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Safety Evaluation Report Related to Disposal of High-Level Radioactive Wastes in a Geologic Repository at Yucca Mountain, Nevada

Volume 4:
Administrative and Programmatic
Requirements

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Safety Evaluation Report Related to Disposal of High-Level Radioactive Wastes in a Geologic Repository at Yucca Mountain, Nevada

Volume 4: Administrative and Programmatic Requirements

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NOTE TO READER: In June 2008, the U.S. Department of Energy (DOE) submitted a license application seeking authorization to construct a geologic repository at Yucca Mountain. After docketing the DOE license application, the U.S. Nuclear Regulatory Commission (NRC) staff began documenting its review in a Safety Evaluation Report (SER). In March 2010, DOE filed a motion to withdraw its application before the Atomic Safety and Licensing Board. On September 30, 2010, DOE's Office of Civilian Radioactive Waste Management ceased operations and assigned its Yucca Mountain-related responsibilities to other offices within DOE. The Atomic Safety and Licensing Board denied DOE's motion to withdraw, and in September 2011, the Commission announced it was evenly divided on whether to overturn or uphold this decision. The Commission directed the Atomic Safety and Licensing Board, in recognition of budgetary limitations, to complete all necessary and appropriate case management activities, and the Atomic Safety and Licensing Board suspended the proceeding on September 30, 2011.

In August 2013, the U.S. Court of Appeals for the District of Columbia Circuit issued a decision granting a *writ of mandamus* and directing the NRC to resume the licensing process for DOE's license application. In November 2013, the Commission directed the NRC staff to complete and issue the SER associated with the NRC staff's review of the license application. Because of the lapse in time and changes within DOE between license application submittal and the issuance of this SER volume, some information in the application does not reflect current circumstances (e.g., organizational structure). In addition, scientific information continues to be published in areas relevant to the topics considered in the license application. When these situations are relevant to the NRC staff's evaluation of the license application in this volume, the SER identifies and addresses them, as appropriate.

The SER details the NRC staff's review of DOE's license application and supporting information, consistent with the NRC's regulations and the Yucca Mountain Review Plan (YMRP) (NRC, 2003aa), as supplemented by the Division of High-Level Waste Repository Safety Director's Policy and Procedure Letter 14: Application of YMRP for Review Under Revised Part 63 (NRC, 2009ab).

This volume is one of five volumes that comprise the SER. Each volume is to be published separately as it is completed; however, the volume number may not be published in sequence (e.g., Volume 3 was published before Volume 2). The SER volume number and section number within a volume are based on the YMRP. Use of SER section numbers that correspond to the YMRP section numbers facilitated the NRC staff's writing of the SER and allows the reader to find the applicable review methods and acceptance criteria within the YMRP. The following table provides the topics and SER sections for each volume.

Chapter	SER Section	Title
Volume 1 General Information		
1	1.1	General Description
2	1.2	Proposed Schedules for Construction, Receipt, and Emplacement of Waste
3	1.3	Physical Protection Plan
4	1.4	Material Control and Accounting Program
5	1.5	Description of Site Characterization Work
Volume 2 Repository Safety Before Permanent Closure		
1	2.1.1.1	Site Description as it Pertains to Preclosure Safety Analysis
2	2.1.1.2	Description of Structures, Systems, Components, Equipment, and Operational Process Activities
3	2.1.1.3	Identification of Hazards and Initiating Events
4	2.1.1.4	Identification of Event Sequences
5	2.1.1.5	Consequence Analyses
6	2.1.1.6	Identification of Structures, Systems, and Components Important to Safety; and Measures to Ensure Availability of the Safety Systems
7	2.1.1.7	Design of Structures, Systems, and Components Important to Safety and Safety Controls
8	2.1.1.8	Meeting the 10 CFR Part 20 As Low As Is Reasonably Achievable Requirements for Normal Operations and Category 1 Event Sequences
9	2.1.2	Plans for Retrieval and Alternate Storage of Radioactive Wastes
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Chapter	SER Section	Title
Volume 3 Repository Safety After Permanent Closure		
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4	2.5.2	Records, Reports, Tests, and Inspections
5	2.5.3.1	Training and Certification of Personnel
6	2.5.3.2	U.S. Department of Energy Organizational Structure as it Pertains to Construction and Operation of Geologic Repository Operations Area
7	2.5.3.3	Personnel Qualifications and Training Requirements
8	2.5.5	Plans for Startup Activities and Testing
9	2.5.6	Plans for Conduct of Normal Activities, Including Maintenance, Surveillance, and Periodic Testing
10	2.5.7	Emergency Planning
11	2.5.8	Controls to Restrict Access and Regulate Land Uses
12	2.5.9	Uses of Geologic Repository Operations Area for Purposes Other Than Disposal of Radioactive Wastes
Volume 5 Proposed Conditions on the Construction Authorization and Probable Subjects License Specifications		
1	2.5.10.1	Proposed Conditions on the Construction Authorization
2	2.5.10.2	Probable Subjects of License Specifications

References

NRC. 2009ab. "Division of High-Level Waste Repository Safety Director's Policy and Procedure Letter 14: Application of YMRP for Review Under Revised Part 63." Published March 13, 2009. ML090850014. Washington, DC: NRC.

NRC. 2003aa. NUREG-1804, "Yucca Mountain Review Plan—Final Report." Rev. 2. ML032030389. Washington, DC: NRC.

ABSTRACT

Volume 4, Administrative and Programmatic Requirements, of this Safety Evaluation Report (SER) documents the U.S. Nuclear Regulatory Commission (NRC) staff's review and evaluation of the U.S. Department of Energy's (DOE) Safety Analysis Report (SAR), provided in its June 3, 2008, license application, as updated on February 19, 2009. Specifically, the NRC staff reviewed SAR Chapter 3, Research and Development Program to Resolve Safety Questions; Chapter 4, Performance Confirmation Program; and Chapter 5, Management Systems (except for SAR Section 5.4, Expert Elicitation, which is evaluated in SER Volume 3, Repository Safety After Permanent Closure, Chapter 20). In its application, DOE seeks authorization from the Commission to construct a repository at Yucca Mountain. The NRC staff also reviewed information DOE provided in response to the NRC staff's requests for additional information and other information that DOE provided related to the SAR. In particular, SER Volume 4 documents the results of the NRC staff's evaluation to determine whether DOE's research and development program, performance confirmation program, and other programmatic and administrative controls, systems, and programs meet applicable regulatory requirements. Based on its review, the NRC staff finds, with reasonable assurance, that, except as noted below, DOE has addressed applicable requirements including 10 CFR 63.21, "Content of Application"; 10 CFR 63.121, "Land Ownership and Control"; 10 CFR Part 63, Subpart D, "Records, Reports, Tests, and Inspections"; 10 CFR Part 63, Subpart F, "Performance Confirmation Program"; 10 CFR Part 63, Subpart G, "Quality Assurance"; 10 CFR Part 63, Subpart H, "Training and Certification of Personnel"; and 10 CFR Part 63, Subpart I, "Emergency Planning Criteria."

The NRC staff is proposing one condition of construction authorization in this SER Volume related to the description of programs designed to resolve safety questions. Pursuant to 10 CFR 63.32(b)(4), in the event that DOE identifies any safety questions that would require research and development programs in the future, the results of those programs must be appropriately reported to the NRC.

The NRC staff finds that DOE has not met the requirements 10 CFR 63.121(a) and 10 CFR 63.121(d)(1) regarding ownership of land and water rights, respectively.

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EXECUTIVE SUMMARY

Background

Volume 4, Administrative and Programmatic Requirements, of this Safety Evaluation Report (SER) documents the U.S. Nuclear Regulatory Commission (NRC) staff's review and evaluation of the U.S. Department of Energy's (DOE) Safety Analysis Report (SAR), provided in its June 3, 2008, license application (LA), as updated on February 19, 2009. Specifically, the NRC staff reviewed SAR Chapter 3: Research and Development Program to Resolve Safety Questions; Chapter 4: Performance Confirmation Program; and Chapter 5: Management Systems (except for SAR Section 5.4, Expert Elicitation, which is evaluated in SER Volume 3, Repository Safety After Permanent Closure, Chapter 20). In its application, DOE seeks authorization from the Commission to construct a repository at Yucca Mountain. The NRC staff also reviewed information DOE provided in response to the NRC staff's requests for additional information and other information that DOE provided related to the SAR. In particular, SER Volume 4 documents the results of the NRC staff's evaluation to determine whether DOE's research and development program, performance confirmation program, and other programmatic and administrative controls, systems, and programs will ensure that the repository meets applicable regulatory requirements.

Research and Development Program to Resolve Safety Questions

DOE is required by 10 CFR 63.21(c)(16) to identify those structures, systems, and components (SSCs) of the geologic repository, both surface and subsurface, that require research and development to confirm the adequacy of the design. For SSCs important to safety and for engineered and natural barriers important to waste isolation, DOE is required to provide a detailed description of the programs designed to resolve safety questions, including a schedule indicating when these questions would be resolved.

The NRC staff has reviewed the SAR and other information submitted in support of the license application and finds, with reasonable assurance, that DOE provided an adequate description of research and development programs that would resolve safety questions that require research and development, should such issues be identified; and therefore, has addressed 10 CFR 63.21(c)(16). Neither DOE in its SAR nor the NRC staff in its review of the SAR identified any safety questions that require research and development required in 10 CFR 63.21(c)(16). The NRC staff identified a proposed condition of construction authorization that would require DOE, if it identifies safety questions that result in research and development programs being conducted, to report the results of those programs to the NRC in accordance with 10 CFR 63.32(b)(4).

Performance Confirmation Program

DOE is required by 10 CFR 63.21(c)(17) to describe a performance confirmation program that meets the requirements listed in 10 CFR Part 63, Subpart F. The purpose of a performance confirmation program is to evaluate the adequacy of assumptions, data, and analyses that inform the applicant's evaluations. DOE described that key geotechnical and design parameters and any interactions between natural and engineered systems and components will be monitored. DOE also described that changes will be analyzed throughout site characterization, construction, emplacement, and operation to identify any significant changes in the conditions assumed in the LA that may affect compliance with the postclosure performance

objectives specified at 10 CFR 63.113(b) and 10 CFR 63.113(c). In addition, DOE considered the preclosure performance objectives (i) for the design of the geologic repository operations area such that it would permit implementation of a performance confirmation program [10 CFR 63.111(d)] and (ii) to retain the ability to retrieve waste until Commission review of the Performance Confirmation Program [10 CFR 63.111(e)].

The NRC staff has reviewed the SAR and other information submitted in support of the license application and finds, with reasonable assurance, that the description required by 10 CFR 63.21(c)(17) meets the requirements of 10 CFR Part 63, Subpart F.

Quality Assurance Program

DOE is required by 10 CFR 63.21(c)(20) to describe the quality assurance (QA) program to be applied to the SSCs important to safety and to the engineered and natural barriers important to waste isolation. The description must include a discussion of how the applicable requirements of 10 CFR 63.142 will be satisfied. DOE's QA program is described in the Quality Assurance Requirements and Description (QARD) (DOE, 2009gt), which DOE incorporated into the LA by reference. DOE described that applicable requirements will be satisfied primarily through commitments to Quality Assurance Requirements for Nuclear Plants, NQA-1-1983 (American Society of Mechanical Engineers, 1983aa), and other documents whose use, DOE states, the NRC staff finds to be acceptable.

The NRC staff has reviewed the SAR and other information submitted in support of the license application and finds, with reasonable assurance, that DOE's QA program description satisfies 10 CFR 63.21(c)(20) and the applicable 10 CFR Subpart G quality assurance requirements.

Records, Reports, Tests, and Inspections

DOE is required by 10 CFR 63.21(c)(23) to describe the program to be used to maintain the records described in 10 CFR 63.71 and 10 CFR 63.72. DOE provided program descriptions for reporting deficiencies to the NRC (10 CFR 63.73), performing tests for the NRC or allowing the NRC to perform tests (10 CFR 63.74), and allowing the NRC to inspect the Geologic Repository Operations Area (GROA) and adjacent areas to which DOE has rights of access (10 CFR 63.75). DOE described the recordkeeping and reporting programs for receipt, handling, and disposition of radioactive waste to provide a complete history of the movement of the waste from the shipper through all phases of storage and disposal. DOE described a program to maintain records of construction of the geologic repository operations area in a manner that ensures their usability for future generations.

The NRC staff has reviewed the SAR and other information submitted in support of the license application and finds, with reasonable assurance, that the requirements in 10 CFR 63.21(c)(23) to provide a description of the program to be used to maintain records described in 10 CFR 63.71 and 63.72, and 10 CFR 63.73, 10 CFR 63.74, and CFR 63.75 are addressed.

DOE Organizational Structure as it Pertains to Construction and Operation of Geologic Repository Operations Area

DOE is required by 10 CFR 63.21(c)(22)(i) to provide information concerning the organizational structure pertaining to construction and operation of the GROA and a description of any delegations of authority and assignments of responsibilities. DOE provided a description of the organizational structure for the construction and operations for the GROA, including the description of any delegations of responsibilities.

The NRC staff has reviewed the SAR and other information submitted in support of the license application and finds, with reasonable assurance, that the requirements in 10 CFR 63.21(c)(22)(i) are satisfied.

Key Positions Assigned Responsibility for Safety and Operations of Geologic Repository Operations Area

DOE is required by 10 CFR 63.21(c)(22)(ii) to provide information concerning the identification of key positions that are assigned responsibility for safety at, and operation of, the GROA. DOE described key positions, their responsibilities, and qualifications, and identified qualified alternates to act in the absence of DOE staff assigned to the key positions.

The NRC staff has reviewed the SAR and other information submitted in support of the license application and finds, with reasonable assurance, that the requirement in 10 CFR 63.21(c)(22)(ii) is satisfied.

Personnel Qualifications and Training Requirements

DOE is required by 10 CFR 63.21(c)(22)(iii) to provide information concerning the personnel qualifications and training requirements concerning activities at the GROA. DOE's personnel qualifications and training requirements must address the general requirements, the training and certification program, and the physical requirements required by 10 CFR Part 63, Subpart H, Training and Certification of Personnel. DOE described the management of the training function, identification of functional areas requiring training, objectives for training, organization training guides, and evaluation of trainee learning. DOE described on-the-job training, personnel qualification and certification, performance evaluations, physical condition of operational personnel, and QA audits to determine training program effectiveness. DOE described that operation of systems and components that are important to safety will be performed only by trained and certified personnel or by personnel under the direct supervision of an individual with training and certification in such operation and that supervisory personnel will also be certified in the operations they supervise. DOE described that it would implement a program for training, proficiency testing, certification, and requalification of operating and supervisory personnel, and a program for evaluating the physical condition and general health of personnel certified for operations that are important to safety.

The NRC staff has reviewed the SAR and other information submitted in support of the license application and finds, with reasonable assurance, that the requirements of 10 CFR 63.21(c)(22)(iii) and 10 CFR part 63, Subpart H are satisfied.

Plans for Startup Activities and Testing

DOE is required by 10 CFR 63.21(c)(22)(iv) to provide the plans for startup activities and startup testing at the GROA. DOE described the compatibility of testing programs with applicable regulatory guidance and the use of experience from similar activities. DOE described test procedure development, approval by authorized personnel, and evaluation of test results, format, and content of test procedures. DOE described component testing, systems functional testing, cold integrated systems testing, and operational readiness review. DOE also described testing for protection of workers and the public, initial startup operations testing, the schedules for startup activities and testing, and evaluating functional adequacy of new or untested SSCs.

The NRC staff has reviewed the SAR and other information submitted in support of the license application and finds, with reasonable assurance, that the requirement in 10 CFR 63.21(c)(22)(iv) is satisfied.

Plans for Conduct of Normal Activities, including Maintenance, Surveillance, and Periodic Testing

DOE is required by 10 CFR 63.21(c)(22)(v) to provide information concerning plans for conduct of normal activities, including maintenance, surveillance, and periodic testing of SSCs of the GROA. DOE described its plan and procedure development, testing, and approval by authorized personnel. DOE described its management systems for operation of the repository, including administrative and procedural safety controls; and the specific types of plans and procedures to be developed for normal operations, maintenance, and periodic surveillance testing. DOE also described experience from other DOE facilities as guidance for developing plans and procedures for conduct of normal activities.

The NRC staff has reviewed the SAR and other information submitted in support of the license application and finds, with reasonable assurance, that the requirements in 10 CFR 63.21(c)(22)(v) are satisfied.

Emergency Planning

DOE is required by 10 CFR 63.21(c)(21) to provide a description of the plan for responding to, and recovering from, radiological emergencies that may occur any time before permanent closure and decontamination or decontamination and dismantlement of surface facilities, as required by 10 CFR 63.161. DOE provided a description of its emergency plan for responding to, and recovering from, radiological emergencies that may occur any time before permanent closure and decontamination or decontamination and dismantlement of surface facilities.

The NRC staff has reviewed the SAR and other information submitted in support of the license application and finds, with reasonable assurance, that the requirements in 10 CFR 63.21(c)(21) and 10 CFR 63.161 are satisfied.

Controls to Restrict Access and Regulate Land Uses

DOE is required by 10 CFR 63.21(c)(24) to describe the controls to restrict access and to regulate land uses at the Yucca Mountain site and adjacent areas, including a conceptual design of monuments that would be used to identify the site after permanent closure, in accordance with the requirements in 10 CFR 63.121. DOE described the (i) ownership of the land where the GROA is located and the land being free and clear of significant encumbrances [10 CFR 63.121(a)(1) and (2)], (ii) additional controls for permanent closure [10 CFR 63.121(b)], (iii) additional controls through permanent closure [10 CFR 63.121(c)], and (iv) water rights [10 CFR 63.121(d)(1) and (2)].

The NRC staff has reviewed the SAR and other information submitted in support of the license application and finds, with reasonable assurance, that: (i) the requirements at 10 CFR 63.121(a)(1) and 10 CFR 63.121(a)(2) regarding ownership of the land where the GROA is located are not met, because the lands where the GROA would be located have not been acquired by DOE, are not under the control and jurisdiction of DOE, and are not free of significant encumbrances; (ii) the requirements related to a description of controls for permanent closure in 10 CFR 63.21(c)(24), 10 CFR 63.121(b), and 10 CFR 63.121(d)(2) are satisfied because DOE has provided an adequate description of the type of controls it would use to prevent adverse human actions that could significantly reduce the geologic repository's ability to achieve isolation during the postclosure period; (iii) the requirements at 10 CFR 63.21(c)(24) and 10 CFR 63.121(c) regarding a description of additional controls through permanent closure are satisfied, because DOE has provided an adequate description of the proposed restrictions and controls it would establish outside the GROA to ensure the requirements of 10 CFR 63.111(a) and (b) are met; (iv) the requirement at 10 CFR 63.121(d)(1) regarding water rights is not met, because DOE has not obtained such water rights that DOE determined may be needed to accomplish the purpose of the GROA; and (v) the requirement at 10 CFR 63.21(c)(24) regarding a description of monuments is satisfied because DOE acceptably described its conceptual design of monuments that would be used to identify the site after permanent closure.

Uses of the Geologic Repository Operations Area for Purposes other than Disposal of Radioactive Wastes

DOE is required, by 10 CFR 63.21(c)(22)(vii), to include information concerning plans for any uses of the GROA for purposes other than radioactive waste disposal, with an analysis of the effects, if any, that such uses may have on the operation of the SSCs important to safety and the engineered and natural barriers important to waste isolation. DOE described potential other uses of the GROA and analyzed the effects that such uses may have on the operation of the SSCs important to safety and on the engineered and natural barriers important to waste isolation. DOE described its procedures to manage the two ongoing other uses of the GROA (protection of cultural resources and protection of flora and fauna).

The NRC staff has reviewed the SAR and other information submitted in support of the license application and finds, with reasonable assurance, that the requirement in 10 CFR 63.21(c)(22)(vii) is satisfied.

References

American Society of Mechanical Engineers. 1983aa. ANSI/ASME NQA-1-1983, "Quality Assurance Program Requirements for Nuclear Facilities." New York City, New York: American Society of Mechanical Engineers.

DOE. 2009gt. DOE/RW-0333P, "Quality Assurance Requirements and Description (QARD)." Rev. 21. ML090230236. Las Vegas, Nevada: DOE, Office of Civilian Radioactive Waste Management.

ACRONYMS AND ABBREVIATIONS

ANSI/ASME	American National Standards Institute/American Society of Mechanical Engineers
DOE	U.S. Department of Energy
EALs	emergency action levels
EBS	engineered barrier system
ECRB	Enhanced Characterization of the Repository Block Cross-Drift
EP	emergency plan
ESF	Exploratory Studies Facility
GROA	geologic repository operations area
HLW	high-level radioactive waste
HLWRS	High-Level Waste Repository Safety
ISG	interim staff guidance
ITS	important to safety
MCO	multicanister overpacks
MOX	mixed oxide
NRC	U.S. Nuclear Regulatory Commission
NWTRB	Nuclear Waste Technical Review Board
OCRWM	Office of Civilian Radioactive Waste Management
PCSA	preclosure safety analysis
QA	quality assurance
QARD	quality assurance requirements and description
RAI	request for additional information
SAR	Safety Analysis Report
SSCs	structures, systems, and components
SER	Safety Evaluation Report
SNF	spent nuclear fuel
TSPA	total system performance assessment
YMRP	Yucca Mountain Review Plan

INTRODUCTION

Volume 4: Administrative and Programmatic Requirements, of this Safety Evaluation Report (SER), documents the U.S. Nuclear Regulatory Commission (NRC) staff's review and evaluation of the U.S. Department of Energy (DOE) Safety Analysis Report (SAR), provided in its June 3, 2008, license application (LA) (DOE, 2008ab), as updated on February 19, 2009 (DOE, 2009av). The NRC staff also reviewed information DOE provided in response to the NRC staff's requests for additional information and other information DOE provided related to the SAR. In particular, SER Volume 4 documents the results of the NRC staff's evaluation to determine whether DOE's research and development program, performance confirmation program, and administrative controls, systems, and programs meet applicable regulatory requirements.

Other portions of the NRC staff's safety review have been, or will be, documented in other volumes. SER Volume 1, NUREG-1949 (NRC, 2010aa, published August, 2010) contains the results of the NRC staff's review of DOE's General Information. SER Volume 2 will document the results of the NRC staff's review and evaluation of DOE's compliance with preclosure safety objectives and requirements. SER Volume 3 documents the results of the NRC staff's review and evaluation of whether the proposed repository design will comply with the performance objectives and requirements that apply after the repository is permanently closed. SER Volume 5 will document probable subjects of license specifications and proposed conditions of construction authorization.

NRC's regulations at 10 CFR Part 63 provide site-specific criteria for geologic disposal at Yucca Mountain. Pursuant to 10 CFR Part 63, there are several stages in the licensing process: the site characterization stage, the construction stage, a period of operations, and termination of the license. The multi-staged licensing process affords the Commission the flexibility to make decisions in a logical time sequence that accounts for DOE collecting and analyzing additional information over the construction and operational phases of the repository. The period of operations includes (i) the time during which emplacement would occur, (ii) any subsequent period before permanent closure during which the emplaced wastes are retrievable, and (iii) permanent closure. In addition, 10 CFR Part 63 represents a risk-informed, performance-based regulatory approach to the review of geological disposal. This risk-informed, performance-based regulatory approach uses risk insights, engineering analysis and judgments, performance history, and other information to focus on the most important activities and to focus the review on areas most significant to safety or performance. Therefore, the SER includes discussions regarding how the NRC staff used risk information in its review of DOE's application. In conducting its review, the NRC staff was guided by the review methods and acceptance criteria outlined in the Yucca Mountain Review Plan (YMRP) (NRC, 2003aa), as supplemented by the Division of High-Level Waste Repository Safety Director's Policy and Procedure Letter 14: Application of YMRP for Review Under Revised Part 63 (NRC, 2009ab).

Research and Development Program to Resolve Safety Questions

The NRC staff evaluates DOE's description of a research and development program to resolve safety questions. The program is required to identify, describe, and discuss those safety features or components for which further technical information is required, to confirm the adequacy of design, and engineered or natural barriers. Safety questions related to structures, systems, and components important to safety or related to natural and engineered barriers important to waste isolation may be identified by NRC during the license review or by DOE

during its own evaluations. If DOE identifies safety questions that result in research and development programs being conducted, the results of those programs must be reported to the NRC in accordance with 10 CFR 63.32(b)(4). The NRC staff's evaluation of DOE's description of a research and development program to resolve safety questions is in SER Section 2.3.

Performance Confirmation Program

The NRC staff evaluates DOE's description of a performance confirmation program. Performance confirmation is the program of tests, experiments, and analyses that is conducted to evaluate the adequacy of the information used to demonstrate compliance with the performance objectives in 10 CFR 63 Subpart E. The Performance Confirmation Program is designed to confirm the adequacy of assumptions, data, and analyses that support the findings used to permit construction of the repository and waste emplacement. The Performance Confirmation Program evaluates information supporting compliance demonstrations of the postclosure performance objectives for individual protection [10 CFR 63.113(b)] and groundwater protection [10 CFR 63.113(c)], as well as consideration of certain preclosure aspects of repository performance [e.g., the ability to retrieve waste addressed in 10 CFR 63.111(e)]. The NRC staff's evaluation of DOE's performance confirmation program is in SER Section 2.4.

Administrative Controls, Systems, and Programs

The NRC staff evaluates DOE's administrative controls, systems, and programs that DOE would utilize to control activities to ensure that the repository meets applicable regulatory requirements. Administrative controls, systems, and programs are provided for important to safety and important to waste isolation structures, systems, and components to ensure they are maintained and operated within analyzed conditions, and are capable of performing their intended functions. Management systems and procedures implement these administrative and procedural safety controls. The NRC staff's evaluation of DOE's administrative controls, systems, and programs is in the following SER sections:

- Section 2.5.1, Quality Assurance Program
- Section 2.5.2, Records, Reports, Tests and Inspections
- Section 2.5.3.1, DOE Organizational Structure as it Pertains to Construction and Operation of Geologic Repository Operations Area
- Section 2.5.3.2, Key Positions Assigned Responsibility for Safety and Operations of Geologic Repository Operations Area
- Section 2.5.3.3, Personnel Qualifications and Training Requirements
- Section 2.5.5, Plans for Startup Activities and Testing
- Section 2.5.6, Plans for Conduct of Normal Activities, including Maintenance, Surveillance, and Periodic Testing

- Section 2.5.7, Emergency Planning
- Section 2.5.8, Controls to Restrict Access and Regulate Land Uses
- Section 2.5.9, Uses of the Geologic Repository Operations Area for Purposes other than Disposal of Radioactive Wastes

References

DOE. 2008ab. DOE/RW-0573, "Yucca Mountain Repository License Application." Rev. 0. ML081560400, ML081560542. Las Vegas, Nevada: DOE, Office of Civilian Radioactive Waste Management.

DOE. 2009av. DOE/RW-0573, "Yucca Mountain Repository License Application." Rev. 1. ML090700817, ML090710096. Las Vegas, Nevada: DOE, Office of Civilian Radioactive Waste Management.

NRC. 2010aa. NUREG-1949, "Safety Evaluation Report Related to Disposal of High-Level Radioactive Wastes in a Geologic Repository at Yucca Mountain, Nevada. Vol. 1: General Information." ML102440298. Washington, DC: NRC.

NRC. 2003aa. NUREG-1804, "Yucca Mountain Review Plan—Final Report." Rev. 2. ML032030389. Washington, DC: NRC.

NRC. 2009ab. "Division of High-Level Waste Repository Safety Director's Policy and Procedure Letter 14: Application of YMRP for Review Under Revised Part 63." Published March 13, 2009. ML090850014. Washington, DC: NRC.

CHAPTER 1

2.3 Research and Development Program to Resolve Safety Questions

2.3.1 Introduction

Safety Evaluation Report (SER) Section 2.3 provides the U.S. Nuclear Regulatory Commission (NRC) staff's review of the U.S. Department of Energy's ("DOE" or "applicant") research and development program to resolve safety questions. This review considers information provided in DOE's Safety Analysis Report (SAR) Chapter 3 (DOE, 2008ab). This SAR chapter was unchanged in DOE's license application update, submitted to NRC in February 2009 (DOE, 2009av).

Safety questions requiring research and development programs on the adequacy of the design of structures, systems, and components (SSCs) of the geologic repository important to safety, both surface and subsurface, or related to natural and engineered barriers important to waste isolation could be identified by DOE in the SAR or SAR updates or by the NRC staff as a result of its review of the SAR. DOE provided information on identification of safety questions requiring research and development programs in SAR Section 3.1. DOE discussed the elements that would be contained in a research and development program in SAR Section 3.2. Such programs would be separate and distinct from DOE's Performance Confirmation Program described in SAR Chapter 4 and reviewed by the NRC staff in SER Section 2.4.

2.3.2 Regulatory Requirements

The requirement for a description of research and development programs to resolve identified safety questions is specified in 10 CFR 63.21(c)(16), which provides

- DOE is required to identify those SSCs of the geologic repository, both surface and subsurface, that require research and development to confirm the adequacy of design.
- For SSCs important to safety and for engineered and natural barriers important to waste isolation, DOE shall provide a detailed description of the programs designed to resolve safety questions, including a schedule indicating when these questions would be resolved.

In addition, if a construction authorization is granted, the Commission shall incorporate, in accordance with 10 CFR 63.32(b)(4), provisions in the construction authorization requiring DOE to provide periodic or special reports on any research and development programs being conducted to resolve safety questions .

In its review, the NRC staff used guidance in the Yucca Mountain Review Plan (YMRP) Section 2.3 (NRC, 2003aa).

2.3.3 Technical Evaluation

2.3.3.1 Identification and Description of Safety Questions

DOE provided information on its process for identification of safety questions requiring research and development programs in SAR Section 3.1. DOE did not identify any safety questions with

respect to (i) SSCs important to safety or (ii) engineered and natural barriers important to waste isolation (SAR Section 3.1).

The NRC staff reviewed the information DOE provided in SAR Section 3.1 and in SAR Chapters 1 and 2 (preclosure and postclosure) for safety questions that would require research and development for (i) SSCs important to safety or (ii) engineered and natural barriers important to waste isolation. The NRC staff also did not identify any safety questions requiring research and development programs. The NRC staff's review of the applicant's SSCs important to safety and engineered barriers important to waste isolation is in Volume 3 of this SER, and will also be documented in Volume 2 of this SER. On the basis of its review, the NRC staff finds that DOE has acceptably concluded that there are no safety questions that would require research and development at this time.

2.3.3.2 Research and Development Programs Related to Safety Questions

DOE stated in SAR Section 3.2 that a specific research and development program would be developed for each identified safety issue related to SSCs of the geologic repository important to safety, both surface and subsurface, or related to natural and engineered barriers important to waste isolation, and that each program would be separate and distinct from DOE's Performance Confirmation Program described in SAR Chapter 4. Further, DOE stated that the results of research and development programs, including periodic progress updates, would be provided to the NRC.

The NRC staff evaluated DOE's description in SAR Section 3.2 of how each research and development program would

- Identify and describe safety questions
- Identify and describe the research and development that will be conducted to resolve safety questions
- Provide a schedule for completing the activities relative to the projected start-up date of repository operations
- Provide design alternatives or operational restrictions available if the results of program activities do not acceptably resolve the safety questions

Based upon its review, the NRC staff determines that the information in SAR Section 3.2 adequately describes how DOE would develop and implement a research and development program to resolve safety questions should any be identified because the discussion in SAR Section 3.2 addresses how DOE would provide (i) a detailed description of the programs designed to resolve safety questions; (ii) a schedule indicating when these questions would be resolved; and (iii) design alternatives or operational restrictions available, if the results of the program do not demonstrate acceptable resolution of the problem. Therefore, the NRC staff concludes that DOE's description is adequate because it addresses applicable guidance in the YMRP and the requirements in 10 CFR 63.21(c)(16).

In the event that DOE identifies any safety questions that would require a research and development program in the future, and in accordance with 10 CFR 63.32(b)(4), the following condition for construction authorization should be included:

Proposed Condition of Construction Authorization: If DOE identifies safety questions that require research and development programs, the results of those programs must be reported to the NRC in accordance with 10 CFR 63.32(b)(4). DOE shall furnish such periodic reports in a timely manner beginning no later than 6 months following the identification of a safety question that requires a research and development program and every 6 months thereafter until the completion of the research and development program or resolution of the issue.

Section 63.32(b)(4) requires that the specified reports be provided on a periodic or special reporting basis. The NRC staff proposes that any results of research and development programs being conducted to resolve safety questions be furnished in a timely manner beginning no later than 6 months following the identification of safety questions requiring such reports. Furnishing periodic reports every 6 months on the results of research and development programs is consistent with the frequency for progress reports during the conduct of site characterization activities as specified at 10 CFR 63.16.

2.3.4 Evaluation Findings

The NRC staff has reviewed the SAR, which includes information required by 10 CFR 63.21(c)(16) that is related to identification of safety questions that require research and development programs. Because neither DOE in its SAR nor the NRC staff in its review of the SAR identified any safety questions that require research and development, the NRC staff finds, with reasonable assurance, that DOE has adequately addressed 10 CFR 63.21(c)(16).

DOE has provided an adequate description of research and development programs that would resolve safety questions that require research and development upon their identification. DOE stated that it will provide periodic or special reports on any research and development programs being conducted to resolve safety questions. In accordance with 10 CFR 63.32(b)(4), a construction authorization should include the following condition:

- If DOE identifies safety questions that result in research development programs being conducted, the results of those programs must be reported to the NRC in accordance with 10 CFR 63.32(b)(4). DOE shall furnish such periodic reports in a timely manner beginning no later than 6 months following the identification of a safety question that requires a research and development program and every 6 months thereafter until the completion of the research and development program or resolution of the issue.

2.3.5 References

- DOE. 2009av. DOE/RW-0573, "Yucca Mountain Repository License Application." Rev. 1. ML090700817. Las Vegas, Nevada: DOE, Office of Civilian Radioactive Waste Management.
- DOE. 2008ab. DOE/RW-0573, "Yucca Mountain Repository License Application." Rev. 0. ML081560400. Las Vegas, Nevada: DOE, Office of Civilian Radioactive Waste Management.
- NRC. 2003aa. NUREG-1804, "Yucca Mountain Review Plan—Final Report." Rev. 2. ML032030389. Washington, DC: NRC.

CHAPTER 2

2.4 Performance Confirmation Program

2.4.1 Introduction

Safety Evaluation Report (SER) Section 2.4 provides the U.S. Nuclear Regulatory Commission (NRC) staff's evaluation of the U.S. Department of Energy's ("DOE" or "applicant") description of the Performance Confirmation Program, as presented in the Safety Analysis Report (SAR) (DOE, 2008ab, Section 4), and references therein. This SAR section was changed in DOE's License Application update, which was submitted to the U.S. Nuclear Regulatory Commission (NRC) in February 2009 (DOE, 2009av). DOE also provided additional information on its Performance Confirmation Program in its response to the NRC staff's requests for additional information (DOE, 2009gm, DOE, 2010ap).

The Performance Confirmation Program is the set of tests, experiments, and analyses that are conducted, where practicable, to evaluate the adequacy of the assumptions, data, and analyses supporting DOE's application to construct and operate a high-level waste (HLW) repository at Yucca Mountain. The objective of performance confirmation is to monitor key geotechnical and design parameters, including interactions between natural and engineered systems and components throughout construction, operation, and through to closure, to identify significant changes from the conditions assumed and evaluated in the license application that would affect postclosure safety. Changes in parameters and conditions during construction, operation, and through to closure are identified by the Performance Confirmation Program by comparison with baseline and expected values. Baseline values are developed for the Performance Confirmation Program using assumptions, data, and analyses that DOE provided in its SAR to support the license application, and that the NRC evaluates in making its licensing decision.

The performance confirmation program does not confirm preclosure performance in general (i.e., testing and monitoring structures, systems, and components important to safety), it addresses only those aspects of preclosure performance with interactions between engineered and natural systems as might affect postclosure performance objectives, and for the special case of retrievability. For a construction authorization, the applicant is required to provide a description of a program for performance confirmation that meets the requirements of 10 CFR Part 63, Subpart F.

The Performance Confirmation Program must be explicitly linked to a performance assessment that satisfies 10 CFR 63.113. The Performance Confirmation Program may evolve during construction and operation as the performance assessment is iteratively updated with new information obtained from ongoing performance confirmation monitoring and testing activities. Should a construction authorization be issued, DOE would have appropriate flexibility to change the activities and parameters, as indicated by site and facility conditions and the results from updated performance assessment during construction and operation (NRC, 2001aa, NRC, 1992af).

Information and analyses from the Performance Confirmation Program are required for a license amendment for permanent closure, at the time of which an update is required of the performance assessment of the geologic repository for the period after permanent closure under 10 CFR 63.51(a)(1). The updated assessment for the license amendment for permanent closure must include any performance confirmation data collected under the program required

by 10 CFR 63, Subpart F, and pertinent to compliance with 10 CFR 63.113. The option to retrieve waste, which must be maintained until closure, is linked to the completion of the performance confirmation program and update of the performance assessment required for the license amendment for permanent closure in 10 CFR 63.51.

The NRC staff's evaluation and regulatory findings are based on DOE's descriptions of proposed performance confirmation activities, schedules, and reporting, as detailed in SAR Chapter 4, references contained therein, the applicant's responses to RAIs (DOE, 2009gm; DOE, 2010ap), and correspondence and reports pertaining to the period from 2010 to 2014. DOE is not required to have a finalized plan for performance confirmation activities in the application for a construction authorization, but rather, must provide a description of a program that meets 10 CFR 63, Subpart F.

2.4.2 Regulatory Requirements

The regulatory requirements for performance confirmation are in 10 CFR 63.21(c)(17) and 10 CFR Part 63, Subpart F, "Performance Confirmation Program." Under 10 CFR 63.21(c)(17), the SAR must include a description of the performance confirmation program that meets the requirements of 10 CFR 63, Subpart F. The four areas in 10 CFR 63, Subpart F are (i) General requirements (10 CFR 63.131), (ii) Confirmation of geotechnical and design parameters (10 CFR 63.132), (iii) Design testing (10 CFR 63.133), and (iv) Monitoring and testing waste packages (10 CFR 63.134).

A preclosure performance objective that the geologic repository operations area must be designed so as to permit implementation of a Performance Confirmation Program is specified in 10 CFR 63.111(d). The NRC staff will evaluate the applicant's design information as to whether it would permit the implementation of a Performance Confirmation Program in SER Volume 2, Section 2.1.1.2.

The NRC staff reviewed DOE's description of its Performance Confirmation Program using the applicable guidance in the "Yucca Mountain Review Plan" (YMRP) Section 2.4 (NRC, 2003aa). The YMRP acceptance criteria for the performance confirmation program are

- General requirements established for such a program
- Requirements established for confirmation of geotechnical and design parameters
- Requirements established for design testing
- Requirements established for monitoring and testing waste packages

2.4.3 Technical Evaluation

The NRC staff reviewed the DOE description of its Performance Confirmation Program in the SAR and additional information describing the Performance Confirmation Program in the Performance Confirmation Plan (SNL, 2008aq) to determine whether the information DOE provided satisfies the requirements for a performance confirmation program in 10 CFR 63.21(c)(17) and 10 CFR Part 63, Subpart F, "Performance Confirmation Program." The NRC staff review focused on DOE's description of the general program aspects and on the proposed performance confirmation activities using the guidance in the YMRP (NRC, 2003aa, Section 2.4). DOE provided an overview of the Performance Confirmation Program in SAR Section 4.1 and a description of the four components of its program in SAR Section 4.2. The four components of DOE's performance confirmation program track the four

parts of 10 CFR 63, Subpart F; General requirements (10 CFR 63.131); Confirmation of geotechnical and design parameters (10 CFR 63.132); Design testing (10 CFR 63.133); and Monitoring and testing of waste packages (10 CFR 63.134). The NRC staff's review of DOE's description of its Performance Confirmation Program is found in SER Sections 2.4.3.1 through 2.4.3.4.

2.4.3.1 General Requirements for Performance Confirmation

The NRC staff's technical evaluation of the information DOE provided to meet requirements in 10 CFR 63.131 (General requirements) is discussed in the following three subsections: (i) General Description of the Performance Confirmation Program (SER Section 2.4.3.1.1), (ii) Performance Confirmation Activities that are not generally related to the underground openings (SER Section 2.4.3.1.2), and (iii) Summary of the NRC Staff Evaluation of the General Requirements for Performance Confirmation (SER Section 2.4.3.1.3).

2.4.3.1.1 General Description of the Performance Confirmation Program

DOE stated that the performance confirmation will provide data to verify the adequacy of the information presented in the license application by providing data to confirm that (i) subsurface conditions are as expected, and (ii) the behavior of repository system barriers is consistent with performance assessment results (SNL, 2008aq, Section 1.1). The information in the license application includes assumptions, data, and analyses that support DOE's postclosure safety determinations (SAR Section 4.1). DOE stated that the Performance Confirmation Program would evaluate the information supporting the performance assessments for individual protection and groundwater protection, as well as consideration of specific preclosure aspects of repository performance, such as retrievability (SAR Section 4.1).

DOE identified two objectives for the Performance Confirmation Program. First, DOE stated that the program will provide information, where practicable, to confirm that subsurface conditions encountered during construction and waste emplacement operations are within the range of conditions assumed in the SAR. This includes monitoring subsurface conditions and testing to confirm geotechnical and design assumptions for retrievability. The NRC staff will document its review of retrievability in SER Section 2.1.2. Second, DOE stated that its performance confirmation program will provide information to confirm that the natural and engineered barriers are functioning as described in SAR Chapter 2. To accomplish these objectives, DOE described its (i) methodology for identifying systems and components functioning as barriers, (ii) planned implementation, and (iii) expected schedule.

Identification of Barriers, Systems and Components, and Activities

DOE identified in SAR Table 4-1 the natural and engineered barriers that DOE concluded were important to waste isolation. DOE specified the natural and engineered system and components functioning as part of those barriers, and DOE related those barriers to particular performance confirmation activities. In addition to identification of activities linked to barrier performance, DOE identified other activities that supported the ability to retrieve waste, or that confirm disruptive event parameters. DOE identified the Upper Natural Barrier, Engineered Barrier System, and Lower Natural Barrier as important to waste isolation. DOE stated that important barriers are those that prevent or substantially reduce the rate of movement of water or radionuclides from the repository to the accessible environment, or those barriers that prevent the release or substantially reduce the release rate of radionuclides from the waste. For each of the barriers, DOE listed the relevant (i) barrier; (ii) feature, event, or process;

(iii) effect on barrier capability; and (iv) core parameter characteristic for each performance confirmation activity in its Performance Confirmation Plan (SNL, 2008aq; addendum to Revision 5, Table A–2[a]).

DOE described the methodology for selecting performance confirmation activities in SAR Section 4.1.1 and SNL (2008aq; Section 1.4.1). DOE stated that the performance confirmation activities were selected using a risk-informed, performance-based methodology using the approach described as follows. DOE described an approach to identify geotechnical and design parameters and determine appropriate testing activities that DOE stated were relevant to the identified natural and engineered systems and components functioning as barriers. DOE's approach consisted of (i) using subject matter experts to identify relevant geotechnical and design parameters and (ii) determining appropriate testing activities on the basis of the application of the following three criteria:

- Sensitivity of barrier capability and system performance to the parameter
- Level of confidence in the current knowledge about the parameter
- Accuracy of information obtained by a particular test

DOE stated that its analysis was based on its understanding of the performance assessment and barrier capability that existed prior to completing the DOE total system performance assessment (TSPA) (SNL, 2008ag) presented in the SAR. Because the models used by DOE to develop the TSPA had been updated since the analysis was used to identify the performance confirmation activities, DOE conducted a second review comparing the planned activities to the representation of key features and processes in the final TSPA models. In the second review, which is described in the Performance Confirmation Plan addendum (SNL, 2008aq, Appendix A[a]), DOE compared the final TSPA presented in the SAR, the postclosure nuclear safety design bases (SNL, 2008ad), and the Performance Confirmation Plan. DOE did not identify new performance confirmation activities as a result of its additional review, because DOE concluded, based upon this comparison, that the previously identified activities were sufficient to confirm the license application basis.

The DOE Performance Confirmation Plan identified 20 activities for performance confirmation. From SAR Section 4.2 and Table 4-1, these 20 activities, grouped by the SER subsection in which they are evaluated by the NRC staff, are

- SER Section 2.4.3.1.2
 - Precipitation Monitoring
 - Subsurface Water and Rock Testing
 - Unsaturated Zone Testing
 - Saturated Zone Monitoring
 - Saturated Zone Fault Hydrology Testing
 - Saturated Zone Alluvium Testing
- SER Section 2.4.3.2
 - Seepage Monitoring
 - Drift Inspection
 - Thermally Accelerated Drift Near-Field Monitoring
 - Thermally Accelerated Drift In-Drift Environment Monitoring
 - Subsurface Mapping
 - Seismicity Monitoring
 - Construction Effects Monitoring

- Thermally Accelerated Drift Thermal-Mechanical Monitoring
- SER Section 2.4.3.3
 - Seal and Backfill Testing
- SER Section 2.4.3.4
 - Dust Buildup Monitoring
 - Waste Package Monitoring
 - Corrosion Testing
 - Corrosion Testing of Thermally Accelerated Drift Samples
 - Waste Form Testing

DOE stated that some activities were selected to confirm postclosure performance objectives, and for the special case of retrievability, based on current technical information and total system performance assessment results. Other activities were selected to meet specific requirements described in 10 CFR Part 63, Subpart F [e.g., subsurface mapping, thermally accelerated drift thermal-mechanical response monitoring, seal and backfill (if part of the design) testing, and waste package monitoring]. DOE stated that periodic reassessment of performance confirmation activities, based on updated technical information and total system performance assessment results, (i) will be performed during construction and operations to assure the continued relevance of the activities, and (ii) may lead to new activities being added and currently planned activities being curtailed or deleted (SAR Section 4.1; SNL, 2008aq, Section 4).

In the description of the 20 candidate activities, DOE included *in-situ* monitoring, laboratory and field testing, and *in-situ* experiments that would acquire data to use directly, or in analyses for the selected geotechnical and design parameters and natural and engineered systems and components.

The NRC Staff Review

The NRC staff reviewed the description that DOE provided for the identification of systems and components functioning as barriers, and the testing and monitoring activities associated with those systems and components, in the Performance Confirmation Program. The NRC staff notes that the requirements in 10 CFR 63.131 link the Performance Confirmation Program to DOE's performance assessment, specifically to barriers designed or assumed by DOE to function after permanent closure. Furthermore, the NRC staff notes that the identification and description of barriers and their capabilities described in the Performance Confirmation Program (SAR Section 4 and SNL, 2008aq) is consistent with the information that the applicant presented in SAR Section 2.1 and DOE (2009an, Expanded Table 2.1-1) and which the NRC staff evaluates in SER Section 2.2.1.1 (Multiple Barriers). In that section, the NRC staff concludes that the design features of the engineered barrier system and the natural features of the geologic setting that are considered barriers important to waste isolation had been acceptably identified by DOE.

