dip of all known and suspected faults. The extent to which faults may act as pathways to the accessible environment from the conceptual design of a repository appropriate to the site should be estimated if possible.

Provide information on surface offsets and net slip of all the Quaternary faults and the amount of basement offset associated with each fault. All assumptions for determining true offset should be explicitly stated. The movement history, including rate of displacement and recurrence interval, should be identified. Absolute and relative dating techniques should be applied where possible. If more than one period of Quaternary faulting is present within the candidate area or site, the fault systems of different ages should be tabulated, and the evidence for the age of each fault should be presented.

3.3.2.3 Folding History. The folding history of the candidate area and site should be discussed, and a map that shows the location and trend of fold belts in the candidate area should be included.

Describe the geometry, symmetry, wavelength and amplitude of the folds, their mode of origin (e.g., flexural slip), and their attitude relative to the earth's surface (upright, inclined, overturned, or recumbent). The trend and plunge of the fold axis and the strike and dip of the axial surface of each major fold, along with its sense of asymmetry, should be mapped. Cleavage, fractures, and faults associated and penecontemporaneous with the folding should be delineated from available information. Any change in porosity and permeability of the rocks due to folding should be discussed.

Describe the overall nature of the folding. "Thin-skinned" tectonics should be distinguished from "thick-skinned" or basement tectonics.

If more than one period of folding is present, the evidence that allows the relative and/or absolute dating of the individual episodes of folding should be included.

3.3.2.4 Jointing History. The jointing history of the candidate area and site should be described as thoroughly as possible. A map showing the location and trend of all known joint sets should be included. For each joint set, the areal distribution, the attitude, and the intensity of jointing (i.e., joint spacing) within the candidate area and site should be presented. Absolute or relative dating of the joint sets should be provided when known.

The mineralogy and age of fillings along joints of any age should be discussed. The possibility that joints may form pathways from the depth of a conceptual design of a repository appropriate to the site to the accessible environment should be discussed. The effect of various joint sets on the fracture permeability of the rock should be provided, or the appropriate sections of Chapter 5, "Hydrology," should be referenced. The relationship of joints to the regional faulting and folding should be described.

The mode of origin of the joints (i.e., extension or shear mechanism) should be discussed. If microcracks are present, describe their geometric and genetic relationships to systematic and nonsystematic joints.

A table listing the various joint sets, in order of age along with their principal characteristics, should be included.

3.3.2.5 Uplift, Tilting, and Subsidence. Uplift, tilting, and subsidence in the candidate area and site, including effects caused by withdrawing or injecting fluids and mining, should be discussed when applicable. This discussion should include the suspected causes of uplift, tilting, and subsidence as well as the rate, magnitude, and areal extent of the uplift, tilting, and subsidence. Quaternary deformation not classified as folds, faults, or joints, e.g., features related to salt tectonics, should also be described.

3.3.2.6 Active Stress Field. The active stress field in the candidate area and site should be discussed. All in situ stress measurements that have been done within the candidate area should be summarized. The data should be tabulated to show the method of stress measurement (e.g., overcoring, the flat jack method), the depth of the measurement, and the actual magnitude and orientation of the principal stresses.

3.3.2.7 Vertical Crustal Movement. Existing data on crustal movements should be summarized and tabulated. Time-dependent gravity and geodetic surveys and geomorphic analyses of landforms should be summarized.

3.4 Seismicity of Candidate Area and Site

The seismic information presented in this section should provide a description of the available seismic data and their relationship to the geologic and tectonic conditions of the candidate area and site. The rationale for using any seismic parameters as bases for any portion of the conceptual design of a repository appropriate to the site should be explained. Information needs for which sufficient data are not currently available should be identified, and plans to obtain the information should be set forth in Part C of the SCR.

3.4.1 Seismicity of Candidate Area

Provide a description of the seismic history of the candidate area. Relate historic earthquakes to seismic and tectonic zones. Whenever it is available, the following information should be provided: hypocentral coordinates, origin time, magnitude, total dislocation, focal mechanism, and error estimates for these data. Present a regional scale map of all the listed earthquake epicenters.

Identify the technique used to locate all hypocenters and to determine magnitudes. Differentiate earthquakes on the basis of focal depth, where applicable.

Whenever applicable, define the precise locations of hypocenters of small earthquakes, and use these locations to map zones where relief of crustal stress is occurring. Identify seismic conditions that influenced the conceptual design of a repository appropriate to the site.

Provide a listing of all known historic earthquakes of magnitude greater than 3 or MM intensity greater than IV that have been reported for the candidate area. When information is available, estimates of intervals of recurrence, maximum probable and credible earthquake magnitudes for the candidate area, and how these estimates were derived should also be discussed.

The probability of future major earthquakes within the candidate area should be discussed. Available information on focal mechanisms should be evaluated with respect to tectonics and stress distribution. Information needs for which sufficient data are not currently available should be identified. Plans for obtaining this information should be included in Part C of the SCR.

When earthquakes are located on the basis of arrival times of seismic waves, the particular seismic waves should be identified. The local seismic-velocity model used for interpreting and refining travel-time data should be documented.

Revised locations of earthquake epicenters or hypocenters that differ substantially from original locations should be noted. Whenever a revised location is adopted in place of an original location, an explanation for the preference should accompany the revised location. Focal mechanisms that differ significantly from the majority derived for the region should be specifically noted.

3.4.2 Seismicity of Site

The seismicity of the proposed site should be described. The relationship between the seismicity of the proposed site and geologic features should be discussed. Information needs for which sufficient data are not currently available should be identified. If applicable, plans for seismic studies and monitoring programs should be described in Part C of the SCR.

3.5 Long-Term Regional Stability with Respect to Tectonic and Geological Processes

Based on Quaternary and present-day active tectonic, geophysical, and geological processes, an assessment of the future stability of the candidate area should be presented with emphasis on the next 10,000 years. Pre-Quaternary structures located within active stress fields should also be assessed. All models, assumptions, parameters, and sensitivity tests to be used for making these assessments should be explicitly stated.

3.6 Subsurface Drilling and Mining

Comprehensive information pertaining to past and present drilling and mining operations should be presented for the candidate area and site. This

should include a tabulation of all active and abandoned wells, boreholes, and excavations at the candidate area distinguishing between those wells, boreholes, and excavations that preceded site exploration and those that were part of site exploration. The tabulation should also include such information as the location, depth, diameter, drilling method, casing left in the hole, and method of plugging or sealing. The methods used to investigate the extent of previous drilling and excavation should be discussed. A map showing the location of active and abandoned wells, boreholes, and excavations and the plan view of the conceptual design of a repository appropriate to the site should be provided. If the information is available, describe the former use of previous boreholes and the types of testing that were conducted in them. Copies of representative data, logs, and interpretations should be included. Documentation related to calibration procedures and data-massaging techniques should be provided. Interpretation of results should be supported with adequate references. Discuss the adequacy of the historical record in determining the likelihood of undiscovered wells, boreholes, and excavations in the volume of rock and their possible effects on the site. Also include any known boreholes that were lost because of cave-ins or equipment failures.

Provide available information on the effects of the active and abandoned wells, boreholes, and excavations on the principal hydrogeologic units. If sufficient information is available, the presence of potential pathways should be indicated and the net flux and hydraulic gradients created by them should be assessed. (If the information in this paragraph is included in the discussion of hydrology, the appropriate sections of Chapter 5, "Hydrology," may be referenced.)

Provide descriptions, plans, and sections of all active or inactive underground mines within the candidate area, including both conventional mines and in situ extraction types of operations whenever applicable. Describe the kinds of minerals extracted, methods of mineral extraction, the volume of rock removed, and the volume of rock replaced. Include a statement of the present condition of the workings as to subsidence, stability, and flooding.

3.7 Mineral and Hydrocarbon Resources

Information pertaining to the mineral and hydrocarbon resources of the candidate area and site should be presented in this section.

3.7.1 Mineral Resources

To the extent that information on the mineral resources is available prior to site characterization, the following information should be provided.

The resources of the site should be compared with the resources in comparable areas (those of similar size and geology). Total resources, both identified and undiscovered as defined in the U.S. Geological Survey Bulletin 1450a,* should be included.

*"Principles of the Mineral Classification System of the U.S. Bureau of Mines and the U.S. Geological Survey," U.S.G.S. Bulletin 1450a, 1976.

Provide a tabulation of the total resources, including (1) the quantity of resources, (2) the cutoff values used in estimating (1), (3) the present gross value of each substance, (4) the present net value of each substance, i.e., the gross value less the costs for exploring, developing, extracting, and marketing the substance, and (5) the unit values of the minerals evaluated in (3) and (4). For each substance, describe the method of assessment.