The NRC staff finds that DOE's method to select geotechnical and design parameters to measure or observe and DOE's method to select the natural and engineered systems and components to monitor and test are acceptable because (i) the methods are risk-informed and performance-based; (ii) DOE assessed its selection of performance confirmation activities against the final TSPA in the SAR to determine whether any changes in activities were needed; and (iii) the methodology is consistent with the DOE's technical bases in SAR Section 2, including the natural and engineered barrier system (EBS) and components. In addition, the NRC staff reviewed the specific activities currently identified for the Performance

Confirmation Program. As discussed below, based on (i) knowledge gained from prelicensing interactions with DOE, (ii) the NRC staff's review in SER Sections 2.2.1.3.1 through 2.2.1.3.10 and 2.2.1.3.12 through 2.2.1.3.14, and (iii) the NRC staff's review of specific candidate parameters for each test and monitoring activity in SER Sections 2.4.3.1.2 and 2.4.2.2 through 2.4.3.4, the NRC staff finds that the 20 activities in the Performance Confirmation Program acceptably cover risk-important, performance-based assumptions and technical bases presented in the SAR. In addition, the NRC staff finds that the DOE description of its Performance Confirmation Program meets the requirement in 10 CFR 63.131(c) because the program includes *in-situ* monitoring, laboratory and field tests, and field testing.

The NRC staff notes that during construction and operation, new information and analyses incorporated into an updated performance assessment may necessitate modifications to the set of Performance Confirmation Program activities, or to the parameters and methods identified for any of the activities (NRC, 2001aa), as described in the application and in SNL (2008aq).

Implementation of the Performance Confirmation Program

DOE stated in SAR Section 4.1.2 that performance confirmation test plans will provide detailed information on the 20 activities, including (i) baseline information; (ii) anticipated changes to be observed or measured during the period of the tests, including those that may be changed by site investigations, construction, and operations; and (iii) identification of what constitutes trends or variations beyond the anticipated range during the monitoring or testing period. Additionally, DOE stated that it plans to update the Performance Confirmation Plan periodically to ensure that it is consistent with the SAR and reflects the most current performance assessment. Performance confirmation test plans have been written for seismic monitoring (SNL, 2007bo), precipitation monitoring (SNL, 2013aa), and construction effects monitoring (BSC, 2006al). DOE stated that other test plans will be prepared sequentially, and the Performance Confirmation Plan will be revised and updated as program development continues. DOE (2009gm) stated that future performance confirmation test plans will be provided to NRC at issuance, prior to test implementation. In its Performance Confirmation Plan (SNL, 2008aq), DOE stated that the Performance Confirmation Program must be flexible, with specific details of the program evolving as necessary in response to information obtained from performance confirmation activities. DOE described a phased approach for implementing its Performance Confirmation Program. DOE stated that candidate activities remain preliminary until they are finalized in the performance confirmation test plans, and that DOE will provide future performance confirmation test plans to NRC when the plans are completed.

DOE stated [SAR Section 4.1.2; Performance Confirmation Plan Sections 5.2.2 and 5.2.3; DOE (2009gm)] that it would consider potential adverse effects on the natural and engineered elements of the geologic repository before initiating any *in-situ* monitoring, test, or experiment to acquire data. DOE stated in its performance confirmation activity descriptions why the activity is not expected to adversely affect the ability of the repository to meet performance objectives, or that any adverse effect is minimized. DOE (2009gm) stated that test construction and performance confirmation activities will be evaluated during detailed test planning for their impact to waste isolation and test-to-test interferences prior to test implementation, and that these evaluations will be documented for each performance confirmation activity under the DOE Site Performance Protection Evaluation Program.

The NRC Staff Review

The NRC staff reviewed the description DOE provided for the implementation of the Performance Confirmation Program. On the basis of information discussed above, the NRC staff finds that DOE described an acceptable process for documenting consideration of potential adverse effects. In particular, the NRC staff finds that the DOE description of procedures to consider adverse effects meets the requirement in 10 CFR 63.131(d)(1) because DOE (2009gm) stated that test construction and performance confirmation activities will be evaluated for their impact to waste isolation prior to test implementation, and that these evaluations will be documented for each performance confirmation test activity under the DOE Site Performance Protection Evaluation Program.

Schedule and Duration

In SAR Section 4.1, DOE stated that the Performance Confirmation Program began during site characterization, assumes a 100-year preclosure period for performance confirmation activities, and will continue until permanent closure. DOE stated that during the time from initiation of construction until repository closure, performance confirmation activities will include *in situ* monitoring and testing and laboratory testing (SNL, 2008aq, Section 1.1). DOE stated that data and information collected during construction and operation would be compared against information presented in the license application to confirm that subsurface conditions are as expected and behavior of repository system barriers is consistent with performance assessment assumptions, inputs, and results. Baseline information, which will be derived from information presented in the license application, includes site characterization data and assumptions, inputs, and analyses from the performance assessment. DOE provided a timeline for planned performance confirmation activities in SAR Figure 4-2, and provided a schedule for issuance of test plans in DOE (2009gm, Table 1).

The NRC Staff Review

The NRC staff reviewed the DOE description of the duration and schedule of the Performance Confirmation Program provided in SAR Section 4 and the Performance Confirmation Plan (SNL, 2008aq). The NRC staff reviewed the description of the timeline DOE provided for each individual activity in SER Sections 2.4.3.1.2 and 2.4.3.2 through 2.4.3.4 for compliance with 10 CFR 63.131(c), 10 CFR 63.132(e), 10 CFR 63.133(b), and 10 CFR 63.134(d), as appropriate for the particular activity.

The NRC staff evaluated DOE's description of the duration and schedule of the activities to be conducted under the Performance Confirmation Program to determine whether, in accordance with 10 CFR 63.131(b), the program started during site characterization, and it will continue until permanent closure. As evaluated in SER Section 2.4.3, DOE began its Performance Confirmation Program during site characterization, and DOE has provided plans and descriptions of performance confirmation activities that will continue until permanent closure. Therefore, the NRC staff finds that DOE's description of its Performance Confirmation Program meets the 10 CFR 63.131(b) requirement.

As indicated in the "Note to Reader" for this Volume of the SER, in March 2010, DOE filed a motion to withdraw its application before the Atomic Safety and Licensing Board. Furthermore, on February 26, 2010, DOE informed the NRC that it would cease performance confirmation activities, including data collection, at the Yucca Mountain site (DOE, 2010ar). On May 21, 2010, DOE further informed the NRC that it was suspending all license application

tasks (DOE, 2010as). On September 30, 2010, DOE's Office of Civilian Radioactive Waste Management ceased operations and assigned its Yucca Mountain-related responsibilities to other offices within DOE. The cessation of these activities does not affect or alter the assumptions, data, and analyses DOE has provided in support of its license application with respect to the Performance Confirmation Program. Should a construction authorization issue, DOE must implement the approved Performance Confirmation Program.

2.4.3.1.2 Performance Confirmation Activities

In SER Sections 2.4.3.1.2.1 through 2.4.3.1.2.6, the NRC staff reviews the individual performance confirmation activities that DOE identified for precipitation monitoring, subsurface water and rock testing, unsaturated zone testing, saturated zone monitoring, saturated zone fault hydrology testing, and saturated zone alluvium testing. These activities are reviewed in this General Requirements for Performance Confirmation SER Section because they are activities not directly linked to the portion of the natural system that may potentially be perturbed by construction, operations, and emplacement. Other activities listed in SAR Table 4-1 are reviewed by the NRC staff in SER Sections 2.4.3.2 through 2.4.3.4.

2.4.3.1.2.1 Precipitation Monitoring

DOE described precipitation monitoring in SAR Section 4.2.1.1; DOE (2009gm); Performance Confirmation Plan, Section 3.3.1.1; and SNL (2013aa). DOE stated that the purpose of precipitation monitoring is to confirm the water flux input at the ground surface that is used in conceptual and numerical models of the hydrologic conditions described in SAR Section 2.3.1. DOE also stated that precipitation represents the predominant input of water into the upper natural barrier and that the information collected for this activity will confirm and extend the precipitation record for the site. DOE stated that precipitation monitoring began during site characterization, and DOE stated in SAR Section 4.2 that it will continue until closure.

Although DOE identified precipitation rate, quantity, and chemical composition as candidate parameters in SAR Table 4-1 and Performance Confirmation Plan Table 3-2, DOE (2009gm) clarified that the test plan will specify precipitation rate and precipitation quantity. DOE (2009gm) stated that these two parameters will meet the objectives of the activity. DOE stated in SNL (2013aa) that the baseline information will be the range of precipitation derived from the synthetic data records used in the Total System Performance Assessment simulations. In SNL (2013aa), DOE stated it would compare data from six monitoring stations with the baseline information used in the license application performance assessment. The DOE analysis will include comparison with the range of precipitation used in the performance assessment and trend analysis on the data from each station.

The NRC Staff Review

The NRC staff reviewed the description DOE provided for the precipitation monitoring activity. The NRC staff finds that the candidate parameters of precipitation rate and quantity are acceptable because they would measure the maximum possible water input into models that are used to represent the features and processes in the unsaturated zone of the Upper Natural Barrier. Also, the NRC staff finds DOE's description of baseline parameter development acceptable because it will use information from the performance assessment that reflects the flux of water at the ground surface. These NRC staff findings are also based on the NRC staff's understanding of the climate and infiltration at Yucca Mountain, obtained from prelicensing experience and the NRC staff's review in SER Section 2.2.1.3.5 (Climate and Infiltration).

Based on DOE's description, the NRC staff finds that the proposed precipitation monitoring activity meets the requirements of the relevant portions of 10 CFR 63.131(a), 10 CFR 63.131(c), and 10 CFR 63.131(d) because the program would

- Provide data that DOE can use in models of the unsaturated zone to demonstrate whether the Upper Natural Barrier is functioning as anticipated
- Provide baseline information and analysis for precipitation parameters so that DOE can monitor and analyze changes from baseline parameters that might affect performance of the geologic repository

2.4.3.1.2.2 Subsurface Water and Rock Testing

DOE described the subsurface water and rock testing activity in SAR Section 4.2.1.3 and in Performance Confirmation Plan Section 3.3.1.3. DOE stated that the purpose of this activity is to evaluate whether the Upper Natural Barrier functions as expected and to confirm that actual subsurface conditions encountered are consistent with observation and predictions, thereby verifying assumptions for the magnitude and distribution of flow paths used in conceptual and numerical models of the unsaturated zone. DOE stated that it will analyze pore-water samples derived from rock cores obtained from selected locations for performance confirmation for dissolved ions, analyze the rock cores for uranium and strontium isotopes, and obtain fracture coatings from within the drifts and analyze those coatings for isotope geochemistry. DOE initiated sampling and laboratory analysis of water, rock, and fracture-filling materials during site characterization and used the geochemical data to infer present and historical percolation fluxes at selected locations (SAR Section 2.3.2). DOE stated that it will continue this practice throughout repository construction. DOE stated that the first issuance of the performance confirmation test plan for this activity is scheduled for completion before subsurface construction.

In SAR Table 4-1 and Performance Confirmation Plan Table 3-2, DOE identified chloride concentration; isotopic composition for U, Sr, and O; H-3; Cl/Cl-36; Tc-99; and I-129/I-127 as the candidate parameters that will be used to infer water flux distribution and magnitude. DOE stated that baseline information will be identified in a performance confirmation test plan for subsurface water and rock testing and will be based on scientific analysis from performance assessment input data, analysis, and model information contained in the SAR and references cited therein.

The NRC Staff Review

The NRC staff reviewed the description DOE provided for the subsurface water and rock testing activity. The NRC staff finds that the suite of candidate parameters is acceptable because they reflect the behavior of features and processes related to the distribution of flow in the unsaturated zone that would indicate that the relevant portion of the Upper Natural Barrier is functioning as anticipated. Also, the NRC staff finds the DOE description of baseline development acceptable because it will use information from the performance assessment and from the SAR that reflects the flow and transport barrier capability of the Lower Natural Barrier. These NRC staff findings are also based on the NRC staff's understanding of the unsaturated zone at Yucca Mountain, obtained from prelicensing experience and the NRC staff's review in SER Section 2.2.1.3.6 (Unsaturated Zone Flow). The NRC staff finds that DOE's description of the subsurface water and rock testing activity meets the requirements of the relevant portions of 10 CFR 63.131 because the activity would

- Provide data that will indicate whether the actual hydrological conditions encountered during construction are within the limits assumed in SAR Section 2.3.2 and reports cited therein
- Provide data that will indicate whether the unsaturated zone water flux component of the Upper Natural Barrier is functioning as anticipated
- Provide baseline information and analysis for geochemical parameters used to infer water flux so that DOE can monitor and analyze changes from the baseline condition of parameters that might affect performance of the geologic repository

2.4.3.1.2.3 Unsaturated Zone Testing

DOE described the unsaturated zone testing activity in SAR Section 4.2.1.4 and Performance Confirmation Plan Section 3.3.1.4. DOE stated that the purpose of this activity is to confirm that sorptive properties of the Topopah Springs Tuff crystal-poor member below the repository are within established limits used in performance assessment models. DOE indicated that the sorptive properties of rock below the repository are a component of the Lower Natural Barrier that may affect retardation of radionuclides; and thus, can slow movement towards and reduce radionuclide levels at the accessible environment. DOE stated that it will use unsaturated zone testing to evaluate transport properties and field sorptive properties of the Topopah Spring Tuff crystal-poor member in ambient seepage alcoves or drifts where there are no waste packages. This DOE activity includes *in-situ* experiments, field mapping, field testing, and laboratory analysis of samples collected from the field tests. DOE stated that transport and sorption testing will be conducted in two or more seepage-monitoring alcoves located within the repository. DOE performed similar activities during site characterization to characterize comparable parameters in nonwelded tuffs below the repository. DOE stated that unsaturated zone testing will begin during construction and will continue to the early stages of the emplacement period.

In SAR Table 4-1 and Performance Confirmation Plan Table 3-2, DOE identified sorption parameters, van Genuchten parameters describing fractures and matrix, colloid/colloid-facilitated transport parameters, fracture density, apertures, coatings, air permeability, seepage, alcove temperature, and relative humidity as candidate parameters. DOE indicated that these candidate parameters were used in SAR Sections 2.3.2 and 2.3.8 to infer or support conceptual models and input parameters for flow and transport models and can be used during performance confirmation for the same purpose but in different geologic units. DOE stated that baseline information will be identified in a performance confirmation test plan for unsaturated zone testing and will be based on scientific analysis from performance assessment input data, analysis, and model information contained in the SAR and references cited therein.

The NRC Staff Review

The NRC staff reviewed the description DOE provided for the unsaturated zone testing activity. The NRC staff finds that the suite of candidate parameters is acceptable because the parameters reflect the behavior of features and processes related to flow and transport in the unsaturated zone that will indicate that the relevant portion of the Lower Natural Barrier is functioning as anticipated. Also, the NRC staff finds the DOE description of baseline development acceptable because it will use information from the performance assessment from the SAR that reflects the unsaturated flow and transport barrier capability of the Lower Natural

Barrier. These NRC staff findings are also based on the NRC staff's understanding of the unsaturated zone at Yucca Mountain, obtained from precicensing experience and the NRC staff's review in SER Section 2.2.1.3.7 (Radionuclide Transport in the Unsaturated Zone).

Based on DOE's description, the NRC staff finds that the subsurface water and rock testing activity meets the requirements of the relevant portions of 10 CFR 63.131 because the activity would

- Provide data that will indicate whether the actual conditions encountered during construction are within the limits assumed in SAR Sections 2.3.2 and 2.3.8 and reports cited therein
- Provide data that will indicate whether the unsaturated zone portion of the Upper Natural Barrier is functioning as anticipated
- Provide baseline information and analysis for geochemical parameters used to infer water flux so that DOE can monitor and analyze changes from the baseline condition of parameters that might affect performance of the geologic repository

2.4.3.1.2.4 Saturated Zone Monitoring

DOE described the saturated zone monitoring activity for the saturated volcanic rocks and alluvium in SAR Section 4.2.1.5 and Performance Confirmation Plan Section 3.3.1.5. DOE stated that the purpose of this activity is to evaluate hydrologic and chemical parameters used in the DOE saturated zone flow and transport models and includes monitoring the potential presence of repository radionuclides in downgradient wells and the arrival of radionuclides from upgradient sources, such as nuclear testing. The saturated zone flow and transport models encompass features and processes of the saturated zone that may limit or delay movement of radionuclides to the accessible environment and is part of the Lower Natural Barrier. DOE stated that (i) this activity began during site characterization, (ii) the test plan will be completed during construction (DOE, 2009gm, Table 1), and (iii) this activity will continue during the repository construction and emplacement periods until permanent closure (SAR Section 4.2.1.5).

DOE stated that saturated zone monitoring includes measuring water levels, Eh, and pH in site and Nye County wells, and analyzing radionuclide concentrations in water samples obtained from the wells. In SAR Table 4-1 and Performance Confirmation Plan Table 3-2, DOE identified water level and hydrochemical indicators (Eh, pH, radionuclide concentrations, and colloid characteristics) as the candidate parameters. DOE indicated that these candidate parameters were used in SAR Sections 2.3.9 to infer or support conceptual models and input parameters for flow and transport models in the saturated zone, and can be used during performance confirmation for the same purpose. DOE stated that baseline information will be identified in a performance confirmation test plan for saturated zone testing, and will be based on scientific analysis from performance assessment input data, analysis, and model information contained in the SAR and references cited therein.

The NRC Staff Review

The NRC staff reviewed the description DOE provided for the saturated zone monitoring activity. The NRC staff finds that the suite of candidate parameters is acceptable because the parameters reflect the behavior of features and processes related to flow and transport in the

saturated zone that will indicate that the relevant portion of the Lower Natural Barrier is functioning as anticipated. In SER Section 2.2.1.3.9, the NRC staff noted that changes to geochemical candidate parameter values (particularly Eh and pH), depending on magnitude and direction of the changes, may significantly change transport characteristics and, therefore, estimates of dose. Also, the NRC staff finds DOE's description of baseline development acceptable because it will use information from the performance assessment and the SAR that reflects the flow and transport barrier capability of the saturated zone portion of the Lower Natural Barrier. These NRC staff's findings are also based on the staff's understanding of the saturated zone at Yucca Mountain, obtained from precicensing experience and the NRC staff's review in SER Sections 2.2.1.3.8 (Saturated Zone Flow) and 2.2.1.3.9 (Radionuclide Transport in the Saturated Zone).

Based on DOE's description, the NRC staff finds that the subsurface water and rock testing activity meets the requirements of the relevant portions of 10 CFR 63.131(a), 10 CFR 63.131(c), and 10 CFR 63.131(d) because the activity would

- Provide data that will indicate whether the saturated zone conditions are within the limits assumed in SAR Section 2.3.9 and reports cited therein
- Provide data that will indicate whether the saturated zone portion of the Lower Natural Barrier is functioning as anticipated
- Provide baseline information and analysis for hydrochemical parameters used to infer radionuclide transport so that DOE can monitor and analyze changes from the baseline condition of parameters that might affect performance of the geologic repository

2.4.3.1.2.5 Saturated Zone Fault Hydrology Testing

DOE described the saturated zone fault hydrology testing activity in SAR Section 4.2.1.6 and in Performance Confirmation Plan Section 3.3.1.6. DOE stated that the purpose of this activity is to evaluate fault parameter assumptions used in the saturated zone flow and transport models. DOE described the tuff portion of the saturated zone barrier as complicated by faulting and tilting, with faults acting as both barriers to and preferential pathways for flow. DOE described its planned tests as similar to tests previously performed by DOE at the C-well testing complex, and may include monitoring of water levels, single borehole and cross-hole hydraulic and tracer tests, field sample collection, and laboratory analysis of samples. DOE stated that it plans to drill additional boreholes in or near faults to perform the testing. DOE identified the Solitario Canyon Fault system and an undetermined location downgradient of the repository as candidate test locations, with candidate formations including the Tertiary tuff, the Crater Flat Group, and the Paintbrush Group. DOE stated this activity will include several phases, each between 1 and 3 years in duration, and that it would be initiated by DOE during construction.

In SAR Table 4-1 and in Performance Confirmation Plan Table 3-2, DOE identified transmissivity; hydraulic conductivity; water flux and specific discharge; effective flow porosity; longitudinal dispersivity; sorption parameters; parameters describing diffusion between flowing and stagnant water; colloid or colloid-facilitated transport parameters; Eh; pH; and natural colloid concentrations, including anisotropy, as candidate parameters. DOE indicated that these candidate parameters were used in saturated zone modeling (SAR Section 2.3.9), to infer or support conceptual models and input parameters for other aspects of the flow and transport models, and can be used during performance confirmation for the same purpose for flow and transport modeling in faults of the saturated zone. DOE stated that baseline information will be

synthesized from performance assessment assumptions and from published results from analogue sites in fractured and faulted rocks (SNL, 2008aq, Section 3.3.1.6).

The NRC Staff Review

The NRC staff reviewed the description DOE provided for the saturated zone fault hydrology testing activity. The NRC staff finds that the suite of candidate parameters is acceptable because the parameters reflect the behavior of features and processes related to flow and transport in the saturated fault zones that will indicate whether the relevant portion of the Lower Natural Barrier is functioning as anticipated. Also, the NRC staff finds DOE's description of baseline parameter development acceptable because it will use information from the performance assessment and the SAR that reflects the flow and transport barrier capability of the saturated zone portion of the Lower Natural Barrier. These NRC staff findings are also based on the NRC staff's understanding of the saturated zone at Yucca Mountain, obtained from precicensing experience and the staff's review in SER Sections 2.2.1.3.8 (Saturated Zone Flow) and 2.2.1.3.9 (Radionuclide Transport in the Saturated Zone). Based on DOE's description, the NRC staff finds that the saturated zone fault hydrology testing activity meets the requirements of the relevant portions of 10 CFR 63.131 because the activity would

- Provide data that will indicate whether the actual hydrogeologic conditions in faults are within the limits assumed in SAR Section 2.3.9 and reports cited therein
- Provide data on the hydrogeologic behavior of faults that would indicate whether the saturated zone portion of the Lower Natural Barrier is functioning as anticipated
- Provide baseline information on the hydrogeological behavior of faults from assumptions and inputs used in saturated zone models supporting the performance assessment, and from analogue site data

2.4.3.1.2.6 Saturated Zone Alluvium Testing

DOE described the saturated zone alluvium testing activity in SAR Section 4.2.1.7, Performance Confirmation Plan Section 3.3.1.7, and DOE (2009gm). DOE stated that the purpose of this activity is to confirm inputs and assumptions for the alluvium in the DOE saturated zone flow and transport models. DOE stated that the activity will include testing and monitoring of the alluvium to measure direct and indirect values of parameters that characterize saturated zone hydrologic conditions in the alluvium south of the site. DOE stated that it will perform testing at the existing Alluvial Testing Complex, which is also the site of hydraulic testing performed by DOE during site characterization (SAR Section 2.3.9.2.2.1). DOE stated its planned tests will include monitoring of water levels, single borehole and cross-hole hydraulic and tracer tests in the saturated portion of the alluvium, field sample collection, and laboratory analysis. DOE also stated that it will conduct laboratory batch and column sorption tests to compare the sorption properties of tracers and radionuclides. DOE stated that testing associated with this activity is expected to be between 1 and 3 years in duration. DOE stated the testing at the Alluvial Testing Complex started during site characterization and that it "could be resumed at any time. DOE stated that the performance confirmation test plan for saturated zone alluvium testing will be completed during construction.

In SAR Table 4-1 and Performance Confirmation Plan Table 3-2, DOE identified transmissivity, hydraulic conductivity, water flux and specific discharge, effective flow porosity, longitudinal dispersivity, sorption parameters, parameters describing diffusion between flowing and stagnant

water, colloid or colloid-facilitated transport parameters, Eh, pH, and natural colloid concentrations as the candidate parameters. DOE indicated that these candidate parameters were used in SAR Section 2.3.9 to infer or support conceptual models and input parameters for other aspects of the flow and transport models and can be used during performance confirmation for the same purpose for flow and transport in faults of the saturated zone. DOE stated that baseline information will be synthesized from performance assessment assumptions and results and from analysis and model reports cited in the Performance Confirmation Plan (SNL, 2008aq, Section 3.3.1.7).

The NRC Staff Review

The NRC staff reviewed the description DOE provided for the saturated zone alluvium testing activity. The NRC staff finds that the suite of candidate parameters is acceptable because the parameters reflect the behavior of features and processes related to flow and transport in the saturated alluvium that will indicate that the relevant portion of the saturated zone of the Lower Natural Barrier is functioning as anticipated. Also, the NRC staff finds the DOE description of baseline development acceptable because it will use information from the performance assessment from the SAR that reflects the flow and transport barrier capability of the alluvium in the saturated zone portion of the Lower Natural Barrier. These NRC staff findings are also based on the NRC staff's understanding of the saturated zone at Yucca Mountain, obtained from prelicensing experience and the staff's review in SER Sections 2.2.1.3.8 (Saturated Zone Flow) and 2.2.1.3.9 (Radionuclide Transport in the Saturated Zone). Based on DOE's description, the NRC staff finds that the saturated zone alluvium testing activity meets the requirements of the relevant portions of 10 CFR 63.131 because the activity would

- Provide data that will indicate whether the hydrogeologic conditions in the alluvium are within the limits assumed in SAR Section 2.3.9 and reports cited therein
- Provide data that will indicate whether the saturated alluvial portion of the Lower Natural Barrier is functioning as anticipated
- Provide baseline information on the hydrogeological behavior of alluvium from assumptions and inputs used in saturated zone models supporting the performance assessment

2.4.3.1.3 Summary of the NRC Staff Evaluation on General Requirements for Performance Confirmation

The NRC staff reviewed DOE's description of the Performance Confirmation Program in SAR Sections 4.1 and 4.2 and the Performance Confirmation Plan.

On the basis of the NRC staff's evaluation in SER Sections 2.4.3.1.1 (concerning the general description of a Performance Confirmation Program) and 2.4.3.1.2 (concerning the individual activities of precipitation monitoring, subsurface water and rock testing, unsaturated zone testing, saturated zone monitoring, saturated zone fault hydrology testing, and saturated zone alluvium testing), the NRC staff finds, with reasonable assurance, that

- The regulatory requirements at 10 CFR 63.131(a) are satisfied because DOE described a program that will provide data to indicate whether (i) actual subsurface conditions encountered and changes in those conditions during construction and waste

emplacement operations are within the limits assumed in the SAR and (ii) natural and engineered systems and components that are designed or assumed to operate as barriers after permanent closure are functioning as intended and anticipated.

- The regulatory requirement at 10 CFR 63.131(b) is satisfied because DOE described a program that began during site characterization and will continue until permanent closure.
- The regulatory requirement at 10 CFR 63.131(c) is satisfied because DOE described a program that would include *in-situ* monitoring, laboratory and field testing, and *in-situ* experiments that will provide data required by 10 CFR 63.131(a).
- The regulatory requirements at 10 CFR 63.131(d)(1),(2),(3) are satisfied because DOE described a program that will be implemented so that (i) it does not adversely affect the ability of the geologic and engineered systems to meet performance objectives; (ii) it provides baseline information and analysis on identified parameters and processes that may be changed by site characterization, construction, and operation; and (iii) it monitors and analyzes changes of parameters from baseline conditions that could affect repository performance.

2.4.3.2 Confirmation of Geotechnical and Design Parameters

DOE provided information addressing confirmation of geotechnical and design parameters in SAR Sections 4.1.1, 4.1.3, 4.2.1, and 4.2.2; SAR Tables 4-1 and 4-2; and DOE (2009gm). In SAR Section 4.2.2, DOE stated that the Performance Confirmation Program includes a continuing program of surveillance, geotechnical testing, and geologic mapping to confirm geotechnical and design parameters, as well as evaluation of thermal effects on geotechnical parameters. In SAR Table 4-1 and Section 4.2, DOE provided a description of the activity and candidate parameters for eight geotechnical and design parameter activities. These activities, which the NRC staff reviews under 10 CFR 63.132 (Confirmation of geotechnical and design parameters) are (i) seepage monitoring, (ii) drift inspection, (iii) thermally accelerated drift near-field monitoring, (iv) thermally accelerated drift in-drift environment, (v) subsurface mapping, (vi) seismicity monitoring, (vii) construction effects monitoring, and (viii) thermally accelerated drift thermal-mechanical monitoring.

The NRC staff's evaluation of geotechnical and design parameters is organized into three sections: (i) the Program for Measuring, Testing, and Geologic Mapping (SER Section 2.4.3.2.1); (ii) the Surveillance Program to Evaluate Subsurface Conditions Against Design Assumptions (SER Section 2.4.3.2.2); and (iii) Thermally Accelerated Drift Thermal-Mechanical Monitoring (SER Section 2.4.3.2.3).

2.4.3.2.1 Program for Measuring, Testing, and Geologic Mapping

In SAR Section 4.2.2, DOE described the geotechnical and design monitoring and testing that would occur during construction and operations to confirm geotechnical and design parameters. The geotechnical and design parameter activities described by DOE are (i) seepage monitoring (SAR Section 4.2.1.2), (ii) drift inspection (SAR Section 4.2.1.8), (iii) thermally accelerated drift near-field monitoring (SAR Section 4.2.1.9), (iv) thermally accelerated drift in-drift environment (SAR Section 4.2.1.11), (v) subsurface mapping (SAR Section 4.2.2.1), (vi) seismicity

monitoring (SAR Section 4.2.2.2), (vii) construction effects monitoring (SAR Section 4.2.2.3), and (viii) thermally accelerated drift thermal-mechanical monitoring (SAR Section 4.2.2.4).

The NRC staff reviews seven of eight activities listed above that comprise surveillance, measurement, testing, geologic mapping activities [10 CFR 63.132(a)] in SER Sections 2.4.3.2.1.2 through 2.4.3.2.1.7, and reviews the eighth activity listed above, thermally accelerated drift thermal-mechanical monitoring [10 CFR 63.132(e)], in SER Section 2.4.3.2.3.

2.4.3.2.1.1 Seepage Monitoring

DOE described seepage monitoring in SAR Section 4.2.1.2 and Performance Confirmation Plan Section 3.3.1.2. DOE stated the purpose of the seepage monitoring activity is to evaluate the spatial and temporal distributions of seepage flux derived from the seepage models for ambient and thermally perturbed conditions. In addition, DOE stated it would obtain samples of seepage water, if possible, for chemical analysis. DOE stated that seepage water provides the primary medium for radionuclide release and transport from the EBS, and that the seepage water chemistry influences possible engineered component degradation that may be induced through aqueous corrosion. DOE included seepage process and abstraction in the Upper Natural Barrier, and noted that seepage flux is an output parameter from the Upper Natural Barrier that is provided to the EBS.

DOE stated that it plans to conduct specific tests or measurements in (i) unventilated (sealed) alcoves (using remote video systems to identify seepage) or boreholes; (ii) the thermally accelerated drift (see SER Section 2.4.3.2.1.5) using remote video systems to identify seepage and monitoring of humidity and temperature of the air exiting the drift; (iii) drifts prior to emplacement as part of the drift inspection program (SER Section 2.4.3.2.1.3); and (iv) ventilation inlet areas to characterize barometric pressure, humidity, temperature, and wind speed of ventilated air. DOE indicated that (i) seepage was monitored in sealed, ambient-condition alcoves and in the Enhanced Characterization of the Repository Block Cross-Drift (ECRB) during site characterization, (ii) the seepage monitoring test plan will be completed before subsurface construction (DOE, 2009gm, Table 1), (iii) seepage monitoring will begin as subsurface construction proceeds, and (iv) seepage monitoring will continue through closure.

In SAR Table 4-1 and Performance Confirmation Plan Table 3-2, DOE identified seepage rate, locations, and quantity and chemical composition as candidate monitoring parameters. In addition, DOE stated it would monitor the barometric pressure, temperature, and humidity of ventilated air as candidate parameters. DOE stated that the baseline data for this activity would be synthesized from the seepage model results in the performance assessment, as well as from seepage reports cited in the SAR.

The NRC Staff Review

The NRC staff reviewed the description DOE provided for the seepage monitoring. The NRC staff finds that these candidate parameters are appropriate because they include direct measures of the quantity and quality of waters that may seep into mined openings at Yucca Mountain under ambient (unventilated) and low temperature conditions, as well as indirect measures (barometric pressure, temperature, and humidity) that may be used to perform a liquid vapor water balance and thereby estimate alterations in seepage as induced by evaporation under thermally loaded conditions. Also, the NRC staff finds DOE's description of baseline parameter development acceptable because baseline information will be synthesized by DOE from performance assessment results, as well as from analysis and model reports cited

in SNL (2008aq, Section 3.3.1.2). These NRC staff findings are also based on the staff's understanding of seepage processes and unsaturated zone and engineered features at Yucca Mountain, obtained from precicensing experience and the NRC staff's review in SER Section 2.2.1.3.6 (Unsaturated Zone Flow).

Based on DOE's description, the NRC staff finds that the proposed seepage monitoring activity meets the requirements of the relevant portions of 10 CFR 63.132 because the program would

- Provide data to demonstrate whether the Upper Natural Barrier is functioning as anticipated
- Provide data to confirm subsurface conditions related to seepage
- Provide baseline information and analysis for seepage parameters so that DOE can monitor and analyze changes from baseline values of parameters that might affect performance of the geologic repository

2.4.3.2.1.2 Drift Inspection

DOE described the drift inspection activity in SAR Section 4.2.1.8 and Performance Confirmation Plan Section 3.3.1.8. DOE stated that the purpose of the activity is to evaluate drift stability assumptions and rockfall size and to confirm by direct observation that the engineered barriers are performing as designed and that the design preserves until closure the option to retrieve waste. To evaluate these criteria, DOE stated that it plans to perform regular nonemplacement drift inspections, as well as periodic inspections of selected emplacement drifts and a thermally accelerated drift. DOE stated that it also plans to perform reactive observations of the condition of underground openings subsequent to any significant seismic events. DOE stated that the drift inspection activity will begin during operations and continue through to closure.

In SAR Table 4-1 and Performance Confirmation Plan Table 3-2, DOE identified temperature, humidity, seepage, rockfall size and frequency, ground support conditions, engineered barrier component positions (such as waste package positions and rail alignment), and drift continuity as candidate monitoring parameters. DOE stated that certain plans are conceptual in nature because the monitoring devices are not presently available, and further development of specific monitoring devices will be needed. For example, DOE explained that a remote monitoring device capable of obtaining data in the high-temperature and high-radiation environment of emplacement and thermally accelerated drifts is presently not available. DOE described the development of baseline values for this activity as being derived from drift stability analysis and model reports cited in the Performance Confirmation Plan (SNL, 2008aq, Section 3.3.1.8), which included assumptions used in conceptual models and ranges used for inputs in numerical models for drift stability.

The NRC Staff Review

The NRC staff reviewed the description DOE provided for the drift inspection activity. The NRC staff finds that the candidate parameters are appropriate because they include (i) direct measures of drift geomechanical conditions for emplacement, thermally accelerated, and nonemplacement drifts; (ii) parameters used in drift stability calculations (e.g., temperature); and (iii) measures that can be used to evaluate the consequence of drift degradation

(e.g., temperature, humidity, and seepage). The NRC staff notes that future development of monitoring devices is assumed in the DOE description of the drift inspection activity. The NRC staff finds this approach acceptable because, as noted in NRC (2001aa), the Commission does not want to limit DOE's options regarding testing methodologies for activities that will occur in the future, and (ii) test plans that would include details of the tests are not required at the time of the construction authorization application, though DOE stated that the test plans would be finalized prior to implementation of the test or monitoring activity. Also, the NRC staff finds DOE's description of baseline parameter development acceptable because baseline information will be developed from DOE analysis and model reports used to support drift stability assumptions and model input data in the SAR. These NRC staff findings are also based on the NRC staff's understanding of geotechnical and seepage processes at mined openings at Yucca Mountain, obtained from prelicensing experience and the NRC staff's review in SER Section 2.2.1.3.2 (Mechanical Disruption of Engineered Barriers) and 2.2.1.3.6 (Unsaturated Zone Flow).

Based on DOE's description, the NRC staff finds that the proposed drift inspection activity meets the requirements of the relevant portions of 10 CFR 63.132 because the program would

- Provide data for in-drift stability and seepage models to demonstrate whether the EBS is functioning as anticipated
- Provide data to confirm subsurface conditions related to drift integrity and flux of water at drift walls
- Identify specific geotechnical parameters to be measured or observed, including their connection to interactions between natural and engineered systems and components
- Provide baseline information and analysis for geotechnical and seepage parameters so that DOE can monitor and analyze changes from baseline values of parameters that might affect performance of the geologic repository

2.4.3.2.1.3 Thermally Accelerated Drift Near-Field Monitoring

DOE described thermally accelerated drift near-field monitoring in SAR Section 4.2.1.9 and in Performance Confirmation Plan Section 3.3.1.9. DOE stated that the purpose of the near-field monitoring for the thermally accelerated drift is to assess the modeled repository performance bases pertaining to drift seepage. DOE indicated that this activity supports the bases for barrier capabilities of the Upper Natural Barrier and the EBS. DOE will use information from the *in-situ* thermally accelerated drift test to evaluate conceptual model assumptions and input parameters in the thermal-hydrologic-mechanical-chemical models for the near-field environment (coupled processes), and output results from those thermal-hydrologic-mechanical-chemical models would be used to support abstractions in the performance assessment. DOE stated that it will perform monitoring using boreholes drilled into the near-field rock from an observation drift adjacent to the thermally accelerated drift. DOE also stated that it will test the rock core collected from the boreholes to confirm *in-situ* rock moisture content and chemistry and to monitor changes resulting from heating due to emplaced waste. DOE also stated that arrays of boreholes will be designed for specific tests to be performed. DOE identified the following monitoring methods that may be used for data collection in the near-field surrounding the drift: (i) in-hole logging of water saturation using neutron and induction logging, (ii) tomographic analysis utilizing electrical resistivity and ground penetrating radar, (iii) air permeability testing

using gas injection and associated pressure response, (iv) chemical analysis of water obtained from cores, (v) rock displacement and stress measurements, and (vi) temperature sensors. DOE's plan consists of constructing a drift to be used for the thermally accelerated tests by emplacing actual waste packages and closing the drift; thus, no active ventilation will be used to remove heat, unlike in the emplacement drifts. DOE stated that the first issuance of the performance confirmation test plan for this activity is scheduled for the operation period. In SAR Section 4.2.2.4, DOE stated that it plans to initiate these tests during repository operations and will continue them until closure.

In SAR Table 4-1 and Performance Confirmation Plan Table 3-2, DOE identified rock-mass moisture content, temperature and thermal gradients, fracture air permeability, mechanical deformation, mechanical properties, and water chemistry as candidate monitoring parameters. DOE indicated that baseline information will be developed from (i) comparisons made with thermal tests performed during site characterization but done under different conditions, configurations, and features (e.g., different rock types), which are cited in analysis and model reports cited in SNL (2008aq, Section 3.3.1.9), and (ii) new information on thermal loading that becomes available upon receipt and characterization of waste packages.

The NRC Staff Review

The NRC staff reviewed the description DOE provided for the thermally accelerated drift near-field monitoring activity. The NRC staff finds that these candidate parameters for thermal characteristics (i.e., temperature and thermal gradients), hydrologic characteristics (i.e., rock-mass moisture content, air permeability), mechanical characteristics (i.e., mechanical deformation and mechanical properties), and chemical characteristics (i.e., water chemistry) are acceptable because (i) thermal, hydrological, mechanical, and chemical processes significantly affect near-field model results; and (ii) the identified candidate parameters for each of the four characteristics are the most important parameters for indicating significant changes to the behavior for each characteristic. Also, the NRC staff finds the DOE description of baseline parameter development acceptable because baseline information, although not yet available because it relates to conditions created by actual waste packages or to conditions in rock units different from those encountered in previous tests done during site characterization, will be developed from numerical models and thermal evaluations cited in the Performance Confirmation Plan (SNL, 2008aq, Section 3.3.1.9). These NRC staff findings are also based on the staff's understanding of thermal-hydrological-mechanical-chemical processes in the near-field at Yucca Mountain, obtained from prelicensing experience and the NRC staff's review in SER Sections 2.2.1.3.6 (Unsaturated Zone Flow) and 2.2.1.3.2 (Mechanical Disruption of Engineered Barriers).

Based on DOE's description, the NRC staff finds that the proposed thermally accelerated drift near-field monitoring activity meets the requirements of the relevant portions of 10 CFR 63.132 because the program would

- Provide data to demonstrate whether the EBS is functioning as anticipated under conditions that represent those in emplacement drifts
- Provide baseline information and analysis for thermal-hydrological-mechanical-chemical parameters so that DOE can monitor and analyze changes from baseline values of parameters that might affect performance of the geologic repository

2.4.3.2.1.4 Thermally Accelerated Drift In-Drift Environment Monitoring

DOE described thermally accelerated drift in-drift environment monitoring in SAR Section 4.2.1.11, DOE (2009gm), and Performance Confirmation Plan Section 3.3.1.11. DOE stated that the purpose of thermally accelerated drift in-drift environment monitoring is to provide information to evaluate the in-drift physical and chemical environment to support evaluating performance lifetimes of the waste package container and drip shield supports under conditions expected in the emplacement drifts. DOE stated that the information it obtains will be used to evaluate assumptions used in in-drift physical and chemical environment models. DOE stated that it plans to use a remote monitoring device to obtain data within the thermally accelerated drift. DOE stated that, as demonstrated in the Drift Scale Test during site characterization, the technology to provide a remote means to make measurements in bulkheaded alcoves is available. DOE stated that the high-temperature and high-radiation environments representative of post emplacement conditions in a thermally accelerated drift would require integration of specific technology that is not yet available to accomplish measurements and inspections. DOE stated that details of the test methodology will be developed and documented in the detailed performance confirmation test plan. DOE also stated that monitoring will begin after constructing the *in situ* thermally accelerated drift and emplacement of waste packages and will continue until permanent closure.

In SAR Table 4-1 and Performance Confirmation Plan Table 3-2, DOE identified the following candidate monitoring parameters: temperature; relative humidity; gas composition; radionuclides; pressure; radiolysis; thin films evaluation; condensation water quantities; and composition or ionic characteristics, including microbial effects. DOE stated that baseline information will be synthesized from analysis and model reports covering in-drift conditions cited in SNL (2008aq, Section 3.3.1.11), and new information on thermal loading that becomes available on receipt and characterization of waste packages.

The NRC Staff Review

The NRC staff reviewed the description DOE provided for the thermally accelerated drift in-drift environment monitoring activity. The NRC staff finds that the candidate parameters are acceptable because they directly assess the in-drift environmental conditions that affect the performance of EBS components. The NRC staff notes that future development of monitoring devices is assumed in the DOE description of the drift inspection activity. The NRC staff finds this uncertainty acceptable because, as noted in NRC (2001aa), the Commission does not want to limit DOE's options regarding testing methodologies for activities that will occur in the future, and (ii) test plans that would include details of the tests are not required at the time of the construction authorization application, though the test plans would be finalized prior to implementation of the test or monitoring activity. Also, the NRC staff finds the DOE description of baseline parameter development acceptable because baseline information of expected conditions (i.e., the baseline) would be synthesized from information in analysis and model reports using *in situ* heater tests performed at temperatures similar in magnitude to that expected in the test activity; although information on the actual conditions created by emplaced waste packages does not exist at this time. These NRC staff findings are also based on the staff's understanding of conditions and processes in the in-drift physical and chemical environment at Yucca Mountain, obtained from precicensing experience and the NRC staff's review in SER Sections 2.2.1.3.1 (Degradation of Engineered Barriers) and 2.2.1.3.3 (Quantity and Chemistry of Water Contacting Engineered Barriers and Waste Forms).

Based on DOE's description, the NRC staff finds that the proposed thermally accelerated drift in-drift environment monitoring activity meets the requirements of the relevant portions of 10 CFR 63.132 because the program would

- Provide data to demonstrate whether the EBS is functioning as anticipated
- Identify geotechnical and design parameters and interactions between natural and engineered systems and components
- Provide baseline information and analysis for thermal-hydrological-mechanical-chemical parameters so that DOE can monitor and analyze changes from baseline values of parameters that might affect performance of the geologic repository

2.4.3.2.1.5 Subsurface Mapping

DOE described the subsurface mapping activity in SAR Section 4.2.2.1 and in the Performance Confirmation Plan Section 3.3.2.1. DOE stated that the purpose of the subsurface mapping is to confirm that the actual subsurface conditions encountered during construction are within the range of conditions used for design and performance assessment. DOE stated that the activity will provide information during construction and operation to support evaluations of (i) designed ground support components, (ii) the stability of emplacement and non-emplacement openings, (iii) predictions of thermal loading on the walls of emplacement drifts based on thermohydrologic modeling using updated information or actual thermal output of emplaced waste, (iv) near-field hydrologic characteristics of the emplacement drifts, and (v) the presence of anomalous infillings that might have deleterious effects on waste isolation characteristics of the repository. DOE stated that mapping will begin soon after underground construction begins; will be conducted as new drifts, mains, and shafts are excavated; and will end soon after the last opening is excavated. DOE stated that the first issuance of the performance confirmation test plan for this activity is scheduled for the construction period, before subsurface construction (DOE, 2008gm, Table 1).

In SAR Table 4-1 and Performance Confirmation Plan Table 3-2, DOE identified fracture characteristics (e.g., orientation, length, infilling, aperture), fault zone characteristics (offset, location, and age), stratigraphic contacts, and lithophysal characteristics as candidate parameters. DOE stated that the candidate parameters provide supporting information for characterizing geomechanical, hydrological, and thermal properties. DOE stated that baseline information for this activity would be derived from integrated site models, which includes the three-dimensional representations of the rock layers and faults, hydrological and thermal rock properties, and mineral abundance.

The NRC Staff Review

The NRC staff reviewed the description DOE provided for the subsurface mapping activity. The NRC staff finds that these candidate parameters are appropriate because they can be used directly to confirm anticipated subsurface conditions that have been used by DOE to construct models pertinent to performance assessment and repository design. Also, the NRC staff finds that the DOE description of baseline parameter development is acceptable because baseline information will be derived from the integrated site models, which are the three-dimensional representations of the geology at Yucca Mountain that were developed during site characterization and used in the SAR. These NRC staff findings are also based on the staff's

understanding of the subsurface geology at Yucca Mountain, obtained from precicensing experience and the staff's review of the site geology in SER General Information Section 1.5, and from the staff's review of subsurface geology in SER Volumes 2 and 3 (e.g., SER Sections 2.1.1.1 through 2.1.1.4, 2.1.1.7, 2.2.1.1, 2.2.1.2.1, 2.2.1.2.2, 2.2.1.3.2 through 2.2.1.3.10, and 2.2.1.3.14 through 2.2.1.3.15).

Based on the DOE description, the NRC staff finds that the proposed subsurface mapping activity meets the requirements of the relevant portions of 10 CFR 63.132 because the program would

- Provide subsurface mapping data to confirm subsurface features and conditions related to geology are within limits assumed in the SAR
- Provide subsurface mapping data to ensure that geotechnical and design parameters are confirmed
- Provide subsurface mapping data to evaluate against design assumptions
- Identify specific geotechnical parameters to be measured or observed, including their connection to interactions between natural and engineered systems and components

2.4.3.2.1.6 Seismicity Monitoring

DOE described seismicity monitoring in SAR Section 4.2.2.2, DOE (2009gm), Performance Confirmation Plan Section 3.3.2.2, and the Performance Confirmation Test Plan for Seismicity Monitoring (SNL, 2007bo). DOE stated that the purposes of seismicity monitoring are to assess the regional seismic activity that is used in simulations of the seismic disruption scenario to evaluate the barrier capability of the Engineered Barrier System (EBS) and to collect field observations of any large magnitude fault displacement after significant local or regional seismic events. DOE stated that the methodology would include use of the existing area/regional seismic monitoring network and onsite monitoring and inspections identified in SNL Tables 2-3 and 2-4 (2007bo) following a significant seismic event. DOE's seismicity monitoring began during site characterization in the Exploratory Studies Facility (ESF) and ECRB. DOE stated that the monitoring at the existing stations would continue through repository closure.

DOE identified candidate parameters for seismicity monitoring in SAR Table 4-1 and SNL (2007bo). The candidate parameters are event detection; event magnitude; event location; strong-motion data collection and analysis; and seismic attenuation investigations {within 50 km [31.1 mi]}. DOE indicated that the baseline information of expected range and condition limits is developed from historical records and analyses in SNL (2008aq, Section 3.3.2.2).

The NRC Staff Review

The NRC staff reviewed the description DOE provided for the seismic monitoring activity. The NRC staff finds that these parameters are appropriate because they can be used to (i) re-evaluate the historic earthquake information distribution and spectra, (ii) re-evaluate inputs used for the preclosure seismic design of the repository, and (iii) assess the impact of future seismic activity on the repository. Also, the NRC staff finds DOE's description of baseline parameter development acceptable because baseline information is derived from a catalog of historical and instrumentally recorded earthquakes that was compiled for the region within

300 km [186.4 mi] of the repository site and used in the SAR. These NRC staff findings are also based on the staff's understanding of seismic probabilities and consequences at Yucca Mountain, obtained from prelicensing experience and the NRC staff's review in SER Section 2.2.1.3.2 (Mechanical Disruption of Engineered Barriers).

Based on DOE's description, the NRC staff finds that the proposed drift inspection activity meets the requirements of the relevant portions of 10 CFR 63.132 because the program would

- Provide data for drift stability models to demonstrate whether the EBS is functioning as anticipated
- Provide data to confirm subsurface conditions related to drift integrity
- Provide data for specific geotechnical parameters, including their connection to interactions between natural and engineered systems and components
- Provide baseline information and analysis for seismic and geotechnical processes and features so that DOE can monitor and analyze changes from baseline values of parameters that might affect performance of the geologic repository

2.4.3.2.1.7 Construction Effects Monitoring

DOE described construction effects monitoring in SAR Section 4.2.2.3, DOE (2009gm), Performance Confirmation Plan Section 3.3.2.3, and BSC (2006a). DOE stated that the purpose of the construction effects monitoring activity is to monitor the response (e.g., drift wall movement, rockfall) of emplacement and main drift excavations to confirm drift degradation analysis predictions and assumptions, underground opening stability, and the ability to retrieve waste. DOE stated that geomechanical conditions observed for the construction effects monitoring activity supports evaluation of the Upper and Lower Natural Barriers. DOE stated that construction effects monitoring (i) began during site characterization, (ii) will continue during construction, (iii) will cease in emplacement drifts after waste is emplaced, and (iv) will continue long-term monitoring in mains and shafts until closure SNL (2008aq, Section 3.3.2.2).

DOE identified candidate parameters and methodologies for observations and measurements in SAR Table 4-1 and Performance Confirmation Plan Table 3-2 as (i) drift convergence using tape and rod extensometers; (ii) tunnel stability using visual observations; (iii) engineered ground support systems evaluation using visual observation; and (iv) geotechnical parameter measurements by laboratory and field tests (for example, *in-situ* rock stress measurements) at selected locations representative of rock properties from the subsurface mapping activity. DOE's measurement methodology includes convergence pins, multipoint extensometers, and single-point extensometers. DOE described the proposed methods, locations, and timing of its measurements for the types of measurement methods listed above (BSC, 2006a); the locations and timing depend on the type of measurement method. DOE stated in SAR Section 4.2.2.3 that baseline development for rock properties would be derived from observations made during site characterization and geotechnical design and model analyses.

The NRC Staff Review

The NRC staff reviewed the description DOE provided for the construction effects monitoring activity in SAR Section 4.2.2.3, Performance Confirmation Plan Section 3.3.2.3, and

BSC (2006a). The NRC staff finds that the proposed candidate parameters are acceptable because they are a direct measure of the mechanical deformation and degradation of a drift. Also, the NRC staff finds DOE's description of baseline parameter development acceptable because (i) baseline information will be synthesized from reports cited in BSC (2004a) and the SAR, and (ii) baseline for parameters in BSC Tables 1-1 and 1-2 (2006a) are consistent with DOE's ground control analyses that support the subsurface design reviewed by the NRC staff in SER Section 2.1.1.2.3.7.2 and 2.1.1.2.3.7.3. Based on the above and knowledge gained from precicensing interactions with DOE and the NRC staff's review in SER Section 2.2.1.3.2 (Mechanical Disruption of Engineered Barriers), the NRC staff finds acceptable DOE's selection of candidate parameters, description of locations and modes of measurement, and description of baseline development.

Based on DOE's description, the NRC staff finds that the construction effects monitoring activity meets the requirements of the relevant portions of 10 CFR 63.132 because DOE's description indicates that the program will

- Provide data to monitor subsurface conditions and evaluate against design assumptions during the construction and operation periods.
- Provide baseline information and analysis of parameters for construction effects so that DOE can monitor and analyze changes from baseline condition that might affect performance of the geologic repository.
- Identify specific geotechnical parameters to be measured or observed, including their connection to interactions between natural and engineered systems and components.

2.4.3.2.2 Surveillance Program to Evaluate Subsurface Conditions Against Design Assumptions

In SAR Section 4.2.2, DOE stated that the Performance Confirmation Program includes a continuing program of surveillance, geotechnical testing, and geologic mapping to confirm geotechnical and design parameters during repository construction and operation.

DOE indicated that the drift inspection, subsurface mapping, and construction effects monitoring performance confirmation activities are the components of a surveillance program to evaluate subsurface conditions against design assumptions during the construction and operation periods. DOE also stated that other performance confirmation activities would provide supporting information for surveillance, geotechnical testing, and geologic mapping to confirm geotechnical and design parameters, including the activities of seepage monitoring, thermally-accelerated drift near-field monitoring, thermally accelerated drift in-drift environment monitoring, seismicity monitoring, and thermally accelerated drift thermomechanical monitoring. DOE stated that geotechnical and design monitoring and testing will occur during repository construction and operations. DOE also stated that the monitoring and testing program will include (i) monitoring of subsurface conditions; (ii) comparison of measurements and observations with the original design bases and assumptions; (iii) comparison of performance confirmation monitoring and measurement results with the original design bases and assumptions to determine the need for design modifications and changes to construction methods, if necessary, as described in SAR Section 4.1.3; (iv) evaluation of the significance of performance confirmation monitoring and measurement results, as described in SAR

Section 4.1.3; and (v) reporting performance confirmation results and the evaluation of impacts on repository performance.

As DOE described in SAR Section 4.1.1, DOE evaluations of impacts on repository performance would provide information that could lead DOE to report recommended design or construction method changes to the NRC. In SAR Section 4.1.3, DOE described a procedure for documenting and reporting exceedance of limits for parameters derived from expected ranges and uncertainty as derived from inputs, assumptions, or performance assessment results. DOE stated it plans to (i) notify the NRC when a monitored geotechnical or design parameter exceeds condition limits established in the performance confirmation test plans; (ii) submit a subsequent evaluation report providing detailed information on the event, including recommended changes, if any, after initial NRC notification; and (iii) provide information to the NRC with respect to changes, tests, experiments, and deficiencies.

The NRC Staff Review

The NRC staff evaluated the information in SAR Sections 4.1.1, 4.1.3, 4.2.1.8, and 4.2.2–4.2.2.4 and the Performance Confirmation Plan on DOE's surveillance program to evaluate subsurface conditions against design assumptions. The NRC staff finds that the subsurface mapping, drift inspections, and construction effects monitoring activities, plus relevant supporting information from the seepage monitoring, thermally-accelerated drift near-field monitoring, thermally accelerated drift in-drift environment monitoring, seismicity monitoring, and thermally accelerated drift thermomechanical monitoring activities, comprise an acceptable surveillance program to evaluate subsurface conditions because these activities would provide data to confirm the design bases, assumptions, and modeling results. The NRC staff evaluation of each of the activities providing data on surveillance, measurements, and geologic mapping are in SER Sections 2.4.3.2.1 and 2.4.3.2.3.

The NRC staff finds that DOE's description of a surveillance program is acceptable for confirming geotechnical and design parameters because it includes provisions for (i) determining the need for modifications to the design or construction methods if significant differences exist between measurements and observations and original design bases and assumptions and (ii) reporting differences between measurements and observations and the original design bases and assumptions, their significance to health and safety, and recommended changes to NRC. Therefore, the NRC staff finds that DOE's description of a reporting procedure meets the relevant requirements of 10 CFR 63.132(a) and (d).

2.4.3.2.3 Thermally Accelerated Drift Thermal-Mechanical Monitoring

DOE described thermally accelerated drift thermal-mechanical monitoring in SAR Section 4.2.2.4, DOE (2009gm), and the Performance Confirmation Plan Section 3.3.2.4. DOE stated that the purpose of thermally accelerated drift thermal-mechanical monitoring is to assess deformation of the drift periphery and invert under thermal conditions, thereby providing an indication of overall drift stability in conjunction with construction effects monitoring and drift inspection. DOE stated that it plans to remotely monitor deformation of the drift periphery and invert, anticipating that existing technology must be adapted to the high-temperature and high-radiation environment within the thermally accelerated drift. DOE stated that (i) a thermally accelerated drift thermal-mechanical monitoring test plan will be completed during operations (DOE, 2009gm, Table 1), (ii) the activity will begin after construction of the thermally accelerated drift and emplacement of waste packages, and (iii) monitoring will continue until closure (SNL, 2008aq, Section 3.3.2.4).

In SAR Table 4-1 and Performance Confirmation Plan Table 3-2, DOE identified drift convergence, drift shape, drift degradation, ground support visual condition, rail alignment, invert visual condition, pallet visual condition, waste package alignment, and spacing as candidate monitoring parameters. DOE stated that the observations and measurements from the thermally accelerated drift thermal-mechanical monitoring activity would be compared to thermal-mechanical-hydrological-chemical model results to determine if assumptions of rock properties and drift stability exceed a predetermined limit, which would be based on DOE's evaluation of the effect on performance assessment results (SNL, 2008aq, Section 3.3.2.4).

The NRC Staff Review

The NRC staff reviewed the description DOE provided for the thermally accelerated drift thermal-mechanical monitoring activity. The NRC staff finds that these candidate parameters are acceptable because they directly assess the mechanical deformation of the drift and emplaced Engineered Barrier System (EBS) components and interactions between the natural system and engineered systems and components. Also, the NRC staff finds DOE's description of baseline parameter development acceptable because baseline information, although not yet available because it relates to conditions created by actual waste packages, would be synthesized from ranges and distributions for geotechnical parameters and design bases used in preclosure design and postclosure performance analyses. These NRC staff findings are also based on the staff's understanding of the thermomechanical processes at Yucca Mountain, obtained from prelicensing experience and the staff's review in SER Section 2.2.1.3.2 (Mechanical Disruption of Engineered Barriers).

Based on DOE's description, the NRC staff finds that the proposed subsurface mapping activity meets the requirements of the relevant portions of 10 CFR 63.132 because the program would

- Conduct monitoring of thermomechanical response in a thermally accelerated drift until closure
- Provide data to confirm the thermomechanical response of the natural system and the engineered systems and to confirm that components are within limits assumed in the SAR
- Provide baseline information that can be used to confirm, along with the construction effects and drift inspection activities, that the thermomechanical response of the natural system and the engineered systems and components are within design limits

2.4.3.2.4 Summary of the NRC Staff Evaluation on Confirmation of Geotechnical and Design Parameters

The NRC staff reviewed DOE's confirmation of geotechnical and design parameters. On the basis of the NRC staff's evaluation in SER Sections 2.4.3.2.1 through 2.4.3.2.3, the NRC staff finds that DOE's plans for confirmation of geotechnical and design parameters are acceptable because

- The Performance Confirmation Plan establishes a program during construction and operation for surveillance, measurement testing, and geologic mapping, to confirm geotechnical and design parameters, including natural processes, pertaining to natural

systems and components that are assumed to operate as barriers after permanent closure [10 CFR 63.132(a)].

- DOE's program includes provisions for monitoring subsurface conditions against design assumptions during repository construction and operation [10 CFR 63.132 (b)].
- DOE's program identifies specific geotechnical and design parameters to be observed including any interactions between natural and engineered systems [10 CFR 63.132 (c)].
- The Performance Confirmation Program will provide data from measurements and observations to confirm original design bases, and if changes are observed, provides a mechanism for analyzing the impacts and initiating corrective measures [10 CFR 63.132 (d)].
- The proposed plan includes *in situ* monitoring of the thermomechanical response of the underground facility until permanent closure to ensure performance of geologic and engineered features are within design limits [10 CFR 63.132 (e)].

Therefore, the NRC staff finds that DOE's confirmation of geotechnical and design parameters satisfies requirements in 10 CFR 63.132.

2.4.3.3 Design Testing

DOE provided a description of a program for design testing (other than for waste packages, which are evaluated in SER Section 2.4.3.4) of engineered systems and components in SAR Sections 4.1.1, 4.1.3, and 4.2.3; SAR Table 4-1 and 4-2; and DOE (2010ap). DOE stated that the only performance confirmation activity in the design testing group (other than for waste packages) is seal testing for boreholes, shafts, and ramps.

DOE identified other activities that also address design testing for the drip shield, invert, and waste package pallet, and interactions between different engineered components and between the natural and engineered systems. These other activities are reviewed by the NRC staff in other sections, as follows: (i) corrosion testing and testing under the anticipated thermal and chemical environment of EBS components, such as drip shield and pallet materials are evaluated in SER Section 2.4.3.4 (Monitoring and Testing of Waste Packages); (ii) invert interaction with other components is reviewed in SER Section 2.4.3.2.3 (Thermally Accelerated Drift Thermal-Mechanical Monitoring); (iii) testing and interactions of natural and engineered systems and components used in the design is an aspect of seepage monitoring, thermally accelerated drift near-field monitoring, construction effects monitoring, and thermally accelerated drift thermal-mechanical monitoring, which the NRC staff evaluates in this section (SER Section 2.4.3.3.1).

Seal and Backfill Testing

DOE described the seal and backfill testing activity in SAR Section 4.2.3.1, DOE (2010ap), and Performance Confirmation Plan Section 3.3.3.1. DOE stated that the purpose of the seal and backfill testing activity is to evaluate design assumptions for implementing methods to seal (backfilling and plugging) shafts, ramps, and boreholes for permanent repository closure. DOE indicated that (i) backfilling and sealing of access drifts will provide long term stability to the repository; (ii) sealing of shafts, ramps, and boreholes will limit water intrusion into the

repository; and (iii) backfilling of shafts and ramps will provide repository stability. For shafts and ramps, DOE described a criterion for seal locations that includes placement at interfaces between highly fractured and relatively unfractured rock, such that flowing water would be drained into the host rock. DOE stated that it plans to backfill shafts, ramps, and boreholes, but not emplacement drifts. DOE also stated that it will develop a final design for shaft and ramp seals on the basis of information gained from construction measurements and observations (SAR Section 4.2.3.1). In SAR Section 4.2.3.1, DOE stated that seal and backfill testing includes laboratory testing of the effectiveness of borehole seals, *in-situ* field testing of the effectiveness of ramp and shaft seals, and field testing of backfill placement and compaction procedures. DOE stated that (i) a test plan will be completed during construction (DOE, 2009gm, Table 1), (ii) laboratory tests on borehole seals will be completed during the early development stage of construction, and (iii) field tests will be completed prior to backfilling shafts and ramps, or backfilling and plugging boreholes, and prior to permanent closure (SAR Section 4.2.3.1).

In SAR Table 4-1 and Performance Confirmation Plan Table 3-2, DOE identified the configuration and performance of shaft, ramp, and borehole seal materials, and the laboratory and field hydraulic and pneumatic seal effective permeability as the candidate test parameters. DOE stated that it plans to develop baseline information for the performance, testing, analysis, placement, and compaction of backfill materials, using applicable engineering literature.

The NRC Staff Review

The NRC staff reviewed the description DOE provided for the seal testing activity. The NRC staff finds that these candidate parameters are appropriate because they include (i) evaluations of the seal materials and performance and (ii) parameters that directly measure seal performance (e.g., hydraulic and pneumatic effective permeability). Also, the NRC staff finds DOE's description of baseline parameter development acceptable because it will use applicable information on backfill and sealing that is widely available in engineering literature from analogous and Yucca Mountain-specific applications, including those referenced in Performance Confirmation Plan Section 3.3.3.1. These NRC staff findings are also based on the staff's understanding of seismic probabilities and consequences at Yucca Mountain, obtained from precicensing experience and the NRC staff's review in SER Section 2.2.1.3.2 (Mechanical Disruption of Engineered Barriers).

Based on DOE's description, the NRC staff finds that the proposed performance confirmation sealing and backfill testing activities for boreholes, shafts, and ramps meet the requirements of the relevant portions of 10 CFR 63.133 because the program would

- Provide laboratory data to evaluate the effectiveness of borehole seals during the early stages of operation
- Provide *in-situ* data to evaluate the effectiveness of seal and backfill designs and to assess interactions of natural and engineered systems prior to actual backfill
- Provide data for development of baseline information for seals and backfill
- Initiate testing as early as practicable

Summary of the NRC Staff Review of Design Testing

On the basis of the NRC staff's evaluation in SER Section 2.4.3.3 and the NRC staff's evaluations of (i) seepage monitoring (SER Section 2.4.3.2.1.1), (ii) thermally accelerated drift near-field monitoring (SER Section 2.4.3.2.1.3), (iii) thermally accelerated drift in-drift environment monitoring (SER Section 2.4.3.2.1.4), (iv) construction effects monitoring (SER Section 2.4.3.2.1.7), and (v) thermally accelerated drift thermal-mechanical monitoring (SER Section 2.4.3.2.3), the NRC staff finds that DOE adequately described

- A performance confirmation plan for design testing of engineered systems and components used in the design [10 CFR 63.133(a)]
- How the tests will be conducted so that thermal interaction effects of waste packages, drip shield, rock, unsaturated zone and saturated zone water are addressed [10 CFR 63.133(a)]
- A schedule whereby testing will begin during early or developmental stages of construction, or initiated as early as practicable [10 CFR 63.133(a),(b)]
- A test program that would evaluate the effectiveness of backfill placement and compaction procedures against design requirements prior to permanent backfill placement in shafts, access tunnels, and boreholes [10 CFR 133(c)]
- A design testing program that would evaluate the effectiveness of borehole, shaft, and ramp seals to be demonstrated in tests before full-scale sealing proceeds [10 CFR 63.133(d)]

Therefore, the NRC staff finds that DOE's description of a performance confirmation program for design testing meets the requirements in 10 CFR 63.133.

2.4.3.4 Monitoring and Testing Waste Packages

DOE provided information addressing the monitoring and testing of the waste package in SAR Sections 4.1, 4.1.1, 4.1.3, 4.2, and 4.2.4; SAR Tables 4-1 and 4-2; and DOE (2010ap; DOE, 2009gm). In SAR Section 4.2.4, DOE stated that waste package monitoring and testing performance confirmation activities include remote monitoring of a representative set of waste packages and plans for laboratory testing of waste package and drip shield materials representative of those emplaced in the repository. DOE's description of the monitoring and testing waste packages performance confirmation activities included corrosion testing of waste package and drip shield materials and internal waste package conditions.

The NRC staff's evaluation of the DOE description of performance confirmation activities for monitoring and testing waste packages is in the following two sections: (i) Program for Monitoring and Testing the Condition of Waste Packages (SER Section 2.4.3.4.1) and (ii) Waste Form Testing (SER Section 2.4.3.4.2), which is the one proposed activity that focuses on the internal condition of waste packages. In SER Section 2.4.3.4.1, the NRC staff evaluates the dust buildup monitoring, waste package monitoring, corrosion testing, and corrosion testing of thermally accelerated drift samples.

2.4.3.4.1 Program for Monitoring and Testing the Condition of Waste Packages

In SAR Section 4.2.4 and Performance Confirmation Plan Section 3.3.4, DOE described its program for monitoring and testing the condition of waste packages. For two of the activities in this group, DOE stated that (i) dust buildup monitoring and (ii) in-drift environment monitoring of the thermally accelerated drift would be designed to provide information for the monitoring of emplaced waste packages. For these two activities, DOE stated that it would select representative waste packages in terms of materials, design, structure, fabrication, inspection methods, and environment. For environmental conditions, DOE indicated it would monitor parameters that reflect coupled thermal-hydrologic-chemical processes that affect the amount and chemistry of the water reaching the waste package surface and temperature of the waste package surface. For the other activities in this group, DOE stated that the activities would focus on laboratory corrosion testing of waste package and drip shield materials and corrosion testing of thermally accelerated drift samples. In SAR Section 4.2.4, DOE stated that, to the extent practicable, the laboratory experiments would be designed to include representative repository emplacement environments. DOE stated that waste package monitoring would include corrosion monitoring through the use of test samples (often referred to as coupons).

The NRC staff reviews DOE's performance confirmation activities in SER Sections 2.4.3.4.1.1 through 2.4.3.4.1.5, respectively, for dust buildup monitoring, thermally accelerated drift in-drift environment monitoring, waste package monitoring, corrosion testing, and corrosion testing of thermally accelerated drift samples.

2.4.3.4.1.1 Dust Buildup Monitoring

DOE described the dust buildup monitoring activity in SAR Section 4.2.1.10 and Performance Confirmation Plan Section 3.3.1.10. DOE stated that the purpose of the activity is to evaluate assumptions of dust buildup and potential chemical effects on EBS components (waste package and drip shield). DOE stated (i) that dust buildup contributes to corrosion of the waste package and the drip shield because dust buildup potentially impacts water chemistry and deliquescence and (ii) that this activity is important to evaluating the bases for the expected chemical conditions for the EBS to establish whether they are representative. DOE stated that it plans to (i) collect and analyze waste package and drip shield material specimens exposed in emplacement drifts to measure salts present in the dust and (ii) collect dust from the thermally accelerated drift and other selected locations. DOE described a plan to use a remotely operated vehicle to collect dust samples. DOE stated that the details for this performance confirmation activity, and remote methods for sample collection, will be developed, finalized, and documented in the performance confirmation test plan. DOE stated that (i) dust analyses were conducted on dust samples from the ESF during site characterization (SNL, 2008aq, Section 3.3.1.10); (ii) the test plan will be completed during the operations period (DOE, 2009gm, Table 1); and (iii) the test activity will continue during operations, but in emplacement drifts, the thermally accelerated drift, and other selected locations (SAR Section 4.2.1.10).

In SAR Table 4-1 and Performance Confirmation Plan Table 3-2, DOE identified the following as candidate parameters: quantity, physical properties, and chemical composition of dust deposited on the waste package, drip shield, rail, and ground support surfaces. DOE stated that baseline information and expected variability will be developed from analysis and model reports on in-drift physical and chemical environments cited in SNL (2008aq, Section 3.3.1.10).

The NRC Staff Review

The NRC staff reviewed the DOE description of the dust buildup monitoring activity. The NRC staff finds that the candidate parameters for dust buildup monitoring are acceptable because they include direct measures of the physical properties and chemical composition of dusts that may accumulate on the surfaces of the waste package and drip shield. Because DOE will be collecting samples from emplacement drifts, the NRC staff finds that the environment of the waste packages that DOE will monitor and test is representative of the emplacement environment. Also, the NRC staff finds DOE's description of baseline parameter development acceptable because baseline information, including expected variability, will be developed from DOE's analysis and model reports on in-drift physical and chemical environments cited in the SAR. The NRC staff also finds DOE's description of the collection of samples from the thermally accelerated drift would be performed consistent with safe operations in the GROA because DOE stated that remote devices will be used in the high temperature and high radiation environment. These NRC staff findings are also based on the staff's understanding of dust buildup and the in-drift physical and chemical environment, obtained from prelicensing experience and the NRC staff's review of the in-drift physical and chemical environment in SER Sections 2.2.1.3.1 (Degradation of Engineered Barriers) and 2.2.1.3.3 (Quantity and Chemistry of Water Contacting Engineered Barriers and Waste Forms).

Based on DOE's description, the NRC staff finds that the proposed dust buildup activity meets the requirements of the relevant portions of 10 CFR 63.134 because the program would

- Provide data to confirm that physical and chemical conditions on engineered barrier components are within limits assumed in the SAR and are representative of conditions in emplacement drifts
- Be consistent with safe operations in the GROA
- Provide baseline information developed from assumptions, inputs, and observations of and analyses of physical and chemical properties of dust accumulation used in the performance assessment
- Provide data starting in the operations period and continuing as long as practicable

2.4.3.4.1.2 Waste Package Monitoring

DOE described the waste package monitoring activity in SAR Section 4.2.4.1 and Performance Confirmation Plan Section 3.3.4.1. DOE stated that the purpose of waste package monitoring is to (i) confirm the condition of selected, representative waste packages in the repository emplacement drifts; (ii) evaluate waste package integrity; and (iii) confirm the absence of leakage and leak paths. DOE stated that field waste package monitoring includes the number of packages monitored; locations, durations, and design of the testing; and waste packages selected for underground monitoring. DOE also stated that the waste packages to be monitored will be representative in terms of materials, design, structure, fabrication, and of inspection methods. In addition, DOE stated that waste packages selected for monitoring, on a yearly basis or less frequently, will be representative of different configurations, and of different environmental conditions that may occur in the underground facility. DOE described a plan to use remote visual observation to monitor the selected set of waste packages for external corrosion evidence. DOE stated that performance confirmation monitoring will be integrated

with underground operations to develop a remotely operated vehicle or other monitoring technology compatible with operations. DOE stated that the high-temperature and high-radiation environments representative of post emplacement conditions require integration of specific technology applications for measurement and inspections. DOE stated that it is also considering the potential for using technology to sense the differential pressure between the waste package inner and outer sections. If this technology is not found to be practicable, DOE indicated that other testing methods and approaches will be identified and documented in the detailed performance confirmation test plan that would be completed during the operations period. DOE stated that it plans to initiate waste package monitoring during the early stages of waste emplacement operations and will continue as long as practical until repository closure.

In SAR Table 4-1 and Performance Confirmation Plan Table 3-2, DOE identified as candidate monitoring parameters, external visual corrosion and potentially the internal pressure of the waste package. DOE stated that the baseline information will be developed from performance assessment results and from analysis and model reports on waste packages cited in SNL (2008aq, Section 3.3.4.1).

The NRC Staff Review

The NRC staff reviewed DOE's description of the waste package monitoring activity. The NRC staff finds that these candidate parameters are acceptable because they include direct and indirect measures of waste package corrosion under relevant repository environmental conditions. Also, the NRC staff finds the DOE description of baseline parameter development acceptable because baseline information will be synthesized from performance assessment results, as well as from information obtained from analysis and model reports used for the SAR and cited in SNL (2008aq, Section 4.2.4.1). The NRC staff also finds that DOE's description of the collection of samples from the thermally accelerated drift would be performed consistent with safe operations in the GROA because DOE stated that remote devices will be used in the high temperature and high radiation environment. These NRC staff findings are also based on the staff's understanding of the waste packages and expected environmental conditions and corrosion processes, obtained from prelicensing experience and the NRC staff's review of the in-drift physical and chemical environment in SER Section 2.2.1.3.1 (Degradation of Engineered Barriers).

The NRC staff finds that the applicant's description of the proposed waste package monitoring activity meets the requirements of the relevant portions of 10 CFR 63.134 because the program would

- Provide data to confirm waste package corrosion extent and rates are within limits assumed in the SAR and are representative of conditions in emplacement drifts
- Provide baseline information developed from assumptions, inputs, and analyses of waste package corrosion used in the performance assessment
- Be consistent with safe operation in the GROA
- Provide data starting in the operations period and continuing as long as practicable

2.4.3.4.1.3 Corrosion Testing

DOE described corrosion testing in SAR Section 4.2.4.2 and Performance Confirmation Plan Section 3.3.4.2. DOE stated that the purpose of the corrosion testing activity is to confirm information used to evaluate the performance of the materials and to confirm designs for fabrication of the waste package, emplacement pallet, and drip shield components of the EBS. DOE stated that it will measure the general corrosion rate and evaluate the overall corrosion performance of the waste package and the drip shield materials to confirm results of corrosion models used in the performance assessment. DOE stated that laboratory testing will consist of long-term corrosion tests, thermal aging tests, and electrochemical testing. DOE planned tests for Alloy 22, Type 316L stainless steel, and titanium alloys including (i) continuation of tests, using corrosion coupons, performed at the Long-Term Corrosion Test Facility to collect data on general corrosion rates, passive film properties, localized corrosion and stress corrosion cracking susceptibility, and post-test sample corrosion features; (ii) thermal aging tests to evaluate phase transformations in Alloy 22; and (iii) shorter term, electrochemically based testing for obtaining parameters in predicting localized corrosion susceptibility and measuring general corrosion rates. DOE stated that the samples will be representative of the waste package and drip shield materials, including processes used to fabricate, assemble, weld, and stress relieve these materials. DOE stated that laboratory corrosion tests conducted up to the point of license application “are considered and evaluated in the process for developing a long-term corrosion testing strategy” (SAR Section 4.2.4.2). DOE indicated that the long-term strategy will identify the requisite facilities to evolve and enhance existing data. DOE stated that (i) the corrosion testing activity started during site characterization, (ii) a test plan will be completed during construction, and (iii) testing will continue during construction and operation until permanent closure.

In SAR Table 4-1 and Performance Confirmation Plan Table 3-2, DOE identified as the candidate parameters, measurements of Alloy 22, Stainless Steel Type 316L, and Titanium Grade 7 and Grade 29 mass loss rate, passive current density, surface dissolution, open circuit potential, critical potential, stress corrosion cracking, microbial effects, surface passive film stability, and mechanical properties. DOE stated that baseline information will be developed from performance assessment results and from analysis and model reports cited in SNL (2008aq, Section 3.3.4.2).

The NRC Staff Review

The NRC staff reviewed DOE’s description of the corrosion testing activity in SAR Section 4.2.4.3 and SNL (2008aq, Section 3.3.4.3). The NRC staff finds that these candidate parameters are acceptable because they directly assess the corrosion properties of the EBS materials that may be used to confirm the results of corrosion models. Also, the NRC staff finds the DOE description of baseline parameter development acceptable because baseline information will be synthesized by DOE from performance assessment results, as well as from information obtained from analysis and model reports cited in SNL (2008aq, Section 4.2.4.2). These NRC staff findings are also based on the NRC staff’s understanding of corrosion processes in environments similar to those expected in emplacement drifts, obtained from prelicensing experience and the NRC staff’s review of the in-drift physical and chemical environment in SER Section 2.2.1.3.1 (Degradation of Engineered Barriers).

Based on DOE’s description, the NRC staff finds that the proposed corrosion testing activity meets the requirements of the relevant portions of 10 CFR 63.134 because the program would

- Provide data that DOE can use to confirm corrosion processes and rates are within limits assumed in the SAR, and are representative of conditions in emplacement drifts
- Provide baseline information developed from assumptions, inputs to corrosion models, and results of corrosion models, as incorporated in the performance assessment
- Provide data for as long as practicable, up to permanent closure

2.4.3.4.1.4 Corrosion Testing of Thermally Accelerated Drift Samples

DOE described the corrosion testing of thermally accelerated drift samples activity in SAR Section 4.2.4.3 and Performance Confirmation Plan Section 3.3.4.3. DOE stated that the purpose of this activity is to confirm information used to evaluate corrosion models in the performance assessment. DOE stated that it plans to (i) expose test coupons, which will be representative of the waste package and drip shield materials, to the environment in the thermally accelerated drift and (ii) subsequently characterize the samples in the laboratory to measure the general corrosion rate and evaluate the corrosion performance of the waste package and drip shield materials. DOE stated that the test coupons will be representative of the waste package, waste package pallet, and drip shield, including processes used to fabricate, assemble, weld, and stress relieve the material. DOE stated it would use Alloy 22, Stainless Steel Type 316L, and Titanium Grade 7 and Grade 29. DOE indicated that test coupons will periodically be removed from the test drift using a remote collection system. DOE stated that laboratory characterization of exposed coupons will be consistent with techniques used to characterize exposed test samples in the corrosion testing activity (SAR Section 4.2.4.2, SER Section 2.4.3.4.1.4) in terms of specimen characteristics, postexposure characterization, and analyses. DOE stated that it plans to initiate this activity during operations and that after exposure in the thermally accelerated drifts for periods of several years, and up to the length of time before the repository is closed, samples will be periodically withdrawn for analysis and characterization.

In SAR Table 4-1 and Performance Confirmation Plan Table 3.2, DOE identified measurements of Alloy 22, Stainless Steel Type 316L, and Titanium Grade 7 and Grade 29 mass loss rate, passive current density, surface dissolution, open circuit potential, critical potential, stress corrosion cracking, microbial effects, surficial passive film stability, and mechanical properties as the candidate parameters. DOE stated that the baseline information will be developed from performance assessment results and from analysis and model reports cited in SNL (2008aq, Section 3.3.4.3).

The NRC Staff Review

The NRC staff reviewed the description DOE provided for the corrosion testing of thermally accelerated drift sample testing in SAR Section 4.2.4.3 and SNL (2008aq, Section 3.3.4.3). The NRC staff finds that these candidate parameters are acceptable because they directly assess the corrosion properties of EBS materials and would confirm the results of corrosion models used for performance assessment. Also, the NRC staff finds DOE's description of baseline parameter development acceptable because baseline information would be synthesized from performance assessment results, and from information obtained from analysis and model reports cited in SNL (2008aq, Section 4.2.4.3). The NRC staff finds the proposed corrosion testing would be performed under conditions representative of emplacement drifts because DOE's description indicates that coupons will be exposed to the environment of the *in-situ*

thermally accelerated test drift that uses representative waste packages, as discussed in the NRC staff's evaluation in SER Section 2.4.3.2.1.4. The NRC staff also finds that collection of samples from the thermally accelerated drift would be performed, consistent with safe operations in the GROA, because DOE stated that remote devices will be used in the high temperature and high radiation environment. These NRC staff's findings are also based on the staff's understanding of corrosion processes in environments similar to those expected in emplacement drifts, obtained from precicensing experience, and the NRC staff's review of the in-drift physical and chemical environment in SER Section 2.2.1.3.1 (Degradation of Engineered Barriers).

Based on DOE's description, the NRC staff finds that the proposed corrosion testing of thermally accelerated drift sample testing activity meets the requirements of the relevant portions of 10 CFR 63.134 because the program would

- Provide data that DOE can use to confirm corrosion processes and rates are within limits assumed in the SAR, and are representative of conditions in emplacement drifts
- Provide baseline information developed from assumptions, inputs to corrosion models, and results of corrosion models, as incorporated in the performance assessment
- Provide data for as long as practicable, up to permanent closure
- Be consistent with safe operations in the GROA

2.4.3.4.2 Waste Form Testing

DOE described one activity in the area of laboratory experiments that focuses on the internal condition of waste packages. The waste form testing activity is described by DOE in SAR Section 4.2.4.4, Performance Confirmation Plan Section 3.3.4.4, and DOE (2009gm).

DOE stated that the purpose of the waste form testing activity is to confirm assumptions and results of waste form degradation models and in-package expected conditions. DOE described in SAR Section 4.2.4.4 how the movement of liquid or vapor-phase water through cracks in the waste package can initiate coupled processes. DOE described the coupled processes inside the package that may result in (i) the availability of water, degradation of waste form and steel components, and variations in pH values and (ii) mobility of fission and activated products, solubility of actinides, and colloid mobility, for dose assessment radionuclides. DOE stated that the waste form testing activity will include waste package coupled effects testing in the laboratory setting under simulated internal waste package conditions. DOE stated that this activity will provide information to confirm its assumptions used in the SAR for waste package source-term models used in performance assessments. DOE stated that (i) aspects of this activity began during site characterization, (ii) a test plan will be completed during construction (DOE, 2009gm), and (iii) the activity will be expanded to include a simulated waste package and will continue until at least the early stages of waste emplacement.

In SAR Table 4-1 and Performance Confirmation Plan Table 3-2, DOE identified as the candidate parameters radionuclide release rate, dissolution rate, environmental and hydrochemical indicators (Eh, pH, colloid characteristics), bare waste form dissolution, fuel rod waste form dissolution, and waste form and waste package performance under coupled chemical environments. Among the environmental and hydrochemical indicators (Eh, pH,

colloid characteristics) and waste form and waste package performance under coupled chemical environments, DOE (2009gm) determined that general candidate parameters are (i) pH-buffering capabilities of stainless steel corrosion products, (ii) aqueous chemical characteristics of the corrosion products domain, (iii) radionuclide sorption properties of stainless steel corrosion products, and (iv) colloid generation potential of corroding stainless steel. DOE stated that the baseline information for waste form testing will be synthesized from performance assessment results and from analysis and model reports cited in SNL (2008aq, Section 3.3.4.4).

The NRC Staff Review

The NRC staff reviewed the description DOE provided for the waste form testing activity. The NRC staff finds that the suite of candidate parameters is acceptable because the parameters reflect processes for the degradation rate of the waste and the release of radionuclides. The NRC staff finds DOE's description of baseline development acceptable because it will use information from the performance assessment and the SAR that reflects waste form degradation and the release of radionuclides. These NRC staff findings are also based on the staff's understanding of waste form degradation processes for the conditions expected at Yucca Mountain, obtained from prelicensing experience and the NRC staff's review in SER Section 2.2.1.3.4 (Radionuclide Release Rates and Solubility Limits).

Based on the DOE description, the NRC staff finds that the waste form testing activity meets the requirements of the relevant portions of 10 CFR 63.134 because the activity would

- Provide data from laboratory experiments on waste form degradation and radionuclide release rates for environments, to the extent practicable, that are expected to be representative of the conditions experienced by emplaced waste packages
- Provide data that will indicate whether the waste form degradation and radionuclide release rates are within the limits assumed in SAR Section 2.3.9 and reports cited therein
- Provide baseline information and analysis for waste form degradation parameters used to estimate radionuclide release rates to monitor and analyze changes from the baseline condition that might affect performance of the geologic repository
- Continue collection of data to the early stages of emplacement

2.4.3.4.3 Summary of the NRC Staff Evaluation of Monitoring and Testing Waste Packages

The NRC staff reviewed DOE's plans for monitoring and testing waste packages. On the basis of the NRC staff's evaluation in SER Sections 2.4.3.4.1 and 2.4.3.4.2, the NRC staff finds that DOE's description of a performance confirmation plan for monitoring and testing waste packages is acceptable because DOE included, for the activities of (i) dust buildup monitoring, (ii) waste package monitoring, (iii) corrosion testing, (iv) corrosion testing of thermally accelerated drift samples, and (v) waste form testing,

- Candidate parameters that reflect the feature and processes for each of the activities
- A method for developing baseline information that is based on inputs or results from the performance assessment presented in the SAR or on analysis and model reports cited in the SAR, for each of the activities
- A program for monitoring and testing the condition of waste packages at the geologic repository operations area (GROA) using waste packages that would be representative of those to be emplaced in the underground facility in terms of materials, design, structure, fabrication, and inspection methods [10CFR 63.134(a)]
- A consideration of the environment of waste package emplacement that will be representative of the emplacement environment and is consistent with safe operations at the geologic repository operations area [10 CFR 63.134(b)]
- A program of laboratory experiments that focuses on the internal condition of the waste packages (i.e., waste form testing) that, to the extent practical, duplicates the environment experienced by emplaced waste packages [10CFR 63.134(c)]
- A schedule for monitoring and testing that will begin as soon as practicable, and monitoring and testing will continue as long as practical, up to the time of permanent closure [10 CFR 63.134(d)]

Therefore, the NRC staff finds that DOE's performance confirmation program for monitoring and testing waste packages satisfies 10 CFR 63.134.

2.4.4 Evaluation Findings

The NRC staff reviewed SAR Chapter 4 and other information submitted in support of the license application and concludes, with reasonable assurance, that the applicant has provided the description required by 10 CFR 63.21(c)(17), which meets the following requirements:

- [For 10 CFR 63.131 General requirements]
 - DOE described a program that will provide data to indicate whether (i) actual subsurface conditions encountered and changes in those conditions during construction and waste emplacement operations are within the limits assumed in the SAR and (ii) natural and engineered systems and components that are designed or assumed to operate as barriers after permanent closure are functioning as intended and anticipated [10 CFR 63.131(a)].
 - DOE has provided its plans and descriptions of performance confirmation activities that started during site characterization, and will continue until permanent closure [10 CFR 63.131(b)].
 - DOE described a program that will include *in situ* monitoring, laboratory and field testing, and *in situ* experiments [10 CFR 63.131(c)].
 - DOE described a program that will be implemented so that (i) it does not adversely affect the ability of the geologic and engineered systems to meet

performance objectives, (ii) it provides baseline information and analysis on identified parameters and processes that may be changed by site characterization, construction, and operation, and (iii) it monitors and analyzes changes of parameters from baseline conditions that could affect repository performance [10 CFR 63.131(d)(1),(2), and (3)].

- [For 10 CFR 63.132 Confirmation of geotechnical and design parameters]
 - DOE stated it would establish a program for surveillance, measurement, testing, and geologic mapping to confirm geotechnical and design parameters pertaining to natural systems and components that are assumed to operate as barriers after permanent closure [10 CFR 63.132(a)].
 - DOE included provisions for monitoring subsurface conditions for comparison with and evaluation against design assumptions during repository construction and operation [10 CFR 63.132(b)].
 - DOE identified specific geotechnical and design parameters to be measured or observed, including any interactions between natural and engineered systems [10 CFR 63.132(c)].
 - DOE described a program that includes comparison of measurements and observations with original design bases, and if significant differences are found, provides a mechanism for analyzing the impacts and initiating corrective measures [10 CFR 63.132(d)].
 - DOE's description included *in situ* monitoring of the thermo-mechanical response of the underground facility until permanent closure [10 CFR 63.132(e)].
- [For 10 CFR 63.133 Design testing]
 - DOE's description for design testing of engineered systems and components included thermal interaction effects of the waste packages, drip shield, rock, and unsaturated zone and saturated zone water [10 CFR 63.133(a)].
 - DOE described a schedule whereby design testing will begin during early or developmental stages of construction [10 CFR 63.133(a)], or initiated as early as practicable [10 CFR 63.133(b)].
 - DOE described a plan to test and evaluate the effectiveness of backfill placement and compaction procedures against design requirements prior to permanent backfill placement in shafts, access tunnels, and boreholes [10 CFR 63.133(c)].
 - DOE described a program to test and evaluate the effectiveness of borehole, shaft, and ramp seals that would be conducted before full-scale operation proceeds to sealing of boreholes, shafts, and ramps [10 CFR 63.133(d)].
- [For 10 CFR 63.134 Monitoring and testing waste packages]
 - DOE described a plan to establish a program for monitoring and testing the condition of waste packages at the geologic repository operations area that are representative of conditions for emplaced waste in the underground facility [10CFR 63.134(a)].

- DOE described a program that included laboratory experiments that focuses on the internal condition of the waste packages [10CFR 63.134(c)].
- DOE stated that the environment experienced by the emplaced waste packages would be duplicated in the laboratory experiments to the extent practicable [10CFR 63.134(b) and (c)].
- DOE stated that the monitoring and testing of waste packages would begin as soon as practicable, and monitoring and testing would continue as long as practical, up to the time of permanent closure [10CFR 63.134(d)].

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CHAPTER 3

2.5.1 Quality Assurance Program

2.5.1.1 Introduction

Safety Evaluation Report (SER) Section 2.5.1 evaluates the U.S. Department of Energy's ("DOE" or "applicant") information on the quality assurance (QA) program. The U.S. Nuclear Regulatory Commission (NRC) staff's evaluation is based on information that DOE provided in the Yucca Mountain Repository License Application (DOE, 2008ab), Chapter 5, "Management Systems," and Safety Analysis Report (SAR) Section 5.1, "Quality Assurance."

In SAR Section 5.1, the applicant stated that the Office of Civilian Radioactive Waste Management Quality Assurance Requirements and Description (QARD) (DOE, 2008af) describes the requirements of the QA program that apply to activities at the Yucca Mountain repository. In SAR Section 5.1 the applicant also states that the QARD is incorporated into the license application by reference. As part of its review of the applicant's license application, the NRC staff reviewed the QARD. In the introduction to the QARD, DOE stated that the QA program applies to (i) the structures, systems, and components important to safety; (ii) design and characterization of barriers important to waste isolation; and (iii) related activities (quality-affecting work). In the introduction to the QARD, DOE also stated that the QA program applies to activities occurring prior to receipt of high-level radioactive waste and spent nuclear fuel for disposal in the Yucca Mountain repository, and that the QARD will be revised prior to receiving a license to receive and possess waste to address facility operations.

2.5.1.2 Regulatory Requirements

The QA program requirements for the content of the Yucca Mountain repository application are in 10 CFR 63.21(c)(20), which requires that the Safety Analysis Report (SAR) include a description of the QA program to be applied to quality-affecting work, and that the description of the QA program include a discussion of how the applicable requirements of 10 CFR 63.142 will be satisfied. The requirements for QA are in 10 CFR Part 63, Subpart G (10 CFR 63.141–144), and the scope of the QA program is in 10 CFR 63.141. The requirements for the description of the QA program, applicability requirements for the QA program, and 18 QA criteria are in 10 CFR 63.142. The requirements for implementing the QA program are in 10 CFR 63.143, and the requirements for making changes to the QA program are in 10 CFR 63.144.