3.7.2 Hydrocarbon Resources

Describe and locate any past or present oil and gas wells in the candidate area. Discuss the likelihood of future development in the candidate area, including both reserves and potential resources.

4. GEOENGINEERING

In this chapter the mechanical, thermal, and thermomechanical properties of the rock units and the expected mechanical boundary conditions that are the basis for the conceptual design of the geologic repository should be presented. Each discussion should include a brief summary of generic information from similar rock units and projects and site-specific information,* if available. The information should be in sufficient detail to (1) permit an understanding of the geomechanical basis of the proposed conceptual design of a repository appropriate to the site (Chapter 8), and (2) support the discussion of design issues in Part C. The discussions should include values or ranges of values for the design parameters used in the conceptual design and should provide the rationale for selecting these preliminary values.

For each of the properties of the rock units, include a discussion of the equipment and procedures used, including their limitations and the errors produced by them. (Equipment and procedures should be referenced to the appropriate standards, e.g., ASTM, where available.) Geologic borehole logs, geologic cross sections, or photographs accumulated during preliminary site exploration activities should be provided when possible to show where tests were conducted or samples were taken. Any measures taken to preserve or restore the *in situ* chemical and physical environment during site exploration should be described. The anisotropy of the properties should be addressed. If isotropic approximations are assumed, justify that assumption.

4.1 Mechanical Properties of Rock Units - Continua

Present the mechanical properties of the rock units as determined by laboratory tests on samples of the potential host rock and of other rock units important for the conceptual design of a repository appropriate to the site and its performance if available. Also present available generic data from similar rock units. Include site-specific information, when available, on elastic and inelastic behavior, compressive and tensile strength, and effects of heating and fluid pressure on these properties.

4.2 Mechanical Properties of Rock Units - Large Scale

Present the results of any large-scale laboratory and field tests such as plate-bearing tests, hydrostatic test chambers, flat jacks, Goodman jacks, and convergence tests. ("Large-scale" here means tests of sufficient size to take into account the discontinua (fractures, joints, inhomogeneities, etc.) of the media.) Discuss the relationship of the results of the laboratory tests to the results of the large-scale tests. Provide site-specific data, if available, as well as available generic data for similar rock units and environments.

4.3 Mechanical Properties of Rock Units - Discontinua

Describe the mechanical properties of discontinua (fractures, joints, bedding planes, inclusions, voids) present in the rock units. Provide site-specific data

*Site-specific information means information gained from tests done in, or samples taken from, limited borings, surface outcrops, near-surface test facilities, pre-existing tunnels or mines, etc., near the site proposed for characterization. It does not imply that a shaft has been sunk.

as well as available generic data from similar rock units and environments. If the information is available, the discussion should include the coefficient of friction, the compressibility of fractures and filling materials, and the effect of heating and changes of pore pressure on the mechanical properties of the joints, fractures, bedding planes, and other discontinua. Discuss the effects of the discontinua on the mechanical properties of the rock mass (e.g., strength and deformation characteristics).

4.4 Thermal and Thermomechanical Properties - Laboratory Results

Present the results of laboratory studies of the thermal properties of the rock units. Provide available site-specific data as well as generic data from similar rock units.

Include discussions on the thermal conductivity, heat capacity, and coefficient of thermal expansion of the rock units.

4.5 Stress Field

Present the stress field data, if available, and list the assumptions used to infer stress from field observation. Also present applicable stress measurements that have been made in the candidate area or at the site. Include a discussion of the expected direction and magnitude of the principal stresses as a function of depth.

4.6 Special Geoengineering Properties

Describe any special thermal, mechanical, thermomechanical, or other properties of the rock units that were considered in developing the conceptual design of a repository appropriate to the site (e.g., brine migration, thermal decrepitation, thermal dewatering). Provide available site-specific data as well as generic data from similar rock units.

4.7 Excavation Characteristics of Rock Mass

Describe excavation investigations that have been conducted within the candidate area, and discuss pertinent excavation experience in similar rock type under similar conditions using various techniques such as controlled blasting and mechanical nonblasting. This discussion should include information on how the investigations were monitored, analyzed, and applied to the conceptual design of a repository appropriate to the site. The discussion should also include an assessment of the potential damages produced by the various techniques and appropriate methods for avoiding or mitigating such damages.

5. HYDROLOGY

Include in this chapter pertinent information gathered on hydrologic conditions of the candidate area and site. Surface and subsurface hydrologic regimes should be addressed. The information should be presented in sufficient detail to (1) describe the hydrology based on available literature and preliminary site exploration activities and (2) provide information to be used to analyze the hydrologic aspects of the planned site characterization program.

Include, as applicable, data sources and estimated uncertainties. Discuss any significant consequences of the uncertainties about conclusions drawn from the data.

5.1 Description of Surface Hydrology

Describe the hydrologic framework of the surface waters of the candidate area and site. Address the location and physical and hydrologic characteristics of surface-water bodies such as streams, lakes, and shore regions influencing the site. Include a description of existing and proposed water control structures, both upstream and downstream, that may influence conditions at the site.

5.2 Floods

5.2.1 Flood History

Provide the date, level, peak discharge, and related information for major historical flood* events in the candidate area. Include stream floods, surges, seiches, tsunami, dam failures, ice jams, floods induced by landslides, and similar events.

Discuss whether the site is flood dry or non-flood dry using procedures presented in ANSI N170-1976.** If procedures other than those presented in ANSI N170-1976 are used, state the reasons and describe the procedures.

Discuss the potential for future flooding of the site. Include long-term changes in the hydrometeorology of the region and the potential for floods induced by maximum glaciation. Describe planned or ongoing studies to thoroughly investigate the potential for future flooding. Include geologic evidence of Pleistocene and Holocene flooding in the assessment of future flood potential.

5.2.2 Flooding Protection

Describe the static and dynamic consequences of all types of flooding that could occur at the candidate area and site. Present the plans and any completed flow analyses needed to ensure that these types of flooding would allow continued integrity of surface and subsurface structures at the site.

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*A flood is defined as any abnormally high water stage or overflow from a stream, floodway, lake, or coastal area that results in significantly detrimental effects.

**See American National Standards Institute (ANSI) Standard N170-1976, "Standards for Determining Design Basis Flooding at Power Reactor Sites." Copies may be obtained from the American Nuclear Society, 555 North Kensington Avenue, La Grange Park, Illinois 60525.

5.3 Locations and Distances to Points of Surface-Water Use

5.3.1 Present Quantity and Quality of Surface Water Extracted

Provide a tabulation of existing surface-water intakes (including collector well systems) downstream of any identified ground-water discharge areas. For each surface-water intake, provide the location, population served, type of intake, and the maximum daily and average quantities of water pumped. Also, the water quality at the intake locations and the type of treatment given to the water before distribution should be discussed.

5.3.2 Projected Surface-Water Uses

Estimate quantities and potential areas of water use for the region for 50 and 100 years into the future. Base the projections on expected growth rate of the region; industries likely to develop in the future because of location, climate, or natural resources; and probable changes in the technology or economic requirements. Do not base the projections on extrapolations of historical data alone. Also locate possible points of withdrawal for any potential future water users that have been identified.

5.4 Chemical, Biological, and Ecological Composition of Adjacent Watercourses

Describe the chemical, biological, and ecological composition of adjacent bodies of water that could potentially be affected by releases from the facility. The chemical data should be sufficient to determine the salt seep or salt discharge rates into drainage basins for dissolution studies. This description should include measured baseline data derived from historical records and onsite monitoring programs prior to site characterization activities.

Identify, to the extent possible, the source and nature of the background pollutants (e.g., chemical species and physical characteristics such as color and temperature), the range of concentrations involved, and the time variation in release. Information relating to water quality characteristics should include measurements made on, or in close proximity to, the site.

The seasonal cycles of physical and chemical limnological parameters should be provided. Additionally, information that describes the bottom and shoreline configuration, sedimentation rates (suspended and bed load), sedimentation graduation analysis, and distribution (sorption) coefficients should be included.

5.5 Surface-Water/Ground-Water Disposition of Releases

Identify, define, and map all known sources of ground-water discharge within the candidate area, including springs, seeps, and wells. Provide an estimate of the rate of ground-water discharge at these points. If the discharge is through a stream channel or lake bed, the discharge per square meter of lake bed or linear meter of stream channel should be estimated. Provide the bases for the discharge estimates such as base flow measurements, water balance calculations, and aquifer hydraulics.