2.5.1.3 Review Process

The purpose of the NRC staff's review is to determine whether DOE's QA program description complies with the applicable requirements of 10 CFR Part 63. The NRC staff reviewed DOE's description of the QA program to be applied to quality-affecting work using guidance in the "Yucca Mountain Review Plan" (YMRP) Section 2.5.1.3 (NRC, 2003aa). YMRP Section 2.5.1.3 identifies the following 18 acceptance criteria that the NRC staff used in its evaluation of DOE's QA program description:

- (1) QA Organization
- (2) QA Program
- (3) Design Control
- (4) Procurement Document Control

- (5) Instructions, Procedures, and Drawings
- (6) Document Control
- (7) Control of Purchased Material, Equipment, and Services
- (8) Identification and Control of Materials, Parts, and Components
- (9) Control of Special Processes
- (10) Inspection
- (11) Test Control
- (12) Control of Measuring and Test Equipment
- (13) Handling, Storage, and Shipping
- (14) Inspection, Test, and Operating Status
- (15) Nonconforming Materials, Parts, or Components
- (16) Corrective Action
- (17) Records
- (18) Audits

The QARD comprises (i) 18 sections corresponding to the 18 acceptance criteria listed previously; (ii) Supplement I, "Software"; (iii) Supplement II, "Sample Control"; (iv) Supplement III, "Scientific Investigation"; (v) Supplement IV, "Field Surveying"; (vi) Supplement V, "Control of the Electronic Management of Information"; (vii) Appendix A, "Waste Custodian Interface"; (viii) Appendix B (intentionally left blank); and (ix) Appendix C, "Storage and Transportation."

The NRC staff also reviewed DOE's QA program description using YMRP Section 2.5.1.5, "References," which provides documents that contain staff positions and provisions to which DOE can commit to follow. However, as provided in YMRP Section 2.5.1, exceptions and alternatives to the documents and positions in YMRP Section 2.5.1.5 may be adopted by DOE, provided DOE can otherwise demonstrate that its approach satisfies applicable regulatory requirements. The NRC staff's evaluation of DOE modifications to the commitment documents in YMRP Section 2.5.1.5 are provided in the SER section to which they apply.

2.5.1.4 Technical Review

In SER Section 2.5.1.4.1 the NRC staff summarizes the applicant's information in SAR Section 5.1. In SER Section 2.5.1.4.2 the NRC staff documents its review relative to the 18 acceptance criteria in YMRP Section 2.5.1.3as listed previously and its review of modifications to the commitment documents in YMRP Section 2.5.1.5, where applicable. In SER Section 2.5.1.5 the NRC staff summarizes its evaluation and presents its findings.

2.5.1.4.1 Summary of DOE's QA Program in the License Application

In SAR Section 5 the applicant states that the QA program provides the QA requirements for the design and construction of the repository and that the requirements of the QA program are applied to DOE and its contractors' quality-affecting work. In SAR Section 5.1 the applicant also states that the QARD is incorporated into the license application by reference. The QARD addresses the scope and the criteria of DOE's QA program. The NRC staff reviewed DOE's description of the scope of its QA program. In the QARD Introduction, DOE stated that the QA program applies to structures, systems, and components important to safety, to the design and characterization of barriers important to waste isolation, and to related activities. In the QARD Glossary, DOE also described the scope of QA, and that QA includes quality control, consistent with the requirements at 10 CFR 63.141. The NRC staff finds that DOE adequately described the scope of the QA program because it is consistent with 10 CFR 63.141.

When DOE submitted the license application, QARD Revision 20 (DOE, 2008af) was in effect. During its initial review of QARD Revision 20, the NRC staff issued to DOE requests for additional information (DOE, 2009gs, 2008aj,ak). Subsequently, DOE incorporated many of its responses to the NRC staff's request for additional information into QARD Revision 21 (DOE, 2009). The NRC staff describes in this SER those responses to NRC staff's requests for information that DOE did not incorporate into QARD Revision 21 (DOE, 2009gt). The NRC staff based its review of DOE's QA program on QARD Revision 21 and the responses to the NRC staff's requests for information not incorporated therein.

2.5.1.4.2 NRC Staff Evaluation of DOE's QA Program

In the following 18 subsections, the NRC staff documents its evaluation of whether DOE's QA program description is consistent with the guidance in YMRP Section 2.5.1.3 and satisfies the applicable regulatory requirements identified in SER Section 2.5.1.2. The NRC staff reviewed DOE's QA program description based on the information provided in the SAR and the QARD.

Each of the following subsections addresses one of the acceptance criteria in YMRP Section 2.5.1.3 and the commitment documents in YMRP Section 2.5.1.5 associated with that subject. The information in each subsection is generally presented in the order in which the associated subcriteria are discussed in the corresponding YMRP acceptance criterion and in the order in which the information is presented in the QARD. In several of the following subsections, pertinent information located in a QARD supplement or appendix relating to specific subcriteria is also discussed.

2.5.1.4.2.1 QA Organization

The requirements for the organizational elements responsible for the QA program are in 10 CFR 63.142(b) and provide that DOE (i) establish and execute a QA program, (ii) clearly define authority and duties of persons and organizations performing QA activities, and (iii) provide sufficient authority and organizational freedom to individuals and organizations to effectively perform QA functions. The NRC staff reviewed QARD Section 1.0, "Organization," using YMRP Section 2.5.1.3, Acceptance Criterion 1.

QARD Section 1.0 described the positions that would be responsible for establishing, managing, verifying, and interpreting the QA program, and it identified the reporting relationships of the organizations responsible for implementing quality-affecting activities, levels of authority, and lines of communication.

In the QARD DOE defined roles and responsibilities between DOE and waste custodians (QARD Appendix A), and between NRC licensees and certificate holders (QARD Appendix C). The NRC staff reviewed DOE's description of the management controls that would be used when individuals or organizations responsible for establishing and executing the QA program delegate quality-affecting work to others. DOE would require that quality-affecting work be performed by waste custodians, NRC licensees, and NRC certificate holders using QA programs equivalent to the QARD. DOE stated that it will perform reviews of documentation to verify that quality-affecting work performed by commercial licensees/certificate holders and their contractors is performed in a manner that complies with applicable QA requirements and, where applicable, the Standard Contract for Disposal of Spent Nuclear Fuel and/or High-Level Radioactive Waste (10 CFR 961).

The NRC staff reviewed DOE's QARD for (i) management positions with responsibility for the QA program within DOE and its principal contactors, (ii) the responsibilities of each organizational element, and (iii) identification of a management position that would retain overall responsibility for the effectiveness of the QA program.

The NRC staff reviewed DOE's QARD for provisions for training and qualifying individuals and organizations performing QA functions. The QARD provides that those individuals have clear lines of authority and direct access to appropriate management levels, are free from cost and schedule pressures, and have stop work authority.

The NRC staff also reviewed DOE's QARD for (i) the organizational position established to resolve disputes involving quality, (ii) QA personnel being involved in day-to-day activities, and (iii) assuring that policies for the implementation of the QA program are documented and are made mandatory.

Evaluation Findings Regarding QA Organization

On the basis of the NRC staff's review of the QARD discussed in the previous section, the NRC staff finds DOE's description of the organizational elements responsible for the QA program consistent with YMRP Section 2.5.3, Acceptance Criterion 1. Therefore, the NRC staff finds, with reasonable assurance, that the description regarding the QA organization addresses how the requirements of 10 CFR 63.142(b) will be satisfied.

2.5.1.4.2.2 QA Program

The requirements for the activities related to the QA program are in 10 CFR 63.142(c) and provide that DOE (i) establish a QA program that complies with the requirements of 10 CFR Part 63, Subpart G, at the earliest practicable time; (ii) identify the structures, systems, and components to be covered by the QA program and the major organizations participating in the program; (iii) accomplish activities affecting quality under suitably controlled conditions; and (iv) regularly review the status and adequacy of the QA program. The NRC staff reviewed QARD Section 2.0, "QA Program," using guidance in the YMRP Section 2.5.1.3, Acceptance Criterion 2.

QARD Section 2.0 establishes the scope of the QA program and identifies requirements for planning and special topics related to the QA program. The NRC staff reviewed the QARD, which states that the QA program applies to quality-affecting work and that demonstration tests and testing of computer software will be performed in accordance with requirements contained in applicable design documents and the QARD. The QARD also states that DOE will plan for any special controls, processes, test equipment, tools, and skills needed for verification of quality by inspection and test.

The NRC staff reviewed the QARD, which states that work is prescribed by controlled implementing documents. The QARD states that the DOE director will issue a policy statement directing mandatory compliance with the QARD for DOE personnel and principal contractors. The QARD also states that DOE will review procedures using individuals who are trained and qualified in QA practices and concepts, and that DOE will review principal contractor procedures prior to initiation of the activity governed by the procedure.

The NRC staff reviewed the QARD, which describes the commitment of DOE, its contractors, and waste custodians to implement the QA requirements of 10 CFR Part 63. The QARD states

that QARD changes will be performed in accordance with 10 CFR 63.144. The QARD also states that DOE will not use an optional graded QA process for quality-affecting work.

The NRC staff reviewed the QARD, which states that nonconforming characteristics will be reviewed, to include the need for reporting in accordance with 10 CFR Part 21 and 10 CFR 63.73, and that recommended dispositions of nonconforming items will be reviewed and approved by individuals who are independent of the work that produced the disposition. The QARD states that, where specific QA controls appropriate for procurement of items for nuclear applications cannot be imposed, procurement and dedication of commercial grade items may be substituted for basic components subject to assuring that the dedicated items will perform their intended safety and waste isolation functions. The QARD also states that (i) work will be prescribed by controlled implementing procedures, (ii) work will be accomplished in accordance with procedures, and (iii) work will be suspended if it cannot be accomplished as described in procedures.

The NRC staff reviewed the QARD, which states that the DOE Yucca Mountain Program director will perform or direct the performance of management assessments of DOE organizations and principal contractors. The QARD also states that management assessments will (i) be performed by personnel outside the QA organization; (ii) be planned, documented, and performed biennially; (iii) evaluate the adequacy of resources and personnel provided to achieve and ensure quality; (iv) evaluate the scope, status, adequacy, effectiveness, and compliance of the QA program; and (v) identify conditions adverse to quality and recommend corrective actions.

The NRC staff reviewed the QARD, which states that DOE will ensure the availability of a sufficient number of trained personnel to implement activities described in this QARD before initiating the activities. The NRC staff reviewed the QARD appendices regarding delegation of work and the responsibilities between DOE and waste custodians for work associated with acceptance of spent nuclear fuel and high-level waste (Appendix A), and between DOE and commercial licensees/certificate holders for work associated with storage of spent nuclear fuel and transportation of spent nuclear fuel and high-level waste (Appendix C).

The NRC staff reviewed the QARD, which establishes requirements for planning and executing tests required to demonstrate that items will perform satisfactorily in service, including preoperational tests. The QARD also states that the QA program applies to quality-affecting work such as preclosure tests, experiments, and scientific studies.

The NRC staff reviewed the QARD, which states that readiness reviews will be conducted for the planned scope of work to ensure that objective evidence exists demonstrating that (i) work prerequisites have been satisfied, (ii) personnel have been trained and qualified, and (iii) implementing documents and management controls are approved. The QARD also states that indoctrination, training, and qualification of personnel will be provided before performing activities within the scope of the QA program.

The NRC staff reviewed the QARD, which states that DOE and principal contractors maintain a matrix or other similar cross reference which provides the relationship between the QARD and implementing documents.

The NRC staff reviewed the following DOE modifications to commitment documents:

- DOE provided a modification to Regulatory Guide 1.28, “Quality Assurance Program Requirements,” Revision 3 (NRC, 1985aa), which documents NRC’s endorsement of NQA–1–1983, “Quality Assurance Program Requirements for Nuclear Facilities” (American Society of Mechanical Engineers, 1983aa). The scope of NQA–1–1983 sets forth guidance for the establishment and execution of QA programs during the design, construction, operation, and decommissioning of nuclear facilities. However, DOE stated in the QARD that it will apply NQA–1–1983 through construction. DOE’s modification to NQA–1–1983 clarifies that the QARD will be revised before the receipt of a license to receive and possess waste to address activities beyond construction to include facility operation, permanent closure, decontamination, and dismantling of surface facilities. The NRC staff determines that this DOE modification is acceptable because DOE will use a phased approach to controlling all quality-affecting activities for the design, construction, operation, and decommissioning of nuclear facilities as described in NQA–1–1983.
- DOE provided a modification to NQA–1–1983, Supplement 2S-2, “Supplementary Requirements for the Qualification of Nondestructive Examination Personnel.” Supplement 2S–2 provides for the implementation of American Society of Nondestructive Testing Recommended Practice No. SNT–TC-1A (American Society of Nondestructive Testing, 1975aa), which establishes a 3-year recertification interval for nondestructive examination personnel. DOE’s modification states that it will implement provisions of the SNT–TC–1A (American Society of Nondestructive Testing, 1980aa) edition; in lieu of the 3-year recertification interval, Level III nondestructive examination personnel may be recertified on a 5-year interval and qualification and certification will include a performance demonstration as part of the practical examination. The NRC staff determines that this DOE modification is acceptable because the use of the 5-year interval is consistent with YMRP Acceptance Criterion 9.
- DOE provided a modification to NQA–1–1983, Supplement 2S–3, “Supplementary Requirements for the Qualification of Quality Assurance Program Audit Personnel” (American Society of Mechanical Engineers, 1983aa). Supplement 2S–3 provides that personnel selected for QA auditing assignments shall have experience or training commensurate with the scope, complexity, or special nature of the activities to be audited. DOE’s modification states that the lead auditor will, before starting the audit, ensure that the assigned personnel collectively have experience or training commensurate with the scope, complexity, or special nature of the work to be audited. The NRC staff determines that this DOE modification is acceptable because Supplement 2S–3 also states that the necessary auditor qualifications may be provided collectively.
- DOE provided a modification to Regulatory Guide 1.8, “Qualification and Training of Personnel for Nuclear Power Plants,” Revision 3 (NRC, 2000ae). DOE’s modification states that commitment to this guide is limited to Regulatory Position C.2.1.1, “Quality Assurance.” The NRC staff reviewed Regulatory Position C.2.1.1, which provides qualification criteria for QA personnel. The QARD Introduction states that the QARD applies to design, procurement, and construction activities for the Yucca Mountain repository. The NRC staff determines that this DOE modification to Regulatory Guide 1.8 (NRC, 2000ae) is acceptable because the only position described in Regulatory Guide 1.8 applicable to the QARD for the Yucca Mountain repository is that

of Quality Assurance in Regulatory Position C.2.1.1. Other positions described in Regulatory Guide 1.8 would be applicable to personnel working for nuclear power plants.

- DOE provided a modification to ANSI/ANS 3.1-1993, "Selection, Qualification, and Training of Personnel for Nuclear Power Plants" (American Nuclear Society, 1993aa). DOE's modification stated that commitment to ANSI/ANS 3.1-1993 is limited to Paragraph 4.3.7, "Quality Assurance." Paragraph 4.3.7 provides the education and experience requirements for QA personnel. The QARD Introduction states that the QARD applies to design, procurement, and construction activities for the Yucca Mountain repository. The NRC staff determines that this DOE modification is acceptable because the only position described in ANSI/ANS 3.1-1993 applicable to the QARD for Yucca Mountain repository is that of QA in Paragraph 4.3.7. The remaining positions described in ANSI/ANS 3.1-1993 would be for personnel working for nuclear power plants.
- DOE provided a modification to NUREG-1297, "Peer Review for High-Level Nuclear Waste Repositories" (NRC, 1988ac). DOE's modification stated that its commitment to NUREG-1297 is limited to Section III, "Definitions," and Section IV, "Staff Position." The NRC staff determines that this DOE modification is acceptable because NUREG-1297, Sections III and IV provide specific guidance for conducting peer reviews, whereas the remaining sections of NUREG-1297 provide background information.
- DOE provided a modification to NUREG-1563, "Branch Technical Position on the Use of Expert Elicitation in the High-Level Radioactive Waste Program" (NRC, 1996aa). DOE's modification stated that commitment to NUREG-1563 is limited to Section 3, "Branch Technical Position, and Appendix A, "Glossary," with one exception: Branch Technical Position, Step 7, "Post-Elicitation Feedback," recommends documenting the rationale for any revisions to elicited evaluations after the experts receive feedback on their initial evaluations. DOE explained that it does not require documentation of the rationale for revisions to an expert's initial assessment in the expert elicitation report. First, the NRC staff determines that DOE's modification to use only NUREG-1563 Section 3 and Appendix A is acceptable because these sections provide specific guidance for conducting the expert elicitation process, whereas the remaining sections of NUREG-1563 provide background information. Second, the NRC staff also determines that DOE's modification to not require documentation of the rationale for revisions to an expert's initial assessment in the expert elicitation report is acceptable because this process is consistent with NUREG-2117, "Practical Implementation Guidelines for SSHAC Level 3 and 4 Hazard Studies" (NRC, 2012aa), which updates the expert elicitation process described in NUREG-1563.

Evaluation Findings Regarding QA Program

On the basis of the NRC staff's review of the QARD and other guidance documents discussed in the previous section, the NRC staff finds DOE's description of the activities related to the QA program consistent with YMRP Section 2.5.3, Acceptance Criterion 2. Therefore, the NRC staff finds, with reasonable assurance, that the description regarding the QA program addresses how the requirements of 10 CFR 63.142(c) will be satisfied and that QA program changes will be performed in accordance with 10 CFR 63.144.

2.5.1.4.2.3 Design Control

The requirements for the activities related to design control are in 10 CFR 63.142(d), which provide that DOE (i) establish measures to assure that applicable regulatory requirements and the design basis for those structures, systems, and components to which the QA program applies are correctly translated into specifications, drawings, procedures, and instructions; (ii) establish measures to identify and control design interfaces; and (iii) coordinate among participating design organizations. The NRC staff reviewed QARD Section 3.0, "Design Control," using YMRP Section 2.5.1.3, Acceptance Criterion 3.

QARD Section 3.0 provides controls to ensure that designs are defined and controlled. The NRC staff reviewed the QARD, which states that the scope of the design control includes design activities associated with the preparation and review of design documents, and correct translation of applicable regulatory requirements, design bases, and site characteristics into design, procurement, and procedural documents. The QARD Glossary states that "design" includes specifications; drawings; design criteria; design bases; structures, systems, and components performance requirements for preclosure; and natural and engineered barriers of the repository system.

The NRC staff reviewed the QARD, which states that design control measures are established and applied to (i) the design of items that are important to safety; (ii) engineered and natural barriers that are important to waste isolation; (iii) the description of the geologic setting and the plans for data collection and analysis activities that will generate information pertinent to the repository design and that will be relied on in site characterization, licensing, and performance confirmation; (iv) computer software used in such activities; and (v) development of as-built drawings and related documentation.

The NRC staff reviewed the QARD, which states that design drawings and specifications are reviewed by individuals or groups, other than those that generated the document, that are trained and qualified in QA practices and concepts to ensure that the documents are prepared, reviewed, and approved in accordance with applicable implementing documents. The QARD also states that errors and deficiencies in approved design documents, including design methods that could adversely affect important to safety structures, systems, and components or important to waste isolation barriers, will be documented and action taken to ensure (i) all errors and deficiencies are corrected, (ii) that deviations from specified quality standards will be identified and formally documented, (iii) and that procedures will be established to ensure control of these deviations.

The NRC staff reviewed the QARD, which states that (i) design interfaces will be identified and controlled; (ii) design efforts will be coordinated among participating design organizations and across technical disciplines; and (iii) interface controls will include the assignment of responsibility and the establishment of implementing documents among participating design organizations and technical disciplines for the review, approval, release, distribution, and revision of documents to ensure that structures, systems, and components are compatible geometrically, functionally, and with the environment.

The NRC staff reviewed the QARD, which states that (i) the dimensional accuracy and completeness of design drawings and specifications will be checked and documented; (ii) design drawings and specifications will be reviewed by individuals or groups, other than those that generated the document, that are trained and qualified in QA practices and concepts; (iii) design drawing and specifications are prepared, reviewed, and approved in accordance with

applicable implementing documents; and (iv) design drawings and specifications contain the necessary QA requirements.

The NRC staff reviewed the QARD, which states that (i) guidelines or criteria will be established and described for determining the method of design verification; (ii) design verification will be performed by competent individuals or groups other than those that performed the original design; (iii) design verification will be performed in a timely manner before release for procurement, manufacture, construction, or release to another organization for use in other design work; (iv) procedural controls will provide criteria for determining when design documents that reflect the commitments of the SAR receive formal design verification by interdisciplinary or multi-organizational teams or by an individual; and (v) responsibilities of the verifier, areas and features to be verified, pertinent considerations to be verified, and the extent of documentation will be identified in procedures.

The NRC staff reviewed the QARD, which states that where design adequacy is to be verified by qualification tests (i) the test method will be identified; (ii) prototype, component, or feature testing will be performed as early as possible before the installation would become irreversible; and (iii) testing will demonstrate the adequacy of structures', systems', and components' performance under conditions that simulate the full range, including the most adverse anticipated design conditions as determined by analysis.

The NRC staff reviewed the QARD Supplement III, "Scientific Investigation," which states that (i) scientific notebooks will be reviewed by an independent qualified individual to verify there is sufficient detail to retrace the investigations and confirm the results, or repeat the investigation and achieve comparable results, independent of the original investigator; (ii) data will be identified in a manner that facilitates traceability to associated documentation and facilitates traceability to its qualification status; (iii) all documentation resulting from scientific investigation will be transparent, identify principal lines of investigation considered, and be legible and in a form suitable for reproduction, filing, and retrieval; and (iv) model development and approaches to validation will be planned, controlled, and documented. QARD Supplement III also states that data from scientific investigation activities that are used as direct input to site characterization, and scientific analysis or performance modeling that addresses safety and waste isolation issues, will be qualified from origin. QARD Supplement III further states that, before use in addressing safety and waste isolation issues, internal and external unqualified data will be qualified and reviewed to determine the technical correctness of the data. The NRC staff reviewed the QARD Supplement III, which states that scientific investigations, including data identification, data reduction, and model development and use, will be planned, performed transparently, documented in scientific notebooks, coordinated with organizations providing input to or using the results of investigations, and will have the accuracy, precision, and representativeness of results determined.

DOE provided a response (DOE, 2008ak) to the NRC staff's request for additional information for how each of the alternatives presented in the technical assessment method for qualifying existing data described in QARD Section III.2.7A.1 provides assurance of quality equivalent to the four methods identified in NUREG-1298, "Qualification of Existing Data for High-Level Nuclear Waste Repositories" (NRC, 1988ab). DOE explained that the technical assessment method for qualifying existing data described in QARD Section III.2.7A.1 provides assurance of quality equivalent to the four methods identified in NUREG-1298 because it follows the same formal process as those methods and considers the same qualification attributes to provide the desired level of confidence that the data are suitable for their intended use. The NRC staff

determines that DOE's methods for qualifying existing data are acceptable because the qualification process is defined, controlled, verified, and documented.

The NRC staff reviewed the QARD Supplement I, "Software," which states that (i) controls will be established to permit authorized access and prevent unauthorized access to the operating environment; (ii) software validation will be planned, performed, documented, and verified to ensure that the software satisfies the requirements for its intended use; (iii) a plan addressing software QA will be in existence for each new software project at the start of the software life cycle; (iv) software life cycle phases are requirements, design, implementation, testing, installation, operations, and retirement; (v) a software configuration management process will be established to include configuration identification, configuration change control, and status accounting; (vi) individuals or organizations developing and supplying software or software services under contract shall be required to have policies and procedures that meet the QARD; (vii) software engineering elements must define the baseline documents that are to be maintained as records; (viii) a software problem reporting and resolution system will be implemented for software errors and failures to ensure problems are promptly reported and a formal processing of problem resolutions exists; (ix) user organizations control and document the use of issued software items such that comparable results can be obtained, with differences explained, through independent replication of the process; and (x) software requirements will be implemented through various means such as policies, procedures, plans, specifications, and work practices that provide the framework for software engineering activities.

The NRC staff reviewed the QARD, which states that (i) the sampling plan basis, including any supporting analyses for the use of sampling plans for quality-affecting work, such as inspection and commercial dedication, will be documented; (ii) changes to final designs, field changes, and nonconforming items dispositioned as use as is or repair will be justified and will be subject to design control measures commensurate with those applied to the original design; (iii) measures will be provided to ensure personnel are notified of design changes that may affect the performance of their duties; and (iv) after the construction authorization is issued, DOE stated that design changes will be evaluated in accordance with 10 CFR 63.44; this DOE commitment is addressed in SER Volume 5, License Specifications, Section 2.5.10.1.3.1.1.1.

In QARD Supplement III, "Scientific Investigation," DOE provided the following two modifications to commitment documents.

- The first DOE modification is to NUREG-1298 (NRC, 1988ab), "Qualification of Existing Data for High-Level Nuclear Waste Repositories." NUREG-1298, Section IV, Staff Position 2, identifies four alternative or combinations of methods that are acceptable for the process of qualifying data. DOE's modification stated that, in addition to the four methods listed, DOE uses a fifth method, "Technical Assessment," which includes one or a combination of the following: (i) determination that the employed methodology is acceptable, (ii) determination that confidence in the data acquisition or developmental results is warranted, or (iii) confirmation that the data have been used in similar applications. The NRC staff determines that this DOE modification is acceptable because DOE established adequate procedures describing methods for reviewing and qualifying data used in design that were collected without a fully implemented 10 CFR Part 63 QA program, and the alternative methods DOE describes in this modification are consistent with the methods for qualifying data discussed NUREG-1298.

- The second DOE modification is to NUREG–1636, “Regulatory Perspectives on Model Validation in High-Level Radioactive Waste Management Programs: A Joint NRC/SKI White Paper” (NRC, 1999ad). NUREG–1636 has two primary sections: Section 2, “International Experience with Model Validation,” and Section 3, “Model Validation Approach from a Regulatory Perspective.” DOE’s modification stated that it commits to the requirements and recommendations in only NUREG–1636, Section 3 presented in QARD Supplement III, Subsection III.2.6, “Model Development and Use.” The NRC staff determines that this DOE modification is acceptable because NUREG–1636, Section 2 provides international efforts for model validation and is not directly applicable to Yucca Mountain activities, where NUREG-1636, Section 3 is applicable. Furthermore, QARD Subsection III.2.6 provides model development methods and approaches to model validation for Yucca Mountain consistent with the model validation information in NUREG–1636, Section 3.

In QARD Section 3.2.9, “Commitment Document Positions,” DOE provided additional modifications to commitment documents for NQA–1–2000, “Quality Assurance Requirements for Nuclear Facility Applications” (American Society of Mechanical Engineers, 2000aa). The NRC staff guidance in YMRP Section 2.5.1.5 establishes NQA–1–2000, Subpart 2.7, “Quality Assurance Requirements for Computer Software for Nuclear Facility Applications,” as the only subpart of NQA–1–2000 that DOE is expected to commit to in its QA program. However, in the description of design control in the QARD, DOE added modifications to NQA–1–2000 subparts other than Subpart 2.7. DOE also provided modifications to Regulatory Guide 1.54, “Service Level I, II, and III Protective Coatings Applied to Nuclear Power Plants,” Revision 1 (NRC, 2000ak), which is not identified in YMRP Section 2.5.1.5. The NRC staff determined that DOE’s modifications to NQA–1–2000 and Regulatory Guide 1.54 do not affect the NRC staff’s determination on whether DOE’s QA program description satisfies regulatory requirements.

Evaluation Findings Regarding Design Control

On the basis of the NRC staff’s review of the QARD, DOE’s response to NRC staff’s request for additional information, and other guidance documents discussed in the previous section, the NRC staff finds DOE’s description of the activities related to design control consistent with YMRP Section 2.5.3, Acceptance Criterion 3. Therefore, the NRC staff finds, with reasonable assurance, that the description regarding design control addresses how the requirements of 10 CFR 63.142(d) will be satisfied.

2.5.1.4.2.4 Procurement Document Control

The requirements for the activities related to procurement document control are in 10 CFR 63.142(e) and provide that DOE establish measures to assure that applicable regulatory requirements, design bases, and other requirements necessary to assure adequate quality are suitably included or referenced in the documents for procurement of material, equipment, and services. The NRC staff reviewed QARD Section 4.0, “Procurement Document Control,” using YMRP Section 2.5.1.3, Acceptance Criterion 4.

In the QARD Section 4.0 DOE establishes requirements to ensure that procurement documents and any changes contain appropriate technical and QA requirements. The NRC staff reviewed the QARD, which states that (i) reviews will ensure that applicable requirements are correctly stated, inspectable, and controllable; (ii) there are adequate acceptance criteria; (iii) the procurement document has been prepared, reviewed, and approved and procurement documents will require suppliers to have QA programs consistent with the applicable

requirements of the QARD; and (iv) when specified by controlling procedures, procurement documents will be reviewed by individuals or groups, other than those that generated the document that are trained and qualified in QA practices and concepts, and who will concur with these documents, with respect to the QA-related aspects.

The NRC staff reviewed the QARD, which states that procurement documents will include (i) technical requirements, including drawings, specifications, codes, standards, regulations, procedures, and instructions that describe the technical requirements of the items or services to be furnished; (ii) tests, inspections, and acceptance requirements that the purchaser will use to monitor and evaluate the performance of the supplier; (iii) identification of the schedule for submittal of documents to the purchaser for information, review, or approval and when the purchaser requires the supplier to maintain specific QA records, the retention times and disposition will be prescribed; (iv) purchaser requirements for the supplier to report nonconformances dispositioned as use-as-is or repair to the purchaser for approval of the disposition; and (v) instructions relative to the performance of special processes.

The NRC staff reviewed the QARD, which states that procurements will be planned and documented to ensure a systematic approach to the procurement process. The QARD states that the procurement process will (i) identify procurement methods and organizational responsibilities, and provide for procurement document preparation, review, and change control; (ii) identify selection of procurement sources; (iii) identify proposal/bid evaluation and award; and (iv) include participation of representatives from the technical organizations and individuals that are trained and qualified in QA practices and concepts. The QARD also states that the supplier's QA program description document will be accepted by the purchaser prior to the start of work.

DOE provided a modification to NQA-1-1983, Supplement 4S-1, "Supplementary Requirements for Procurement Document Control" (American Society of Mechanical Engineers, 1983aa). Supplement 4S-1, Subsection 2.3 provides that suppliers have a documented QA program. DOE's modification states that when purchasing analytical services to support scientific investigation, data to support scientific investigation, or commercial calibration services from calibration laboratories accredited by a nationally recognized accrediting body, a QA program is not required to be imposed; these procurements will be controlled in accordance with QARD Subsections 7.2.12B, "Commercial Procurement of Analytical Services," 7.2.12C, "Commercial Procurement of Data," and 7.2.12D, "Commercial Procurement of Calibration Services." The NRC staff determines that this modification is acceptable for two reasons. First, QARD Section 4.2.1C states that, as an alternative to requiring a documented QA program for the procurement of analytical services to support scientific investigation, procurement of data, or commercial calibration services, the procurement may be controlled in accordance with QARD Sections 7.2.12B, 7.2.12C, and 7.2.12D, respectively. Second, QARD Sections 7.2.12B, 7.2.12C, and 7.2.12D establish procurement controls that are consistent with NQA-1, Supplement 4S-1, and NQA-1, Supplement 7S-1, "Supplementary Requirements for Control of Purchased Items and Services."

Evaluation Findings Regarding Procurement Document Control

On the basis of the NRC staff's review of the QARD and other guidance documents discussed in the previous section, the NRC staff finds DOE's description of the activities related to the procurement document control consistent with YMRP Section 2.5.3, Acceptance Criterion 4. Therefore, the NRC staff finds, with reasonable assurance, that the description regarding

procurement document control addresses how the requirements of 10 CFR 63.142(e) will be satisfied.

2.5.1.4.2.5 Instructions, Procedures, and Drawings

The requirements for the activities related to instructions, procedures, and drawings are in 10 CFR 63.142(f) and provide that activities affecting quality must be prescribed by documented instructions, procedures, or drawings of a type appropriate to the circumstances and must be accomplished in accordance with these instructions, procedures, or drawings. The requirements for implementation of the QA program are in 10 CFR 63.143, and provide that implementation of the QA program shall be based on the QA criteria in 10 CFR 63.142. The NRC staff reviewed QARD Section 5.0, "Procedures, Instructions, and Drawings," using YMRP Section 2.5.1.3, Acceptance Criterion 5.

DOE stated that the QA program consists of the QARD and those documents that implement the QARD. QARD Section 5.0 establishes the requirements to ensure that the QA program is implemented through instructions, procedures, and drawings, and that work is prescribed by, and performed in accordance with, those implementing documents. The NRC staff reviewed the QARD, which states that, consistent with the requirements in 10 CFR 63.142 and 10 CFR 63.143, (i) the QA program and quality-affecting work will be prescribed by controlled implementing documents of a type appropriate to the circumstance and will be accomplished in accordance with the implementing documents; (ii) quantitative and qualitative acceptance criteria for determining that prescribed activities have been satisfactorily accomplished; and (iii) prescribed results have been satisfactorily attained. The QARD also states that implementing documents, including changes, will be reviewed prior to approval and issuance for correctness, adequacy, completeness, accuracy, and compliance with established requirements by individuals other than the preparer who are trained and qualified in QA practices and concepts.

Evaluation Findings Regarding Instructions, Procedures, and Drawings

On the basis of the NRC staff's review of the QARD discussed in the previous section, the NRC staff finds DOE's description of the activities related to the instructions, procedures, and drawings consistent with YMRP Section 2.5.3, Acceptance Criterion 5. Therefore, the NRC staff finds, with reasonable assurance, that the description regarding instructions, procedures, and drawings addresses how the requirements of 10 CFR 63.142(f) will be satisfied and that the QA program will be implemented in accordance with 10 CFR 63.143.

2.5.1.4.2.6 Document Control

The requirements for activities related to document control are in 10 CFR 63.142(g) and provide that DOE establish measures to control the issuance of documents, such as instructions, procedures, and drawings, including changes, that prescribe all activities affecting quality. The NRC staff reviewed QARD Section 6.0, "Document Control," using YMRP Section 2.5.1.3, Acceptance Criterion 6.

QARD Section 6.0 establishes requirements to ensure that documents within the scope of the QARD, including changes, are reviewed for adequacy, approved for release, distributed for use at the location where the work is being performed, and used at the work location. The NRC staff reviewed the QARD, which states that (i) controlled documents include, but are not limited to, documents that specify quality or technical requirements or prescribe activities that are

governed by the QARD (e.g., design documents; procurement documents; procedures, instructions, and drawings; QA program description documents; and SARs for distribution and use); (ii) the review of documents will be performed by individuals, other than the preparer, who are trained and qualified in QA practices and concepts, and the organizational position responsible for approving documents for release shall be identified; (iii) the latest version of documents will be available for use prior to the start of work at the location where the activity is performed, and the disposition of cancelled or superseded documents will be controlled to ensure that they are not used to perform work; and (iv) a process will be established to identify the current status of each document that is required to be controlled. The QARD states that changes to documents will be reviewed and approved by the same functional organizations that performed the original review and approval unless DOE designates another responsible functional organization. The QARD also states that the type of document to be used to perform work will be appropriate to the nature and circumstances of the work being performed and that design drawings, including as-built drawings, will be developed and controlled.

DOE provided a modification to NQA-1-1983, Supplement 6S-1, "Supplementary Requirements for Document Control" (American Society of Mechanical Engineers, 1983aa). Supplement 6S-1, Subsection 3.1 provides that major changes described in Subsection 3.1 be reviewed and approved by the same organizations that performed the original review and approval, and minor changes described in Supplement 6S-1, Subsection 3.2 do not have to receive the same review and approval as the original documents. DOE's modification states that, in lieu of defining changes as major or minor, DOE will (i) limit the scope of the minor changes category to the inconsequential editorial corrections described in QARD Section 6.2.8, "Editorial Corrections" and (ii) treat controlled document changes outside the scope of QARD Section 6.2.8 as major changes. The NRC staff determine that this DOE modification is acceptable because, consistent with NQA-1-1983, Supplement 6S-1, the editorial corrections described in QARD Section 6.2.8 are minor and do not need to be reviewed and approved by the same organization that performed the original review and approval.

Evaluation Findings Regarding Document Control

On the basis of the NRC staff's review of the QARD and other guidance documents discussed in the previous section, the NRC staff finds DOE's description of the activities related to document control consistent with YMRP Section 2.5.3, Acceptance Criterion 6. Therefore, the NRC staff finds, with reasonable assurance, that the description regarding document control addresses how the requirements of 10 CFR 63.142(g) will be satisfied.

2.5.1.4.2.7 Control of Purchased Material, Equipment, and Services

The requirements for activities related to control of purchased material, equipment, and services are in 10 CFR 63.142(h) and provide that DOE establish measures to assure that purchased material, equipment, and services, whether purchased directly or through contractors and subcontractors, conform to the procurement documents. The NRC staff reviewed QARD Section 7.0, "Control of Purchased Material, Equipment, and Services," using YMRP Section 2.5.1.3, Acceptance Criterion 7.

QARD Section 7.0 establishes requirements for planning and executing procurements to ensure that purchased items and services meet specified requirements. The NRC staff reviewed the QARD, which states that (i) the organizational responsibilities of the purchaser for source evaluation and selection will be identified; (ii) source verification procedures provide for audits, surveillance, or inspections to ensure that the supplier complies with QA and technical

requirements; (iii) the results of procurement source evaluation and selection will be documented; (iv) spare parts will be subject to QA program controls, codes, and standards, and technical requirements equal to or greater than the original requirements; (v) suppliers will verify that furnished items or services comply with purchaser procurement document requirements before offering the items or services for acceptance; (vi) items that have passed required inspections and tests will be identified to preclude the inadvertent installation, use, or operation of items that have not passed required inspections and tests; (vii) supplier-furnished documentation will identify the specific procurement document requirements met by the purchased item or service, include any approved changes, waivers, or deviations applicable to the item or service; (viii) when basic components are not available, commercial grade items may be substituted for basic components provided the necessary assurance that the dedicated items will perform their intended safety or waste isolation function; (ix) the basis for sampling plans, including any supporting analyses for the use of sampling plans for structures, systems, and components and barriers, and activities thereto, such as inspection and commercial dedication, will be documented; and (x) measures will be identified to verify the validity of certificates and the effectiveness of the certification process. The NRC staff determines that documentary evidence that material and equipment conform to the procurement requirements is available and acceptable as discussed in SER Section 2.5.1.3.2.17.

QARD Section 7.0 states that, for the purchase of ASME Section III Code items, editions of ANSI/ASME NQA-1 (American Society of Mechanical Engineers, 1983aa) identified in NRC-endorsed versions of the code may be used for the construction of ASME Section III Code items when the referenced edition of ANSI/ASME NQA-1 is used in conjunction with other QA, administrative, and reporting requirements contained in the code. Further, applicable requirements contained in the QARD or supplier QA program description document will also be met in conjunction with the ASME Section III Code. QARD Section 7.0 states that audits of ASME Code suppliers will confirm that the suppliers are satisfactorily implementing (i) their accredited ASME Code QA program, (ii) the technical and quality provisions specified in the purchase order, (iii) the applicable provisions of the QARD or principal contractor QA program description document, and (iv) applicable requirements contained in the regulations. QARD Section 7.0 also states that documentary evidence that items or services conform to procurement documents will be available at the purchaser's facility before the item is installed or before the service is used.

DOE provided two modifications to NQA-1-1983, Supplement 7S-1, "Supplementary Requirements for Control of Purchased Items and Services."

- The first modification is to Supplement 7S-1, Section 10, "Commercial Grade Items," which provides requirements for the commercial grade procurement of items. DOE's modification states that, in lieu of the requirements specified in Section 10, DOE will implement a commercial grade item dedication program in accordance with QARD Section 7.2.12A, "Commercial Grade Items." The NRC staff reviewed QARD Section 7.2.12A where DOE states that the dedication process will be implemented consistent with Electric Power Research Institute (EPRI) "Guideline for the Utilization of Commercial Grade Items in Nuclear Safety Related Applications" (NCIG-07), EPRI NP-5652 (Electric Power Research Institute, 1988aa). The NRC staff determines that this modification is acceptable because QARD Section 7.2.12A provides dedication process controls consistent with EPRI NP-5652, as endorsed by NRC Generic Letter 1989-002, "Actions To Improve the Detection of Counterfeit and Fraudulently Marketed Products" (NRC, 1989ab), and NRC Generic Letter 1991-005, "Licensee

Commercial-Grade Procurement and Dedication Programs” (NRC, 1991ab). EPRI NP-5652 is consistent with the guidance provided in YMRP Acceptance Criterion 7.

- DOE’s second modification states that as an alternative to the imposition of all otherwise applicable requirements of Supplement 7S-1 for the procurement of analytical services in support of scientific investigations, the procurement of data in support of scientific investigation, or the procurement of commercial calibration services, DOE will implement the purchaser-related requirements described in QARD Sections 7.2.12B, “Commercial Procurement of Analytical Services,” 7.2.12C, “Commercial Procurement of Data,” or 7.2.12D, “Commercial Procurement of Calibration Services.” The NRC staff reviewed QARD Sections 7.2.12B, 7.2.12C, and 7.2.12D and determines that they provide adequate controls for the related procurement activities. The NRC staff determines that this modification is acceptable because the established controls are consistent with Supplement 7S-1 in that procurements are planned, procurement sources are evaluated, and supplier performance is evaluated.

DOE stated that it will follow EPRI NP–5652 (Electric Power Research Institute, 1988aa), “Guideline for the Utilization of Commercial Grade Items in Nuclear Safety Related Applications (NCIG-07),” as endorsed and modified by NRC Generic Letters 89-02 (NRC, 1989ab) and 91-05 (NRC, 1991ab). The NRC staff guidance in YMRP Section 2.5.1.5 establishes EPRI NP-5652 as a noncommitment document (i.e., a document that DOE may consider if its QA program addresses a subject covered by the document). The NRC staff determined that this modification has no bearing on the NRC staff’s findings on whether DOE’s QA program description is acceptable for a construction authorization because DOE will implement its commercial grade dedication in accordance with an NRC approved approach in EPRI NP-5652.

Evaluation Findings Regarding Control of Purchased Material, Equipment, and Services

On the basis of the NRC staff’s review of the QARD and other guidance documents discussed in the previous section, the NRC staff finds DOE’s description of the activities related to control of purchased material, equipment, and services consistent with YMRP Section 2.5.3, Acceptance Criterion 7. Therefore, the NRC staff finds, with reasonable assurance, that the description regarding control of purchased material, equipment, and services addresses how the requirements of 10 CFR 63.142(h) will be satisfied.

2.5.1.4.2.8 Identification and Control of Material, Parts, and Components

The requirements for activities related to identification and control of material, parts, and components (items) are in 10 CFR 63.142(i) and provide that measures be established for the identification and control of items, including partially fabricated assemblies. The NRC staff reviewed QARD Section 8.0, “Identification and Control of Material, Parts, and Components,” using YMRP Section 2.5.1.3, Acceptance Criterion 8.

QARD Section 8.0 establishes requirements for the identification and control of items to ensure that only correct and accepted items are used or installed. The NRC staff reviewed the QARD, which states that identification will be maintained on items or in documents traceable to the items; items will be identified from the time of initial fabrication, or receipt, up to and including installation or end use; identification will relate an item to an applicable design or other pertinent specifying document; and correct identification of items will be verified and documented prior to release for fabrication, assembly, shipping, or installation.

The NRC staff reviewed the QARD, which states that item identification methods will include use of physical markings to the maximum extent possible, and if physical markings are either impractical or insufficient, other appropriate means will be used, such as physical separation, labels, or tags attached to containers. The QARD also states that physical markings, when used, will be applied using materials and methods that provide a clear and legible identification; not detrimentally affect the function or service life of the item; be transferred to each part of an identified item when the item is subdivided; and not be obliterated or hidden by surface treatments, coatings, or after installation unless other means of identification are substituted.

The NRC staff reviewed QARD Supplement II, "Sample Control," which states that (i) samples will be controlled and identified in a manner consistent with their intended use; (ii) a unique identifier will be maintained on the samples or in a manner that ensures that identification is established and maintained; (iii) samples will maintain their same unique identifier from their initial collection through final use; (iv) sample identification will be documented and verified before the sample is released for use or analysis; (v) sample identification methods will include use of physical markings; and (vi) if physical markings are either impractical or insufficient, other appropriate means will be employed.

Evaluation Findings Regarding Identification and Control of Material, Parts, and Components

On the basis of the NRC staff's review of the QARD discussed in the previous section, the NRC staff finds DOE's description of the activities related to identification and control of material, parts, and components consistent with YMRP Section 2.5.3, Acceptance Criterion 8. Therefore, the NRC staff finds, with reasonable assurance, that the description regarding identification and control of material, parts, and components addresses how the requirements of 10 CFR 63.142(i) will be satisfied.

2.5.1.4.2.9 Control of Special Processes

The requirements for activities related to control of special processes are in 10 CFR 63.142(j) and provide that DOE establish measures to assure that special processes, including welding, heat treating, and nondestructive testing, are controlled and accomplished by qualified personnel using qualified procedures in accordance with applicable codes, standards, specifications, criteria, and other special requirements. The NRC staff reviewed QARD Section 9.0, "Control of Special Processes," using YMRP Section 2.5.1.3, Acceptance Criterion 9.

QARD Section 9.0 establishes that controls for processes affecting the quality of items or services are controlled and that special processes that control or verify quality, such as welding, heat treating, chemical cleaning, and nondestructive examination are controlled and accomplished by qualified personnel using qualified procedures in accordance with applicable codes, standards, specifications, criteria, and other requirements. The NRC staff reviewed the QARD, which states that the requirements for qualification of personnel, procedures, or equipment for special processes will be specified or referenced in implementing documents; special processes will produce results whereby the results are highly dependent on the control of the process and the skill of the operator; and the quality of the results cannot be readily determined by inspection or test of the item.

The NRC staff reviewed the QARD, which states that implementing documents will be used to ensure that process parameters are controlled and that the specified environmental conditions

are maintained. The QARD also states that (i) implementing documents identify organizational responsibilities, including those for individuals or groups that are trained and qualified in QA practices and concepts, for the qualification of special process equipment and personnel; (ii) records will be maintained for each special process method, as will provisions for recording evidence of acceptable accomplishment of special processes using qualified procedures, equipment, and personnel; (iii) qualification requirements for personnel, implementing documents, and equipment will comply with specified requirements; (iv) conditions necessary for accomplishment of the special process will exist; and (v) requirements of applicable codes, standards, and specifications, including acceptance criteria for the special process will be in place.

The NRC staff reviewed the QARD, which states that (i) nondestructive examination will include radiography, magnetic particle, ultrasonic, liquid penetrant, eddy current, neutron radiography, acoustic emission, and leak testing; (ii) personnel who perform nondestructive examinations will be qualified and certified per SNT-TC-1A (American Society of Nondestructive Testing, 1980aa) and will undergo a performance demonstration as part of the practical examination; and (iii) implementing documents will be established for the control and administration of nondestructive examination personnel training, examination, and certification.