Discuss the potential for contamination of surface waters as a result of either surface or subterranean releases. Any surface discharge areas (springs and seeps) of aquifers that could become contaminated by releases from the subsurface operations during site characterization should be identified.

5.6 Regional Hydrologic Reconnaissance of Candidate Area and Site

Describe the regional hydrogeologic framework and regional ground-water flow systems and their boundaries.*

5.6.1 Hydrogeologic Units

Present a hydrogeologic column of the region in a form as detailed as the information allows. Include the principal hydrogeologic units (includes both confining units and aquifers), their stratigraphic relationships, lithology, generalized potentiometric levels for a given time and location, and hydrologic characteristics. The terminology should be consistent with the terminology used in the regional stratigraphic column presented in Section 3.2. A hydrogeologic map of the candidate area should be presented indicating areal extent of the regional hydrogeologic units and unit interfaces.** Cross sections should be provided where appropriate.

5.6.2 Relationships Among Hydrogeologic Units

Describe the relationships among the regional hydrogeologic units. The principal relationships sought are potentiometric levels, recharge-discharge and leakage, hydrochemical facies, and ground-water residence times. References should be made to the hydrogeologic map and to the cross sections presented in Section 5.6.1.

5.6.3 Potentiometric Level

Define the time history and areal distribution of measured potentiometric levels of each principal hydrogeologic unit. The method of presenting the data can include hydrographs, potentiometric contour maps, and graphs to identify the characteristic fluctuations resulting from the various types of recharge-discharge (i.e., seasonal precipitation and evaporation fluctuations, seasonal pumping variations, seasonal response to surface-water bodies, etc.). Potentiometric surface maps should include such information as the location of the monitoring wells, hydrogeologic unit boundaries, surface-water bodies, and specific well information (i.e., perforation interval and elevations, total depth history, casing, method of well completion, etc.).

5.6.4 Hydraulic Characteristics of Principal Hydrogeologic Units

For each of the principal hydrogeologic units, provide the ranges, mean values, and methods for determining the principal hydraulic characteristics such

*Definitions of ground-water terminology used in this chapter are consistent with U.S. Geological Survey Water Supply Paper No. 1988, Definitions of Selected Ground-Water Terms - Revisions and Conceptual Refinements (1972).

**Use, where practicable, internationally recognized map symbols (UNESCO, International Legend for Hydrologic Maps, Paris, France, 1970, 101 p.).

as hydraulic conductivity, storage coefficient, effective porosity, and saturated thickness. Also include a discussion of the appropriateness of assuming Darcian flow conditions in the various hydrogeologic units.

5.7 Regional Ground-Water Flow System

Provide detailed information on the regional ground-water flow system, including identification of recharge and discharge areas, principal ground-water flow paths, and ground-water ages based on isotopic hydrochemistry.

5.7.1 Identification of Recharge-Discharge Areas

Identify the areas and modes of recharge and discharge, residence times of the ground water, and the bulk rates of ground-water flow for the specific hydrogeologic units. Also include surface- and ground-water interrelationships. Present the information on hydrogeologic maps developed for the region.

5.7.2 Principal Ground-Water Flow Paths

Describe the principal ground-water flow paths with the associated fluxes and travel times to the accessible environment if known. Use cross sections and maps to indicate the principal ground-water flow paths.

5.7.3 Isotopic and Regional Hydrochemistry

Describe the results of any investigations of the isotopic composition of ground-water samples. Include stable isotopes, e.g., D/H, O^{16}/O^{18}, and unstable isotopes, e.g., C^{14}, H^3, Cl^{36}. Discuss the implication of the isotopic data concerning the age of the ground water, relative degree of circulation within the hydrogeologic unit, and areas and modes of recharge to the hydrogeologic units.

Describe the results of any studies of the regional hydrochemical zones. The major ions of interest are Na^+, Ca^{++}, Mg^{++}, Cl^-, Fe, Mn^{++}, HCO_3^-, CO_3^{--}, and SO_4^{--}. The individual hydrochemical zones should be presented in graphic form showing the relationship among the principal ions. Each zone should also be delimited by its pH, Eh, total dissolved solids (TDS), organic carbon, organic complexes (fulvic and humic acids), and aforementioned principal ions.* The major dissolved gases such as carbon dioxide, methane, and hydrogen sulfide should be included. Information on ambient ground-water temperature should also be provided. If any of the information in the section is not currently available, discuss any plans for obtaining it within the context of the site characterization program in Part C of the SCR.

5.8 Ground-Water Uses

Identify the principal regional ground-water users, including locations, rates, typical well construction, and hydrogeologic unit source. Include

*Field and laboratory analysis methods should conform to those in National Handbook of Recommended Methods for Water Data Acquisition, Chapter 5, Federal Interagency Committee on Water Data, Office of Water Data Coordination, U.S. Geological Survey, Reston, Virginia, 1977-78.

irrigation, industrial, municipal, domestic livestock, and energy resource development uses. Identify areas of large ground-water pumping or injection on the regional hydrogeologic map. Include the extent of depression or impression cones on the potentiometric surfaces.

5.8.1 Regional Ground-Water Aquifers Used for Human Activities

Identify the specific aquifer units that provide the sources for the ground-water uses identified in Section 5.8. Also present the relationship between ground-water use and aquifer storage and recharge to identify areas of stress on the aquifer and mining of the ground-water resource.

5.8.2 Regional Ground-Water Management Plans

Identify the regional ground-water management agencies and their programs. Also provide an assessment, using this information, of regional ground-water projections for the foreseeable future, preferably the next 50- to 100-year period. Include ground-water use, potentiometric level changes, and hydrochemical changes.

5.9 Site Hydrogeologic System

Describe the site hydrogeologic systems to the extent that available information will permit.

5.9.1 Baseline Monitoring

Provide information gathered from the baseline monitoring* program that includes seasonal variations, long-term trends in potentiometric levels, and hydrochemistry of the principal hydrogeologic units, if available.

5.9.1.1 Monitoring Network. Provide specifications and designs (i.e., locations, elevations of screens and measuring points, elevations of seals), selection process for choosing location and depth of data collection systems, hydrogeologic units being monitored, method and frequency of measurement, and method of hydrochemical sampling for the monitoring network used in establishing the baseline monitoring program.

5.9.1.2 Potentiometric Levels. Provide representative hydrographs and potentiometric surface maps for each principal hydrogeologic unit. The hydrographs should include precipitation, surface-water levels, and rates of ground-water pumpage where appropriate. Based on this information, provide completed assessment for the potential for long-term or significant short-term changes in the water levels, and indicate them on hydrographs and potentiometric maps.

*Baseline monitoring means the establishment and operation of an engineered surveillance system for continuous measurement and recording of existing ground-water conditions that will serve as an historical data base for future observational comparisons.

5.9.1.3 Hydrochemistry. Provide the previously gathered information on the hydrochemistry of the principal hydrogeologic units. In characterizing each unit, identify the principal ions, dissolved gases, natural radioisotopes, Eh-pH values, organic components, temperatures, density of the fluid(s), and major ions. Using this information, provide completed assessments of temporal and spatial variations of the hydrochemistry.

5.9.2 Hydraulic Characteristics of Matrix and Fluid

Information on hydraulic characteristics of the matrix and fluid for each principal hydrogeologic unit and a discussion of statistical parameters and values should be provided. The methods of determination, range, and mean values should also be provided. The information should be grouped into separate sections for each hydrogeologic unit and should include the following characteristics:

1. Intrinsic Permeability (cm^2). Indicate whether the intrinsic permeability is developed by secondary processes such as fracturing, weathering, dissolution, or degassing of igneous rocks and the extent to which Darcian flow can be assumed.

2. Hydraulic Conductivity (cm/sec) and Transmissivity (m^2/day). Indicate the representative volume applicable and the saturated thicknesses assumed.

3. Total and Effective Porosity (dimensionless). Indicate the nature of the pore space, i.e., interstitial, fractured, or solutioning, and distinguish primary and secondary porosity.

4. Storage Coefficient. Indicate whether phreatic or confined conditions are constant throughout the region.

5.9.3 Ground-Water Flow System

Describe the ground-water flow system using the previously described hydraulic characteristics, and identify the accessible environment and credible pathways.

5.9.3.1 Accessible Environment and Credible Pathways. Identify the accessible environment associated with the conceptual design of a repository appropriate to the site. The credible pathways for ground-water transport from the conceptual design of a repository appropriate to the site to the accessible environment should also be identified.

5.9.3.2 Potentiometric Levels and Head Relationships. Provide a synthesis and analysis of potentiometric levels and head relationships as described in paragraph 5.6.3. Include hydraulic gradients, flow directions, and potential for variations.

5.9.3.3 Recharge-Discharge and Leakage. Provide information on completed investigations on the location and rates of recharge-discharge and leakage for the principal hydrogeologic units. Fully document these investigations. Where appropriate, constant head, no-flow, and constant flux boundary conditions should be identified and indicated on the appropriate hydrogeologic map. Provide plans to use the regional and site hydrochemical analyses to identify or verify the location of recharge, discharge, and mixing zones.

5.9.4 Ground-Water Velocity and Travel Time

Describe the method of determination and the ranges of values for the average interstitial velocities for Darcian flow conditions or the maximum velocities for fractured flow of the principal hydrogeologic units based on the representative elementary volume. Using the information gathered on credible pathways, indicate the expected range of advective travel times from the conceptual design of a repository appropriate to the site to the accessible environment.

5.9.4.1 Radionuclide Transport Factors. Provide information on the methods and the results of investigations performed to determine the factors influencing radionuclide transport for each hydrogeologic unit occurring in the credible pathway. The investigations and methods of analysis should take into consideration the temperature, viscosity, water chemistry, retardation, and oxidation-reduction potential within the hydrogeologic units and the projected thermal flux due to the emplaced waste.

5.9.4.2 Geothermal Gradient and Thermal Convective Component. Identify the existing geothermal gradient, and assess the effect of the thermal convective component introduced by the emplaced waste on the ground-water transport.

5.9.5 Hydrochemistry and Ground-Water Age

Describe the results of completed investigations of the hydrochemistry and ground-water age of each principal hydrogeologic unit. Include the tests and method of sampling performed and to be performed for the hydrochemical investigation.

Identify the isotopes (i.e., C^{14}, H^3, O^{16}/O^{18}, D/H, Cl^{36}) used for ground-water age determinations, including the field and laboratory techniques used, the range of values, and an error analysis of the results.

5.9.6 Monitoring and Verification

Provide information on the specific monitoring and verification programs, including their spatial and temporal distribution, implemented for the hydrologic system associated with the geologic repository.

5.9.6.1 Baseline Condition Changes. Specify the aspects of the monitoring program that will permit detection of baseline condition changes necessary to assess hydrologic stability, and provide an historical background.

5.9.6.2 Well Construction, Development, and Completion. Describe well construction and development techniques. Include such details as locations; elevations of screens and measuring data; hydrogeologic units encountered; method of development; types and locations of borehole seals, casing, and screen materials; mode of drilling; and method and schedule of development.

5.9.6.3 Monitoring Methods. Describe the method of sampling and/or surveillance used. Provide information on the indirect methods of sampling such as geophysical techniques and TV surveillance. Also provide information on the direct methods of sampling such as water sampling, potentiometric level readings, and pressure testing. Indicate the hydrogeologic information collected using each monitoring method.

5.9.7 Local Ground-Water Users

Identify all the local ground-water users, including locations, rates, typical well construction, and hydrogeologic unit source. Include irrigation, industrial, municipal, domestic livestock, and energy resource development users. Determine what effect, if any, the local ground-water users have on the site's ground-water flow system.

6. GEOCHEMISTRY

In this chapter present pertinent descriptions of the geochemical properties of the rocks, minerals, sediments, and water of the candidate area and site. Include anticipated geochemical reactions that have influenced the conceptual design of a repository appropriate to the site. Include generic data from similar rock types and site-specific information, if available. The information should be presented in sufficient detail to (1) permit an understanding of the geochemical factors of the candidate area and site, based on available literature and site-screening studies, and (2) support the planned site characterization program.

For each of the following sections, include the rationale for the values chosen. For natural variables (e.g., rock compositions and ground-water chemistry), indicate expected ranges of values and by what process these were assumed. For engineering variables (e.g., composition of backfill, waste form, canister, temperature, and pressure), indicate why these particular values were assumed and what is the reasonable range of expected values. For chemical and geochemical reactions (e.g., any of the reactions among the waste, water, rock, barrier, canister), indicate the rationale for the identification of these reactions (e.g., theoretical, laboratory experimental, observed in nature) and to what extent the nature of the reactions would be expected to change because of changing conditions at the site (e.g., changes in solubility of constituents in ground water resulting from heating the ground water).

6.1 Host Rock Geochemistry

For rocks and fracture fill materials along credible pathways to the accessible environment, describe the petrology and mineralogy of the rocks and material in the fractures. Describe the inferred or measured distribution and abundance of mineral phases that will affect radionuclide migration, and identify mineral assemblages and amorphous components that buffer pH and Eh of ground water.

6.2 Hydrogeochemistry

For the proposed host rock unit and other rock units along credible pathways to the accessible environment, provide the following information when available:

1. Major, minor, and trace-element composition of ground water, including organic and inorganic species, dissolved and suspended (i.e., colloids),
2. Ionic strength of ground water,
3. Complexing agents (organic and inorganic),
4. pH,
5. Eh (measured and calculated), dissolved oxygen, redox couples (i.e., Fe^{+2}/Fe^{+3}),
6. Temperature,
7. Pressure,
8. Gas composition,
9. Sorption-desorption isotherms, including those for fracture filling,
10. Sorption capacity,

11. Ion exchange,
12. Filtration,
13. Chemical substitution,
14. Isotopic exchange,
15. Diffusion into pores,
16. Acid-base,
17. Solution-precipitation,
18. Thermodynamic information,
19. Reaction mechanisms,
20. Impact of kinetic effects on retardation,
21. Retardation factors (Rf),
22. Mass distribution coefficient (Kd),
23. Surface distribution coefficient (KA),
24. Solubilities of radionuclides, and
25. Extent of solution saturation by potential precipitates.

Discuss the methods used to obtain the data as well as the QA programs applied to data collection. If information on any (or all) of these geochemical parameters is not available at the time the SCR is submitted, describe the proposed plans for obtaining this information during site characterization. (The proposed plans may be described in Part C.)

6.3 Chemistry of Waste, Barriers, and Environment of a Conceptual Design Repository Appropriate to Site

Describe anticipated interactions among the waste form, engineered barriers, and environment of a conceptual design of a repository appropriate to the site. Include analyses of generic interactions and, if available, include analyses of interactions of proposed specific waste forms and engineered barriers for the site.

Describe the anticipated (1) chemical composition and form of the waste, (2) solubility of the waste form in ground water under varying anticipated environmental conditions (e.g., temperature, oxidation states), and (3) species released by the leaching of the waste form under anticipated conditions.

Describe anticipated chemical and mineralogical composition of any barriers, solubility of these barriers under varying anticipated physico-chemical conditions, any changes in speciation imposed on radionuclides released from the waste, and speciation of wastes crossing the engineered barrier/natural geological systems boundary.

Describe anticipated interactions of the waste water and rock. Include (1) hydrothermal alteration of the proposed host rock during the thermal pulse, (2) changes in the chemistry of the ground water in the proposed host rock during the thermal pulse, and (3) the effect of changes of mineralogy and hydrology on the radionuclide migration.

6.4 Natural Analogs

Provide pertinent data, analyses, and current level of assessment of natural geochemical analogs to the site. Provide a basis for comparing and contrasting the analog environment with the site.

Describe any field tests from other sites that may be useful in interpreting expected results obtained from this site during site characterization.

6.5 Geochemical Stability

Describe the expected geochemical stability of the site. Include (1) potential human influences (i.e., solution mining, injection disposal, ground-water withdrawal, ground-water mining) and (2) natural changes due to climatic variation.

7. CLIMATOLOGY AND METEOROLOGY

Provide a description of the climatology and meteorology of the candidate area and site. An analysis of paleoclimatic conditions should provide an assessment of the climatic changes that might occur in the future, based on evaluations of the past and present climatic conditions. Paleoclimatic analysis should include at least the complete climatic spectrum ranging from maximum glacial to maximum interglacial conditions. Sources of the information and data provided should be referenced. Identify those areas where sufficient data or information are presently not available.

7.1 Recent Climate and Meteorology

A climatological and meteorological description should be provided for the candidate area and site.

7.1.1 Climate

The general climate should be described with respect to types of air masses, synoptic features and frontal systems, and general airflow patterns and relationships between synoptic-scale atmospheric processes and local (site) meteorological conditions. Climatological characteristics attributable to the terrain should be identified. Data should be provided in sufficient detail to indicate impacts on the conceptual design and potential operation of a repository at the site.