Evaluation Findings Regarding Control of Special Processes

On the basis of the NRC staff's review of the QARD discussed in the previous section, the NRC staff finds DOE's description of the activities related to control of special processes consistent with YMRP Section 2.5.3, Acceptance Criterion 9. Therefore, the NRC staff finds, with reasonable assurance, that the description regarding control of special processes addresses how the requirements of 10 CFR 63.142(j) will be satisfied.

2.5.1.4.2.10 Inspection

The requirements for activities related to inspection are in 10 CFR 63.142(k) and provide that (i) DOE establish and execute a program for inspection of activities affecting quality to verify conformance with the documented instructions, procedures, and drawings for accomplishing the activity and (ii) the inspections be performed by individuals other than those who performed the activity being inspected. The NRC staff reviewed QARD Section 10.0, "Inspection," using YMRP Section 2.5.1.3, Acceptance Criterion 10.

QARD Section 10.0 establishes requirements for developing, planning, and executing an effective inspection program. The NRC staff reviewed the QARD, which states that (i) inspection planning will be performed and documented; (ii) individuals that are trained and qualified in QA practices and concepts will participate in planning activities; and (iii) applicable codes, standards, specifications, and design documents will be used to develop inspection plans. The QARD states that the elements of inspection plans identify (i) characteristics to be inspected; (ii) the description of inspection or process monitoring that will be used; (iii) the organization responsible for performing the inspection; (iv) mandatory hold points; (v) acceptance criteria; (vi) measuring and test equipment to be used; (vii) the sampling plan, if used; and (viii) methods to record inspection results.

The NRC staff reviewed the QARD, which states that (i) the individual who performs an inspection to verify conformance of an item to specified acceptance criteria will be qualified, (ii) inspections performed by personnel during on-the-job training will be performed under the direct observation and supervision of a qualified person and verification of conformance will be

by the qualified person, (iii) inspections for acceptance will be performed by individuals other than those who performed or directly supervised the work being inspected, (iv) those individuals will not report directly to the supervisor immediately responsible for performance of the work, and (v) statistical sampling methods will be based on recognized standard practices.

The NRC staff reviewed the QARD, which states that (i) items in process or under construction will be inspected to verify quality; (ii) inspection and process monitoring both will be conducted when control is inadequate with only one method; (iii) a combination of inspection and process monitoring methods, when used, will be performed in a systematic manner to ensure that the quality of the item is met; and (iv) controls will be documented for the coordination and sequencing of the work. The NRC staff also reviewed the QARD, which states that final inspection (i) will be planned to determine conformance of the item to specified requirements, including completeness, markings, calibration, adjustments, protection from damage, or other characteristics; (ii) will examine quality records not previously examined for completeness; (iii) will review the resolution of identified nonconformances; and (iv) will reinspect modifications, repairs, or replacements, as appropriate.

The NRC staff reviewed the QARD, which states that inspection documentation will identify the item inspected, date of inspection, name of the inspector and data recorder, type or method of inspection, inspection criteria, results, measuring and test equipment used and calibration information, acceptance of inspection results, and the inspection status of the item inspected.

The NRC staff reviewed the QARD Supplement IV, "Field Surveying," which states that examples of work that have the potential to require field surveying services for location determination include site characterization, explorations, and installations. QARD Supplement IV states that the field survey system is a permanent system of horizontal and vertical controls that will be established and maintained, and that this system will be used in accordance with implementing documents to obtain the accurate location and relocation of designated features, including locations of sample or data collection. QARD Supplement IV also states that pertinent survey documents will be identified, maintained, and verified for completeness as the work progresses.

DOE provided a modification to NQA-1-1983, Supplement 10S-1, "Supplementary Requirements for Inspection" (American Society of Mechanical Engineers, 1983aa). Supplement 10S-1, Section 2.2, "Qualifications," states that each person who verifies conformance of work activities for purposes of acceptance shall be qualified to perform the assigned inspection task. DOE's modification stated that, in lieu of the qualification requirement of Section 2.2, inspections may be performed by trainees during on-the-job training; these inspections will be performed under the direct observation and supervision of a qualified person; verification of conformance will be by the qualified person until proper certification is achieved; and data recorders, equipment operators, or other inspection or test team members who are supervised by a qualified inspector will not be required to be qualified inspectors. The NRC staff determines that this DOE modification is acceptable because DOE's inspection controls are consistent with NQA-1-1983, Supplement 10S-1 in that DOE states qualified persons will observe equipment operations, tests, and inspections performed by unqualified individuals, and final inspection and acceptance will be performed by qualified inspectors.

Evaluation Findings Regarding Inspection

On the basis of the NRC staff's review of the QARD and other guidance documents discussed in the previous section, the NRC staff finds DOE's description of the activities related to

inspection consistent with YMRP Section 2.5.3, Acceptance Criterion 10. Therefore, the NRC staff finds, with reasonable assurance, that the description regarding inspection addresses how the requirements of 10 CFR 63.142(k) will be satisfied.

2.5.1.4.2.11 Test Control

The requirements for activities related to test control are in 10 CFR 63.142(l) and provide that DOE establish a test program to assure that all testing required to demonstrate that structures, systems, and components important to safety will perform satisfactorily in service is identified and performed in accordance with written test procedures which incorporate the requirements and acceptance limits contained in applicable design documents. The NRC staff reviewed QARD Section 11.0, "Test Control," using YMRP Section 2.5.1.3, Acceptance Criterion 11.

QARD Section 11.0 establishes requirements for planning and executing tests required to demonstrate that items will perform satisfactorily in service. The NRC staff reviewed the QARD, which states that tests will (i) be performed in accordance with implementing documents that incorporate requirements and acceptance criteria contained in applicable design documents and (ii) include prototype qualification tests, component or feature qualification tests, production tests, proof tests prior to installation, construction tests, preoperational tests, testing of computer software, and tests supporting the acquisition of data.

The NRC staff reviewed the QARD, which states that test planning will require identification of documents to perform tests, provide criteria for determining the accuracy requirements of test equipment, and define how and when testing activities are performed. The QARD establishes provisions for (i) performing testing as early as possible before the installation would become irreversible; (ii) identification of the item to be tested, test requirements, and acceptance limits; (iii) identification of test methods and instructions; (iv) identification of test prerequisites that address calibrated instrumentation, including accuracy requirements, trained personnel, condition of test equipment, and the completeness of the item to be tested; (v) identification of required environmental conditions; and (vi) identification of data acquisition and storage, mandatory hold points, and methods to record results.

The NRC staff reviewed the QARD, which states that tests will be performed in accordance with implementing documents that address when a test is required, describing (i) how tests are performed, and ensuring that testing is conducted by trained and appropriately qualified personnel; (ii) test objectives and prerequisites; and (iii) test acceptance criteria. The NRC staff reviewed the QARD, which also states that test results will be documented to include the item tested; date of test; type of observation and test criteria; measuring and test equipment used with calibration information; test results and acceptability; actions taken for deviations; and the names of qualified tester, data recorder, and the person evaluating and accepting the test results.

Evaluation Findings Regarding Test Control

On the basis of the NRC staff's review of the QARD discussed in the previous section, the NRC staff finds DOE's description of the activities related to test control consistent with YMRP Section 2.5.3, Acceptance Criterion 11. Therefore, the NRC staff finds, with reasonable assurance, that the description regarding test control addresses how the requirements of 10 CFR 63.142(l) will be satisfied.

2.5.1.4.2.12 Control of Measuring and Test Equipment

The requirements for activities related to control of measuring and test equipment are in 10 CFR 63.142(m) and provide that DOE establish measures to assure that tools, gages, instruments, and other measuring and testing devices (equipment) used in quality-affecting activities are properly controlled, calibrated, and adjusted at specified periods to maintain accuracy within necessary limits. The NRC staff reviewed QARD Section 12.0, "Control of Measuring and Test Equipment," using YMRP Section 2.5.1.3, Acceptance Criterion 12.

QARD Section 12.0 establishes measures that equipment used in quality-affecting activities is properly controlled, calibrated, and adjusted at specified periods to maintain accuracy within necessary limits. The NRC staff reviewed the QARD, which states that master calibration standards will have a greater accuracy than standards being calibrated, master calibration standards will have an accuracy of at least four times the required accuracy of the equipment being calibrated, and a calibration or calibration check will be performed when the accuracy of the equipment is suspect or when it has passed its calibration due date. The NRC staff reviewed the QARD, which also states that calibrated equipment will be labeled, tagged, or uniquely marked or documented to indicate the due date of the next calibration.

The NRC staff reviewed the QARD, which states that the use of equipment will be documented and controlled to ensure that such equipment is of proper type, range, accuracy, and tolerance to determine conformance to requirements and that documentation will identify the processes monitored, the data collected, or equipment inspected or tested since the last calibration. The NRC staff reviewed the QARD, which also states that equipment will be considered out of calibration if (i) the calibration due date has passed, (ii) the equipment produces results known to be in error, (iii) or the calibration status cannot be determined. The QARD also states that out-of-calibration equipment will be controlled by tagging or segregating or will be otherwise controlled to prevent use and that when equipment is found to be out of calibration, the validity of results obtained using that equipment since its last valid calibration will be evaluated.

The NRC staff reviewed the QARD, which states that (i) equipment will be handled and stored to maintain accuracy; (ii) selection of equipment will be controlled to ensure that it is the proper type for the intended use; and (iii) calibration documentation will include identification of the equipment, traceability to the calibration standard, calibration data, identification of the individual performing the calibration, date of calibration and recalibration due date, results of the calibration, and statement of acceptability.

DOE provided a modification to NQA-1-1983, Supplement 12S-1, "Supplementary Requirements for Control of Measuring and Test Equipment" (American Society of Mechanical Engineers, 1983aa). Supplement 12S-1, Section 3.2, states that out-of calibration devices shall be tagged or segregated and not used until they have been recalibrated. DOE's modification states that out-of-calibration equipment will be tagged and controlled to prevent reissue until it has been recalibrated; if previously calibrated equipment that is in use is used after it is found to be out of calibration, the validity of results obtained using that equipment since its last valid calibration will be evaluated to determine acceptability for previously collected data, processes monitored, or items previously inspected or tested. The NRC staff determines that this modification is acceptable because DOE will continue to verify that the equipment is calibrated before use, identify and control equipment that is not calibrated, and verify results produced by uncalibrated or suspect equipment consistent with NQA-1-1983, Supplement 12S-1.

Evaluation Findings Regarding Control of Measuring and Test Equipment

On the basis of the NRC staff's review of the QARD and other guidance documents discussed in the previous section, the NRC staff finds DOE's description of the activities related to control of measuring and test equipment consistent with YMRP Section 2.5.3, Acceptance Criterion 12. Therefore, the NRC staff finds, with reasonable assurance, that the description regarding control of measuring and test equipment addresses how the requirements of 10 CFR 63.142(m) will be satisfied.

2.5.1.4.2.13 Handling, Storage, and Shipping

The requirements for activities related to handling, storage, and shipping are in 10 CFR 63.142(n) and provide that DOE establish measures to control the handling, storage, shipping, cleaning, and preservation of material and equipment in accordance with work and inspection instructions to prevent damage or deterioration. The NRC staff reviewed QARD Section 13.0, "Handling, Storage, and Shipping," using YMRP Section 2.5.1.3, Acceptance Criterion 13.

QARD Section 13.0 establishes requirements for the handling, storage, cleaning, packaging, shipping, and preservation of items and consumables to prevent damage or loss and to minimize deterioration. The NRC staff reviewed the QARD, which states that (i) handling, storage, cleaning, packaging, shipping, and preservation of items will be conducted in accordance with documents or instructions; (ii) if required, special equipment protective environments will be provided; and (iii) verified and maintained special handling tools and equipment will be used and controlled and operated to ensure proper handling. The NRC staff reviewed the QARD, which also states that measures will be established for marking and labeling for the packaging, shipping, handling, and storage of items to identify, maintain, and preserve the item and that markings and labels will indicate the presence of special environments or the need for special controls.

Evaluation Findings Regarding Handling, Storage, and Shipping

On the basis of the NRC staff's review of the QARD discussed in the previous section, the NRC staff finds DOE's description of the activities related to handling, storage, and shipping consistent with YMRP Section 2.5.3, Acceptance Criterion 13. Therefore, the NRC staff finds, with reasonable assurance, that the description regarding handling, storage, and shipping addresses how the requirements of 10 CFR 63.142(n) will be satisfied.

2.5.1.4.2.14 Inspection, Test, and Operating Status

The requirements for activities related to inspection, test, and operating status are in 10 CFR 63.142(o) and provide that DOE establish measures to indicate the status of inspections and tests performed on individual items of the high-level waste repository by markings such as stamps, tags, labels, routing cards, or other suitable means. The NRC staff reviewed QARD Section 14.0, "Inspection, Test, and Operating Status," using YMRP Section 2.5.1.3, Acceptance Criterion 14.

QARD Section 14.0 establishes requirements to identify the inspection, test, and operating status of items throughout fabrication, construction, installation, and testing. The NRC staff reviewed the QARD, which states that items that have passed inspections and tests will be identified to preclude the inadvertent installation, use, or operation of items that have not passed

required inspections and tests. The NRC staff reviewed the QARD, which also states that (i) the status of required inspection and tests of items will be indicated to preclude inadvertent bypassing of such inspections and tests; (ii) the status of inspections and tests will be identified either on the items or in documents traceable to the items; (iii) the status will be maintained through the use of status indicators or other means; (iv) the authority for applying and removing status indicators will be specified; and (v) to prevent the inadvertent use or operation of an item that is out of service, status indicators will be placed at all locations where operation of the item can be initiated.

Evaluation Findings Regarding Inspection, Test, and Operating Status

On the basis of the NRC staff's review of the QARD discussed in the previous section, the NRC staff finds DOE's description of the activities related to inspection, test, and operating status consistent with YMRP Section 2.5.3, Acceptance Criterion 14. Therefore, the NRC staff finds, with reasonable assurance, that the description regarding inspection, test, and operating status addresses how the requirements of 10 CFR 63.142(o) will be satisfied.

2.5.1.4.2.15 Nonconforming Material, Parts, or Components

The requirements for activities related to nonconforming material, parts, or components are in 10 CFR 63.142(p) and provide that DOE establish measures to control materials, parts, or components which do not conform to requirements in order to prevent their inadvertent use or installation. The NRC staff reviewed QARD Section 15.0, "Nonconforming Material, Parts, or Components," using YMRP Section 2.5.1.3, Acceptance Criterion 15.

QARD Section 15.0 establishes requirements for the control of items that do not conform to requirements in order to prevent inadvertent installation or use of the items. The NRC staff reviewed the QARD, which states that (i) nonconformances will be documented and reported to the appropriate levels of management responsible for the conditions, (ii) organizations affected by the nonconformance will be notified, (iii) nonconformances will be tracked and trended, (iv) nonconformance documentation will clearly describe the characteristics that do not conform to specified criteria, (v) nonconforming characteristics will be reviewed, and (vi) recommended dispositions of nonconforming items will be approved by individuals who are independent of the work that produced the disposition.

The NRC staff reviewed the QARD, which states that (i) nonconformance review will include determining the need for corrective action reporting in accordance with 10 CFR Part 21 and 10 CFR 63.73; (ii) recommended dispositions will be approved by competent individuals who are independent of the work that produced the disposition; (iii) the responsibility and authority for reviewing, evaluating, and approving the disposition, and closing nonconformances will be specified; (iv) further processing, delivery, installation, or use of a nonconforming item will be controlled; and (v) nonconforming items will be segregated and identified by marking, tagging, or other methods that are legible and easily recognizable. The QARD also states that if the identification of a nonconforming item is not practical, then the container, package, or segregated storage area will be identified; if segregation is impractical or impossible due to physical conditions, other precautions will be employed to preclude inadvertent use.

The NRC staff reviewed the QARD, which states that (i) the disposition of use as is, limited use, reject, repair, or rework for nonconforming items will be documented; (ii) the technical justification for the acceptability of a nonconforming item that has been dispositioned as repair, limited use, or use as is shall be documented; (iii) items that do not meet original design

requirements that are dispositioned as use as is or repair will be subject to design control measures commensurate with those applied to the original design; (iv) the disposition of an item to be reworked or repaired will contain a requirement to verify acceptability; and (v) replacement items shall be inspected and tested in accordance with the original inspection and test requirements or acceptable alternatives.

DOE provided a modification to NQA-1-1983, Supplement 15S-1, "Supplementary Requirements for the Control of Nonconforming Items" (American Society of Mechanical Engineers, 1983aa). Supplement 15S-1, Subsection 4.4, "Final Disposition," provides for four types of disposition: use as is, reject, repair, or rework. DOE's modification states that it will use an additional disposition, "limited use," and that this disposition will only be used for samples governed by QARD Supplement II, "Sample Control." The NRC staff determined that this DOE modification is acceptable because QARD Supplement II, Section II.2.4 states that if Yucca Mountain site collected samples have limited use, then methods will be established that preclude using the sample beyond its intended use, while QARD Section 15.2.1, "Documenting, Reporting, and Evaluating Nonconforming Items," states that nonconformance documentation will clearly identify and describe the characteristics that do not conform to specified criteria. DOE's modification is consistent with NQA-1-1983, Supplement 15S-1, Section 4.4, which states that the final disposition of nonconforming items shall be identified and documented.

Evaluation Findings Regarding Nonconforming Material, Parts, or Components

On the basis of the NRC staff's review of the QARD and other guidance documents discussed in the previous section, the NRC staff finds DOE's description of the activities related to nonconforming material, parts, or components consistent with YMRP Section 2.5.3, Acceptance Criterion 15. Therefore, the NRC staff finds, with reasonable assurance, that the description regarding nonconforming material, parts, or components addresses how the requirements of 10 CFR 63.142(p) will be satisfied.

2.5.1.4.2.16 Corrective Action

The requirements for activities related to corrective action are in 10 CFR 63.142(q) and provide that DOE establish measures to assure that conditions adverse to quality, such as failures, malfunctions, deficiencies, deviations, defective material and equipment, and nonconformances, are promptly identified and corrected; if significant conditions are adverse to quality, the measures must assure that the cause of the condition is determined and corrective action taken to preclude repetition. The NRC staff reviewed QARD Section 16.0, "Corrective Action," using YMRP Section 2.5.1.3, Acceptance Criterion 16.

QARD Section 16.0 establishes requirements to ensure conditions adverse to quality are promptly identified and corrected as soon as practical. The NRC staff reviewed the QARD, which states that (i) a condition adverse to quality will be identified and documented when a failure, malfunction, deficiency, deviation, defective item, or nonconformance is identified and (ii) conditions adverse to quality will be classified to distinguish between conditions adverse to quality and significant conditions adverse to quality, and evaluated for reportability in accordance with 10 CFR Part 21 and 10 CFR 63.73.

The NRC staff reviewed the QARD, which states that conditions adverse to quality will be documented, tracked, and reported to the appropriate levels of management responsible for the conditions, which will complete remedial action as soon as practical. The NRC staff reviewed the QARD, which also states that, for significant conditions adverse to quality, (i) criteria for

determining the condition will be documented; (ii) the condition will be documented and reported to management personnel responsible for the condition and their upper management in a prompt manner; (iii) the condition will be evaluated by the QA organization to determine whether stopping work is warranted and the QA organization will issue such orders to responsible management after a stop work condition has been identified; (iv) responsible management will determine the extent and impact of the condition, and document the results; (v) responsible management will document and complete remedial action; (vi) responsible management will document the root cause of the problem and take corrective action to prevent recurrence as soon as practical; and (vii) processes will be established to verify the implementation of corrective action.

The NRC staff reviewed the QARD, which states that (i) criteria will be established for determining adverse quality trends, (ii) reports of nonconformances and conditions adverse to quality will be evaluated to identify adverse quality trends, (iii) trend evaluation will be performed in a manner and at a frequency that provides for prompt identification of adverse quality trends and assists in identifying the root cause, and (iv) trend evaluations will be promptly distributed to management for review and appropriate corrective action.

Evaluation Findings Regarding Corrective Action

On the basis of the NRC staff's review of the QARD discussed in the previous section, the NRC staff finds DOE's description of the activities related to corrective action consistent with YMRP Section 2.5.3, Acceptance Criterion 16. Therefore, the NRC staff finds, with reasonable assurance, that the description regarding corrective action addresses how the requirements of 10 CFR 63.142(q) will be satisfied.

2.5.1.4.2.17 QA Records

The requirements for activities related to QA records are in 10 CFR 63.142(r) and provide that DOE maintain sufficient records to furnish evidence of activities affecting quality. The NRC staff reviewed QARD Section 17.0, "QA Records," using YMRP Section 2.5.1.3, Acceptance Criterion 17.

QARD Section 17.0 establishes requirements to ensure that QA records that furnish documentary evidence of quality are specified, prepared, and maintained. The NRC staff reviewed the QARD, which states that (i) QA record types includes scientific, engineering, and operational data and logs, and laboratory and field notebooks and logbooks; (ii) data reduction documents; (iii) results of reviews, inspections, tests, audits, and material analysis; (iv) monitoring of work performance; (v) maintenance and modification procedures and related inspection results; (vi) reportable occurrences; (vii) QA program changes that reduce commitments; (viii) computer software supporting a safety or waste isolation function; (ix) qualification of personnel and equipment; (x) qualification of special process procedures; and (xi) documentation such as design records, drawings, specifications, procurement documents, calibration procedures and reports, design review reports, peer review reports, nonconformance reports, corrective action reports, and as-built drawings. Additional information for QA records developed during inspections and testing is provided in SER Section 2.5.1.3.2.10, "Inspection," and SER Section 2.5.1.3.2.11, "Test Control" (including documenting that the inspection and test records identify the inspector or data recorder, the type of observation, the results, the acceptability, and the action taken in connection with any deficiencies noted).

The NRC staff reviewed the QARD, which states that (i) implementing documents will identify those documents that will become QA records and the organization responsible for submitting the QA records; (ii) individuals creating QA records will ensure that the QA records are legible, accurate, complete, appropriate, and identifiable; (iii) individuals handling QA records will protect them from damage or loss; and (iv) QA records will be indexed to identify their location and record retention times.

The NRC staff reviewed the QARD, which states that QA records will be stored and preserved in predetermined storage facilities that meet the requirements of applicable standards, codes, and regulatory agencies in accordance with an approved implementing document that provides (i) a description of the storage facility and the filing system to be used; (ii) a method for verifying the QA records received are in agreement with the transmittal document and that the records are legible; (iii) a description of controls governing QA record access, retrieval, and removal; (iv) a method for filing supplemental information; and (v) a method for disposition of superseded QA records. The NRC staff reviewed the QARD, which also provides for (i) storage methods to preclude deterioration of QA records to minimize the risk of damage or destruction and provide adequate protection of radiographs, photographs, negatives, microform, and electronic and magnetic media; (ii) retrieval of QA records; and (iii) access control to storage facilities.

The NRC staff reviewed the QARD, which states that lifetime QA records will be retained and maintained until the license is amended for permanent closure and include those that (i) would be of significant value in demonstrating capability for safe operation; (ii) would be of significant value in maintaining, reworking, repairing, replacing, or modifying an item; (iii) would be of significant value in determining the cause of an accident or malfunction of an item; and (iv) provide required baseline data for in-service inspection. The NRC staff reviewed the QARD, which also states that nonpermanent QA records (i) are those required to show evidence that an activity was performed in accordance with the applicable requirements but need not meet the criteria for lifetime QA records and (ii) will be retained until the issuance of a license to receive and possess waste, or for a minimum of 10 years. For programmatic nonpermanent QA records, the retention period will be considered to begin on completion of the activity, and for product nonpermanent QA records, the retention period will be considered to commence upon completion of delivery. The NRC staff reviewed the QARD, which also describes DOE's long-term single storage facility for the storage of QA records, dual storage facilities, and temporary storage facilities.

The NRC staff reviewed the QARD Supplement V, "Control of The Electronic Management of Information," and the controls DOE will establish to ensure that (i) information is protected from damage and destruction, (ii) a description is prepared of how information will be stored, (iii) storage and transfer media are properly identified, (iv) the completeness and accuracy of the information input are maintained, (v) the security and integrity of the information are maintained, and (vi) transfers of information are error free.

DOE provided four modifications to NQA-1-1983, Supplement 17S-1, "Supplementary Requirements for Quality Assurance Records" (American Society of Mechanical Engineers, 1983aa).

- Supplement 17S-1 addresses the storage of QA records, but it does not include a provision for the temporary storage of QA records. DOE's modification states that QA records will be temporarily stored in a container or facility with a 1-hour fire rating or dual storage will be provided; single storage, containers, or facilities will bear an Underwriters' Laboratories label (or equivalent) certifying 1-hour fire protection or be certified by a

person competent in the technical field of fire protection; and the period of time allowed for records to be in temporary storage will be specified in appropriate procedures. Although NQA-1-1983, Supplement 17S-1, does not address temporary storage of QA records, the NRC staff determines that this DOE modification is acceptable because the controls that DOE has established for the temporary storage of QA records are consistent with YMRP Acceptance Criterion 17, Subcriterion 8, which states that suitable controls should be established and described for controlling, protecting, and maintaining QA records before they are entered and stored in a QA record storage area.

- Subsection 4.4.2, "Alternate Single Facility," provides acceptable alternatives to a typical single storage facility. DOE's modification stated that, for Subsection 4.4.2, DOE will not be using an alternate facility. The NRC staff determines that this DOE modification is acceptable because this provision is not applicable, as DOE will not be using an alternate storage facility.
- Section 5, "Retrieval," states that storage systems shall provide for retrieval of information in accordance with planned retrieval times based upon the record type. DOE's modification stated that its records retrieval system is not configured in such a manner as to provide retrieval times based on the type of record and that the retrieval times for all record types are the same regardless of record type. The NRC staff determines that this DOE modification is acceptable because DOE will use the same retrieval times for all record types regardless of record type, which satisfies the standards in Section 5.
- Section 6, "Disposition," identifies certain conditions and events prior to which a supplier's nonpermanent records shall not be disposed. DOE's modification stated that, in addition to the provisions of Section 6, DOE will implement the procedures specified in QARD Section 17.2.8B, "Nonpermanent QA Records," which discusses retention of such records. The NRC staff determines that this DOE modification is acceptable because DOE's procedures for retention of nonpermanent QA records contained in QARD Section 17.2.8B are consistent with, and in addition to, those in Section 6.

Evaluation Findings Regarding QA Records

On the basis of the NRC staff's review of the QARD and other guidance documents discussed in the previous section, the NRC staff finds DOE's description of the activities related to QA records consistent with YMRP Section 2.5.3, Acceptance Criterion 17. Therefore, the NRC staff finds, with reasonable assurance, that the description regarding QA records addresses how the requirements of 10 CFR 63.142(r) will be satisfied.

2.5.1.4.2.18 Audits

The requirements for activities related to audits are in 10 CFR 63.142(s) and provide that DOE carry out a comprehensive system of planned and periodic audits to verify compliance with all aspects of the quality assurance program and to determine the effectiveness of the program. The NRC staff reviewed QARD Section 18.0, "Audits," using YMRP Section 2.5.1.3, Acceptance Criterion 18.

QARD Section 18.0 establishes requirements for performing a comprehensive system of planned and periodic internal and external QA audits to verify compliance with all aspects of the QA program and to determine the effectiveness of the QA program. The NRC staff reviewed

the QARD, which states that audits will be performed in areas where the requirements of the QARD or supplier QA program description document are applicable, including (i) determination of site features that effect site suitability; (ii) preparation, review, approval, and control of early procurements; (iii) indoctrination and training programs; (iv) interface control between the DOE and suppliers; (v) corrective action, calibration, and nonconformance control systems; (vi) SAR commitments; (vii) development and control of computer software supporting a safety or waste isolation function; and (viii) the purchase of American Society of Mechanical Engineers Code items.

The NRC staff reviewed the QARD, which states that internal audits will be (i) coordinated with the responsible line manager and scheduled in a manner to provide coverage, consistency, and coordination with ongoing work; (ii) scheduled at a frequency commensurate with the status and importance of the work to begin as early in the life of the work as practical and continue at intervals consistent with the schedule for accomplishing the work; (iii) supplemented by additional audits of specific subjects, when necessary, to provide an adequate assessment of compliance and effectiveness; and (iv) performed at intervals not to exceed 12 months or at least once during the life of the work, whichever is shorter.

The NRC staff reviewed the QARD, which states that external audits will be scheduled (i) to begin as early in the life of the work as practical, (ii) to continue at intervals consistent with the schedule for accomplishing the work, and (iii) at a frequency commensurate with the status and importance of the work. The NRC staff reviewed the QARD, which also states that external audits for compliance and effectiveness will be (i) performed triennially or at least once during the life of the work, whichever is shorter; (ii) supplemented by additional audits of specific subjects when necessary to provide an adequate assessment of compliance or effectiveness; (iii) performed on suppliers when the suppliers or external organizations do not maintain a purchaser-accepted audit program; and (iv) performed when the supplier has completed sufficient work to demonstrate that its organization is implementing a QA program that has the required scope for purchases placed during the audit period.

The NRC staff reviewed the QARD, which states that the auditing organization will develop and document an audit plan for each scheduled audit to identify the audit scope, requirements for performing the audit, audit personnel, work to be audited, organizations to be notified, applicable documents, audit schedule, and implementing documents or checklists to be used. The NRC staff reviewed the QARD, which also states that (i) the auditing organization will select and assign auditors who are independent of any direct responsibility for performance of the activity being audited; (ii) audit personnel will have sufficient authority and organizational freedom to make the audit process meaningful and effective; and (iii) the audit will be led by a qualified auditor, include a member of the QA organization, and include indoctrinated and trained technical specialists.

The NRC staff reviewed the QARD, which states that (i) the audit team leader will ensure that the audit team is prepared before starting the audit, (ii) audits are performed in accordance with written procedures or checklists, (iii) elements that have been selected for audit are evaluated against specified requirements, (iv) objective evidence is examined to the depth necessary to determine whether these elements are being implemented effectively, (v) audit results are documented and reported to management having responsibility for the area audited, and (vi) conditions requiring prompt corrective action are reported immediately to management. The NRC staff reviewed the QARD, which also states that the audit report will be prepared and signed by the audit team leader and issued to management of the audited organization and will include (i) a description of the audit scope; (ii) identification of the auditors and persons

contacted during the audit; (iii) a summary of the audit results, including a statement on the effectiveness of the QA program elements that were audited; and (iv) a description of each reported condition adverse to quality in sufficient detail to enable corrective action to be taken.

The NRC staff reviewed the QARD, which states that management of the audited organization will (i) investigate conditions adverse to quality, (ii) determine and schedule corrective action, and (iii) identify measures to prevent recurrence. The NRC staff reviewed the QARD, which also states that the adequacy of corrective actions for audit finding responses will be evaluated and accepted by the auditing organization prior to closure and that follow-up action will be taken by the auditing organization to verify that audit finding corrective action is accomplished in a timely manner.

DOE provided a modification to Regulatory Guide 1.28, Revision 3 (NRC, 1985aa), Regulatory Positions C.3, "Audits," which provides guidelines for scheduling internal and external audits. DOE's modification states that, in lieu of the requirements specified in Regulatory Position C.3., DOE will implement the requirements of QARD Subsection 7.2.12D, "Commercial Procurement of Calibration Services," when purchasing commercial calibration from accredited calibration laboratories. The NRC staff reviewed QARD Subsection 7.2.12D, which states that, for suppliers of commercial calibration services with accreditation by a nationally recognized accrediting body, a documented review of the supplier's accreditation may be used in lieu of external audits, inspections, or tests following delivery or in-process surveillances may be made during the performance of the service. QARD Section 7.2.12D also provides the requirements for accreditation review, procurement documentation, critical characteristics identification and verification, calibration documentation, and equipment certification. The NRC staff determined that this DOE modification is acceptable because the controls established in QARD Section 7.2.12D for purchasing commercial calibration from accredited calibration laboratories are consistent with Regulatory Guide 1.28, Position C.3.

Evaluation Findings Regarding Audits

On the basis of the NRC staff's review of the QARD and other guidance documents discussed in the previous section, the NRC staff finds DOE's description of the activities related to audits consistent with YMRP Section 2.5.3, Acceptance Criterion 18. Therefore, the NRC staff finds, with reasonable assurance, that the description regarding audits addresses how the requirements of 10 CFR 63.142(s) will be satisfied.

2.5.1.5 Evaluation Findings

The NRC staff reviewed DOE's QA program description presented in the QARD. Based on its review and evaluation of DOE's QA program description above, the NRC staff finds, with reasonable assurance, that the description required by 10 CFR 63.21(c)(20) adequately addresses how the applicable requirements of 10 CFR 63.142 will be satisfied. The description also adequately addresses the requirements in 10 CFR 63.141, 63.143, and 63.144.

2.5.1.6 References

American Nuclear Society. 1993aa. ANSI/ANS-3.1-1993, "American National Standard for Selection, Qualification, and Training of Personnel for Nuclear Power Plants." La Grange, Illinois: American Nuclear Society.

American Society of Mechanical Engineers. 2000aa. "Quality Assurance Requirements for Nuclear Facility Applications." NQA-1-2000. New York City, New York: American Society of Mechanical Engineers.

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Electric Power Research Institute. 1988aa. "Guideline for the Utilization of Commercial Grade Items in Nuclear Safety Related Applications (NCIG-07)." EPRI NP-5652. Palo Alto, California: Electric Power Research Institute.

NRC. 2012aa. NUREG-2117, "Practical Implementation Guidelines for SSHAC Level 3 and 4 Hazard Studies." Rev. 1. ML12118A445. Washington, DC: U.S. Nuclear Regulatory Commission.

NRC. 2003aa. NUREG–1804, “Yucca Mountain Review Plan—Final Report.” Rev. 2. ML032030389. Washington, DC: U.S. Nuclear Regulatory Commission.

NRC. 2000ae. Regulatory Guide 1.8, “Qualification and Training of Personnel for Nuclear Power Plants.” Rev 3. ML003706932. Washington, DC: U.S. Nuclear Regulatory Commission.

NRC. 2000ak. Regulatory Guide 1.54, “Service Level I, II, and III Protective Coatings Applied to Nuclear Power Plants.” Rev. 1. ML003714475. Washington, DC: U.S. Nuclear Regulatory Commission.

NRC. 1999ad. NUREG–1636, “Regulatory Perspectives on Model Validation in High-Level Radioactive Waste Management Programs: A Joint NRC/SKI White Paper.” ML012260054. Washington, DC: U.S. Nuclear Regulatory Commission.

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NRC. 1988ac. NUREG–1297, “Peer Review for High-Level Nuclear Waste Repositories.” ML033160259. Washington, DC: U.S. Nuclear Regulatory Commission.

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CHAPTER 4

2.5.2 Records, Reports, Tests, and Inspections

2.5.2.1 Introduction

Safety Evaluation Report (SER) Section 2.5.2 evaluates the U.S. Department of Energy (“DOE” or “applicant”) Safety Analysis Report (SAR) (DOE, 2008ab, Section 5.2) description of the program to be used for (i) maintaining records of the receipt, handling, and disposition of radioactive waste; (ii) maintaining construction records; (iii) retaining records in a manner that ensures their use by future generations; (iv) reporting deficiencies to NRC; (v) performing tests or allowing NRC to perform tests; and (vi) allowing NRC to inspect the geologic repository operations area (GROA) at the Yucca Mountain site. This section was unchanged in DOE’s License Application update, submitted to NRC in February 2009 (DOE, 2009av). DOE provided further information on these topics in its response to NRC staff’s request for additional information (RAI) (DOE, 2009be).

2.5.2.2 Regulatory Requirements

Under 10 CFR 63.21(c)(23), DOE must provide a description of the program to be used to maintain records described in 10 CFR 63.71 and 63.72. Requirements for reporting deficiencies to the NRC are provided in 10 CFR 63.73, requirements for performing tests for the NRC or allowing the NRC to perform tests are provided in 10 CFR 63.74, and requirements for allowing NRC to inspect the GROA at the Yucca Mountain site and adjacent areas to which DOE has rights of access are provided in 10 CFR 63.75. In its review of the SAR and supporting documents, the NRC staff used the review guidance in the Yucca Mountain Review Plan (YMRP) Section 2.5.2.3 (NRC, 2003aa).

2.5.2.3 Technical Evaluation

SAR Sections 5.2.1 and 5.2.2 contain DOE’s process for creating and maintaining records and reports. In SAR Section 5.2.1.1, DOE described its records management program. SAR Section 5.2.1 describes DOE management of the life-cycle stages of records: creation, active maintenance and use, and storage and disposition. SAR Section 5.2.1.2 includes a listing of the construction records that will be maintained: those that describe the construction and as-built configuration of the surface and subsurface structures, systems, and components. SAR Sections 5.2.1.3 and 5.2.1.4 state that procedures for record maintenance and storage will incorporate guidance from NRC Regulatory Issue Summary 2000-18 (NRC, 2000ad) and American National Standards Institute/American Society of Mechanical Engineers (ANSI/ASME) Standard NQA-1-1983 (American Society of Mechanical Engineers, 1983aa), respectively. DOE described its recordkeeping and reporting programs for receipt, handling, and disposition of radioactive waste to include a complete history of the movement of the waste from the shipper through all phases of storage and disposal. DOE stated that these programs also support DOE compliance with other recordkeeping requirements, such as those in 10 CFR Part 21.

The NRC staff evaluated SAR Section 5.2.1 using the YMRP Acceptance Criteria in Section 2.5.2.3 to determine whether the Records Management Program described by DOE will maintain adequate records of the receipt, handling, and disposition of radioactive waste at the Yucca Mountain GROA, and the construction records in a manner that will ensure their

availability for future generations, in accordance with 10 CFR 63.71 and 10 CFR 63.72. The NRC finds that the applicant's description of the program addresses the requirements of 10 CFR 63.71 and 10 CFR 63.72 because DOE, as described in the application, would (i) create and maintain records of construction with sufficient information to support use by future generations, and (ii) maintain records and make reports required by the license, rules, regulations, and orders of the Commission, including records of the complete history of the movement of waste sufficient to support future use.

In SAR Section 5.2.2, DOE stated that it will put methods in place to identify, evaluate, and report deficiencies found in characteristics of the Yucca Mountain site and the design and construction of the GROA that (i) could result in an adverse effect on safety, (ii) deviate significantly from the design criteria or design basis, or (iii) deviate from the condition and terms of the construction authorization. DOE stated that it will put methods in place to evaluate and report deviations and compliance failures, as well as to identify defects and compliance failures, that are associated with substantial safety hazards at the GROA, as required by 10 CFR 63.73(b). DOE stated that these methods will be based on the applicable requirements of 10 CFR 50.55(e), as they apply to the design and the construction authorization of the GROA. Prior to obtaining a license to receive and possess waste, DOE stated that methods will be in place to address reporting the specific events and conditions described in SAR Section 5.7, which according to DOE, are the same as those specified in 10 CFR 72.75. DOE stated that the notification of these events and conditions will occur in accordance with applicable regulations and that written reports of deficiencies will be submitted to the NRC. The SAR, in Section 5.2.2, and the discussion in DOE (2009be) covers reporting for both emergency and nonemergency events and conditions.

The NRC staff evaluated the DOE plans to identify, evaluate, and report deficiencies, as described previously. Based on its evaluation, the NRC staff finds that DOE's plans are adequate because DOE described that its methods will identify, evaluate, and report deficiencies that if uncorrected could adversely affect safety, represent a significant deviation from the design criteria and design bases, or represent a deviation from conditions stated in the terms of a construction authorization. In addition, consistent with the requirements in 10 CFR 63.73(c) and (d), DOE stated that its methods for reporting deficiencies will be based on applicable requirements in 10 CFR 50.55(e) and 10 CFR 72.75.

In SAR Section 5.2.3, DOE described its process for performing, or permitting the NRC to perform, tests that NRC considers appropriate or necessary. DOE stated that, consistent with 10 CFR 63.74(a), these tests will be evaluated to ensure compatibility with ongoing tests. These tests will also be performed by personnel qualified and trained for the particular task, or DOE will assist NRC personnel to ensure that tests are performed in accordance with applicable procedures and requirements. DOE stated that, consistent with 10 CFR 63.74(b), its testing program will include implementing its performance confirmation program required by 10 CFR Part 63, Subpart F. The NRC staff's evaluation of DOE's performance confirmation program can be found in SER Section 2.4 of this volume.

The NRC staff evaluated DOE's plans to establish a process for performing the tests, including DOE's implementation of its performance confirmation program required by 10 CFR Part 63, Subpart F, and allowing NRC personnel to perform the tests. The NRC staff finds that the DOE plan is acceptable because tests will be performed in accordance with applicable procedures and requirements, in accordance with 10 CFR 63.74.

In SAR Section 5.2.4, DOE stated that it will provide immediate and unfettered access to the GROA and adjacent areas for NRC personnel, as required by 10 CFR 63.75(c)(3). In addition, DOE will make its records available for inspection to NRC personnel upon reasonable notice as required by 10 CFR 63.75(b). DOE also stated that it will provide office space for the exclusive use of NRC inspection personnel.

The NRC staff evaluated DOE's plans to (i) allow NRC personnel to inspect the GROA and adjacent areas, to which DOE has rights of access, and to inspect records and (ii) provide space for the exclusive use of NRC inspection personnel. The NRC staff finds that DOE's plans are acceptable because they provide for appropriate access and inspections, and thus meet the requirements of 10 CFR 63.75.

2.5.2.4 Evaluation Findings

NRC staff has reviewed the SAR and other information submitted in support of the license application and finds, with reasonable assurance, that the requirements in 10 CFR 63.21(c)(23) to provide a description of the program to be used to maintain records described in 10 CFR 63.71 and 63.72, and 10 CFR 63.73, 63.74, and 63.75 are addressed. DOE has provided an adequate description of the record keeping and reporting programs for receipt, handling, and disposal of radioactive waste. DOE adequately addressed a program for reporting deficiencies. DOE's program to perform, or permit NRC to perform, necessary tests and to provide NRC personnel records for inspection is adequate.

2.5.2.5 References

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CHAPTER 5

2.5.3.1 U.S. Department of Energy Organizational Structure as it Pertains to Construction and Operation of Geologic Repository Operations Area

2.5.3.1.1 Introduction

Safety Evaluation Report (SER) Section 2.5.3.1 evaluates the U.S. Department of Energy (“DOE” or “applicant”) information concerning the applicant’s organizational structure, as it pertains to construction and operation of the geologic repository operations area (GROA), provided in the DOE Safety Analysis Report (SAR) Section 5.3.1 (DOE, 2008ab), as supplemented by its response to a U.S. Nuclear Regulatory Commission (NRC) request for additional information (RAI) (DOE, 2009az). SAR Section 5.3.1 described delegations of authority and assignments of responsibilities. This SAR section was unchanged in DOE’s license application update, submitted to NRC in February 2009 (DOE, 2009av). DOE provided additional information regarding its organizational structure in response to the NRC staff’s request for additional information (DOE, 2009az).

2.5.3.1.2 Regulatory Requirements

The requirement for DOE to provide in its SAR information concerning the organizational structure pertaining to construction and operation of the GROA at the Yucca Mountain site and a description of any delegations of authority and assignments of responsibilities is specified in 10 CFR 63.21(c)(22)(i).

The NRC staff evaluated the information concerning organizational structure against the regulatory requirements in 10 CFR 63.21(c)(22)(i) using guidance in the Yucca Mountain Review Plan (YMRP) Section 2.5.3.1 (NRC, 2003aa).

2.5.3.1.3 Technical Evaluation

DOE described the organizational structure anticipated at the time of repository construction and operations for the GROA at the Yucca Mountain site, including a description of a procedure for delegations of authority (SAR Section 5.3.1.4). DOE described the responsibilities of the director, management functions and responsibilities, reporting relationships, and principal lines of communication. DOE also provided descriptions of the Executive Advisory Board responsible for advising the director regarding executive-level matters, each of the eight key staff assigned responsibility for safety and operations at the site, and the Onsite Safety Committee responsible for advising the site operations manager regarding operations matters. In response to an NRC staff RAI, DOE provided a revised organizational structure [revised SAR Figure 5.3-1 in (DOE, 2009az)]. DOE stated that the nuclear criticality safety program will be administratively independent of operations and will have responsibilities assigned in a manner consistent with those of other safety programs (such as Radiation Protection). In SAR Section 5.3.1, DOE stated that it will provide specific contact information in license application updates before receiving a construction authorization and again before receiving a license to receive and possess waste. This specific information will include the address of the office of record for each entity in the organization that holds a key onsite or offsite position, a point of contact, a telephone number, a fax number, and an email address. The NRC staff’s evaluation of the applicant’s description of key personnel positions is in SER Section 2.5.3.2. In DOE (2009az),

DOE stated it would revise the license application to reflect the change to SAR Figure 5.3-1 and associated text indicating the organization structure shown in the revised figure.

Based on the information provided, the NRC staff finds, with reasonable assurance, that DOE described an adequate organizational structure for two reasons. First, DOE adequately delineated responsibility and decisionmaking authority during construction and operation of the GROA for all levels of management, staff, and affected organizations so that responsibility for actions can be traced through the management and staff hierarchy of DOE (onsite and at Headquarters), contractors, subcontractors, consultants, service organizations, and other affected organizations. Second, the NRC staff finds the description of the process for delegating authority acceptable because (i) it assures that an identified party will always have responsibility and sufficient authority to act in both routine and emergency situations, and (ii) it ensures the individual is appropriately qualified to hold the position.

The NRC staff, however, notes that because of the lapse in time between the license application submittal and the issuance of this SER volume, some information in the application does not reflect current circumstances. Specifically, the NRC staff notes that DOE's description of the organizational structure refers to the Office of Civilian Radioactive Waste Management (OCRWM). However, in accordance with DOE's September 16, 2010, Memorandum of Understanding (DOE, 2010aq), on September 30, 2010, the OCRWM ceased Yucca Mountain Project activities and the Office of Legacy Management was assigned responsibility for the Yucca Mountain Project records, information systems, and the Licensing Support Network. The NRC staff's evaluation and regulatory findings are based on the organizational structure DOE described in the SAR (as updated by the RAI response), which, as explained above, the NRC staff finds acceptable. If DOE changes the organizational structure in a manner inconsistent with the description in the SAR (as updated by the RAI response) prior to an NRC decision on whether to issue a construction authorization, DOE would need to update its SAR.

2.5.3.1.4 Evaluation Findings

The NRC staff has reviewed the SAR and supporting information and finds that DOE has provided an adequate description of the organizational structure for the construction and operation of the GROA, including the description of any delegations of authority and assignments of responsibilities. Therefore, the NRC staff concludes, with reasonable assurance, that the requirements in 10 CFR 63.21(c)(22)(i) are satisfied.

2.5.3.1.5 References

DOE. 2010aq. "DOE Memorandum of Understanding: Closure of RW and Maintenance of the Yucca Mountain Site." ML14259A554. Washington, DC: NRC.