All information should be fully documented and should be based on data for the most recent 30-year record period. Sources of such information could include National Oceanic and Atmospheric Administration (NOAA) facilities such as the National Climatic Center (NCC) and the National Weather Service (NWS) stations; other government facilities (e.g., military stations); and private organizations such as universities that have maintained quality-controlled data collection programs. The validity of the information provided, with respect to representation of the conditions at and near the site, should be substantiated.

7.1.2 Local and Regional Meteorology

Plans for obtaining sufficient meteorological information to adequately characterize atmospheric dispersion processes (i.e., airflow trajectories, atmospheric stability conditions, depletion and deposition characteristics) within the candidate area should be provided.

7.1.3 Site Meteorological Measurement Program

The meteorological measurement program to be conducted to develop local data and programs that will be used to estimate offsite concentrations of effluents released during site characterization should be described. The information provided should include measurements made, locations and elevations of measurements, descriptions of the instruments used, instrument performance specifications, calibration and maintenance procedures, and data analyses procedures.

7.2 Long-Term Climatic Assessment

An analysis of paleoclimatic conditions at the candidate area and the site should be provided. Based on this analysis and on recent climatic characteristics of the candidate area, an assessment of the magnitude and rate of climatic changes that might be expected to occur in the future should be provided. The information should be presented in sufficient detail to indicate impacts on long-term isolation of the waste.

7.2.1 Paleoclimatology

Provide an analysis of the Quaternary paleoclimatology of the candidate area and the site, including atmospheric, hydrospheric, and cryospheric aspects of the successive climatic regimes, in the context of determining the magnitude of the climatic changes and the rates at which the changes occurred. Changes in precipitation regimes, locations of potential aquifer recharge areas, glaciated areas, and windflow patterns should be identified. Geological, biological, and ecological evidence to support the analysis should be provided. Information should also be provided on the size (areal extent and thicknesses) of any glaciers and on accumulation and ablation rates. The impacts of any glaciers on precipitation regimes and windflow patterns should be discussed. Relationships between air temperatures and regional precipitation, in relationship to the water balance of the area, should also be discussed.

Sources of all information should be provided. The validity and applicability of the information provided, with respect to the representation of conditions at and near the site, should be substantiated.

7.2.2 Future Climatic Variation

An estimate of the potential impact of climatic change on precipitation patterns, windflow regimes, the cryosphere, and sea levels should be discussed.

Based on the reconstruction of the paleoclimate and the recent climate, long-term estimates of the following should be provided:

1. Potential maximum and minimum changes and rates of change in precipitation and air temperature from the present that could be expected to occur,

2. Potential regional windflow and precipitation patterns that may evolve in the future as a result of climatic and geologic changes,

3. The potential for glaciation, including estimates of times of onset of glaciation and lengths and severity of glacial regimes in the site area, and

4. Future fluctuations in sea levels and cryosphere due to climatic changes.

All procedures, including models, used in the climatic extrapolations should be identified, as should all assumptions and areas where insufficient data make extrapolations questionable.

7.2.3 Site Paleoclimatic Investigation

Describe how information obtained during the site characterization stage will be used to increase the data base concerning the paleoclimatology of the area. This could include the examination of sediment core samples for fossil pollen, ancient soil types, lake sediment varve sequences and thicknesses, etc. The application of the information thus developed to supplement places where data are sparse or lacking in the initial investigation should be emphasized. Any changes in the paleoclimatic assessment that results from this investigation should be reflected by revisions to the future climatic condition extrapolations.

8. CONCEPTUAL DESIGN OF A REPOSITORY

Provisions for the inclusion in the SCR of a conceptual design of a repository* appropriate to the named site are set forth in paragraph 60.11(a)(6)(ii). Information on the conceptual design of a repository is needed to allow an assessment of the site characterization program since a substantial amount of the information generated during site characterization will directly relate to the progressive development of a repository design for the site. It is recognized that the conceptual design repository presented in the SCR will be preliminary in nature and may be modified or refined as a result of site characterization activities. Consequently, it is necessary to know at the SCR stage which portions of the conceptual design of a repository are based on results developed during preliminary site exploration activities and which portions are based on assumed parametric values or anticipated site conditions. All assumptions of parametric values (e.g., in situ stress field) and site conditions (e.g., ground-water hydrology) should be clearly documented in the SCR. Assumptions that will be confirmed or refined during site characterization should be noted. To the extent possible, the design bases, design assumptions, preliminary design criteria, and preliminary analyses that have been performed to develop the conceptual design of a repository should be stated.

The information presented in this chapter should be of sufficient detail (1) to permit an understanding of the conceptual design of a repository and its relationship to the site and prospective host rock and (2) to permit an evaluation of the relationship of the planned tests and experiments during site characterization to the resolution of design issues and to the development and modification of the conceptual design of a repository.

8.1 Design of Underground Openings

Provide the general layout and design of proposed subsurface openings in plan and cross section, and show their relationship to proposed plans for in situ testing at depth and to known or inferred geologic and hydrologic conditions of the site. If known, identify proposed locations of shafts and their relationship to the proposed plan for in situ testing at depth and known or inferred subsurface conditions. Provide shaft stability factors based on inferred subsurface rock stresses and ground-water conditions and their relationship to the proposed test shaft(s). Provide the basis used in determining the proposed sizing, shape, and orientation of the major subsurface openings. Include discussions of those considerations given to ground-water conditions, thermal output, the natural and thermally induced stress field, and the need for ventilation. Identify and discuss separately any design limitations due to factors not directly related to waste isolation but to the constructability or operability of the repository. Include factors such as minimum space required for emplacement of the waste, layout requirements for separation and control of excavation and waste emplacement operations, ventilation requirements, and worker safety considerations.

*As used in this guide, the conceptual design of a repository means a design of a repository appropriate to the named site in sufficient detail to allow assessment of the site characterization program with respect to investigative activities that address the ability of the site to host a repository and isolate radioactive waste or that may affect such ability.

8.2 Backfill

Describe the proposed characteristics and functions of the backfill in the conceptual design of a repository. Identify any proposed backfill materials being considered for use at the site. Provide the mechanical properties of the proposed backfill that are critical for the site and design (use ASTM or other applicable standards, as appropriate). Discuss the relationship between the mechanical properties of the proposed backfill and the expected conditions at the site (e.g., temperature, moisture, stress). Describe the geochemical characteristics of the backfill materials, as well as the anticipated chemical interactions among the waste package, backfill, ground water, and host rock under assumed waste emplacement conditions. Identify the measured or inferred material and site parameters used to estimate those reactions. (The geochemical discussion here should be in sufficient detail to describe the geochemical role of the backfill at the site. The full descriptions of the geochemical investigations and the nature of backfill, waste form, package, rock, and ground-water interactions should be provided in Chapters 6, "Geochemistry," or 9, "Waste Form and Package.")

8.3 Strength of Rock Mass

Provide preliminary design values used for the mechanical properties of the rock, including elastic and inelastic behavior of the rock mass, the thermomechanical behavior of the rock mass, and the mechanical behavior of rock discontinuities (e.g., joints, bedding planes, shear zones). Describe how they were determined. (The rock mechanics information should be presented here in sufficient detail to describe the relationship of the rock properties to the design. The full description of the rock mechanics background should be presented in Chapter 4, "Geoengineering.") Describe how these values for the mechanical and thermomechanical behavior of the rock were used in developing the conceptual design of a repository. Present the results of model studies used in developing the conceptual design of a repository appropriate to the site.

8.4 Sealing of Shafts, Boreholes, and Underground Openings

Describe the proposed treatment of the disturbed section of rock around openings and excavated surfaces. Describe proposed design measures to control ground-water movement into the facility. Provide laboratory and field data when available and inferred site conditions on which the selection of the treatment measures was based. Describe the proposed design for the sealing of boreholes and shafts. Provide laboratory and field data and inferred site conditions on which the design was based. Provide the mechanical, chemical, and hydrologic properties of proposed sealing materials.

8.5 Construction

Describe construction techniques being considered for potential repository development at the site. Describe in detail any known or inferred site conditions requiring specialized construction techniques. Describe planned actions to be taken so that construction of exploratory workings at the site would not compromise the integrity of the site.

Describe methods under consideration for breaking and removing rock during construction. Assess the potential impacts of construction on fracturing, and note any special precautions needed to minimize propagation of fractures that could be potential pathways, taking into consideration the inferred rock conditions at the site proposed for characterization. Describe the geotechnical factors expected to bear on the suitability of proposed excavation techniques and their relationship to any information obtained during exploratory drilling. Mechanical excavation methods, controlled blasting, or other measures proposed to be used in the construction of underground openings should be described and related to known or inferred rock conditions and the stability of the conceptual design of a repository. (The full description of excavation investigations should be given in Chapter 4, "Geoengineering.") Describe temporary or permanent support structures proposed and their relationship to the basis of the conceptual design. The methods planned to be used to control, collect, and dispose of ground water during excavation and the relationship of the planned methods to ground-water information obtained from exploratory investigations should be described.