DOE. 2009av. DOE/RW-0573, "Yucca Mountain Repository License Application." Rev. 1. ML090700817. Las Vegas, Nevada: DOE, Office of Civilian Radioactive Waste Management.

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CHAPTER 6

2.5.3.2 Key Positions Assigned Responsibility for Safety and Operations of Geologic Repository Operations Area

2.5.3.2.1 Introduction

Safety Evaluation Report Section 2.5.3.2 evaluates the information provided in the U.S. Department of Energy (“DOE” or “applicant”) Safety Analysis Report (SAR) (DOE, 2008ab, Section 5.3) concerning the identification of key positions assigned responsibility for safety and operations at the repository site. DOE provided more information on this topic in its response to an NRC staff request for additional information (DOE, 2009az). DOE specified, in SAR Section 5.3.1.4, its plan for how qualified alternates will be identified, and in SAR Section 5.3.2, the minimum education and experience levels for these positions. These SAR sections were unchanged in DOE’s license application update, submitted to NRC in February 2009 (DOE, 2009av). DOE provided additional information regarding its identification of key positions in response to the NRC staff’s request for additional information (DOE, 2009az).

2.5.3.2.2 Regulatory Requirements

The requirement for DOE to provide information concerning identification of the key positions that are assigned responsibility for safety at and operation of the geologic repository operations area (GROA) is specified in 10 CFR 63.21(c)(22)(ii).

The NRC staff evaluated DOE’s information concerning identification of key positions for safety and operations at the GROA using guidance in the Yucca Mountain Review Plan (YMRP) Section 2.5.3.2 (NRC, 2003aa). As stated in YMRP Section 2.5.3.2, at the time of a decision on whether to issue a construction authorization, DOE is not expected to have identified specific individuals to fill key positions.

The NRC staff also evaluated DOE’s minimum educational and experience levels to determine whether they are adequate using guidance in ANSI/ANS-3.1-1993, “Selection, Qualification, and Training of Personnel for Nuclear Power Plants” (American Nuclear Society, 1993aa), as endorsed by Regulatory Guide 1.8, “Qualification and Training of Personnel for Nuclear Power Plants” (NRC, 2000ae).

2.5.3.2.3 Technical Evaluation

DOE identified key positions responsible for safety and operations, including construction activities that are expected to take place during GROA operations. DOE provided the minimum education requirements and experience levels required for personnel filling the key positions and their alternates. DOE revised the organizational structure in DOE (2009az) to improve the administrative independence of the Nuclear Criticality Safety Program (NCSP) from operations. The revision combined the criticality safety manager functions with those of the radiation protection manager. The position will be called the radiation protection and criticality safety manager.

The NRC staff evaluated DOE’s plans for key positions for safety and operations at the GROA, including the minimum educational and experience levels, to determine whether 10 CFR 63.21(c)(22)(ii) is satisfied. The NRC staff finds that key positions at the GROA are

similar in scope to those at nuclear power plants during construction and operations. DOE's descriptions of the key positions and DOE's plan, in SAR Section 5.3.1.4, to develop a procedure for delegating authority for key positions in the absence of DOE staff assigned to key positions, including the minimum skills and experience necessary to hold each position, are consistent with the guidance in ANSI/ANS-3.1-1993. The NRC endorsed this guidance in Regulatory Guide 1.8 (NRC, 2000ae). In addition, DOE also stated in SAR Section 2.5.3.2 that alternates qualified to act in the absence of individuals assigned to key management positions would also meet or exceed minimum education and experience requirements. Because DOE's description of key positions and plan to develop a procedure for delegating alternates are consistent with the guidance in ANSI/ANS-3.1-1993 and DOE described how it would identify qualified alternates, the NRC staff finds DOE adequately identified key positions that are assigned responsibility for safety at and operation of the GROA.

2.5.3.2.4 Evaluation Findings

The NRC staff has reviewed the SAR and supporting information and finds that DOE has adequately identified the key positions assigned responsibility for GROA safety and operations and the qualifications of the persons occupying these positions. The NRC staff therefore concludes, with reasonable assurance, that the requirement in 10 CFR 63.21(c)(22)(ii) is satisfied.

2.5.3.2.5 References

American Nuclear Society. 1993aa. ANSI/ANS-3.1-1993, "Selection, Qualification, and Training of Personnel for Nuclear Power Plants."

DOE. 2009av. DOE/RW-0573, "Yucca Mountain Repository License Application." Rev. 1. ML090700817. Las Vegas, Nevada: DOE, Office of Civilian Radioactive Waste Management.

DOE. 2009az. "Yucca Mountain—Response to Request for Additional Information Regarding License Application (Safety Analysis Report Sections 5.3 and 1.14.1), Safety Evaluation Report Vol. 4, Chapter 2.5.3.2." Letter (February 10) J.R. Williams to B. Benney (NRC). Enclosures (1). ML090420250. Las Vegas, Nevada: DOE, Office of Civilian Radioactive Waste Management.

DOE. 2008ab. DOE/RW-0573, "Yucca Mountain Repository License Application." Rev. 0. ML081560400. ML081560542. Las Vegas, Nevada: DOE, Office of Civilian Radioactive Waste Management.

NRC. 2003aa. NUREG-1804, "Yucca Mountain Review Plan—Final Report." Rev. 2. ML032030389. Washington, DC: U.S. Nuclear Regulatory Commission.

NRC, 2000ae. Regulatory Guide 1.8, "Qualification and Training of Personnel for Nuclear Power Plants." ML003706932. Washington, DC: U.S. Nuclear Regulatory Commission.

CHAPTER 7

2.5.3.3 Personnel Qualifications and Training Requirements

2.5.3.3.1 Introduction

Safety Evaluation Report (SER) Section 2.5.3.3 evaluates the U.S. Department of Energy's ("DOE" or "applicant") Safety Analysis Report (SAR) Section 5.3.3, "Personnel Qualification and Training Requirements" (DOE, 2008ab). DOE stated in SAR Section 5.3.3 that the Qualification and Training Program describes the training program for repository operations, as well as for preoperational, functional, and initial startup testing. DOE describes training, proficiency testing, certification, and requalification of operating and supervisory personnel in its description of its Qualification and Training Program. This SAR section was unchanged in DOE's license application update, submitted to the U.S. Nuclear Regulatory Commission (NRC) in February 2009 (DOE, 2009av).

2.5.3.3.2 Regulatory Requirements

The regulatory requirements for the qualification and training of personnel are in 10 CFR 63.21(c)(22)(iii) and 10 CFR Part 63, Subpart H, "Training and Certification of Personnel" (10 CFR 63.151, "General Requirements"; 10 CFR 63.152, "Training and Certification Program"; and 10 CFR 63.153, "Physical Requirements"). Under 10 CFR 63.21(c)(22)(iii), the SAR must include information concerning personnel qualifications and training requirements for activities at the geologic repository operations area (GROA). The general requirements in 10 CFR 63.151 provide that (i) operation of systems and components that have been identified as important to safety (ITS) in the SAR must be performed only by trained and certified personnel or by personnel under the direct visual supervision of an individual with training and certification in such operation and (ii) supervisory personnel who direct operations that are ITS must also be certified in such operations. The training and certification program requirements in 10 CFR 63.152 provide that DOE shall establish a program for training, proficiency testing, certification, and requalification of operating and supervisory personnel. The physical requirements in 10 CFR 63.153 provide that (i) the physical condition and the general health of personnel certified for operations that are ITS may not be such that might cause operational errors that could endanger the public health and safety; (ii) any condition that might cause impaired judgment or motor coordination must be considered in the selection of personnel for activities that are ITS; and (iii) these conditions need not categorically disqualify a person, so long as appropriate provisions are made to accommodate the conditions.

The NRC staff reviewed DOE's description of its personnel qualification and training requirements using the guidance in the "Yucca Mountain Review Plan" (YMRP) Section 2.5.3.3 (NRC, 2003aa). YMRP Section 2.5.3.3 states that at the time of the construction authorization decision, DOE is not required to have an NRC-approved Qualification and Training Program in place, but that DOE will have an NRC-approved personnel training and qualification program in place before it may receive and possess waste. In accordance with 10 CFR 63.21(a), DOE's SAR must include information that is reasonably available. The handling of spent nuclear fuel and high-level waste would not occur prior to issuance of a license to receive and possess waste, and DOE has not finalized designs of facilities, systems, equipment, and associated ITS operations that would be addressed in the finalized Qualification and Training Program

2.5.3.3.3 Technical Review

In SAR Section 5.3.3, DOE provided a description of its program for training, proficiency testing, certification, and requalification of operating and supervisory personnel. DOE also stated that it will submit the Qualification and Training Program to the NRC in a timely manner to facilitate NRC approval prior to receipt of spent nuclear fuel or high-level waste.

2.5.3.3.3.1 Standards for Selection, Training, Qualification, and Certification of Personnel

The standards and Regulatory Guides DOE cited for developing its Qualification and Training Program, as discussed in the following paragraphs, were developed by the nuclear industry or the NRC primarily for nuclear power plant operations. DOE stated that this guidance is also appropriate for use for GROA operations because, like nuclear power plants, the GROA is a nuclear facility and the guidance covers operational activities at the GROA that are similar or identical to those at nuclear power plants.

YMRP Acceptance Criterion 2 states that characteristics of the training program for GROA personnel training and qualification should be consistent with certain sections of American National Standards Institute/American Nuclear Society ANSI/ANS-3.1-1993, "American National Standard for Selection, Qualification, and Training of Personnel for Nuclear Power Plants," (American Nuclear Society, 1993aa). In SAR Sections 5.3.3, 5.3.3.1, and 5.3.3.2.1, DOE stated that the Qualification and Training Program will be analyzed, designed, developed, conducted, and evaluated consistent with ANSI/ANS-3.1-1993 and Regulatory Guide 1.8, "Qualification and Training of Personnel for Nuclear Power Plants," Revision 3 (NRC, 2000ae). The NRC staff evaluated DOE's use of ANSI/ANS-3.1-1993 and Regulatory Guide 1.8 for analyzing, designing, developing, conducting, and evaluating the Qualification and Training Program. On the basis of this review, the NRC staff determines that DOE's use of this guidance is adequate for the following reasons: (i) ANSI/ANS-3.1-1993 is an industry standard that provides criteria for the selection, qualification, and training of personnel for nuclear facilities; and (ii) Regulatory Guide 1.8 provides the NRC's endorsement of ANSI/ANS-3.1-1993 and provides current guidance that is acceptable to the NRC staff regarding qualifications and training for nuclear facility operators. Use of this guidance is consistent with current industry and NRC guidance for analyzing, designing, developing, conducting, and evaluating training for personnel working at nuclear facilities.

In SAR Section 5.3.3, DOE stated that nuclear criticality safety training will be consistent with ANSI/ANS-8.20-1991, "American National Standard for Nuclear Criticality Safety Training" (American Nuclear Society, 1991ab). In SAR Section 5.3.3.2.2, DOE stated that radiation protection training will be consistent with recommendations in American Society for Testing and Materials (ASTM) E 1168-1995, "Standard Guide for Radiological Protection Training for Nuclear Facility Workers," (ASTM International, 1995aa) and applicable guidance in the following Regulatory Guides: Regulatory Guide 8.8, "Information Relevant to Ensuring that Occupational Radiation Exposures at Nuclear Power Stations Will be as Low as is Reasonably Achievable," Revision 3 (NRC, 1978ab); Regulatory Guide 8.27, "Radiation Protection Training for Personnel at Light-Water-Cooled Nuclear Power Plants," (NRC, 1981aa); and Regulatory Guide 8.29, Revision 1, "Instruction Concerning Risks from Occupational Radiation Exposure," Revision 1 (NRC, 1996ac). The NRC staff evaluated DOE's use of ANSI/ANS-8.20-1991, ASTM E 1168-1995, and Regulatory Guides 8.8, 8.27, and 8.29 regarding training in nuclear criticality safety and radiation protection. On the basis of this review, the NRC staff determines that the use of this guidance is adequate for the following reasons: (i) ANSI/ANS-8.20-1991 is

an industry standard that provides a framework for the training of employees associated with fissionable material operations where potential exists for criticality accidents; (ii) ASTM E 1168–1995 is also an industry standard that provides work practices, procedures, and measurement methods for the radiological protection portion of health and safety training for radiation workers at nuclear facilities to keep radiation exposure as low as reasonably achievable (ALARA); (iii) Regulatory Guide 8.8 provides guidance on keeping radiation exposure ALARA during operation and decommissioning of a nuclear facility; (iv) Regulatory Guide 8.27 provides a radiation protection training program consistent with ALARA objectives appropriate for the GROA; and (v) Regulatory Guide 8.29 provides information for workers about health risks and occupational exposure. Therefore, the NRC staff concludes that DOE's use of this guidance is consistent with current nuclear industry and NRC guidance regarding training in nuclear criticality safety and radiation protection for personnel working at nuclear facilities like the GROA.

In SAR Section 5.3.11, DOE stated that ANSI/ANS-3.4-1996, "American National Standard for Medical Certification and Monitoring of Personnel Requiring Operator Licenses for Nuclear Power Plants," (American Nuclear Society, 1996aa) will be followed to certify that the fitness, physical condition, and general health of individuals is acceptable. In SAR Section 5.3.11, DOE also stated that the repository will establish requirements for the physical condition and general health of personnel who operate equipment or controls that are ITS or important to waste isolation (ITWI) in accordance with applicable sections of NRC Regulatory Guide 1.134, "Medical Evaluation of Licensed Personnel at Nuclear Power Plants," Revision 3 (NRC, 1998ab). The NRC staff evaluated DOE's use of ANSI/ANS–3.4–1996 and Regulatory Guide 1.134 for establishing requirements and determining the physical condition and general health of personnel who operate equipment or controls that are ITS or ITWI. On the basis of this review, the NRC staff determines that this guidance is adequate for the following reasons: (i) ANSI/ANS-3.4-1996 provides physical and mental health requirements and addresses the content, extent, and methods of examination of nuclear facility operators; and (ii) Regulatory Guide 1.134 provides information needed for evaluation of the medical qualifications of operator licenses for nuclear power plants and for providing notification to the NRC of an incapacitating disability or illness. The guidance in Regulatory Guide 1.134 for nuclear power plants is applicable to the GROA because the appropriate medical qualifications of operators at the GROA and nuclear power plants are similar. Therefore, the NRC staff concludes that DOE's use of this guidance is consistent with current nuclear industry practices and NRC guidance regarding the physical condition and general health of personnel who operate equipment or controls that are ITS or ITWI at the GROA because those individuals will be examined, certified, and monitored to ensure that fitness, physical condition, and general health requirements are met.

In summary, the NRC staff evaluated DOE's description of the Qualification and Training Program to determine if the standards and Regulatory Guides DOE will use, as discussed in the previous paragraphs, for defining, developing, and implementing its Qualification and Training Program are adequate. Based on this review, the NRC staff concludes that DOE's description identifies the standards and Regulatory Guides that will be used, and that these standards and Regulatory Guides are adequate for their proposed use. Therefore, the NRC staff finds that this portion of DOE's description of its Qualification and Training Program is acceptable because DOE would use adequate standards for establishing its Qualification and Training Program.

2.5.3.3.3.2

General Training, Proficiency Testing, and Certification of GROA Personnel

In SAR Section 5.3.3, DOE described how the Qualification and Training Program established the bases for GROA personnel qualification and defines the qualification requirements of operators, supervisors, and other staff; and it specifies that the Qualification and Training Program will be submitted to the NRC for approval before receipt of spent nuclear fuel or high-level waste at the GROA. The NRC staff evaluated DOE's description of the Qualification and Training Program to determine the bases for GROA personnel qualifications requirements and when DOE plans to seek NRC approval of the program. In SAR Section 5.3.3, DOE stated that training will be designed, developed, and implemented according to ANSI/ANS-3.1-1993 and Regulatory Guide 1.8. DOE stated that employees will be provided with formal training to establish the knowledge and skills necessary to fulfill their assigned tasks. DOE stated that continuing training will be provided, as required, to maintain proficiency in these knowledge and skill components and to update skills to match changes in procedures, job tasks, or repository design. DOE also stated that the Qualification and Training Program will be submitted to the NRC for approval before receipt of spent nuclear fuel or high-level waste at the GROA. On the basis of this review, the NRC staff concludes that DOE's description addresses applicable guidance in the YMRP regarding GROA personnel qualifications requirements and NRC approval of the Qualification and Training Program. Therefore, the NRC staff finds that this portion of DOE's description is acceptable because DOE established the bases for GROA personnel qualification requirements by following the guidance in ANSI/ANS-3.1-1993 and Regulatory Guide 1.8, which provide guidance that is acceptable to the NRC staff regarding personnel qualifications and training. As described in SER Section 2.5.3.3.1, the guidance in ANSI/ANS-3.1-1993 and Regulatory Guide 1.8 for personnel qualification and training is applicable to GROA operations because operational requirements and activities for the GROA and nuclear power plants are similar or identical.

In SAR Section 5.3.3.1, DOE described how the Qualification and Training Program will establish adequate procedures for managing and maintaining the training program, including identification of the personnel responsible for developing training programs, conducting training, retraining employees, and maintaining up-to-date records on the status of trained personnel. The NRC staff evaluated DOE's description of the Qualification and Training Program to identify the procedures for managing and maintaining the training program and maintaining personnel training records. In SAR Section 5.3.3.1, DOE described the organization and management of the training function. DOE stated that (i) line managers will be responsible for the content and effective conduct of training for their personnel; (ii) training responsibilities for line managers will be included in line managers' position descriptions; (iii) line managers will be given the authority to implement training for their personnel; (iv) line managers will ensure that the training program will be conducted in a reliable and consistent manner throughout the areas of training; and (v) the training programs and maintenance of the training programs will be the responsibility of the Training Manager. DOE stated that repository administrative procedures will establish the requirements for indoctrination and training of personnel working on structures, systems and components (SSCs) that are ITS, or ITWI. DOE also stated that training records will be maintained on each employee's qualifications, certifications, experience, training, and retraining, and that training records will be retained in accordance with DOE's records management program. On the basis of this review, the NRC staff concludes that the DOE description addresses applicable guidance in the YMRP regarding procedures for managing and maintaining the training program and personnel training records. Therefore, the NRC staff finds that this portion of DOE's description is acceptable because DOE would establish procedures

for the planning, direction, analysis, development, conduct, evaluation, and control of training, and DOE will maintain up-to-date records on the status of trained personnel.

In SAR Section 5.3.3.2.3.2, DOE described how the Qualification and Training Program would establish training requirements for each job category; and in SAR Section 5.3.3, DOE stated that newly hired personnel would be trained on a timely schedule. The NRC staff evaluated DOE's description of the Qualification and Training Program to determine how DOE would establish training requirements for different job categories and training of newly hired personnel. In SAR Section 5.3.3.2.3.2, DOE stated that after basic knowledge skills, additional comprehensive training in specific areas will be conducted on an employee activity-classification basis. DOE also stated that worker classification-specific training will be tailored to the specific task and skills of the different classifications of employee activities associated with the operations that are ITS or ITWI. In SAR Section 5.3.3, DOE stated that training programs will be provided to personnel within 30 days of reporting to work. On the basis of this review, the NRC staff concludes that DOE's description addresses applicable guidance in the YMRP regarding providing training by job category and providing training to newly hired personnel. Therefore, the NRC staff finds that this portion of DOE's description is acceptable because DOE will train GROA personnel on a job-category basis and will conduct training for newly hired personnel on a timely schedule.

In summary, in SAR Section 5.3.3, DOE stated that its Qualification and Training Program will establish programs for general training, proficiency testing, and certification of GROA personnel. The NRC staff evaluated DOE's description of the Qualification and Training Program to determine how training and certification of GROA personnel would be established. On the basis of this review, as described in SER Section 2.5.3.3.3.2, the NRC staff concludes that DOE's description addresses applicable guidance in the YMRP regarding programs for training and certification of GROA personnel. Therefore, the NRC staff finds that this portion of DOE's description is acceptable because DOE described appropriate programs for general training, proficiency testing, and certification of GROA personnel.

2.5.3.3.3.3 Preoperational and Operational Radioactive Materials Training Program

In SAR Section 5.3.3, DOE described how the Qualification and Training Program would implement and complete a radioactive materials training program before receipt of radioactive material and the conduct of nuclear operations. The NRC staff evaluated DOE's description of the Qualification and Training Program to determine how it will implement the radioactive materials training program for GROA personnel. In SAR Section 5.3.3, DOE stated that the training and certification program would be implemented to provide the required training and certification of personnel before those work activities will be performed. DOE also stated that the training and certification program would be implemented prior to receipt of spent nuclear fuel or high-level waste so that trained and certified personnel receive this material. On the basis of this review, the NRC staff concludes that DOE's description addresses applicable guidance in the YMRP regarding conducting and completing radioactive materials training before receipt of radioactive material. Therefore, the NRC staff finds that this portion of DOE's description is acceptable because DOE GROA operations personnel will be trained before receipt of nuclear material.

In SAR Section 5.3.3.2.1, DOE described how the Qualification and Training Program would establish operator radiation safety training, including standard radiation training and safety topics. The NRC staff evaluated DOE's description of the Qualification and Training Program to

determine the topics covered in operator radiation safety training. In SAR Section 5.3.3.2.1, DOE described operator radiation safety training to include

- Practices of keeping doses ALARA
- Contamination control practices and limits
- Principles of criticality hazard control
- Use of personnel monitoring equipment
- Emergency procedures
- The nature and sources of radiation, including GROA-specific radiological hazards
- Biological effects of radiation
- Principles of nuclear criticality safety
- Risk to pregnant females
- Radiation protection and decontamination practices
- Protective clothing
- Respiratory protection
- Repository access and visitor control

Based on this review, the NRC staff concludes that DOE's description addresses applicable guidance in the YMRP regarding operator radiation safety training. Therefore, the NRC staff finds that this portion of DOE's description is acceptable because DOE will provide training in topics that cover important aspects regarding radiation and criticality safety.

In SAR Section 5.3.3, DOE described how the Qualification and Training Program will instruct individuals who, in the course of their employment, would be likely to receive yearly occupational doses in excess of 1 mSv [100 mrem] on the health protection issues associated with exposure to radioactive materials or radiation. The NRC staff evaluated DOE's description of the Qualification and Training Program to identify if DOE will instruct individuals who may be exposed to radiation. On the basis of this review, the NRC staff concludes that DOE's description addresses applicable guidance in the YMRP regarding training personnel who will likely be exposed to more than 1 mSv [100 mrem]. Therefore, the NRC staff finds that this portion of DOE's description is acceptable because DOE will instruct individuals who will be likely to receive yearly occupational doses in excess of 1 mSv [100 mrem] in the health protection issues associated with exposure to radioactive materials or radiation.

In SAR Section 5.3.3.2.2, DOE described how the Qualification and Training Program would establish that, before any special exposures occur, DOE will inform the individuals involved of estimated doses and associated risks. The NRC staff evaluated DOE's description of the Qualification and Training Program to determine if individuals would be informed of any exposure to radiation and the estimated doses and associated risks. In SAR Section 5.3.3.2.2, DOE described that, before any special exposures occur, it will inform the individuals involved of estimated doses and associated risks. DOE stated that training programs will be established for job positions commensurate with the criticality potential or radiation safety responsibilities associated with each position. On the basis of this review, the NRC staff concludes that DOE's description addresses applicable guidance in the YMRP regarding informing individuals of estimated doses and associated risks from any special exposure. Therefore, the NRC staff finds that this portion of DOE's description is acceptable because DOE will inform the individuals involved of estimated doses and associated risks before any exposures, including special exposures.

In SAR Section 5.3.3.2.2, DOE stated that the Qualification and Training Program will provide adequate training in radiation protection and facility exposure control procedures for personnel whose duties require (i) working with radioactive materials; (ii) entering radiation areas; and (iii) directing the activities of others who work with radioactive materials or enter radiation areas. The NRC staff evaluated DOE's description of the Qualification and Training Program to determine whether DOE will provide adequate training in radiation protection and facility exposure control procedures for affected personnel. In SAR Section 5.3.3.2.2, DOE stated that training programs will be established for job positions commensurate with the criticality potential or radiation safety responsibilities associated with each position. DOE also stated that visitors to a restricted area will be trained in the formal training program or will be escorted by trained personnel while in the area. DOE also stated that typical topics to be covered in radiation and criticality training include radiation protection practices and exposure control procedures, such as practices of keeping doses ALARA. In SAR Section 5.3.3.2.3, DOE stated that operations personnel who operate equipment or controls that are ITS or ITWI will be trained and certified or will operate equipment or controls that are ITS or ITWI under the direct visual supervision of an individual who will be trained and certified in those operations. Based on this review, the NRC staff concludes that DOE's description addresses applicable guidance in the YMRP regarding radiation protection training and facility exposure control training for affected personnel. Therefore, the NRC staff finds that this portion of DOE's description is acceptable because DOE described the radiation training for supervisors and personnel who will work with radioactive materials, supervise work in radiation areas, or otherwise enter radiation areas.

In SAR Section 5.3.3.2.1, DOE described how the Qualification and Training Program established that facility personnel whose duties do not require entering radiation areas or working with radioactive materials will receive sufficient instructions in radiation protection to ensure that they do not enter restricted areas. The NRC staff evaluated DOE's description of the Qualification and Training Program to determine how personnel will receive instructions to preclude them from entering restricted areas. In SAR Section 5.3.3.2.1, DOE stated that personnel assigned to the repository who are not expected to receive occupational radiation doses will be trained in radiation protection and the safety considerations that preclude their entry into restricted areas. On the basis of this review, the NRC staff concludes that DOE's description addresses applicable guidance in the YMRP regarding instructing facility personnel in radiation protection whose duties do not require entering radiation areas. Therefore, the NRC staff finds that this portion of DOE's description is acceptable because DOE will train personnel assigned to the repository who are not expected to receive occupational radiation doses in order to preclude their entry into radiation areas.

In summary, in SAR Section 5.3.3, DOE described how the Qualification and Training Program would establish a preoperational and operational radioactive materials training program. The NRC staff evaluated DOE's description of the Qualification and Training Program to determine whether DOE described an adequate radioactive materials training program. On the basis of this review, as described in SER Section 2.5.3.3.3.3, the NRC staff concludes that DOE's description addresses applicable guidance in the YMRP regarding a preoperational and operational radioactive materials training program. Therefore, the NRC staff finds that this portion of DOE's description is acceptable because DOE described an acceptable preoperational and operational radioactive materials training program.

2.5.3.3.3.4 Operation of Equipment and Controls Identified as ITS is Limited to Trained and Certified Personnel or is Under the Direct Visual Supervision of an Individual With Training and Certification in Their Operation

In SAR Section 5.3.3, DOE described how the Qualification and Training Program would establish that operators of all equipment and controls identified as ITS will be either trained and certified in the ITS operations or will be under the direct visual supervision of an individual who will be trained and certified in the ITS operations; and supervisory personnel who personally direct the operation of equipment and controls ITS will be trained and certified in such operations. The NRC staff evaluated DOE's description of the Qualification and Training Program to determine whether operators of ITS equipment and controls and their supervisors will be trained and certified in such operations. In SAR Section 5.3.3, DOE stated that (i) operators of all ITS equipment and controls will be either trained and certified in the operations or will be under the direct visual supervision of an individual who will be trained and certified in the operations and (ii) supervisory personnel who personally direct the operation of equipment and controls ITS will be trained and certified in such operations. On the basis of this review, the NRC staff concludes that DOE's description addresses the applicable guidance in the YMRP regarding allowing only trained and certified personnel and supervisors to operate ITS equipment or controls. Therefore, the NRC staff finds that this portion of DOE's description is acceptable because operators of all ITS equipment and controls will be either trained and certified in the operations or will be under the direct visual supervision of an individual who will be trained and certified in the operations.

In SAR Section 5.3.3.2.3, DOE described how, in the Qualification and Training Program, operational training would include topics such as installation, design, and operation of SSCs; decontamination procedures; and emergency procedures. In SAR Section 5.3.3.2.3, DOE stated that technical training will provide repository employees with an understanding of applicable installation, design, and operating fundamentals; procedures; emergency procedures; and job practices at the operating repository. On the basis of this review, the NRC staff concludes that DOE's description addresses applicable guidance in the YMRP regarding operational training topics. Therefore, the NRC staff finds that this portion of DOE's description is acceptable because DOE will provide technical training to operations personnel, which will include installation, design, and operation of SSCs; decontamination procedures; and emergency procedures.

In summary, SAR Section 5.3.3 described how the operation of equipment and controls identified as ITS will be limited to trained and certified personnel or will be under the direct visual supervision of an individual with training and certification in their operation under DOE's Qualification and Training Program. The NRC staff evaluated DOE's description of the Qualification and Training Program to determine how DOE will limit operation of ITS equipment and controls to trained and certified personnel and supervisors. On the basis of this review, as described in SER Section 2.5.3.3.3.4, the NRC staff concludes that DOE's description addresses applicable guidance in the YMRP regarding allowing only trained and qualified personnel and supervisors to operate ITS equipment and controls. Therefore, the NRC staff finds that this portion of DOE's description is acceptable because DOE will use only trained and certified personnel to operate ITS equipment and controls or will use trained and certified personnel to supervise such operations.

2.5.3.3.3.5 Operator and Supervisor Requalification Program for SSCs ITS

In SAR Section 5.3.9, DOE described how the Qualification and Training Program would establish a program for requalification of operators, supervisors, and other staff; the nature and duration of training and testing records; and that retraining will be conducted at least every 2 years. DOE also stated that accurate training records will be maintained on each employee's qualifications, certifications, experience, training, and retraining in accordance with DOE's records management program. On the basis of this review, the NRC staff concludes that DOE's description addresses applicable guidance in the YMRP regarding requalification of GROA personnel every 2 years, and maintenance of training and testing records. Therefore, the NRC staff finds that this portion of DOE's description is acceptable because DOE will requalify its operators and supervisors by written tests, oral tests, and on-the-job performance evaluations at a frequency of at least every 2 years, and will retain training and testing records in accordance with DOE's records management program.

2.5.3.3.3.6 Physical Condition and the General Health of Personnel Certified for the Operation of Equipment and Controls ITS

In SAR Section 5.3.11, DOE described how, in the Qualification and Training Program, conditions that might impair judgment or motor coordination resulting in the inability of an operator to perform activities that are ITS will be adequately considered in the selection of personnel to operate such equipment and controls. The NRC staff evaluated DOE's description of the Qualification and Training Program to determine the requirements for the physical condition of personnel who operate ITS equipment or controls. In SAR Section 5.3.11, DOE stated that it would develop requirements for the physical condition and general health of personnel who operate equipment or controls that are ITS or ITWI. DOE stated that individuals designated as operators of equipment or controls that are ITS or ITWI will have a physical examination by a licensed physician every 2 years. DOE stated that permanent conditions of individuals that could cause impaired judgment or motor coordination will be considered for accommodation by the physician performing the physical examination. On the basis of this review, the NRC staff concludes that DOE's description addresses applicable guidance in the YMRP regarding the physical condition and general health of personnel certified for the operation of ITS equipment and controls. Therefore, the NRC staff finds that this portion of DOE's description is acceptable because DOE will determine the physical condition and the general health of personnel certified for the operation of equipment and controls ITS to prevent operational errors that could endanger other GROA personnel or the public health and safety.

2.5.3.3.3.7 Methods for Selecting, Training, and Qualifying Security Guards

As noted in SAR Section 5.3.12, the methods for selecting and qualifying security guards, watchmen, armed response personnel, and other members of the security organization will be described in the Physical Protection Plan. DOE's description of its Physical Protection Plan is evaluated and found to be acceptable in Volume 1, "General Information," Chapter 3, "Physical Protection Plan" of this SER.

2.5.3.3.3.8 Methods Used to Evaluate Operator Testing Procedures

In SAR Section 5.3.8, DOE described the Qualification and Training Program methods for evaluating the effectiveness of the training program through comparison to established objectives and criteria. The NRC staff evaluated DOE's description of the Qualification and Training Program to determine whether methods used to evaluate operator testing procedures

are acceptable. In SAR Section 5.3.8, DOE stated that the Qualification and Training Program will be evaluated to measure its effectiveness. DOE stated that effectiveness will be determined by comparison of actual training performance to established objectives and criteria. On the basis of this review, the NRC staff concludes that DOE's description addresses applicable guidance in the YMRP regarding evaluating the effectiveness of the training program. Therefore, the NRC staff finds that this portion of DOE's description is acceptable because DOE will evaluate operator testing procedures to determine program effectiveness.

2.5.3.3.3.9 Qualifications of Personnel

Qualifications of personnel are discussed in SAR Section 5.3.2, "Key Positions Assigned Responsibility for Safety and Operations at the Site." The NRC staff evaluation of the qualifications of the personnel assigned to GROA key positions is SER Section 2.5.3.2.

2.5.3.3.4 Evaluation Findings

The NRC staff has reviewed DOE's description of the Personnel Qualifications and Training Program and finds, with reasonable assurance, that the requirements of 10 CFR 63.21(c)(22)(iii) and 10 CFR Part 63, Subpart H, Training and Certification of Personnel, are satisfied.

Specifically, in accordance with 10 CFR 63.151, operation of systems and components that are ITS will be performed only by trained and certified personnel or by personnel under the direct supervision of an individual with training and certification in such operation. Supervisory personnel will also be certified in the operations they supervise.

Also, in accordance with 10 CFR 63.152, DOE will establish an adequate program for training, proficiency testing, certification, and requalification of operating and supervisory personnel.

Finally, in accordance with 10 CFR 63.153, DOE will establish an adequate program for evaluating the physical condition and general health of personnel certified for operations that are ITS. Conditions that might cause impaired judgment or motor coordination will be adequately considered in the selection of personnel for activities ITS.

2.5.3.3.5 References

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NRC. 2000ae. Regulatory Guide 1.8, "Qualification and Training of Personnel for Nuclear Power Plants." Rev. 3. ML003706932. Washington, DC: U.S. Nuclear Regulatory Commission.

NRC. 1998ab. Regulatory Guide 1.134, "Medical Evaluation of Licensed Personnel at Nuclear Power Plants." Rev. 3. ML003740140. Washington, DC: U.S. Nuclear Regulatory Commission.

NRC. 1996ac. Regulatory Guide 8.29, "Instruction Concerning Risks from Occupational Radiation Exposure." Rev. 1. ML003739438. Washington, DC: U.S. Nuclear Regulatory Commission.

NRC. 1981aa. Regulatory Guide 8.27, "Radiation Protection Training for Personnel at Light-Water-Cooled Nuclear Power Plants." ML003739628. Washington, DC: U.S. Nuclear Regulatory Commission.

NRC. 1978ab. Regulatory Guide 8.8, "Information Relevant to Ensuring that Occupational Radiation Exposures at Nuclear Power Stations Will be as Low as is Reasonably Achievable." Rev. 3. ML003739549. Washington, DC: U.S. Nuclear Regulatory Commission.

CHAPTER 8

2.5.5 Plans for Startup Activities and Testing

2.5.5.1 Introduction

Safety Evaluation Report (SER) Section 2.5.5 evaluates the plans for startup activities and testing provided in the U.S. Department of Energy (“DOE” or “applicant”) Safety Analysis Report (SAR) Section 5.5 (DOE, 2008ab). This section was unchanged in DOE’s license application update, submitted to the U.S. Nuclear Regulatory Commission (NRC) in February 2009 (DOE, 2009av). Additional information was provided in DOE’s response to the NRC staff’s request for additional information regarding human factors considerations (DOE, 2009go).

The NRC staff’s evaluation and regulatory findings are based on DOE’s descriptions of plans for startup activities and testing of the proposed geologic repository operations area (GROA) facilities in the SAR, as updated by the RAI response. Startup testing ensures that structures, systems, and components (SSCs) that are important to safety and important to waste isolation can be operated in a safe and dependable manner. Startup testing is based on the use of testing plans that are developed to support each facility in phased startup. As stated in YMRP Section 2.5.5, DOE is not required to have detailed procedures in place for startup activities and testing at the time of a decision on whether to authorize construction. A detailed testing and startup activities program for these SSCs would be reviewed by the NRC staff as part of its review of an application to receive and possess waste.

2.5.5.2 Regulatory Requirements

DOE’s SAR must include plans for startup activities and startup testing at the GROA under 10 CFR 63.21(c)(22)(iv). The NRC staff used guidance in the Yucca Mountain Review Plan (YMRP) Section 2.5.5 (NRC, 2003aa), as supplemented by the High-Level Waste Repository Safety (HLWRS) Interim Staff Guidance (ISG) HLWRS–ISG–04 (NRC, 2007ad) in performing its evaluation.

2.5.5.3 Technical Evaluation

The SAR contains 12 sections that address startup activities and testing in two subject areas: (i) Startup and Test Plan Development and (ii) Startup and Testing Activities. Each of these are discussed as follows.

Startup and Test Plan Development

DOE provided its discussion of startup and test plan development in six SAR Sections (5.5.1, 5.5.2, 5.5.3, 5.5.4, 5.5.9, and 5.5.11). YMRP Acceptance Criterion 6 states that pre-startup test programs for GROA SSCs should be consistent with applicable regulatory guidance in Regulatory Guide 3.48, “Standard Format and Content For The Safety Analysis Report For An Independent Spent Fuel Storage Installation or Monitored Retrievable Storage Installation (Dry Storage)” (NRC, 1989aa). DOE stated in SAR Section 5.5.1 that Regulatory Guide 3.48 is not applicable. DOE also stated in SAR Section 5.5.1 that, instead of Regulatory Guide 3.48, it would use Regulatory Guide 1.68, “Initial Test Programs for Water-Cooled Nuclear Power Plants,” Revision 2 (NRC, 1978aa), to the extent that the regulatory positions are applicable to repository SSCs and operations at the geologic repository.

The NRC staff finds that use of Regulatory Guide 1.68 for pre-startup test programs for GROA SSCs is acceptable because it provides appropriate nuclear operations guidance for the scope and depth of initial test programs, test conditions and schedules, test procedures and reports, testing radiation protection systems, testing radioactive waste handling and storage systems, and testing auxiliary and miscellaneous systems.

DOE listed additional NRC regulatory guidance that would be considered during the development of specific test procedures. In SAR Section 5.5.2, Use of Experience from Similar Facilities, DOE describes its use of repository test results, best practices, and lessons learned from similar facilities into the development of the startup test procedures.

In SAR Section 5.5.3, Methods Used to Develop, Review, and Approve Test Procedures and Methods to Evaluate Results, DOE describes how startup testing would be performed, such as using written, reviewed, and approved procedures and qualified personnel following the Testing Program Plan. In SAR Section 5.5.4, Format and Content of Test Procedures, DOE described the use of consistent testing procedures, including the use of prerequisite and precautionary measures to protect workers and the public. In SAR Section 5.5.9, Protection of Workers and the Public, DOE states that a review of the planned startup activities and tests will be performed during startup to ensure that the aggregate effects of the startup test and activities support the overall evaluation of the geologic repository operations level of safety for workers and the public. In SAR Section 5.5.11, Schedules, DOE states that the test procedures would be made available to NRC approximately 90 days prior to use.

Startup and Testing Activities

DOE's discussion of Startup and Testing Activities is also covered in six SAR Sections (5.5.5, 5.5.6, 5.5.7, 5.5.8, 5.5.10, and 5.5.12). In SAR Section 5.5.5, Component Testing, DOE describes its approach to component testing, including factory testing performed by vendors, system flushes, component labeling and calibration, and formal turnover from the construction organization to the startup organization. In SAR Section 5.5.6, System Functional Test, DOE describes further testing once the startup organization accepts control from the construction organization, including component full load and system testing. In SAR Section 5.5.7, Cold Integrated Systems Testing, DOE describes integrated dry runs (or cold tests) to ensure that multiple systems can operate together. Upon completion of cold integration testing, facilities and systems control are transferred to Facility Operations.

In SAR Section 5.5.8, Operational Readiness Review, DOE describes its review of testing, results, and resolution of deficiencies to verify the ability of the facility to safely receive and process spent nuclear fuel (SNF) or HLW. In SAR Section 5.5.10, Hot Testing (initial startup operations), DOE describes confirmatory tests, personnel qualifications, and prerequisites for testing with actual SNF or HLW (hot testing). In SAR Section 5.5.12, Testing and Evaluating Functional Adequacy of New or Untested Systems, Structures and Components, DOE describes a need for particular oversight of untested or new applications or combinations of existing technologies. In general, the surface facilities are similar to nuclear power, and other industry facilities. However, some aspects are unique to the repository, such as the transportation and emplacement vehicle. DOE also stated that additional administrative controls, including hold points, intermediate performance analysis, and expanded oversight would also be applied.

The NRC staff reviewed this information and finds that DOE's plans for startup activities and testing are acceptable because

- DOE described the systems used to develop, review, and approve individual prestartup test procedures.
- DOE described the various types of tests and objectives for the tests to be performed for each GROA SSC important to safety.
- DOE will consider design information and data from preconstruction performance tests or evaluations in development of the startup testing procedures.
- DOE stated that a testing program plan will be developed that describes a consistent test procedure format.
- DOE's test programs will be compatible with applicable regulatory guidance or will provide justification for positions that deviate from the guidance, including the use of RG 1.68, as plans and procedures are developed.
- DOE described a program for managing operating experience and good work practices based on test results, best practices, and lessons learned from DOE sites, NRC-licensed facilities, and other similar facilities.
- DOE test procedures will address objectives, design specifications and other requirements, prerequisites, objectives, test methods, and acceptance criteria.
- DOE test procedures will address prerequisites and precautionary measures needed to protect workers and the public during startup activities.
- DOE described a schedule, over distinct time intervals, corresponding to the phased construction of facilities. Prior to receiving waste at each facility, the startup and testing program will test the capability for handling and processing waste, and limiting the release of radioactive materials.
- DOE will test and evaluate new and untested configurations of SSCs prior to receipt of waste.
- DOE's test plans include cold integrated systems testing and hot testing of each operation involving radioactive waste streams.
- DOE included a comprehensive and integrated approach to initial startup activities and testing that will assess whether SSCs important to safety and waste isolation have been properly constructed and installed, and whether they will fulfill their operational and safety functions in accordance with design requirements.

Based on its evaluation of the SAR and associated references provided by the applicant, the NRC staff finds that the requirement in 10 CFR 63.21(c)(22)(iv) to provide information concerning plans for startup activities and startup testing is satisfied because DOE's description included all the necessary elements to evaluate whether SSCs important to safety and waste isolation have been properly constructed and installed, will fulfill their operational and safety functions, and will meet regulatory and licensing requirements. Therefore, on the basis of this review, NRC staff concludes with reasonable assurance that the requirement in 10 CFR 63.21(c)(22)(iv) is satisfied.

2.5.5.4 Evaluation Findings

The NRC staff finds that DOE has adequately described plans for startup activities and startup testing that would be implemented before DOE would receive and possess waste. Therefore, the NRC staff concludes with reasonable assurance that the requirement in 10 CFR 63.21(c)(22)(iv) is satisfied.

2.5.5.5 References

DOE. 2009av. DOE/RW-0573, "Yucca Mountain Repository License Application." Rev. 1. ML090700817. Las Vegas, Nevada: DOE, Office of Civilian Radioactive Waste Management.

DOE. 2009go. "Yucca Mountain—Response to Request for Additional Information Regarding License Application (Safety Analysis Report Section 5.5), Safety Evaluation Report Vol. 4, Chapter 2.5.5, Set 1, and Yucca Mountain—Response to Request for Additional Information Regarding License Application (Safety Analysis Report Section 5.6), Safety Evaluation Report Vol. 4, Chapter 2.5.6, Set 1." Letter (July 9) J.R. Williams to F. Jacobs (NRC). ML091900678. Washington, DC: DOE, Office of Technical Management.

DOE. 2008ab. DOE/RW-0573, "Yucca Mountain Repository License Application." Rev. 0. ML081560400. Las Vegas, Nevada: DOE, Office of Civilian Radioactive Waste Management.

NRC. 2007ad. Interim Staff Guidance HLWRS-ISG-04, "Preclosure Safety Analysis—Human Reliability Analysis." ML071290571, ML071910213 (guidance). Washington, DC: U.S. Nuclear Regulatory Commission.

NRC. 2003aa. NUREG-1804, "Yucca Mountain Review Plan—Final Report." Rev. 2. ML032030389. Washington, DC: U.S. Nuclear Regulatory Commission.

NRC. 1989aa. Regulatory Guide 3.48, "Standard Format and Content for the Safety Analysis Report for an Independent Spent Fuel Storage Installation or Monitored Retrievable Storage Installation (Dry Storage)." Rev. 1. ML003739163. Washington, DC: U.S. Nuclear Regulatory Commission.

NRC. 1978aa. Regulatory Guide 1.68, "Initial Test Programs for Water-Cooled Nuclear Power Plants." Rev. 2. ML061880482. Washington, DC: U.S. Nuclear Regulatory Commission.

CHAPTER 9

2.5.6 Plans for Conduct of Normal Activities, Including Maintenance, Surveillance, and Periodic Testing

2.5.6.1 Introduction

Safety Evaluation Report Section 2.5.6 evaluates the plans provided in the U.S. Department of Energy (“DOE” or “applicant”) Safety Analysis Report (SAR) (DOE, 2008ab, Section 5.6) for conduct of normal activities, including those activities necessary to maintain and verify proper operations. This section was unchanged in DOE’s license application update, submitted to the U.S. Nuclear Regulatory Commission (NRC) in February 2009 (DOE, 2009av). DOE provided more information on this topic in its response to the NRC staff’s request for additional information (DOE, 2009go).

2.5.6.2 Regulatory Requirements

The requirement for DOE to provide in its SAR information concerning plans for conduct of normal activities, including maintenance, surveillance, and periodic testing of structures, systems, and components (SSCs) of the geologic repository operations area, is specified in 10 CFR 63.21(c)(22)(v).

The NRC staff evaluated DOE’s plans for conduct of normal activities using applicable guidance in the Yucca Mountain Review Plan (YMRP) Section 2.5.6 (NRC, 2003aa), as supplemented by the High-Level Waste Repository Safety (HLWRS) interim staff guidance (ISG) HLWRS–ISG–04 (NRC, 2007ad). As stated in YMRP Section 2.5.6, DOE will develop and implement these procedures and plans prior to receipt and possession of waste.

2.5.6.3 Technical Evaluation

In SAR Section 5.6, DOE described its plan and procedure development, testing, and approval by authorized personnel; management systems for operation of the repository, including administrative and procedural safety controls; and the specific types of plans and procedures to be developed for normal operations, maintenance, and periodic surveillance testing. DOE clarified in (DOE 2009go) that human factors engineering experience and competency is required for independent procedure reviewers. DOE also identified experience from other, similar DOE facilities as guidance for developing plans and procedures for conduct of normal activities.