8.6 Design of Surface Facilities

Provide a description of properties of surface materials and foundation soil or rock considered in the design of structural foundations for surface facilities. Describe expected or known soil and rock conditions and the depth to and quality of foundation soil or rock. Discuss any known or inferred foundation problems. Also, describe sources of water for construction and operation of the proposed facilities.

9. WASTE FORM AND PACKAGE

Evaluate the principal candidate waste forms and packages that may be considered appropriate for the site, and describe how the range of environments anticipated at the site and the resulting design limits would affect these waste forms and packages. To the extent that the information is available prior to site characterization, describe and compare alternative waste forms and packages being considered and their development programs. Provide a basis for evaluating the adequacy of the information to be produced in the site characterization program.

9.1 Description

Describe the candidate waste forms (including physical form and mechanical properties, chemical form and properties, radionuclide inventory, thermal output, expected temperatures, and radiation released) and waste packages (including types of packaging and their properties, container size and shape, and the weight, volume, and number of the containers to be emplaced).

9.2 Design Concepts

Describe the waste form and package design concepts considered appropriate for the site and conceptual design of a repository appropriate to the site. Discuss the independent barriers within the waste package and estimates, if available, of the reliability of these individual barriers.

9.3 Research and Development

Describe the status of research and development on appropriate waste forms and packages as it relates to characterization of the site, including research planned or under way to evaluate the performance of such waste forms and packages.

9.4 Emplacement Environment

If candidate waste packages and materials have been identified, describe the type of environment into which the waste form and packaging may be placed. Include upper bounds that could be expected for:

1. Chemical conditions and processes within and between the waste package and its environment that could compromise or enhance the ability of the waste package to support the performance objectives. Include appropriate thermodynamic equilibria, oxidation/reduction reactions, corrosion, electrochemical reactions, leaching, dissolution, and gas generation.

2. Physical conditions and processes within and between the waste package and its environment that could compromise or enhance the ability of the waste package to support the performance objectives. Include thermal effects, mechanical strength, and mechanical stress.

3. Nuclear conditions and processes within and between the waste package and its environment that could compromise or enhance the ability of the waste package to support the performance objectives. Include radiolysis, potential radiation damage, and potential criticality.

9.5 Alternative Waste Forms and Waste Packages

Sufficient information about alternative waste forms and waste packages should be provided to show full integration of the criteria and decision processes for site selection with those for waste form and waste package selection.

PART C

STANDARD FORMAT AND CONTENT GUIDANCE FOR PRESENTING SITE CHARACTERIZATION PROGRAM

While Parts A and B of the Standard Format provide guidance on the presentation of what is already known about a site, Part C deals with what DOE plans to do in site characterization.

Part C of the Standard Format specifies that the SCR should:

1. Identify issues (questions about a site that are critical to making the findings required by 10 CFR Part 60 for construction authorization);

2. Specify information needs required to make findings on unresolved issues; and

3. Describe the planned methods of data acquisition synthesis and analysis to meet information needs for unresolved issues.

There should be a brief evaluation of the significant options available for resolving issues and for methods of testing and analysis that will reduce the limitations and uncertainties of the tests, methods, data, and interpretations of data. Both the surface testing and in situ testing-at-depth aspects of the planned site characterization program should be included.

The SCR will be principally evaluated according to the completeness of Part C, its most critical part.

In developing Part C of the SCR, DOE should ensure that attention is focused on those aspects of siting, development of waste form and packaging, and conceptual design of a repository that will require the most effort in the site characterization program. While the SCR must be complete in developing the issues of site characterization, it is important--particularly in initial planning phases--that those issues considered critical or most important be identified and given highest priority in the site characterization plan.

10. SITE CHARACTERIZATION PROGRAM

This chapter should provide the rationale behind the proposed site characterization program and should describe in detail the program of exploration and testing to be conducted during site characterization. The description of the site characterization program at the named site should include (1) the issues to be resolved and information to be acquired during site characterization, (2) the tests and experiments to be performed, (3) schedule, sequence, and duration of testing and data analyses, (4) the extent of planned excavation and in situ testing at depth, (5) elements of the conceptual design of a repository appropriate to the site relevant to data acquisition, analyses, and scheduling, (6) key milestones against which the progress of site characterization can be measured, (7) provisions to control any adverse, safety-related effects that may result from site characterization, and (8) the quality assurance methods to be used in data acquisition and analysis. Also to be noted should be the decision points at which the direction of the site characterization program might be changed if warranted by the results obtained.

10.1 Rationale for Planned Site Characterization Program

This section should provide the rationale for the planned site characterization program. This rationale should include a summary discussion of (1) the types of information to be obtained during site characterization; (2) why the information is needed; and (3) whether the information will provide confirmatory or supplemental data and analyses to existing data and analyses or whether the information will be acquired in areas not addressed during site exploration activities. The following sections of this chapter should be appropriately referenced in this rationale. The objectives of the site characterization program should be clearly stated and the relationship between the information presented in Parts A and B and the planned site characterization program clearly established.

10.2 Issues To Be Resolved and Information Required During Site Characterization

This section should identify all known issues related to siting, design of a geologic repository operations area, and waste package and performance assessment as specified in proposed 10 CFR Part 60. The following sections (10.2.1-10.2.4) should contain discussions of the types of information needed to resolve the issues, including, but not be limited to, the following areas of study:

1. Geomorphology,
2. Stratigraphy,
3. Structural geology,
4. Tectonics,
5. Seismicity,
6. Rock mechanics,
7. Hydrology (surface and ground water),
8. Geochemistry,
9. Climatology,
10. Meteorology, and
11. Waste-host rock interactions.

For each of these areas of study, discuss whether the necessary data will be collected from surface or subsurface portions of the planned site characterization program. If any information need is directly related to either the further development of the conceptual design of a repository appropriate to the site or to modeling efforts, this fact should be clearly stated.

Proposed plans for resolving unresolved issues during site characterization, including the specifications for performing the investigations and the applicability and limitations of the investigations for resolving the issues, should be described.

10.2.1 Unresolved Issues Related to Site Selection

Describe any unresolved issues related to the selection of the site for characterization. This description may include issues related to alternative sites, ownership and control of the site, or the identification of favorable siting conditions (e.g., geochemical conditions that promote sorption of radionuclides) or potentially adverse conditions (e.g., active faulting).*

Summarize the extent to which preliminary site exploration activities contributed to the identification of the siting issues. Discuss information obtained during site exploration activities that has led to a partial resolution of the issues.

10.2.2 Unresolved Issues Related to Design of Geologic Repository Operations Area

Describe unresolved issues related to the design of the geologic repository operations area. Identify site characterization plans proposed to obtain information to resolve these issues.

10.2.2.1 Verification or Measurement of Site Conditions. Describe those issues related to site conditions (e.g., host rock, in situ stress field) that are part of the design bases that must be verified or measured during site characterization to verify the compatibility of the proposed conceptual design of a repository and the geologic repository operations area.

10.2.2.2 Design Optimization Issues. Describe the design optimization issues that necessitate data acquisition during site characterization. These are issues in which a structure or material has conflicting performance requirements (e.g., thermal-loading for 1 acre vs. repository size) and an optimum will be determined from investigations during site characterization.

10.2.3 Unresolved Issues Related to Waste Form and Package

This section should identify the issues related to the waste form and waste package, including the emplacement environment, that were not resolved by preliminary site exploration activities or by research and development conducted prior to the submittal of the SCR. Site-specific plans to resolve these issues during the site characterization program should also be included.

*Siting conditions that NRC would categorize as favorable or potentially adverse may be found in proposed 10 CFR Part 60.

10.2.4 Performance Assessment Issues

10.2.4.1 Substantially Completed Analytical Techniques. Describe those performance assessment techniques, including simplifying assumptions and boundary conditions, for which development work is substantially complete, with particular emphasis on identification of the types and quality of data needed and on the plans for verification or validation of performance assessments during or after site characterization. In the description, specific sections from other documents such as user manuals and code documentations may be incorporated by reference provided these documents are either publicly available or, if proprietary, are readily available to the NRC.