The NRC staff reviewed this information and finds that DOE’s plans for conduct of normal activities, including those activities necessary to maintain and verify proper operations, are acceptable because DOE provided information concerning how

- DOE will apply adequate administrative and procedural controls to develop these plans and procedures.
- DOE plans and procedures will address the full range of normal activities for SSCs important to safety, including maintenance, surveillance, and routine periodic testing.

- Personnel with safety, health, environmental, human factors engineering, and quality assurance qualifications, independent of the operating organization, will review plans and procedures.
- DOE will incorporate operating experience and lessons learned from other facilities (operated by both DOE and other entities) into plans and procedures, as appropriate.
- DOE will train and qualify operations personnel, and will consider the qualification and training of personnel for maintenance assignments.

Based on its evaluation of DOE's information concerning plans to conduct normal activities, including maintenance, surveillance, and periodic testing of SSCs of the geologic repository operations area, the NRC staff finds that DOE's information is acceptable because DOE described procedures that will be in place for the conduct of normal activities, including maintenance, surveillance, and periodic testing of SSCs, as required in 10 CFR 63.21(c)(22)(v).

2.5.6.4 Evaluation Findings

The NRC staff finds that DOE has adequately described plans for the conduct of normal activities, including maintenance, surveillance, and periodic testing, that would be implemented before DOE receives and possesses waste. Therefore, the NRC staff concludes with reasonable assurance that the requirement in 10 CFR 63.21(c)(22)(v) is satisfied.

2.5.6.5 References

DOE. 2009av. DOE/RW-0573, "Yucca Mountain Repository License Application." Rev. 1. ML090700817. Las Vegas, Nevada: DOE, Office of Civilian Radioactive Waste Management.

DOE. 2009go. "Yucca Mountain—Response to Request for Additional Information Regarding License Application (Safety Analysis Report Section 5.5), Safety Evaluation Report Vol. 4, Chapter 2.5.5, Set 1, and Yucca Mountain—Response to Request for Additional Information Regarding License Application (Safety Analysis Report Section 5.6), Safety Evaluation Report Vol. 4, Chapter 2.5.6, Set 1." Letter (July 9) J.R. Williams to F. Jacobs (NRC). ML091900678. Washington, DC: DOE, Office of Technical Management.

DOE. 2008ab. DOE/RW-0573, "Yucca Mountain Repository License Application." Rev. 0. ML081560400. ML081560542. Las Vegas, Nevada: DOE, Office of Civilian Radioactive Waste Management.

NRC. 2007ad. Interim Staff Guidance HLWRS-ISG-04, "Preclosure Safety Analysis—Human Reliability Analysis." ML071290571. Washington, DC: U.S. Nuclear Regulatory Commission.

NRC. 2003aa. NUREG-1804, "Yucca Mountain Review Plan—Final Report." Rev. 2. ML032030389. Washington, DC: U.S. Nuclear Regulatory Commission.

CHAPTER 10

2.5.7 Emergency Planning

2.5.7.1 Introduction

Safety Evaluation Report (SER) Section 2.5.7 evaluates the description provided in the U.S. Department of Energy (“DOE” or “applicant”) Safety Analysis Report (SAR) (DOE, 2008ab, Section 5.7) of plans for responding to, and recovering from, radiological emergencies that may occur at the geologic repository operations area (GROA) for disposal of high-level radioactive waste at Yucca Mountain, Nevada, at any time before permanent closure. This SAR section was unchanged in DOE’s License Application update, submitted to the U.S. Nuclear Regulatory Commission (NRC) in February 2009 (DOE, 2009av). DOE provided more information on this topic in its response to the NRC staff’s request for additional information (DOE, 2008ai).

2.5.7.2 Regulatory Requirements

The regulatory requirements for emergency planning are in 10 CFR 63.21(c)(21) and 10 CFR Part 63, Subpart I, “Emergency Planning Criteria” (10 CFR 63.161). Under 10 CFR 63.21(c)(21), the SAR must include a description of the plan for responding to, and recovering from, radiological emergencies that may occur any time before permanent closure and decontamination or decontamination and dismantlement of surface facilities, as required by 10 CFR 63.161. The emergency planning requirements in 10 CFR 63.161 provide that (i) DOE develop and be prepared to implement a plan to cope with radiological accidents that may occur at the GROA at any time before permanent closure and decontamination or decontamination and dismantlement of surface facilities and (ii) the emergency plan (EP) be based on the criteria of 10 CFR 72.32(b), which identifies information to be included in an EP.

The NRC staff reviewed DOE’s description of its EP using the guidance in the “Yucca Mountain Review Plan” (YMRP) Section 2.5.7 (NRC, 2003aa). YMRP Section 2.5.7 references NUREG–1567, “Standard Review Plan for Spent Fuel Storage Facilities” (NRC, 2000ab), as additional guidance. The NRC Spent Fuel Project Office Interim Staff Guidance (ISG)–16, “Emergency Planning” (NRC, 2000aa) revised NUREG–1567, “Emergency Planning” (NRC, 2000ab, Section 10.4.5).

Pursuant to 10 CFR 63.21(a), DOE is required to provide information that is reasonably available. The handling of spent nuclear fuel and high-level waste would not occur prior to issuance of a license to receive and possess waste, and DOE has not finalized designs of facilities, systems, and equipment that would influence various parts of emergency planning. Before a license to receive and possess waste could be issued, the NRC staff would review whether adequate protective measures would be taken by DOE in the event of a radiological emergency at any time before permanent closure and decontamination or decontamination and dismantlement of surface facilities pursuant to 10 CFR 63.41(d).

2.5.7.3 Technical Evaluation

DOE provided a description of the EP for responding to and recovering from radiological emergencies that may occur during operations at the GROA. DOE stated that the information provided was as complete as possible, in the light of information that was reasonably available at that time. DOE stated that it will provide an EP that meets the 10 CFR 72.32(b) requirements

to NRC no later than 6 months prior to the submittal of the updated application for a license to receive and possess waste.

The NRC staff reviewed DOE's description of its EP following applicable guidance in the YMRP Section 2.5.7. In addition, in accordance with 10 CFR Part 63, staff used the criteria in 10 CFR 72.32. The following 16 SER subsections correspond to applicable guidance and criteria in the YRMP and 10 CFR 72.32(b)(1)–(16).

In accordance with 10 CFR 63.21(c)(21), the NRC staff's review of DOE's construction authorization application is focused on the description of an EP that DOE would develop and be prepared to implement, which addresses the 10 CFR 72.32 criteria, as required by 10 CFR 63.161.

2.5.7.3.1 Facility Description

In SAR Section 5.7.2, DOE provided information that would be included in the EP to describe the GROA and the surrounding area. DOE stated in SAR Section 5.7.2 that the EP will include detailed maps of the GROA and the site. DOE also stated that it expects to provide enlarged duplicates of the drawings, suitable for use as wall maps, to NRC with the EP. DOE further stated that these detailed maps will be drawn to scale and will show information that addresses the items identified in ISG–16 Section 3.1. The EP will describe site features affecting emergency response, including communications and assessment centers, assembly and relocation areas, and emergency equipment storage areas. DOE addressed the description of the area near the site and stated that the EP will describe the GROA and the surrounding area and will include a general map that addresses the items listed in ISG–16 Section 3.2.

The NRC staff evaluated DOE's information that would be included in the EP to describe the GROA and the area near the site. On the basis of its review, the NRC staff determined that DOE's description of the facility includes major site features, restricted area boundaries, roads, communication and assessment centers, and other features affecting emergency response, which addresses the applicable guidance and criteria in the YMRP, ISG–16 Sections 3.1 and 3.2, and 10 CFR 72.32(b)(1). Therefore, NRC staff finds that this portion of DOE's description is acceptable because it shows that DOE will develop and be prepared to implement an EP that will include a facility description consistent with applicable guidance and criteria.

2.5.7.3.2 Types of Accidents

In SAR Section 5.7.3.1, DOE stated that the EP will discuss each type of potential accident that could result in the release of radioactive material, as identified in the list of possible internal and external events presented in SAR Section 1.7. DOE stated that it will use the event sequence analysis, which is part of the preclosure safety analysis, to identify each type of potential radioactive materials accident. DOE stated that its use of the event sequence analysis, as part of the preclosure safety analysis, will result in a description of the accidents in terms of the process and physical location where they could occur; how the accidents could occur (e.g., equipment malfunction, instrument failure, human error); possible contributing or complicating factors; and possible onsite and offsite consequences. DOE also stated (DOE, 2008ai) that its EP will include descriptions of any non-radiological, hazardous material release events that could impact emergency response efforts.

The NRC staff evaluated DOE's information on the types of potential accidents in SAR Section 1.7 that would be included in the EP. On the basis of its review, the NRC staff

determines that DOE's description of potential accidents (which includes how the accidents could occur, complicating factors, possible onsite and offsite consequences, and how the types of accidents will be identified using the event sequence analysis) addresses applicable guidance and criteria in the YMRP, ISG-13 Section 3.3, and 10 CFR 72.32(b)(2) regarding identification of accidents. Therefore, the NRC staff finds that this portion of DOE's description is acceptable because it shows that DOE will develop and be prepared to implement an EP that will identify each type of radioactive materials accident consistent with applicable guidance and criteria.

2.5.7.3.3 Classification of Accidents

In SAR Section 5.7.3.2.1, DOE stated that emergency action levels (EALs) will use specific, predetermined, observable criteria that will be used to determine the emergency classification and the initial protective actions required for those emergencies. In addition, DOE stated that the EP will contain EALs, providing initiating conditions, accident mechanisms, postulated equipment or system failures, event indicators, and contributing events. Finally, DOE described Category 1 and Category 2 events that could lead to the initiation of an alert and site area emergency. As defined in 10 CFR 63.2, Category 1 event sequences are those that are expected to occur one or more times before the permanent closure of the GROA and Category 2 event sequences are those that have at least 1 chance in 10,000 of occurring before permanent closure.

The NRC staff evaluated DOE's information on how its EP would classify potential accidents and corresponding EALs. The NRC staff determines that DOE's description explains how its EP would include the responsibility and authority to (i) identify "alerts" or "site area emergencies," (ii) make offsite notifications, (iii) initiate site response, and (iv) activate the emergency response organization. On the basis of its review, the NRC staff concludes that DOE's description addresses the applicable guidance and criteria in the YMRP, ISG-16 Section 3.4, and 10 CFR 72.32(b)(3) regarding classification of accidents. Therefore, NRC staff finds that this portion of DOE's description is acceptable because it shows that DOE will develop and be prepared to implement an EP that will include a system to classify accidents, consistent with applicable guidance and criteria.

2.5.7.3.4 Detection of Accidents

In SAR Section 5.7.4.1, DOE stated that the EP will provide a description of the means for detecting initiating events and accident conditions that apply to each identified accident. The EP will also describe the rationale for the locations and types of devices used to detect accidents as identified in the list of possible internal and external events presented in SAR Section 1.7. In SAR Section 5.7.4.2, DOE stated that the EP will include operating procedures that will identify the means of detection of the event sequences that lead to declaration of an alert or site area emergency. DOE explained that this may include, but is not limited to, visual observations, radiation monitors, smoke or heat detectors, and/or process alarms.

The NRC staff evaluated DOE's information on how accident conditions would be detected in its EP. The NRC staff determines that DOE's description explains how the EP will address means to be used to detect key initiating events and accident conditions and the rationale for the locations and types of detection devices, including notification of the operating staff. On the basis of its review, the NRC staff concludes that DOE's description addresses the applicable guidance and criteria in the YMRP, ISG-16 Section 3.5, and 10 CFR 72.32(b)(4) regarding detection of accidents. Therefore, NRC staff finds that this portion of DOE's description is

acceptable because it shows that DOE will develop and be prepared to implement an EP that addresses how accident conditions would be detected, consistent with applicable guidance and criteria.

2.5.7.3.5 Mitigation of Consequences

In SAR Section 5.7.5.1, DOE stated that the EP will describe the means to mitigate consequences of each type of accident, as presented in SAR Section 1.7. DOE stated that these descriptions will address (i) equipment and design features relied on to mitigate emergencies, (ii) general actions that repository personnel may take to mitigate emergencies, (iii) protective actions to be taken to protect the health and safety of workers and the public, (iv) arrangements for first-aid, medical, and hospital services and underground rescue, (v) facilities available to support mitigation efforts, (vi) types and locations of response and communication equipment available to support mitigation efforts, and (vii) processes for periodically inventorying, testing, and maintaining emergency equipment, including mitigation equipment. DOE also stated (DOE, 2008ai) that its EP will include a description of the criteria for the shutdown of systems or facility(s); the steps to be taken to ensure a safe, orderly shutdown; and the approximate time required for a shutdown based on the type of emergency.

The NRC staff evaluated DOE's description for how the EP will mitigate consequences. The NRC staff determines that DOE's description explains how the EP will include equipment (such as sprinklers), actions (such as automatic activations of systems or emergency response organizations, actions to protect workers, and a program for maintaining equipment), and facilities (such as command and control) to support mitigation efforts. On the basis of its review, the NRC staff concludes that DOE's description addresses the applicable guidance and criteria in the YMRP, ISG-16 Section 3.6, and 10 CFR 72.32(b)(5) regarding mitigation of consequences. Therefore, the NRC staff finds that this portion of DOE's description is acceptable because it shows that DOE will develop and be prepared to implement an EP that addresses the mitigation of consequences, consistent with applicable guidance and criteria.

2.5.7.3.6 Assessment of Releases

In SAR Section 5.7.6.1, DOE stated that the EP will describe radiological sampling and monitoring methods, instrumentation, equipment, and procedures to be used to assess the extent of radiological releases. The EP will also identify organizational positions for which training and qualification for assessment of radioactive releases is required.

The NRC staff evaluated DOE's description for how the EP will assess radiological releases. The NRC staff determines that DOE's description explains how its EP will include fixed and portable radiation monitoring equipment, and procedures necessary to assess the extent of a radiological release. On the basis of its review, the NRC staff concludes that DOE's description addresses the applicable guidance and acceptance criteria in the YMRP, ISG-16 Section 3.7, and 10 CFR 72.32(b)(6) regarding the assessment of releases. Therefore, NRC staff finds that this portion of DOE's description is acceptable because it shows that DOE will develop and be prepared to implement an EP that addresses the assessment of releases, consistent with applicable guidance and criteria.

2.5.7.3.7 Responsibilities

In SAR Section 5.7.7.1, DOE stated that the EP will identify the personnel responsible for ensuring that offsite notifications are performed promptly. The EP will also identify the means to ensure that the communication chain for notifying and mobilizing emergency response personnel is maintained during normal and off-normal working hours (e.g., nights, weekends, and holidays). Additionally, DOE stated that the EP will describe (i) the emergency response organization and the responsibilities and authorities of key positions within the organization, (ii) the responsibilities of repository personnel during a radiological incident, (iii) positions within the organization that have the responsibility for declaring emergencies during normal hours when key personnel and shift organization are present and during off-normal hours when only shift organization is present, (iv) methods for activating the staff necessary for implementation of the EP, and (v) the positions responsible for overall direction of emergency response and notification of local agencies and NRC during normal and off-normal hours.

In SAR Section 5.7.1.2, DOE stated that the site protection manager is a key manager who will be located onsite, will report to the site operations manager, and will be responsible for developing and maintaining the emergency preparedness program in accordance with the license. DOE stated that the records will be maintained for reviews and updates of the EP, for notification of repository personnel and other onsite or offsite response organizations affected by an update of the EP or its implementing procedures, and for review and acceptance of the EP or implementing procedure updates.

The NRC staff evaluated DOE's description of responsibilities for repository personnel during an emergency and for developing, maintaining, and updating the EP. The NRC staff determines that DOE's description (i) explains how its EP will delineate the authorities and responsibilities of key personnel and groups, including responsibilities to notify offsite response organizations and the NRC; (ii) identifies the communication chain for notifying and mobilizing personnel for normal and non-normal working hours; and (iii) includes responsibilities for developing, maintaining, and updating the plan. On the basis of its review, the NRC staff concludes that DOE's description is consistent with applicable guidance and criteria in the YMRP, ISG-16 Section 3.8, and 10 CFR 72.32(b)(7) regarding responsibilities of personnel. Therefore, the NRC staff finds that this portion of DOE's description is acceptable because it shows that DOE will develop and be prepared to implement an EP that addresses responsibilities of personnel, consistent with applicable guidance and criteria.

2.5.7.3.8 Notification and Coordination

In SAR Section 5.7.8.1, DOE stated that the EP will describe the Technical Support Center, located at the repository, and the Operations Facility Center, located offsite, as well as the organization responsible for activating the emergency response organization for performing timely notifications under accident conditions during normal and off-normal hours. Additionally, DOE stated that the EP will identify the offsite location and describe the functions of the Joint Information Center. The EP will also describe the means to notify offsite response organizations and the means to request offsite assistance, including medical assistance. Furthermore, DOE stated that responsible offsite agencies will be identified in the EP and diverse notification methods and equipment will be described to ensure that notification and activation can be performed even if some personnel, equipment, or parts of the Emergency Operations Facility, located offsite, are unavailable.

In SAR Section 5.7.8.2, DOE stated that emergency personnel will take actions as specified in the EP and its implementing procedures. These actions include classifying the emergency, directing staff to assume emergency response roles, sounding the site emergency signal, and providing timely notification to appropriate Federal, State of Nevada, and local agencies of the emergency and requesting assistance (including medical). The implementing procedures will contain the telephone, fax, address, and e-mail information necessary to achieve timely notification of responsible offsite agencies and points of contact. Additionally, the EP states that DOE will contact the NRC Operations Center upon completion of local notifications but not later than 1 hour after an alert or site area emergency has been declared.

The NRC staff evaluated DOE's description of notification and coordination of offsite groups. The NRC staff determines that DOE's description explains how DOE's EP will describe diverse means of promptly notifying onsite response organizations, requesting offsite assistance (including medical), and notifying the NRC, including a commitment to notify the NRC response center immediately after notification of local authorities. The NRC staff also determines that the description of these diverse means addresses a control point for the affected facility operating area where operations would be directed and controlled until control is transferred to a specified emergency response facility, and addresses the fact that unavailability of some personnel, parts of the facility, or equipment would not prevent notification and coordination. On the basis of its review, the NRC staff concludes that DOE's description addresses applicable guidance and criteria in the YMRP, ISG-16 Section 3.9, and 10 CFR 72.32(b)(8) regarding notification and coordination of offsite assistance. Therefore, NRC staff finds that this portion of DOE's description is acceptable because it shows that DOE would develop and be prepared to implement an EP that addresses notification and coordination of offsite groups, consistent with applicable guidance and criteria.

2.5.7.3.9 Information To Be Communicated

In SAR Section 5.7.9.1, DOE stated that the EP will describe the types of information to be provided on repository status and radioactive releases and any recommended protective actions that will be communicated to the offsite response organizations and to NRC in the event of an emergency. SAR Section 5.7.9.2 stated that this information will be consistent with the NRC Event Notification Worksheet (NRC Form 361) modified for repository use (as shown in SAR Figure 5.7-2). Furthermore, in SAR Section 5.7.10.2, DOE stated that the EP will define the requirements to train repository personnel on how to respond to emergencies.

The NRC staff evaluated DOE's description of information to be communicated. The NRC staff determines that DOE's description explains how DOE's EP will describe facility status, radioactive releases, and recommended protective actions, if necessary, to be given to offsite response organizations and to NRC consistent with the NRC Event Notification Worksheet (NRC Form 361). On the basis of its review, the NRC staff determines that DOE's description is consistent with applicable guidance and criteria in the YMRP, ISG-16 Section 3.10, and 10 CFR 72.32(b)(9) regarding information to be communicated to offsite response organizations and to NRC. Therefore, NRC staff finds that this portion of DOE's description is acceptable because it shows that DOE would develop and be prepared to implement an EP that addresses information to be communicated to offsite response organizations and to NRC, consistent with applicable guidance and criteria.

2.5.7.3.10 Training

In SAR Section 5.7.10.1, DOE stated that the EP will define the requirements to train repository personnel on how to respond to emergencies and describe any special instructions and orientation tours in the training offered to offsite support personnel, including police, fire, and medical personnel who may be called upon to respond in an emergency.

As stated in SAR Section 5.7.10.2, SAR Section 5.3 provided a general description of the organizational structure, as it is anticipated to exist at the time of repository construction and operations; the key positions assigned responsibility for safety and operations; and the personnel qualification and training requirements. DOE (2008ai) stated that the EP will include the Emergency Preparedness Training Program document, developed as described in SAR Section 5.3.3. The Emergency Preparedness Training Program will contain the training requirements for each position in the emergency response organization, frequency of retraining, and estimated number of hours of initial training and retraining. DOE also stated that personnel who are not members of the emergency response staff who are permitted inside the GROA without a full-time escort would be required to receive general employee training, as discussed in SAR Section 5.3.3.

The NRC staff evaluated DOE's description of training. The NRC staff determines that DOE's description of its EP addresses how to respond to emergencies, training requirements for each position, frequency of retraining, number of hours of initial training and retraining, training of onsite personnel who are not members of the emergency response staff, and training of offsite support personnel. On the basis of its review, the NRC staff determines that DOE's description is consistent with applicable guidance and criteria in the YMRP, ISG-16 Section 3.11, and 10 CFR 72.32(b)(10) regarding training. Therefore, NRC staff finds that this portion of DOE's description is acceptable because it shows that DOE will develop and be prepared to implement an EP that addresses training, consistent with applicable guidance and criteria.

2.5.7.3.11 Safe Condition

In SAR Section 5.7.11.1, DOE stated that the EP will contain a description of the means for restoring the repository to a safe condition after an emergency in accordance with recovery procedures, as well as criteria for the return to operations. Should the response result in the evacuation of areas, criteria for safe reentry will be provided. Additionally, the EP will describe the procedures for restoring the facility to a safe status after an accident using recovery plans. DOE stated that the recovery plans will include requirements for checking and restoring to normal operation all safety equipment important to safety, and requirements for returning emergency equipment and supplies used during an accident to a state of readiness.

The NRC staff evaluated DOE's description of the means to restore repository operations to a safe condition. The NRC staff determines that DOE's description of its EP addresses (i) the means for reentry and recovery, termination of the emergency, and restoration of emergency equipment, including positions with the authority and responsibility to coordinate recovery planning, reentry, and termination of the emergency; (ii) consideration of toxic, hazardous, or security-related hazards; (iii) accident assessment; (iv) use of volunteers; and (v) control of exposures. On the basis of its review, the NRC staff determines that DOE's description is consistent with applicable guidance and criteria in the YMRP, ISG-16 Section 3.12, and 10 CFR 72.32(b)(11) regarding restoring the repository to a safe condition. Therefore, NRC staff finds that this portion of DOE's description is acceptable because it shows that DOE will

develop and be prepared to implement an EP that addresses restoring the repository to safe condition, consistent with applicable guidance and criteria.

2.5.7.3.12 Exercises

In SAR Section 5.7.12.1, DOE stated that the EP will describe the drills and exercises that will be used to evaluate the major portions of the emergency response capabilities and to maintain key response skills. DOE described an exercise program in SAR Sections 5.7.12.2.1–5.7.12.2.10. The exercise program will include biennial onsite exercises in the form of simulated emergencies; semiannual radiological and health physics, medical, and fire drills; and evaluation of these exercises by individuals not having direct implementation responsibilities for conducting the exercises. DOE stated that evaluations will assess appropriateness of the EP, emergency procedures, activities and equipment, training of personnel, and the overall effectiveness of the response. DOE stated that deficiencies identified by the evaluations for both drills and exercises will contain a provision for correction. The confidentiality of exercise scenarios will be maintained to the extent practicable. DOE also stated that offsite response organizations will be invited to participate in biennial drills and exercises. The EP will also describe required communication checks, including quarterly communication and equipment checks, with offsite response organizations, and the updating of offsite response organization contact information. DOE stated that the repository drill and exercise program is designed to (i) enhance the training provided to the emergency response organization members, (ii) evaluate the overall effectiveness of the emergency response organization, and (iii) verify the adequacy of the interface with offsite emergency response organizations. DOE also stated that repository personnel will conduct drills of varying complexity to allow emergency response organization members to maintain proficiency in their response roles.

The NRC staff evaluated DOE's description of exercises, communication checks, and drills. The NRC staff determines that DOE's description of its EP addresses (i) quarterly communications checks with offsite response organizations; (ii) biennial onsite exercises to test response to simulated emergencies for which the scenarios would not be known to most participants, inviting offsite response organizations to participate; (iii) semiannual radiological and health physics, medical, and fire drills; and (iv) how drills will be evaluated by individuals not having direct implementation responsibilities for conducting the exercises, specifically to enhance the training provided to the emergency response members, evaluate the effectiveness of the emergency response organization, and verify the adequacy of the interface with offsite response organizations. On the basis of its review, the NRC staff determines that DOE's description is consistent with applicable guidance and criteria in the YMRP, ISG–16 Section 3.13, and 10 CFR 72.32(b)(12) regarding exercises, checks, and drills. Therefore, NRC staff finds that this portion of DOE's description is acceptable because it shows that DOE will develop and be prepared to implement an EP that addresses exercises, checks, and drills, consistent with applicable guidance and criteria.

2.5.7.3.13 Hazardous Chemicals (Materials)

In SAR Section 5.7.13.1, DOE stated that the EP will include a certification that the repository has complied with the requirements of the Emergency Planning and Community Right-to-Know Act of 1986 with respect to hazardous materials within the GROA. SAR Table 5.7-9 listed chemicals likely to be used at the repository.

The NRC staff evaluated DOE's description of hazardous materials. The NRC staff determines that DOE's description of its EP addresses certification of compliance with the Emergency Planning and Community Right-to-Know Act of 1986 and includes a list of chemicals likely to be used at the repository. On the basis of its review, the NRC staff determines that DOE's description is consistent with applicable guidance and criteria in the YMRP, ISG-16 Section 3.14, and 10 CFR 72.32(b)(13) regarding hazardous materials. Therefore, NRC staff finds that this portion of DOE's description is acceptable because it shows that DOE will develop and be prepared to implement an EP that addresses hazardous materials, consistent with applicable guidance and criteria.

2.5.7.3.14 Comments on the Plan

In SAR Section 5.7.14.1, DOE stated that the EP will be provided to offsite response organizations identified in the EP for review prior to submittal to NRC. Additionally, the offsite response organizations will have 60 days to review and comment on the EP, and any offsite response organization comments received will be included with the EP that will be submitted to NRC. Furthermore, comments from offsite response organizations, as appropriate, will be dispositioned in subsequent revisions to the EP. If subsequent revisions to the EP affect the offsite response organizations, DOE stated that future revisions will also be provided to those organizations for review. DOE explained that the comment period for subsequent revisions to the EP will be 60 days and any additional comments offsite organizations provide during this period will again be included with the revised EP submitted to NRC.

The NRC staff evaluated DOE's description of how comments from offsite response organizations would be solicited and evaluated. The NRC staff determines that DOE's description of its EP will include a provision that the EP will be provided to offsite response organizations, prior to submission to the NRC, in order to allow 60 days to review and comment. The EP will also provide that if subsequent revisions affect offsite organizations, these future revisions will also be provided to offsite organizations and that any comments and responses will be submitted to NRC with the EP. On the basis of its review, the NRC staff determines that DOE's description is consistent with applicable guidance and criteria in the YMRP, ISG-16 Section 3.15, and 10 CFR 72.32(b)(14) regarding comments from offsite response organizations. Therefore, NRC staff finds that this portion of DOE's description is acceptable because it shows that DOE will develop and be prepared to implement an EP that addresses comments from offsite response organizations, consistent with applicable guidance and criteria.

2.5.7.3.15 Offsite Assistance

In SAR Section 5.7.15.1, DOE stated that to facilitate a coordinated and planned emergency response, provisions for advance arrangements with offsite organizations will be addressed in the EP. These arrangements include (i) identification of offsite response organizations that have agreed to provide support, as well as other support organizations capable of augmenting the planned onsite response; (ii) means for requesting offsite assistance; (iii) provisions for prompt communications among principal response organizations with offsite emergency personnel who would be responding; (iv) provisions for providing and maintaining emergency response facilities and equipment to support the emergency response; (v) the availability of methods, systems, and equipment for assessing and monitoring actual or potential consequences of a radiological emergency; (vi) provisions for medical services for contaminated or injured individuals; (vii) arrangements for radiological emergency response training to be offered to offsite support organizations that may be called upon to assist in an onsite emergency; and (viii) documentation of assistance agreements in the form of letters of

agreement or memoranda of understanding. DOE also stated (DOE, 2008ai) that the EP will include an offer to meet at least annually with each offsite response organization to review items of mutual interest, including relevant changes to the EP, and will discuss the EAL scheme, notification procedures, and overall response coordination process during these meetings.

The NRC staff evaluated DOE's description of offsite assistance. The NRC staff determines that DOE's EP will include (i) a brief description of the arrangements made for requesting and using offsite assistance onsite and provisions that exist for using other organizations capable of augmenting the planned onsite response; (ii) provisions for prompt communications among principal response organizations to offsite personnel who would be responding onsite; (iii) provisions for providing and maintaining emergency facilities and equipment to support the emergency response onsite; (iv) specification of methods, systems, and equipment for assessing and monitoring consequences of a radiological emergency condition; (v) arrangements for medical services for contaminated and injured onsite individuals; and (vi) training in radiological emergency response for offsite personnel who may be called to assist in an emergency. On the basis of its review, the NRC staff determines that DOE's description is consistent with applicable guidance and criteria in the YMRP, ISG-16 Section 3.16, and 10 CFR 72.32(b)(15) regarding offsite assistance. Therefore, NRC staff finds that this portion of DOE's description is acceptable because it shows that DOE will develop and be prepared to implement an EP that addresses offsite assistance, consistent with applicable guidance and criteria.

2.5.7.3.16 Arrangements Made for Providing Information to the Public

In SAR Section 5.7.16.2.1, DOE stated that the Repository Emergency Public Information Program establishes the means for providing accurate and timely information to workers on the repository site and the general public through the media. In addition, DOE stated that the EP will describe arrangements for providing timely information to the public in the event of an emergency. This information will be disseminated to the media and the public through the Joint Information Center. DOE stated that in conjunction with state and local agencies, the repository will conduct an annual orientation for local news media to acquaint them with information that assists them in providing informed coverage of an event and lessen the possibility of errors in reporting.

The NRC staff evaluated DOE's description for how arrangements will be made for providing information to the public. The NRC staff determines that DOE's EP will include the Repository Emergency Public Information Program that disseminates information to the media and the public through the Joint Information Center, including communication of emergency news information and responses to the media and the public. On the basis of its review, the NRC staff determines that DOE's description is consistent with applicable guidance and criteria in the YMRP and 10 CFR 72.32(b)(16) regarding how arrangements will be made for providing information to the public. Therefore, NRC staff finds that this portion of DOE's description is acceptable because it shows that DOE will develop and be prepared to implement an EP that addresses providing information to the public, consistent with applicable guidance and criteria.

2.5.7.4 Evaluation Findings

The NRC staff has reviewed the SAR and other information submitted in support of the license application and finds, with reasonable assurance, that the requirements of 10 CFR 63.21(c)(21) and 10 CFR 63.161 are satisfied. DOE has provided an adequate description of its EP for responding to, and recovering from, radiological emergencies that may occur any time before

permanent closure and decontamination or decontamination and dismantlement of surface facilities, as required by 10 CFR 63.161. DOE stated that it will provide its EP, which will address the 10 CFR 72.32(b) criteria, to NRC no later than 6 months prior to the submittal of the updated application for a license to receive and possess waste.

2.5.7.5 References

DOE. 2009av. DOE/RW-0573, "Yucca Mountain Repository License Application." Rev. 1. ML090700817. Las Vegas, Nevada: DOE, Office of Civilian Radioactive Waste Management.

DOE. 2008ab. DOE/RW-0573, "Yucca Mountain Repository License Application." Rev. 0. ML081560400. Las Vegas, Nevada: DOE, Office of Civilian Radioactive Waste Management.

DOE. 2008ai. "Yucca Mountain—Response to Request for Additional Information Regarding License Application (Safety Analysis Report Section 5.7), Safety Evaluation Report Vol. 4, Chapter 2.5.7, Set 1." Letter (November 5) B.J. Benney to J.R. Williams (NRC). ML083110290. Washington, DC: DOE, Office of Technical Management.

NRC. 2003aa. NUREG-1804, "Yucca Mountain Review Plan—Final Report." Rev. 2. ML032030389. Washington, DC: U.S. Nuclear Regulatory Commission.

NRC. 2000aa. ISG-16, "Emergency Planning." Rev. 0. ML003760096, ML003724570. Washington, DC: U.S. Nuclear Regulatory Commission, Spent Fuel Project Office.

NRC. 2000ab. NUREG-1567, "Standard Review Plan for Spent Fuel Dry Storage Facilities." ML003686776. Washington, DC: U.S. Nuclear Regulatory Commission, Spent Fuel Project Office.

CHAPTER 11

2.5.8 Controls to Restrict Access and Regulate Land Uses

2.5.8.1 Introduction

Safety Evaluation Report (SER) Section 2.5.8 evaluates the description provided in the U.S. Department of Energy (“DOE” or “applicant”) Safety Analysis Report (SAR) (DOE, 2008ab) Section 5.8 for the controls to restrict access and regulate land use at the Yucca Mountain site and adjacent areas. As used in this SER section, the Yucca Mountain site is the proposed land ownership area or proposed preclosure controlled area that DOE identified in SAR Figure 5.8-2. DOE did not change SAR Section 5.8 in its License Application update, submitted to the U.S. Nuclear Regulatory Commission (NRC) in February 2009 (DOE, 2009av). DOE provided more information on the controls to restrict access and regulate land use in its response to the NRC staff’s request for additional information (RAI) (DOE, 2009au). In addition, this SER section evaluates information DOE provided in SAR Section 5.8.1 regarding ownership of lands where the geologic repository operations area (GROA) would be located and SAR Section 5.8.4 regarding water rights to accomplish the purpose of the GROA.

2.5.8.2 Regulatory Requirements

The regulatory requirements at 10 CFR 63.21(c)(24) require DOE to include in its SAR a description of the controls to restrict access to and regulate land use at the Yucca Mountain site and adjacent areas, including a conceptual design of monuments that would be used to identify the site after permanent closure. The information provided in the SAR must be as complete as possible in light of information that is reasonably available at the time of docketing, in accordance with 10 CFR 63.21(a).

The regulatory requirements at 10 CFR 63.121, regarding ownership and control of interests in land, include provisions for (i) ownership of the land where the geologic repository operations area (GROA) is located and the land being free and clear of significant encumbrances [10 CFR 63.121(a)(1) and (2)]; (ii) additional controls for permanent closure [10 CFR 63.121(b)]; (iii) additional controls through permanent closure [10 CFR 63.121(c)]; and (iv) water rights [10 CFR 63.121(d)(1) and (2)]. In its review, the NRC staff used applicable guidance in the “Yucca Mountain Review Plan” (YMRP) Section 2.5.8 (NRC, 2003aa).

2.5.8.3 Technical Evaluation

DOE addresses the requirements of 10 CFR 63.21(c)(24) and 10 CFR 63.121 in SAR Section 5.8 (DOE, 2008ab). DOE identified, in SAR Figure 5.8-2, the proposed preclosure controlled area (also referred to by DOE as the Yucca Mountain site or the proposed land ownership area). The proposed postclosure controlled area is identified as a part of the proposed preclosure controlled area. The proposed GROA is a part of the proposed postclosure controlled area. The GROA, as defined in 10 CFR 63.2, is a high-level radioactive waste facility that is part of a geologic repository, including both surface and subsurface areas, where waste handling activities are conducted. In its response to the NRC staff’s RAI (DOE, 2009au), DOE provided a description of the surface and subsurface portions of the GROA, using Public Land Survey System nomenclature (i.e., township, range, and section).

The NRC staff's evaluation that follows is presented in five subsections: (i) ownership of land, (ii) additional controls for permanent closure, (iii) additional controls through permanent closure, (iv) water rights, and (v) conceptual design of monuments.

2.5.8.3.1 Ownership of Land

The GROA must be located in and on lands that are either acquired lands under the jurisdiction and control of DOE, or lands permanently withdrawn and reserved for its use, as required in 10 CFR 63.121(a)(1). The land on which the GROA will be located must also be free and clear of significant encumbrances, as required by 10 CFR 63.121(a)(2).

In SAR Sections 5.8.1 and 5.8.2.2, DOE provided information regarding land ownership and encumbrances. DOE stated that the GROA and surrounding land within the proposed preclosure controlled area are under the control of several different Federal agencies, including DOE, the U.S. Department of the Interior, and the U.S. Department of Defense. DOE also stated in SAR Section 5.8.1 that it was examining appropriate courses of action that will conform to the requirements of 10 CFR Part 63, including a legislative land withdrawal, to establish effective jurisdiction and control of the land on which the GROA would be located prior to NRC granting a construction authorization. DOE also described, in SAR Section 5.8.1, the course of action it had pursued with respect to ownership of lands. Specifically, in SAR Section 5.8.1, DOE stated that it submitted a land withdrawal bill to Congress in 2007 for the GROA and surrounding area (Senate Bill S.37, introduced May 23, 2007, in the 110th Congress).

In SAR Section 5.8.2.2, DOE stated that the land on which the GROA would be located would be free and clear of encumbrances after completion of the land withdrawal or other acquisition process. In SAR Section 5.8.2.2, DOE stated that the status and occurrence of land encumbrances are dynamic and that a detailed evaluation and discussion of additional land encumbrances are presented in the report, "Land Records for the Proposed Land Withdrawal Area of the Yucca Mountain Repository" (DOE 2007aa).

The NRC staff evaluated the information DOE provided with respect to land ownership and control, including encumbrances. On the basis of its evaluation, the NRC staff determines that DOE's proposed land withdrawal bill was not enacted into law and that DOE has not completed any other land acquisition process. Therefore, the NRC staff concludes that DOE neither has acquired lands to be under its jurisdiction and control for the GROA, nor have the lands for the GROA been permanently withdrawn and reserved for DOE's use. In addition, because DOE has not completed a land withdrawal or other acquisition process, DOE has not demonstrated that such land would be free and clear of significant encumbrances. Therefore, the NRC staff finds that the requirements in 10 CFR 63.121(a)(1) and (a)(2) for ownership and control of the GROA are not satisfied.

2.5.8.3.2 Additional Controls for Permanent Closure

DOE is required by 10 CFR 63.21(c)(24) to provide a description of the controls that it would apply to restrict access and to regulate land use at the Yucca Mountain site and adjacent areas, including a conceptual design of monuments that would be used to identify the site after permanent closure. Section 63.121(b) requires that DOE establish appropriate controls outside the GROA for permanent closure. This section also requires that DOE exercise jurisdiction and control over surface and subsurface estates necessary to prevent adverse human actions that could significantly reduce the geologic repository's ability to achieve isolation. Water rights, as

may be needed to accomplish the purpose of the GROA, are also included in the additional controls to be established for permanent closure, pursuant to 10 CFR 63.121(d)(2).

In SAR Section 5.8.5, DOE described two types of passive institutional controls: (i) monuments and markers and (ii) records related controls. Specifically, in SAR Section 5.8.5, DOE described its conceptual design for the monuments and markers that would be constructed and erected at the time of permanent closure. DOE stated that monuments and markers would be designed to be as permanent as is practicable. DOE described the dimensions of the monuments and markers, emplacement locations for the monuments for the GROA and Yucca Mountain site perimeter, as well as the markers for the postclosure controlled area. DOE stated that the monuments would be engraved with messages in seven languages that provide warnings and information about the buried waste. DOE also stated that the locations for monuments and markers would be selected to minimize potential impacts from seismic activity and to avoid potential flood damage.

With respect to records, DOE stated in SAR Section 5.8.5 that records would be placed in archives and land record systems of local, state, and federal government agencies, and archives elsewhere in the world that would likely be consulted by human intruders. DOE stated that such records would identify the location of the GROA, including the underground facility, boreholes, shafts, ramps, and the boundary of the Yucca Mountain site, and describe the nature and hazard of the waste. DOE further stated that other institutional controls would include government ownership, regulations regarding land or resource use, and other methods of preserving knowledge of the GROA and the hazardous nature of the waste in the repository.

In addition to these passive institutional controls, DOE provided additional information related to access controls in response to the NRC staff's RAI (DOE 2009au). In its response, DOE stated that it will establish an administrative program that identifies and defines restrictions and implementing controls for land areas outside of the GROA that may be necessary for permanent closure. DOE stated that it would propose, as part of the license to receive and possess application process, that license specifications require that the access control program be modified prior to permanent closure to address any continuing or additional restrictions or controls for the postclosure period consistent with the requirements of 10 CFR 63.121(b). DOE also stated that continuing or additional restrictions or controls needed after permanent closure would be identified as part of the DOE application for the license amendment for permanent closure, in accordance with the 10 CFR 63.51(a)(3) requirement to include a detailed description of controls to regulate or prevent activities that could impair long-term isolation of emplaced waste.

In the SAR General Information Section 1.1.1.2, in SAR Section 5.8.4, and in DOE's response to the NRC staff's RAI (DOE 2009au), DOE provided information with respect to water rights that may be needed in the additional controls to be established for permanent closure. In SAR Section 1.1.1.2, DOE provided a description of its site characterization results regarding features and processes related to the hydrology present in the Yucca Mountain region. DOE also provided a discussion of ground-water quality and of water-use patterns. In DOE's response to the NRC staff's RAI, DOE stated that no additional water rights controls are needed for permanent closure.

The NRC staff evaluated DOE's description of the controls that DOE would apply to restrict access and to regulate land use outside the GROA. This included descriptions of public records and other passive institutional controls, access controls, including descriptions of monuments and markers, and water rights. For the following reasons, the NRC staff concludes that DOE

has adequately described appropriate controls it would use over surface and subsurface estates necessary to prevent adverse human actions that could significantly reduce the geologic repository's ability to achieve isolation.

First, the NRC staff determines that the description of institutional controls, including records archives, government ownership, and regulations, is adequate because it includes controls to help ensure information about the location and hazards of the repository will be widely distributed and preserved, which will provide warning information remotely to potential intruders that might deter them from entering the site.

Second, the NRC staff determines that the description DOE provided with respect to controls to prevent access to the site is acceptable because (i) DOE defined the boundary of the site and, as described further in SER Section 2.5.8.3.5, how the boundary would be marked with appropriate monuments and markers that would identify the site and provide important information and warnings regarding the site; and (ii) DOE described its plan to provide details of its access controls at the appropriate time, namely, prior to permanent closure of the repository, which is in accordance with 10 CFR 63.51(a)(3).

Third, the NRC staff determines that DOE's description of the hydrology and water-use patterns in the region of Yucca Mountain is acceptable because it included a description of the (i) hydrogeologic system and features; (ii) regional ground-water flow system; (iii) local climate, ground-water quality, and water-use patterns; and (iv) surface hydrologic features that could potentially affect the GROA operations or safety. Based on this evaluation, the NRC staff determines that DOE's description of water-use patterns is acceptable because there is consideration of the quality of ground water in the region, relative to potential industrial, agricultural, mining, municipal, and residential uses, along with historical groundwater usage and trends; and this information shows no water uses outside the GROA that could have a significant effect on waste isolation. Therefore, the NRC staff concludes that DOE's determination that no additional controls for water rights are needed for permanent closure is reasonable.

For the reasons set forth above, the NRC staff finds that the requirements with respect to controls for permanent closure in 10 CFR 63.21(c)(24), 10 CFR 63.121(b) and 10 CFR 63.121(d)(2) for a description of the controls that DOE would apply to restrict access and to regulate land use at the Yucca Mountain site are satisfied because DOE has provided an adequate description of the type of controls it would use to prevent adverse human actions that could significantly reduce the geologic repository's ability to achieve isolation during the postclosure period, which includes descriptions of public records and other passive institutional controls, access controls, including monuments and markers, and consideration of water rights.

2.5.8.3.3 Additional Controls Through Permanent Closure

DOE is required by 10 CFR 63.21(c)(24) to provide a description of the controls that it would apply to restrict access and to regulate land use at the Yucca Mountain site and adjacent areas. DOE is required by 10 CFR 63.121(c) to establish appropriate controls outside the GROA through permanent closure (i.e., preclosure period) such that it exercises the jurisdiction and control of activities necessary to ensure that the performance objectives in 10 CFR 63.111(a) and 10 CFR 63.111(b) are met.

DOE stated in SAR section 5.8.3.1 that radiation sources are processed at remote locations that are well within the site boundary (i.e., the boundary of the preclosure controlled area) and far

from areas where members of the public would have access. DOE also provided information in Section 1.8 of the SAR that there are no Category 1 event sequences during repository operations and that the radiation dose to members of the public are within the limits specified at 10 CFR 63.111(a) and 10 CFR 63.111(b) for locations both within and outside the GROA (SAR Table 1.8-36). DOE has described procedural safety controls it relied on to: (i) reduce the likelihood of initiating events or an event sequence and (ii) to mitigate the consequences of an event sequence (SAR Section 1.9.3). The procedural safety controls, which are relied upon to meet the requirements of 10 CFR 63.111(a) and (b), are primarily comprised of controls within the GROA (e.g., access controls and canister transfer machine procedures), however, DOE also identified flight restrictions as controls outside the GROA that are relied on to limit the likelihood of initiating events to ensure compliance with dose limits in 10 CFR 63.111(a) and (b).

In SAR Section 5.8.3, DOE stated that land use controls outside the GROA would include the following flight restrictions: (i) prohibiting fixed-wing flights below 14,000 ft (msl) within 9 km [5.6 miles] of the North Portal; (ii) 1,000 overflight limit per year for fixed-wing aircraft above 14,000 ft (msl) within 9 km [5.6 miles] of the North Portal; (iii) overflights are limited to straight and level flights (i.e., maneuvering is not permitted); (iv) carrying ordnance is prohibited within 9 km [5.6 miles] of the North Portal; (v) electronic jamming activities are prohibited within 9 km [5.6 miles] of the North Portal; and (vi) helicopters are not permitted within 0.8 km [0.5 mi] of facilities that process, stage, or age nuclear waste forms. DOE further stated in its response to the NRC staff's RAI (DOE, 2009au) that its administrative program would identify any restrictions and implementing controls for land outside the GROA and that the access control program will include the controls needed during the preclosure period consistent with 10 CFR 63.121(c) to ensure compliance with 10 CFR 63.111. DOE also stated the access control program would be implemented prior to receipt of a license to receive and possess waste.