10.2.4.2 Analytical Techniques Requiring Significant Development. Describe those analytical techniques that are expected to be important for evaluating the performance of the site but that still require significant additional developmental work at the time the SCR is prepared. Include site-specific and generic models and computer codes. Describe the programs formulated for undertaking the developmental work during site characterization.

Describe both the analytical techniques expected to be important for site analysis and the associated data requirements. Available data should be summarized in this section either directly or by reference to other chapters of this report. For each type of analysis, anticipated simplifying assumptions and boundary conditions should be described.

10.2.5 Issues for NRC Review

In this section, any issues related to site selection, alternative candidate areas or sites, or design of the geologic repository operations area that DOE wishes the NRC to review should be presented.

10.3 Planned Tests and Experiments

Planned tests and experiments to be conducted during site characterization should be described in detail. The relationship of the planned tests and experiments to information presented in Parts A and B and to the unresolved issues discussed in Section 10.2 should be clearly stated. The quality assurance program to be applied to data collection during site characterization should also be described.

Suggested Format for Description of Planned Tests and Experiments

1. Title of Test or Experiment.

2. Purpose of Test or Experiment - Summarize why the test or experiment is proposed and what types of information will be obtained.

3. Objective(s) - Discuss how the results of the test or experiment will relate to the overall site characterization program. Describe how the results will be used to help resolve specific information needs or unresolved issues.

4. Descriptive Summary - Summarize the methods, techniques, and analyses used in the test or experiment. Describe in detail the procedures expected to be used.

5. Quality Assurance - Describe the quality assurance program to be applied to data collection, and discuss the limitations and uncertainty in the data.

6. Principal Investigator - Give the name and organization of the principal investigator, if known.

7. Contact - Provide the name, address, and telephone number of the person(s) to contact concerning the status of the test or experiment.

10.4 Planned Testing, Instrumentation, and Monitoring

For each test or experiment described above, the testing and instrumentation that will be necessary for the investigation should be described. The description should include testing method and testing apparatus, data collection systems, methods of analysis and reduction of data, and the applicability and limitations of the testing and instrumentation in acquiring the necessary information.

For each test or experiment requiring short-term or long-term monitoring, the monitoring goal and technique(s) should be described. The description should include specifications for the monitoring system, the instrumentation and data collection systems, the methods of analysis and reduction of data, and the applicability and limitations of the monitoring system in acquiring the necessary information. Identify and evaluate alternative methods of testing and analysis that might achieve the same goals as the methods proposed.

10.5 Planned Site Preparation Activities

In this section, plans for surface and subsurface excavations related to the site characterization program should be presented.

10.5.1 Surface Site Preparation Activities

Describe the surface activities (e.g., construction) needed to prepare the site for site characterization activities. Include the anticipated start and completion dates. State whether the surface activities are related to site characterization at the surface or whether they are preparatory to subsurface activities. Describe any surface facilities to be erected at the site.

10.5.2 Underground Test Facility

Describe the underground test facility to be used for the in situ testing-at-depth portion of the site characterization program. The description should include a detailed layout of the planned excavation, boring locations, and the planned location within the test facility of each anticipated test or experiment. In addition, details of construction, including the location of the underground test facility with respect to the conceptual design of a repository appropriate to the site, should be provided. Particular attention should be paid to shafts excavated and borings made for the underground test facility and their location

with respect to possible future shafts and excavations. An analysis of the potential impact of in situ testing at depth on the integrity of the site should also be included.

10.6 Milestones, Analyses, Decision Points

Describe briefly (1) key milestones to be used to mark progress, (2) data analyses to be performed, (3) use of acquired data, including both direct use of the tests and experiments as well as integration of results of tests and experiments to resolve identified issues or to identify new issues, and (4) stages in the site characterization program when options would be assessed and decisions would be made as to how (or whether) to proceed.

10.7 Schedule

Provide a graphic presentation (flow chart) of the site characterization program in which activities, analyses, milestones, decision points, reports, and submittals for NRC, State, Indian tribal, and public review and any other relevant information are identified. The presentation should be constructed so that tasks accomplished and tasks still to be accomplished can readily be identified. The presentation should also include, as appropriate, the logic leading to decision points and selection among alternatives.

APPENDIX A

SEMIANNUAL REPORTS

In accordance with paragraph 60.11(g) of 10 CFR Part 60, DOE must submit semiannual reports to NRC on the progress of site characterization and of waste form and packaging research and development.

These semiannual reports should:

1. Discuss the results of site characterization activities,

2. Identify (a) new issues not previously mentioned in the SCR; (b) plans to resolve these issues; (c) those studies originally planned that are no longer considered necessary and therefore eliminated from the site characterization program; (d) decision points reached during site characterization; and (e) modifications to schedules, and

3. Report progress in developing the design of a geologic repository operations area appropriate to the site.

The NRC does not believe that it is necessary to issue a separate regulatory guide on the format to be used for these semiannual reports. To the extent appropriate, however, this Standard Format provided for the SCR may be used when submitting information in the semiannual progress reports.

VALUE/IMPACT STATEMENT

1. PROPOSED ACTION

1.1 Description

Sections 202(3) and (4) of the Energy Reorganization Act of 1974, as amended, provide the NRC with licensing and regulatory authority regarding Department of Energy (DOE) facilities used primarily for the receipt and storage* of high-level wastes (HLW) resulting from activities licensed under the Atomic Energy Act and certain other long-term, HLW storage facilities of the DOE. The NRC has issued regulations appropriate for licensing geologic disposal of HLW by DOE in 10 CFR Part 60 (46 FR 13971). Provisions requiring that a program of site characterization be conducted at a minimum of three sites, at least one of which is not salt, prior to the submittal of an application for a license to be issued under 10 CFR Part 60 are set forth in § 51.40 of 10 CFR Part 51. When DOE has formulated preliminary plans for a prospective repository to the extent that site characterization may begin, but prior to the commencement of site characterization at a particular site, DOE must submit a site characterization report (SCR) to NRC.

In order to provide DOE with guidance concerning the types of information and the level of detail that NRC considers appropriate for an SCR and to facilitate NRC review of the SCR, it is proposed that this regulatory guide be published.

1.2 Need for Proposed Action

This regulatory guide is needed so that DOE will be informed in a timely manner of the types of information that NRC feels may ultimately be needed for a license application, i.e., sufficient information about DOE's preferred site to support a finding, prior to construction of a geologic repository, of reasonable assurance that there is no unreasonable risk to public health and safety. Use of the format presented in this regulatory guide in providing the types of information requested in the SCR will help ensure the completeness of the information, will assist the NRC staff as well as States, Indian tribes, and the public in locating specific types of information, and will substantially shorten the time needed by the NRC staff during the review process. For some sites, the amount of information accumulated during preliminary site exploration activities prior to site characterization may be voluminous, and use of the proposed guide will aid in the identification and location of information pertaining to particular issues of interest to both NRC and non-NRC reviewers.

*The NRC interprets "storage" as used in the Energy Reorganization Act to include disposal.

1.3 Value/Impact of Proposed Action

1.3.1 NRC Operations

The proposed guide sets forth the information that NRC anticipates will be needed to review both DOE's process of site selection and plans for site characterization. It is expected to improve consistency in the review of SCRs because of more uniform submittals and to reduce the review effort of the NRC staff.

The review of the SCR may involve an estimated 10 person-year effort (including both NRC staff and contractors/consultants).

1.3.2 Other Government Agencies

The regulatory guide will contribute to the reduction in time required for DOE's preparation of an SCR. Further, the regulatory guide should provide guidance with respect to the types and quality of information that may be needed to support a future application for construction authorization at DOE's preferred site. This guidance for future actions should result in a more efficient effort by DOE. It is not possible at this time to estimate the cost that may be incurred by DOE in following the format set forth in the regulatory guide for SCR submittals since both the level of effort and the amount of information accumulated at each site during preliminary site exploration activities will be variable parameters. Further, some preparations for the submittal of the SCRs may have been conducted by DOE contractors and consultants. However, the proposed regulatory guide should result in a cost reduction to DOE in submitting the SCR because it provides guidance on the specific types of information NRC expects to review, as well as on the level of detail and the reliability of the information. Cost reductions should be attributable to factors such as minimizing the amounts of original data to be submitted, allowing incorporation of certain information by reference from existing DOE environmental impact statements, and providing guidelines to minimize the submittal of superfluous information.

NRC interagency agreements currently exist with both the Bureau of Mines and the Army Corps of Engineers. It is estimated that each of these agencies may spend 1 person-year in reviewing each SCR submitted to NRC. Other Federal government agencies such as the Geological Survey, the Environmental Protection Agency, and the Bureau of Land Management have frequently commented on 10 CFR Part 60 during the rulemaking process, and it may be possible that some, if not all, of these Federal agencies may independently decide to review the SCRs. In any event, the regulatory guide should reduce the time needed by other Federal agencies to review the report(s).

1.3.3 Industry

Since DOE alone is responsible for the submittal of an SCR to NRC, the industry should not be affected by the proposed regulatory guide.

1.3.4 Public

The regulatory guide should be beneficial to the public since it will identify the types of information NRC is requesting from DOE and should facilitate review of the SCR. The required submittal of the SCR to NRC will also

benefit the public because NRC will then transmit copies of the report to appropriate State, Indian tribal, and local officials and will make a copy available at the NRC Public Document Room. These actions should ensure early public awareness and involvement in the review of DOE's planned site characterization program.

There could also be cost reduction to the public resulting from improved efficiency during the review process.

1.4 Decision on Proposed Action

The publication of the regulatory guide on the suggested format to be used by the DOE when submitting SCRs should be undertaken.

2. TECHNICAL APPROACH

2.1 Technical Alternatives

1. Review the SCRs using modifications of existing NRC regulatory guides.

2. Allow DOE to submit, without formal NRC guidance, SCRs based on its perception of the types and level of detail of information that NRC would anticipate reviewing.

2.2 Discussion and Comparison of Technical Alternatives

The first alternative listed above would require the review of SCRs, using modified versions of previously published NRC regulatory guides. This alternative would appear to have a number of disadvantages. First, the proposed regulatory guide differs from a number of existing NRC guides in that the SCR will be submitted during the prelicensing stages and will contain a substantial amount of information on planned site characterization programs in addition to results of earlier studies. These two characteristics of the SCR would distinguish it from reports associated with licensing actions. Therefore, the emphasis of the regulatory guides associated with licensing would not be appropriate, even if modified, to the SCR.

Secondly, the NRC staff, in developing the proposed regulatory guide has considered the types of information it would expect to review in an SCR. If other NRC guides were modified for the SCR it might be possible that important information needs would not surface in a timely manner. Further, it would not be efficient use of staff time to search through other regulatory guides for a "best fit" guide. The SCR is an entirely new document, as the prelicensing and licensing stages of HLW disposal in geologic repositories are new stages.

The second technical alternative would be to allow DOE to submit the SCRs without the guidance provided by the proposed regulatory guide. While this approach could initially save the NRC the costs of developing and publishing the regulatory guide, the overall long-term cost to the Federal government could exceed such initial savings. Without a regulatory guide, DOE would be faced with the problem of trying to anticipate the informational needs of NRC. Lack of initial guidance from NRC could result in the submittal of an SCR with too little or too much detail for this stage of the prelicensing process. If DOE decides to err on the side of submitting too little detail, then the SCR

submittal could be substantially delayed while DOE accumulates the additional information. Furthermore, without NRC guidance DOE might initiate certain types of drilling and testing to obtain data prior to the submittal of the SCR that may be more appropriately conducted after the commencement of site characterization. This in turn could impact site characterization itself as well as NRC's intention for early involvement in site characterization.

2.3 Decision on Technical Approach

Early guidance should be developed for the preparation of SCRs.

3. PROCEDURAL APPROACH

3.1 Procedural Alternatives

Alternative procedural approaches that may be used to provide formal guidance to DOE include:

- Regulation
- Preparation of a regulatory guide
- Branch technical position

3.2 Value/Impact of Procedural Alternatives

3.2.1 Regulation

The advantages of a regulation are that it has the force of law and it is binding on the applicant as well as the NRC staff. Regulations are developed in full public view, following a series of formal steps that entail internal review and external review by the technical community. Public comment is invited on a proposed regulation prior to its adoption by the Commission. The formality of the process affords ample opportunity for all views to surface. In this manner, the ramifications of a proposed regulation and possible alternatives can be evaluated. Open participation by the public and technical community in producing the licensing requirements will add to public confidence in HLW disposal.

In general, regulations can be in the form of overall performance objectives, specific prescriptions to be adhered to by the licensee, or some combination of the two. In areas where a body of operating and licensing experience has been acquired with time, regulation by prescriptive requirements is the most efficient and least ambiguous method available. However, in the case of geologic disposal, there is no body of experience upon which to draw requirements for a regulation.

The NRC has developed the regulations for the disposal of HLW in geologic repositories - 10 CFR Part 60. Provisions for the general types of information to be included in the SCRs are set forth in § 60.11.

3.2.2 Regulatory Guide

Regulatory guides contain recommended procedures that NRC considers acceptable for meeting a given objective, but an applicant is not obligated to follow

them. If the applicant adopts a different approach, the applicant will have to demonstrate that any alternative it chooses will produce acceptable results. Because of time and expense, an applicant may forego this option and adopt the methods suggested by regulatory guides. The advantages of regulatory guides lie in that they can be developed and changed more readily than regulations. This is because the procedures for developing them are not as formal as for regulations. Consequently, regulatory guides are more responsive to changing technology.

3.2.3 Staff Position Paper

Staff position papers (also known as Branch technical positions) are a statement by the staff, usually at the Branch level, of a position on a regulation. There are few formalities in their development. In particular, there is no public review so they can reflect technological changes very rapidly. The lack of external review can be both an advantage and a disdvantage. It allows for quick action; however, if the position is not carefully thought out, it may inadvertently complicate matters. Other ramifications of position papers are that (1) they are not binding on an applicant and (2) they may result in different criteria being applied to different applications if there are too many changes in the staff position papers.

3.3 Decision on Procedural Approach

A regulatory guide would be the most effective means to provide DOE with insight on the types of information and the level of detail NRC would consider appropriate at the time an SCR is submitted. Although 10 CFR Part 60 contains provisions mandating the inclusion of certain types of information in the SCR, it is not always explicit as to what level of detail would be expected. Further, the SCRs primarily address aspects of the earth sciences, e.g., geology, hydrology, climatology. The submittal of prolific amounts of information, all of which may not necessarily relate to the planned site characterization program, could result.

Branch technical positions may be developed by the NRC staff during the prelicensing stages of site exploration and site characterization with respect to particular issues that may arise. However, since the SCRs will address a number of varying issues (e.g., decision process, field work, future testing plans), the development of Branch technical positions may be neither feasible nor appropriate to the initial prelicensing stages.

The publication of a regulatory guide would serve to elaborate on the types of information that could be submitted in responding to the provisions set forth in § 60.11 of 10 CFR Part 60. The regulatory guide could also be more readily modified if deemed necessary. A draft regulatory guide was published for public comment in April 1981. The public comments received have been taken into consideration in the development of this guide. Therefore, there has been opportunity for the public to comment not only on the provisions for the SCRs set forth in 10 CFR Part 60, but also on the guidance suggested by the draft regulatory guide.

4. STATUTORY CONSIDERATION

4.1 NRC Authority

Sections 202(3) and (4) of the Energy Reorganization Act of 1974, as amended, provide the Commission with licensing and regulatory authority regarding DOE facilities used primarily for the receipt and storage of high-level radioactive wastes resulting from activities licensed under the Atomic Energy Act and certain other long-term HLW storage facilities of the DOE. Pursuant to that authority, the Commission has developed criteria (10 CFR Part 60) appropriate to regulating geologic disposal of HLW by the DOE. To implement those provisions of 10 CFR Part 60 concerned with the submittal of an SCR by DOE to NRC, an active regulatory guide should be developed.

4.2 Need for NEPA Statement

The proposed action to develop a regulatory guide for the submittal of the SCR is not a major Federal action, as defined in paragraph 51.5(a) of 10 CFR Part 51 and does not require an environmental impact statement. However, NRC has prepared environmental impact appraisals during the rulemaking process on 10 CFR Part 60 which this regulatory guide implements.

5. RELATIONSHIP TO OTHER EXISTING OR PROPOSED REGULATIONS OR POLICIES

The proposed regulatory guide has been prepared to implement paragraph 60.11(a) of 10 CFR Part 60.

6. SUMMARY AND CONCLUSIONS

In regard to the types of information and level of detail appropriate to SCRs, the NRC should provide guidance to DOE through a regulatory guide. Such guidance will aid in minimizing misunderstandings or misinterpretations of NRC's intentions not only with respect to the nature of the information to be included in the SCR but also with respect to the timing of the submittal of the SCR. The regulatory guide will also serve to provide discussion on why NRC is requesting specific information. Since opportunity for public comment on the draft guide has already been provided and has been considered during the development of the active guide, it is recommended that the active guide be issued.

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