The NRC staff evaluated the information DOE provided with respect to controls outside the GROA through permanent closure necessary to ensure that the performance objectives in 10 CFR 63.111(a) and 10 CFR 63.111(b) are met, which included consideration of the consequence analysis for demonstrating compliance with the performance objectives in 10 CFR 63.111(a) and 10 CFR 63.111(b), and the SSCs important to safety and the safety controls relied on in the PCSA (SAR Section 1.9). On the basis of its evaluation, the NRC staff determines that DOE provided an acceptable description of appropriate controls outside the GROA because: (i) the information on the flight restrictions included appropriate detail regarding the number and types of flights that would be controlled in the airspace over the Yucca Mountain site; and (ii) flight restrictions are the only controls DOE identified outside the GROA that are relied upon in the PCSA (SAR Section 1.9.3) to meet the requirements of 10 CFR 63.111(a) and (b). Additionally, the controls both inside and outside the GROA that DOE relies on in its PCSA, together with the GROA design for structures, systems, and components important to safety, result in no Category 1 event sequences and, under normal operations, the preclosure dose standard at 10 CFR 63.111 is not exceeded for any member of the public outside of the GROA as well as outside of the site boundary. Therefore, because DOE has described appropriate controls of activities outside the GROA necessary to ensure the requirements in 63.111(a) and (b) are met, the NRC staff finds that the requirements with respect to a description of appropriate controls through permanent closure in 10 CFR 63.21(c)(24) and 10 CFR 63.121(c) are satisfied.

SAR Section 5.8.3.1 indicates that DOE's management plan could include further land-use restrictions to control public access that, according to DOE, would be implemented prior to receipt of a license to receive and possess waste. Should DOE identify further access controls

outside the GROA (e.g., land use controls) through permanent closure necessary to ensure that the performance objectives in 10 CFR 63.111(a) and 10 CFR 63.111(b) are met, DOE would need to notify the NRC and obtain approval of any changes to the controls outside the GROA through permanent closure described in SAR Section 5.8.3, in accordance with 10 CFR 63.32(c)(2). This will be discussed further in SER Section 2.5.10.1.3.1.1.2.

2.5.8.3.4 Water Rights

DOE must obtain such water rights as may be needed to accomplish the purpose of the GROA, as required in 10 CFR 63.121(d)(1). In SAR Section 5.8.4 and DOE's response to the NRC staff's RAI (DOE, 2009au), DOE described its approach for obtaining such water rights. DOE estimated a maximum annual water demand of 53.0 hectare-meters [430 acre-ft] for construction (prior to receipt and possession of waste) and a maximum annual water demand of 40.7 hectare-meters [330 acre-ft] for operations (after receipt and possession waste). In SAR Section 5.8.4, DOE stated that it filed a water appropriation request with the Nevada State Engineer on July 22, 1997, for the permanent rights to 53.0 hectare-meters [430 acre-ft] annually from five wells within the proposed preclosure controlled area for the purpose of constructing and operating the repository. In SAR Section 5.8.4, DOE stated that the Nevada State Engineer denied the DOE water appropriation permit applications and that the U.S. Department of Justice, on behalf of DOE, appealed this decision.

The NRC staff evaluated the information DOE provided on obtaining water rights as may be needed to accomplish the purpose of the GROA. DOE's actions to obtain water rights for this purpose have not been successful. Therefore, the NRC staff finds that the regulatory requirement in 10 CFR 63.121(d)(1) has not been satisfied, because DOE has not obtained such water rights that DOE determined may be needed to accomplish the purpose of the GROA.

2.5.8.3.5 Conceptual Design of Monuments

DOE's description of controls must include DOE's conceptual design of monuments that would be used to identify the Yucca Mountain site after permanent closure, as required in 10 CFR 63.21(c)(24). DOE stated in SAR Section 5.8.5 that monuments and/or markers would identify the site at the proposed preclosure controlled area boundary, in the postclosure controlled area, and at the GROA, as identified on a map in SAR Figure 5.8-5 (DOE, 2008ab).

DOE described in SAR Section 5.8.5 the measures it would take to ensure that monuments and markers would be designed, fabricated, and emplaced to be as permanent as is practicable. DOE described two types of monuments: GROA monuments and site-perimeter monuments. One GROA monument will be constructed on Yucca Crest, and one will be constructed at the North Portal area. GROA monuments, as shown in SAR Figure 5.8-6, would be surface structures approximately 12.2 meters [40 feet] in diameter and would stand approximately 7.6 m [25 ft] above the ground surface. The GROA monuments would have solid roofs to prevent rainfall from entering the structures. The site-perimeter monuments, as shown in SAR Figures 5.8-4, would stand approximately 7.6 m [25 ft] above the ground surface to avoid complete burial from future volcanic activity. Markers would be essentially identical to site-perimeter monuments. The site-perimeter monuments would be emplaced in a pattern, as shown in SAR Figure 5.8.5.

DOE stated in SAR Section 5.8.5 that the granite exterior walls of the monuments would serve as information centers containing engraved messages in seven languages that provide

warnings and information about the buried waste. Monument and marker inscriptions would be placed more than 1 m [3 ft] above the land surface to inhibit degradation of the inscriptions by wind-blown particles. Emplacement locations for monuments and markers will be selected to avoid areas with identified faults to minimize potential impacts from seismic activity and to avoid potential flood damage.

The NRC staff evaluated DOE's description of the conceptual design for monuments and markers that would be used to identify the Yucca Mountain site after permanent closure. On the basis of its evaluation, the NRC staff determines that DOE's description of monuments and markers is adequate because the description addressed the conceptual design of the markers and monuments, including their material, location, and message, for identifying the site after permanent closure. Specifically, the NRC staff determines that the description is adequate because it addresses how monuments and markers would (i) be designed to be permanent as is practicable because they will be made from durable granite or basalt and be strategically located to minimize the impact of natural events such as rain and seismic activity and (ii) provide warning information in multiple languages. Therefore, the NRC staff finds that that DOE has satisfied the 10 CFR 63.21(c)(24) requirement for a description of the conceptual design.

2.5.8.4 Evaluation Findings

The NRC staff has reviewed the SAR and other information submitted in support of the license application and finds, with reasonable assurance, that

- The requirements related to a description of controls for permanent closure in 10 CFR 63.21(c)(24), 10 CFR 63.121(b) and 10 CFR 63.121(d)(2) are satisfied because DOE has provided an adequate description of the type of controls it would use to prevent adverse human actions that could significantly reduce the geologic repository's ability to achieve isolation during the postclosure period.
- The regulatory requirement at 10 CFR 63.21(c)(24) regarding a description of monuments is satisfied because DOE acceptably described its conceptual design of monuments that would be used to identify the site after permanent closure.
- The regulatory requirements related to a description of controls through permanent closure at 10 CFR 63.21(c)(24) and 10 CFR 63.121(c) are satisfied because DOE provided an adequate description of the proposed restrictions and controls it would establish outside the GROA to ensure the requirements of 10 CFR 63.111(a) and (b) are met.

The NRC staff also finds that:

- The regulatory requirements at 10 CFR 63.121(a)(1) and 10 CFR 63.121(a)(2) regarding ownership of the land where the GROA is located are not satisfied, because the lands where the GROA would be located have not been acquired by DOE, are not under the control and jurisdiction of DOE, and are not free of significant encumbrances.
- The regulatory requirement at 10 CFR 63.121(d)(1) regarding water rights is not satisfied, because DOE has not obtained such water rights that DOE determined may be needed to accomplish the purpose of the GROA.

2.5.8.5

References

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DOE. 2009av. DOE/RW–0573, "Safety Analysis Report Yucca Mountain Repository License Application." Rev. 1. ML090700817, ML090710096. Las Vegas, Nevada: DOE, Office of Civilian Radioactive Waste Management.

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DOE. 2007aa. "Land Records for the Proposed Land Withdrawal Area of the Yucca Mountain Repository." TDR–MGR–ND–000003. Las Vegas, Nevada: DOE, Office of Civilian Radioactive Waste Management.

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CHAPTER 12

2.5.9 Uses of Geologic Repository Operations Area for Purposes Other Than Disposal of Radioactive Wastes

2.5.9.1 Introduction

Safety Evaluation Report (SER) Section 2.5.9 evaluates the information provided in the U.S. Department of Energy (“DOE” or “applicant”) Safety Analysis Report (SAR) Section 5.9 (DOE, 2008ab) for uses of the geologic repository operations area (GROA) for purposes other than disposal of radioactive wastes. This section was unchanged in the DOE license application update, submitted to the U.S. Nuclear Regulatory Commission (NRC) in February 2009 (DOE, 2009av). DOE provided further information in its response to the NRC staff’s request for additional information (DOE, 2008ad).

2.5.9.2 Regulatory Requirements

The SAR must include information regarding plans for any uses of the GROA at the Yucca Mountain site for purposes other than disposal of radioactive wastes, with an analysis of the effects, if any, that such uses may have on the operation of the structures, systems, and components (SSCs) important to safety and the engineered and natural barriers important to waste isolation, as required by 10 CFR 63.21(c)(22)(vii). The NRC staff used applicable guidance in the Yucca Mountain Review Plan (YMRP) Section 2.5.9 (NRC, 2003aa) in its review of this information and addresses the following acceptance criteria:

- Proposed activities other than disposal of radioactive waste are acceptable
- Procedures for proposed activities other than the disposal of high-level radioactive waste, are acceptable

2.5.9.3 Technical Evaluation

This evaluation reviews (i) proposed uses of the GROA for purposes other than disposal of radioactive wastes and their effects on performance and (ii) procedures for the evaluation and conduct of activities other than waste disposal at the GROA.

2.5.9.3.1 Proposed Uses for Purposes Other Than Waste Disposal and Effects on Performance

In SAR Section 5.9.1, DOE identified three types of activities considered as potential uses of the GROA other than for disposal of radioactive wastes: Native American cultural activities, independent performance monitoring, and flora and fauna protection. Native American cultural activities include (i) ongoing activities to protect cultural artifacts and other resources and (ii) any present or future utilization of the GROA or repository site for ceremonial or other cultural purposes. DOE stated that it will authorize other uses of the GROA only after performing an analysis demonstrating that the associated activities will have no adverse effect on SSCs important to the safety or performance of barriers important to waste isolation.

While DOE stated that there are no plans for such new activities, DOE evaluated the continuation of two activities that were ongoing at the time the license application was submitted: (i) cultural resource protection and (ii) flora and fauna protection.

Cultural Resource Protection

Regarding cultural resource protection, DOE discussion of possible impacts from Native American cultural activities focused on those activities related to identification of existing cultural artifacts and other resources, within the context of the DOE Cultural Resource Management Program. This program includes procedural controls for land-disturbing activities, cultural resource surveys, and identification and mitigation of impacts to identified archaeological sites and artifacts. In its SAR, DOE identified 28 archaeological sites and isolated artifacts within the GROA, including at least 1 that is eligible for inclusion on the National Register of Historic Places (DOE, 2008ad, Enclosure 4).

DOE evaluated the potential impact of surface-disturbing activities associated with cultural resource protection on the operation of SSCs important to safety and the engineered and natural barriers important to waste isolation. In particular, DOE found that such activities would have minimal effect on surficial soils and topography, as they would only affect a small area, such as the marking and protecting of cultural resources.

DOE stated that effects from surface-disturbing activities on the function of the topography and surficial-soil features of the upper natural barrier are controlled by Design Control Parameter 09-04 (SAR Table 1.9.8), such that the function of these features is maintained. DOE concluded, therefore, that the operation of SSCs important to safety and the engineered and natural barriers important to waste isolation would not be adversely impacted by cultural resource protection (DOE, 2008ad, Enclosure 5).

Flora and Fauna Protection

Regarding flora and fauna protection, DOE stated that no plant species within the repository site are listed as threatened or endangered under the Endangered Species Act of 1973 (nor are there proposed or candidate species for such listing), and one animal species found at Yucca Mountain, the desert tortoise, is listed as threatened (SAR Section 5.9). DOE stated that the activities associated with the protection of flora and fauna do not involve construction or similar ground-disturbing activities, nor do they involve permanent changes to the GROA. DOE described reclamation and restoration activities to blend topographic changes from DOE activities into the natural topography and to re-vegetate disturbed areas no longer in use with native plants (DOE, 2008ad, Enclosure 1) to minimize the impact of land disturbances and any potential effects on repository performance. DOE also stated that the U.S. Fish and Wildlife Service has provided a final biological opinion that agrees with DOE-proposed measures to minimize the effects of construction, operations and monitoring, and closure of the repository, on the desert tortoise (SAR Section 5.9.1.3). Effects from surface-disturbing activities on the function of the topography and surficial-soils features of the upper natural barrier are controlled by Design Control Parameter 09-04 (SAR Table 1.9.8), such that the function of these features is maintained. Thus, DOE concluded that the operation of SSCs important to safety and the engineered and natural barriers important to waste isolation are not adversely impacted by flora and fauna protection (DOE, 2008ad, Enclosure 2).

NRC Staff Evaluation

The NRC staff finds that the DOE impact analyses are acceptable for activities currently identified for cultural resource protection and flora and fauna protection because the applicant has provided information regarding its plans for these other uses of the GROA and evaluated the potential impact of these activities on repository performance. Specifically, DOE has evaluated the land disturbances associated with surveying, identifying, and protecting both cultural resources and flora and fauna, and their associated minor surface disturbances. Additionally, DOE described reclamation and restoration activities to minimize the impact of land disturbances and any potential effects on repository performance. Therefore, the NRC staff concludes that the proposed activities other than disposal of radioactive wastes are acceptable.

2.5.9.3.2 Procedures for Proposed Activities Other Than Waste Disposal

DOE also detailed procedures to manage the two referenced ongoing uses of the GROA other than for disposal of radioactive wastes: (i) protection of cultural resources and (ii) protection of flora and fauna. DOE stated that these procedures were implemented in part to fulfill its responsibilities under the National Historic Preservation Act of 1966, Sections 106 and 110 (16 U.S.C. 470 et seq.) and the Endangered Species Act of 1973 (16 U.S.C. 1531 et seq.).

Although there are no requests or plans for such activities, DOE discussed two other potential future uses of the GROA: ceremonial or other cultural heritage purposes and independent performance monitoring. DOE stated that it will develop procedures, prior to waste handling, for authorizing requests to use the GROA for purposes other than waste disposal. DOE stated that these procedures will require a disclosure of the purpose of the activity, a detailed activity description for evaluation, an analysis demonstrating that the activities will have no adverse effect on SSCs or features that are important to safety or important to waste isolation, and access authorization procedures for individuals and groups engaged in these activities.

The NRC staff concludes that DOE's description of these procedures is adequate to support identification of activities and analysis of impacts from these uses because they include evaluation of potential impacts on repository performance and processes for resource protection (e.g., stopping work, deployment of monitors, and notification of appropriate management and authorities).

2.5.9.4 Evaluation Findings

The NRC staff finds that DOE has provided sufficient information regarding plans for the two ongoing uses at the GROA other than for disposal of radioactive wastes: (i) cultural resource protection and (ii) flora and fauna protection. These plans include an analysis of the effects, if any, that such uses may have on the operation of the SSCs important to safety and the engineered and natural barriers important to waste isolation. The NRC staff also finds that DOE has adequately described procedures that would be developed and implemented for evaluating new requests for other uses of the GROA. Therefore, on the basis of this review, the NRC staff concludes with reasonable assurance that the requirement in 10 CFR 63.21(c)(22)(vii) is satisfied.

2.5.9.5

References

DOE. 2009av. DOE/RW-0573, "Yucca Mountain Repository License Application." Rev. 1. ML090700817. Las Vegas, Nevada: DOE, Office of Civilian Radioactive Waste Management.

DOE. 2008ab. DOE/RW-0573, "Yucca Mountain Repository License Application." Rev. 0. ML081560400. Las Vegas, Nevada: DOE, Office of Civilian Radioactive Waste Management.

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CHAPTER 13

Conclusions

The U.S. Nuclear Regulatory Commission (NRC) staff has reviewed and evaluated the U.S. Department of Energy's (DOE) Safety Analysis Report (SAR) Chapter 3: Research and Development Program to Resolve Safety Questions; Chapter 4: Performance Confirmation Program; and Chapter 5: Management Systems (except for SAR Section 5.4, Expert Elicitation, which is documented in SER Volume 3, Repository Safety After Permanent Closure, Chapter 20), and the other information submitted in support of DOE's license application. The NRC staff has found, with reasonable assurance, that, except as noted below, DOE has addressed applicable requirements including 10 CFR 63.21, "Content of Application"; 10 CFR 63.121, "Land Ownership and Control"; 10 CFR Part 63, Subpart D, "Records, Reports, Tests, and Inspections"; 10 CFR Part 63, Subpart F, "Performance Confirmation Program"; 10 CFR Part 63, Subpart G, "Quality Assurance"; 10 CFR Part 63, Subpart H, "Training and Certification of Personnel"; and 10 CFR Part 63, Subpart I, "Emergency Planning Criteria."

The NRC staff is proposing one condition of construction authorization in this SER Volume related to the description of programs designed to resolve safety questions pursuant to 10 CFR 63.32(b)(4): in the event that DOE identifies any safety questions that would require research and development programs in the future, the results of those programs must be appropriately reported to the NRC.

The NRC staff finds that DOE has not met the requirements in 10 CFR 63.121(a) and 10 CFR 63.121(d)(1) regarding ownership of land and water rights, respectively.

CHAPTER 14

Glossary

This glossary is provided for information and is not exhaustive. The glossary provides explanations for the terms shown in italics.

absorption: The process of taking up by capillary, osmotic, solvent, or chemical action of molecules (e.g., *absorption* of gas by water) as distinguished from *adsorption*.

abstracted model: A *model* that reproduces, or *bounds*, the essential elements of a more detailed *process model* and captures *uncertainty* and *variability* in what is often, but not always, a simplified or idealized form. See *abstraction*.

abstraction: Representation of the essential components of a *process model* into a form suitable for use in a *total system performance assessment*. A *model abstraction* is intended to maximize the use of limited computational resources while allowing a sufficient range of sensitivity and *uncertainty* analyses.

adsorb: To collect a gas, liquid, or dissolved substance on a surface as a condensed layer.

adsorption: The adhesion by chemical or physical forces of molecules or ions (as of gases or liquids) to the surface of solid bodies. For example, the transfer of *solute* mass, such as *radionuclides*, in groundwater to the solid geologic surfaces with which it comes in contact. The term *sorption* is sometimes used interchangeably with this term.

advection: The process in which *solutes*, particles, or molecules are transported by the motion of flowing fluid.

aging: The retention of *commercial spent nuclear fuel* on the surface in *dry storage* to reduce its thermal output as necessary to meet proposed repository thermal management goals.

airborne mass loading: The amount of fine particulates resuspending above a surface deposit, generally expressed as mass per unit volume of air.

aleatory uncertainty: An *uncertainty* associated with the chance of occurrence of a feature, event, or process of a physical system or the environment such as the timing of a volcanic event. Also referred to as irreducible *uncertainty* because no amount of knowledge will determine whether or not a chance event will or will not occur. See also *epistemic uncertainty*.

Alloy 22: A nickel-based, *corrosion*-resistant alloy containing approximately 22 weight percent chromium, 13 weight percent molybdenum, and 3 weight percent tungsten as major alloying elements. This alloy is used as the outer container material in U.S. Department of Energy's waste package design.

Alluvial, alluvial fan: Pertaining to the process of moving sediment by running water (see *alluvium*). An *alluvial fan* is a wedge-shaped (fan-shaped in plan view) sedimentary deposit of *alluvium* formed at the base of a slope in arid regions.

alluvium: Detrital (sedimentary) deposits made by flowing surface water on river beds, flood plains, and *alluvial fans*. It does not include subaqueous sediments of seas and lakes.

alternative: In the context of system analysis, plausible interpretations or designs that use assumptions other than those used in the base case, which could also be applicable or reasonable given the available scientific information. When propagated through a quantitative tool such as performance assessment, *alternative* interpretations can illustrate the significance of the *uncertainty* in the base case interpretation chosen to represent the system's probable behavior.

ambient: Undisturbed, natural conditions, such as *ambient* temperature caused by *climate* or natural subsurface thermal gradients, and other surrounding conditions.

anisotropy: Variation in physical properties when measured in different directions. For example, in layered rock, *permeability* is often greater within the horizontal layers than across the horizontal layers.

annual frequency: The number of occurrences of an event in 1 year.

aqueous: Pertaining to water, such as *aqueous phase*, *aqueous species*, or *aqueous transport*.

ash: Fragments of volcanic rock that are broken from *magma* and/or country rock during an explosive volcanic eruption to less than 2 mm [0.08 in] in diameter. See also *tephra* and *pyroclastic*.

ash flow tuff: A type of volcanic rock formed by the deposition and accumulation of dominantly ash-size particles during an explosive eruption. *Ash flows* (also called *pyroclastic flows*) commonly result from eruptions of more viscous, silica-rich *magma* such as *rhyolite*. *Ash flow tuff* forms the *host horizons* for the proposed geologic repository at Yucca Mountain. See also *tuff* and *welded tuff*.

basalt: A common type of *igneous* rock (and/or low-viscosity *magma*) that forms black, rubbly-to-smooth-surfaced lavas and black-to-red *tephra* deposits.

borosilicate glass: A predominantly noncrystalline, relatively homogenous glass formed by melting silica and boric oxide together with other constituents such as alkali oxides. *Borosilicate glass* is a high-level radioactive waste material in which boron takes the place of the lime used in ordinary glass mixtures.

boundary condition: For a *model*, the establishment of a set condition for a given *variable*, often at the geometric edge of the *model*. An example is using a specified groundwater flux for *net infiltration* as a *boundary condition* for an *unsaturated zone flow model*.

bound: An analysis or selection of *parameter* values that yields limiting results, such that any actual result is certain to exceed these limits only with an extremely small likelihood.

breach: A penetration in the waste package caused by failure of the outer and inner containers or barriers that allows the *spent nuclear fuel* or the high-level radioactive waste to be exposed to the external environment and may eventually permit *radionuclide* release.

burnup: A measure of nuclear reactor fuel consumption expressed either as the percentage of fuel atoms that have undergone fission, or as the amount of energy produced per unit weight of fuel.

burnup credit: The concept of taking credit for the reduction in reactivity (ability to undergo fission) due to fuel irradiation. The reduction in reactivity is due to the net reduction of fissile nuclides and the production of parasitic neutron-absorbing nuclides.

caldera: A volcanic depression in the Earth's surface more than 1 km [0.7 mi] wide, formed by the collapse of the upper crust into an evacuated *magma* chamber during or after a large volcanic eruption. Many *calderas* resulting from the explosive eruption of large amounts of *ryholite magma* are several tens of kilometers [up to 20 mi] wide.

calibration: (1) Comparison of *model* results with actual data or observations, and adjusting *model parameters* to increase the precision and/or accuracy of *model* results compared to actual data or observations. (2) For tools used for field or lab measurements, the process of taking instrument readings on standards known to produce a certain response, to check the accuracy and precision of the instrument.

canister: An unshielded cylindrical metal receptacle that facilitates handling, transportation, storage, and/or disposal of high-level radioactive waste. It may serve as (i) a pour mold and container for vitrified high-level radioactive waste; (ii) a container for loose or damaged fuel rods, nonfuel components and assemblies, and other debris containing *radionuclides*; or (iii) a container that provides *radionuclide* confinement. *Canisters* are used in combination with specialized overpacks that provide structural support, shielding, or confinement for storage, transportation, and emplacement. Overpacks used for transportation are usually referred to as transportation *casks*; those used for emplacement in a proposed repository are referred to as waste container.

carbon steel: A steel made with carbon up to about 2 weight percent and only residual quantities of other elements. *Carbon steel* is a tough but ductile and malleable material that is used in some components in the U.S. Department of Energy's design of the engineered barrier system.

cask: (1) A heavily shielded container used for the *dry storage* or shipment (or both) of radioactive materials such as *spent nuclear fuel* or other high-level radioactive waste. *Casks* are often made from lead, concrete, or steel. *Casks* must meet regulatory requirements and are not intended for long-term disposal in a proposed repository. (2) A heavily shielded container that the U.S. Department of Energy would use to transfer *canisters* between waste handling facilities at the proposed repository.

cinder cone: A steep, conical hill formed by the accumulation of *ash* and coarser erupted material (*tephra*) around a volcanic *vent*. Synonymous with *scoria cone*.

cladding: The metal outer sheath of a fuel rod generally made of a zirconium alloy or *stainless steel*, intended to protect the uranium dioxide pellets, which are the nuclear fuel, from *dissolution* by exposure to high-temperature water under operating conditions in a reactor.

climate: Weather conditions, including temperature, wind velocity, precipitation, and other factors, that prevail in a region.

climate states: Representations of *climate* conditions.

colloid: As applied to *radionuclide migration*, *colloids* are large molecules or very small particles, having at least one dimension with the size range of 10^{-6} to 10^{-3} mm [10^{-8} to 10^{-5} in] that are suspended in a solvent. *Colloids* in groundwater arise from clay minerals, organic materials, or (in the context of a proposed geologic repository) from *corrosion* of engineered materials.

commercial spent nuclear fuel: Nuclear fuel rods, forming a fuel assembly, that have been removed from a nuclear power plant after reaching the specified *burnup*.

conceptual model: A set of qualitative assumptions used to describe a system or subsystem for a given purpose. Assumptions for the *model* are compatible with one another and fit the existing data within the context of the given purpose of the *model*.

conduit: A *pathway* along which *magma* rises to the surface during a volcanic eruption. *Conduits* are usually cylindrical and flare upwards toward the surface *vent*. *Conduits* are near-surface *features* and develop along *dikes*, focusing *magma flow* from the longer and possibly narrower *dike* to the vent.

consequence: A measurable or calculated outcome of an event or process that, when combined with the *probability* of occurrence, gives a measurement of *risk*.

conservative: A condition of an analysis or a *parameter* value such that its use provides a pessimistic result, which is worse than the actual result expected.

corrosion: The deterioration of a material, usually a metal, as a result of a chemical or electrochemical reaction with its environment. *Corrosion* includes, but is not limited to, general *corrosion*, microbially influenced *corrosion*, localized *corrosion*, *galvanic corrosion*, and stress corrosion cracking.

coupled processes: A representation of the interrelationships between *processes* such that the effects of variation in one process are accurately propagated among all interrelated *processes*.

criticality: The condition in which a fissile material sustains a chain reaction. It occurs when the number of neutrons present in one generation cycle equals the number generated in the previous cycle. The state is considered critical when a self-sustaining nuclear chain reaction is ongoing.

diffusion: (1) The spreading or dissemination of a substance caused by concentration gradients. (2) The gradual mixing of the molecules of two or more substances because of random thermal motion.

diffusive transport: *Diffusive transport* is the process in which substances carried in groundwater move through the subsurface by means of *diffusion* because of a concentration gradient.

dike: A tabular, generally vertical body of *igneous* rock that cuts across the *structure* of adjacent rocks. *Dikes transport* molten rock (*magma*) from depth to an erupting volcano, but not all *dikes* feed an eruption.

dimensionality: Modeling in one, two, or three dimensions.

direct exposure: The manner in which an individual receives dose from being in close proximity to a source of radiation. *Direct exposures* present an external dose *pathway*.

dispersion (hydrodynamic dispersion): (1) The tendency of a *solute* to spread out from the path it is expected to follow if only the bulk motion of the flowing fluid were to move it. The tortuous path the *solute* follows through openings (pores and *fractures*) causes part of the dispersion effect in the rock. (2) The macroscopic outcome of the actual movement of individual *solute* particles through a porous medium. Dispersion dilutes *solutes*, including *radionuclides*, in groundwater.

disruptive event: An unlikely, off-normal event that, in the case of the proposed repository at Yucca Mountain, could include *volcanic* activity, *seismic* activity, and nuclear *criticality*. *Disruptive events* alter the normal or likely behavior of the system.

dissolution: Dissolving a substance in a solvent.

distribution: In a *total system performance assessment*, the overall scatter of values for a specific set of numbers (e.g., *corrosion* rates, values used for a particular *parameter*, dose results). A term used synonymously with *frequency distribution* or *probability distribution* function. *Distributions* have *structures* that are the *probability* that a given value occurs in the set.

drift: From mining terminology, a horizontal or sub-horizontal underground passage. In the proposed Yucca Mountain repository design, *drifts* include excavations for emplacement of waste canisters (*emplacement drifts*) and access (access mains).

drift degradation: The progressive accumulation of rock rubble in a *drift* created by weakening and collapse of *drift* walls in response to stress from heating or earthquakes.

drip shield: A metallic *structure* placed along the extension of the *emplacement drifts* and above the *waste packages* to prevent *seepage* water from directly dripping onto the *waste package* outer surface. The *drip shield* may also prevent the *drift* ceiling rocks (e.g., due to *drift* spallation) from falling on the *waste package*.

dry storage: Storage of *spent nuclear fuel* without immersion of the fuel in water for cooling or shielding; it involves the encapsulation of spent fuel in a steel cylinder that might be in a concrete or massive steel *cask* or *structure*.

effective porosity: The fraction of a porous medium volume available for fluid flow and/or *solute* storage, as in the saturated zone. *Effective porosity* is less than or equal to the total void space (*porosity*).

empirical: Reliance on observation or experimentation rather than on a theoretical understanding of fundamental *processes*.

emplacement drift: See *drift*.

enrichment: The act of increasing the concentration of fissile isotopes from their value in natural uranium. The *enrichment* (typically reported in atom percent) is a characteristic of nuclear fuel.

eolian: Relating to *processes* caused by near-surface winds.

epistemic uncertainty: A *variability* that is due to a lack of knowledge of quantities or *processes* of the system or the environment. Also referred to as reducible *uncertainty*, because the state of knowledge about the exact value of a quantity or process can increase through testing and data collection. See also *aleatory uncertainty*.

Equilibrium (chemical): The state of a chemical system in which the *phases* do not undergo any spontaneous change in properties or proportions with time; a dynamic balance.

events: In a *total system performance assessment*, (1) occurrences of phenomena that have a specific starting time and, usually, a duration shorter than the time being simulated in a *model* or (2) uncertain occurrences of phenomena that take place within a short time relative to the time frame of the *model*.

event tree: A modeling tool that illustrates the logical sequence of *events* that follow an initiating event.

expected annual dose: The average annual radiological dose calculated for the *reasonably maximally exposed individual*, which includes the likelihood of the individual receiving a dose from all relevant exposure *scenarios*.

expert elicitation: A formal, highly *structured*, and well-documented process whereby expert judgments, usually of multiple experts, are obtained.

Exploratory Studies Facility: An underground laboratory at Yucca Mountain that includes a 7.9-km [4.9-mi] main loop (tunnel); a 2.8-km [1.75-mi] cross *drift*; and a research alcove system constructed for performing underground studies during site characterization.

extrusive (extrusion): In relation to *igneous* activity, an event where *magma* erupts at the surface. An extrusion is the deposit formed by an extrusive event. See also *intrusive*.

fault (geologic): A planar or gently curved *fracture* across which there has been displacement of rocks or sediment parallel to the *fracture* surface.

features: Physical, chemical, thermal, or temporal characteristics of the site or proposed repository system at Yucca Mountain. For the purposes of screening *features*, *events*, and *processes* for the *total system performance assessment*, a feature is defined to be an object, *structure*, or condition that has a potential to affect disposal system performance.

fissure: In relation to *igneous* activity, a *fissure* is an elongated vent or line of *vents*, formed when a *dike* breaks to the surface to start a *volcanic eruption*.

flow: The movement of a fluid such as air, water, or *magma*. *Flow* and *transport* are *processes* that can move *radionuclides* from the proposed repository to the *receptor* group location.

flow pathway: The subsurface course that water or a *solute* (and dissolved material) would follow in a given groundwater velocity field, governed principally by the hydraulic gradient.

fluvial: Processes related to the downslope movement of water in streams and rivers on the Earth's surface.

fracture: A planar discontinuity in rock along which loss of cohesion has occurred. It is often caused by the same stresses that cause folding and faulting. A *fracture* along which there has been displacement of the sides relative to one another is called a *fault*. A *fracture* along which no appreciable movement has occurred is called a joint. *Fractures* may act as paths for fast groundwater movement.

fragility: *Fragility* of a *structure, system, or component* is defined as the conditional *probability* of its failure, given a value of the ground motion, or response *parameter*, such as stress, bending moment, and spectral acceleration.

frequency: The number of occurrences of an observed or predicted event during a specific time period.

galvanic: Pertains to an electrochemical process in which two dissimilar electronic conductors are in contact with each other and with an electrolyte, or in which two similar electronic conductors are in contact with each other and with dissimilar electrolytes.

geochemical: The *distribution* and amounts of the chemical elements in minerals, ores, rocks, soils, water, and the atmosphere; the movement of the elements in nature on the basis of their properties.

geophysics (geophysical survey; geophysical magnetic survey): Study of the physical properties of rocks and sediment and interpretation of data derived from measurements made. Properties commonly measured are the velocity of sound (*seismic waves*) in rocks, density, and magnetic character. A program of measurements made on a series of rocks is usually termed a survey.

half-life: The time required for a radioactive substance to lose half of its activity due to *radioactive decay*. At the end of one *half-life*, 50 percent of the original radioactive material has decayed.

heterogeneity: The condition of being composed of parts or elements of different kinds. A condition in which the value of a *parameter* varies over the space an entity occupies, such as the area around the proposed repository, or with the passage of time.

host horizon, host rock: The rocks in which the proposed Yucca Mountain geologic repository are intended to be mined.

hydrologic: Pertaining to the properties, *distribution*, and circulation of water on the surface of the land, in the soil and underlying rocks, and in the atmosphere.

igneous: (1) An activity or process related to the formation and movement of *magma*, either in the subsurface (*intrusive*) or on the surface (*extrusive*, or *volcanic*). (2) A type of rock that has formed from a molten, or partially molten, material, or *magma*.

infiltration: The process of water entering the soil at the ground surface. *Infiltration* becomes percolation when water has moved below the depth at which evaporation or *transpiration* can return it to the atmosphere. See also *net infiltration*.

intrusive (intrusion): In relation to *igneous* activity, an event where *magma* approaches the surface but does not break through in an eruption (or the unerupted *magma* during an *igneous* event). An intrusion is the solidified rock formed below the surface by an *intrusive* event. See also *extrusive*.

invert: A constructed surface that would provide a level *drift* floor and enable emplacement and support of the *waste packages*.

license application: An application from the U.S. Department of Energy to the U.S. Nuclear Regulatory Commission for a license to construct and operate the proposed repository at Yucca Mountain.

lithophysal: Containing lithophysae, which are holes in *tuff* and other volcanic rocks. One way lithophysae are created is by the accumulation of volcanic gases during the formation of the *tuff*.

magma: Molten or partially molten rock that is naturally occurring and is generated within the Earth. *Magma* may contain crystals along with dissolved gasses.

mathematical model: A mathematical description of a *conceptual model*.

matrix (geology): In general terms, rock material and its pore space. For Yucca Mountain, the rock is conceptually divided into matrix and *fractures*; the matrix is the portion of rock between *fractures*. The pore space in the matrix can be referred to as the primary *porosity*, as opposed to the pore space in *fractures* that can be referred to as secondary *porosity*.

matrix diffusion: The process by which molecular or ionic *solutes*, such as *radionuclides* in groundwater, move from areas of higher concentration to areas of lower concentration. For the proposed Yucca Mountain repository, this process refers to the movement of *radionuclides* by *diffusion* between the *fracture* and *matrix* continua.

matrix permeability: The capability of the *matrix* to transmit fluid.

mean (statistical): For a statistical data set, the sum of the values divided by the number of items in the set. The arithmetic average, sometimes referred to as expected value.

mechanical disruption: Damage to the *drip shield* or *waste package* because of external forces.

median (statistical): A value such that one-half of the observations are less than the value and one-half are greater than the value.

meteorology: The study of climatic conditions such as precipitation, wind, temperature, and relative humidity.

microbe: An organism too small to be viewed with the unaided eye. Examples of *microbes* are bacteria, protozoa, and some fungi and algae.

migration: *Radionuclide* movement from one location to another within the engineered barrier system or the environment.

mineralogical: Of or relating to the chemical and physical properties of minerals, their occurrence, and their classification.

mode (statistical): A statistic for a set of data values that represents the value that occurs most frequently in that set.

model: A depiction of a system, phenomenon, or process, including any hypotheses required to describe the system or explain the phenomenon or process.

model support: A process used to gain confidence in the reasonableness of *model* results through comparison with outputs from detailed process-level *models* and/or *empirical* observations such as laboratory tests, field investigations, and *natural analogues*.

natural analogues: Naturally-occurring, observable *features*, *events*, or *processes*, equivalent to those that might affect the repository in the future. These provide insights on similar *features*, *events*, or *processes* that are required to be examined for the proposed Yucca Mountain repository system. An example might be a *dike* in an existing volcanic system, or a fault that affects similar rocks to those at the repository, both occurring near the repository site or directly relatable to it.

near-field: The area and conditions within the proposed repository including the *drifts* and *waste packages* and the rock immediately surrounding the *drifts*. The *near-field* is the region in and around the proposed repository where the excavation of the proposed repository *drifts* and the emplacement of waste have significantly impacted the natural *hydrologic* system.

net infiltration: The downward flux of infiltrating water that escapes below the zone of evapotranspiration. The bottom of the zone of evapotranspiration generally coincides with the lowermost extent of plant roots.

nominal scenario class: The *scenario*, or set of related *scenarios*, that describes the expected or nominal behavior of the natural system as perturbed only by the presence of the proposed repository at Yucca Mountain. The nominal *scenarios* contain all likely *features*, *events*, and *processes* that have been retained for analysis.

numerical model: An approximate representation of a *mathematical model* that is constructed using a numerical description method such as finite volumes, finite differences, or finite elements. A *numerical model* is typically represented by a series of program statements that are executed on a computer.

occupational dose: The dose received by an individual in the course of employment in which the individual's assigned duties involve exposure to radiation or to radioactive material from licensed and unlicensed sources of radiation, whether in the possession of the licensee or other person. *Occupational dose* does not include doses received from background radiation, from any medical administration the individual has received, from exposure to individuals who were administered radioactive material and released under 10 CFR 35.75, from voluntary participation in medical research programs, or as a member of the public (10 CFR 20.1003, "Occupational dose").

oxidation: A *corrosion* reaction in which the corroded metal forms an oxide, usually applied to reaction with a gas containing elemental oxygen, such as air.

parameter: Data, or values, such as those that are input to computer codes for a *total system performance assessment* calculation.

patch: In the U.S. Department of Energy modeling of *waste package corrosion*, a *patch* is the minimal surface area of the *waste package* over which general corrosion occurs, as opposed to localized corrosion in *pits*.

pathway: A potential route by which *radionuclides* might reach the accessible environment and pose a threat to humans. For example, *direct exposure* is a human external *pathway*, and inhalation and ingestion are human internal *pathways*.

permeability: A measure of the ease with which a fluid such as water or air moves through a rock, soil, or sediment.

phase: A physically homogeneous and distinct portion of a material system, such as the gaseous, liquid, and solid *phases* of a substance. In liquids and solids, single *phases* may coexist.

phase stability: A measure of the ability of a particular *phase* to remain without transformation.

Pit (in material science): A small cavity formed in a solid as a result of localized corrosion.

porosity: The ratio of the volume occupied by openings, or voids, in a soil or rock, to the total volume of the soil or rock. Porosity is expressed as a decimal fraction or as a percentage.

probabilistic: Based on or subject to *probability*.

probability: The chance that an outcome will occur from the full set of possible outcomes. Knowledge of the exact *probability* of an event is usually limited by the inability to know, or compile, the complete set of possible outcomes over time or space.

probability distribution: The set of outcomes (values) and their corresponding probabilities for a random *variable*. See *distribution*.

processes: Phenomena and activities that have gradual, continuous interactions with the system being modeled.

process model: A depiction or representation of a *process*, along with any hypotheses required to describe or to explain the *process*.

pyroclastic: In relation to *igneous volcanic* activity, this describes fragments or fragmental rocks and deposits produced by explosive eruptions, where the *magma* is ripped apart during the release of gas and/or by interaction with surface and near-surface water.

Quaternary: The period of geologic time from about 2 million years ago to the present day.

radioactive decay: The process in which one *radionuclide* spontaneously transforms into one or more different *radionuclides*, which are called daughter *radionuclides*.

radioactivity: The property possessed by some elements (such as uranium) of spontaneously emitting energy in the form of radiation as a result of the decay (or disintegration) of an unstable atom. *Radioactivity* is also the term used to describe the rate at which radioactive material emits radiation.

radiolysis: Chemical decomposition by the action of radiation.

radionuclide: An unstable isotope of an element that decays or disintegrates spontaneously, thereby emitting radiation. Approximately 5,000 natural and artificial radioisotopes have been identified.

range (statistical): The numerical difference between the highest and lowest value in any set.

reasonably maximally exposed individual: A hypothetical person meeting the criteria of 10 CFR 63.312.

receptor: An individual for whom radiological doses are calculated or measured.

redistribution: Mobilization and *transport* of surface deposits by wind and water.

reliability: The *probability* that the item will perform its intended function(s) under specified operating conditions for a specified period of time.

repository footprint: The outline of the outermost locations of where the waste is proposed to be emplaced in the proposed Yucca Mountain repository.

retardation: Slowing or stopping *radionuclide* movement in groundwater by mechanisms that include *sorption* of *radionuclides*, *diffusion* into *rock matrix* pores and microfractures, and trapping of particles in small pore spaces or dead ends of microfractures.

rhyolite: A common type of *igneous* rock that forms light-colored, rough blocky surfaced lavas and white-grayish-yellow *tephra* deposits. A common fragment type is pumice. Rhyolitic *magma* has a high viscosity, and the resulting lava flows are usually quite short and thick. It more frequently erupts explosively from the volcano and forms *ash-flow tuffs*.

risk: The *probability* that an undesirable event will occur, multiplied by the *consequences* of the undesirable event.

risk assessment: An evaluation of potential *consequences* or hazards that might be the outcome of an action, including the likelihood that the action might occur. This assessment focuses on potential negative impacts on human health or the environment.

risk-informed, performance-based: A regulatory approach in which *risk* insights, engineering analysis and judgments, and performance history are used to (i) focus attention on the most important activities; (ii) establish objective criteria on the basis of *risk* insights for evaluating performance; (iii) develop measurable or calculable *parameters* for monitoring system and licensee performance; and (iv) focus on the results as the primary basis for regulatory decision making.

rockfall: In terms of the proposed Yucca Mountain repository, the release of *fracture*-bounded blocks of rock from the *drift* wall, usually in response to an earthquake.

rock matrix: See *matrix*.

runoff: Lateral movement of water at the ground surface, such as down steep hillslopes or along channels, that is not able to infiltrate at a specified location.

scenario: A well-defined, connected sequence of *features*, *events*, and *processes* that can be thought of as an outline of a possible future condition of the proposed repository system. Scenarios can be undisturbed, in which case the performance would be the expected, or nominal, behavior for the system. Scenarios can also be disturbed, if altered by *disruptive events* such as human intrusion or natural phenomena such as *volcanism* or nuclear *criticality*.

scenario class: A set of related *scenarios* sharing sufficient similarities that they can usefully be aggregated for screening or analysis. The number and breadth of *scenario classes* depend on the resolution at which scenarios have been defined.

scoria; scoria cone: Scoria is the *basaltic* equivalent of pumice, a frothy material due to gas-expansion in the *magma*. For scoria cone, see *cinder cone*.

seepage: Water dripping into a *drift*. This usage is specific to Yucca Mountain.

seismic: Pertaining to, characteristic of, or produced by earthquakes or Earth vibrations.

seismic hazard curve: A graph showing the ground motion *parameter* of interest, such as peak ground acceleration, peak ground velocity, or spectral acceleration at a given *frequency*, plotted as a function of its annual *probability* of exceedance.

seismic performance: *Seismic performance of structures, systems, and components* refers to their ability to perform intended safety functions during a *seismic* event, expressed as the annual *probability* of exceeding a specified limit condition (stress, displacement, or collapse). This is also referred to as the *probability* of failure, or *probability* of unacceptable performance, P_F .

sill: A tabular, generally flat-lying body of *intrusive igneous* rock that lies along (is concordant with) the *structure* of adjacent rocks. *Sills* are part of the *transport* system for molten rock (*magma*) rising from depth to the surface. See also *dike*.

sorb: To undergo a process of *sorption*.

solute: A substance that is dissolved in a solution (e.g., radioactive waste dissolved in groundwater)

sorption: The binding, on a microscopic scale, of one substance to another. *Sorption* is a term that includes both *adsorption* and *absorption* and refers to the binding of dissolved *radionuclides* onto geologic solids or *waste package* materials by means of close-range chemical or physical forces. *Sorption* is a function of the chemistry of the radioisotopes, the fluid in which they are carried, and the material they encounter along the *flow* path.

sorption coefficient (K_d): A numerical means to represent how strongly one substance *sorbs* to another.

source term: Types and amounts of *radionuclides* that are the source of a potential release.

spatial variability: A measure of how a property, such as rock *permeability*, varies at different locations in an object such as a rock formation.

speciation: The existence of the elements, such as *radionuclides*, in different molecular forms in the *aqueous phase*.

spent nuclear fuel: Fuel that has been withdrawn from a nuclear reactor following irradiation, the constituent elements of which have not been separated by reprocessing.

stainless steel: A class of iron-base alloys containing a minimum of approximately 10 percent chromium to provide *corrosion* resistance in a wide variety of environments.

stratigraphy: The branch of geology that deals with the definition and interpretation of rock strata; the conditions of their formation, character, arrangement, sequence, age, and *distribution*; and especially their correlation by the use of fossils and other means of identification. See *stratum*.

stratum (plural strata): A layer of rock or soil with geologic characteristics that differ from the layers above or below it.

structure: In geology, the geometric arrangement of rocks, or geologic *features* (or areas of interest) such as folds and *faults*. Includes *features* such as *fractures* created by faulting, and joints caused by various *processes*, including those associated with the heating of rock. For engineering usage, see *structures, systems, and components*.

structures, systems, and components: A *structure* is an element, or a collection of elements, that provides support or enclosure, such as a building, *aging pad*, or *drip shield*. A *system* is a collection of components, such as piping; cable trays; *conduits*; or heating, ventilation, and air conditioning equipment that are assembled to perform a function. A *component* is an item of mechanical or electrical equipment, such as a *canister* transfer machine, transport and emplacement vehicle, pump, valve, or relay.

tectonic: Pertaining to geologic *features* or *events* created by deformation of the Earth's crust.

tephra: A collective term for all clastic (fragmental) materials ejected from a volcano during an eruption and *transported* through the air.

thermal chemical: Of or pertaining to the effect of heat on chemical conditions and reactions.

thermohydrologic: Of or pertaining to changes in groundwater movement due to the effects of changes in temperature.

thermal mechanical: Of or pertaining to changes in mechanical properties from effects of changes in temperature.

total system performance assessment: A *risk assessment* that quantitatively estimates how the proposed Yucca Mountain repository system will perform in the future under the influence of specific *features, events, and processes*, incorporating *uncertainty* in the *models* and *uncertainty* and *variability* of the data.

transparency: The ease of understanding the process by which a study was carried out, which assumptions are driving the results, how they were arrived at, and the rigor of the analyses leading to the results. A logical structure ensures completeness and facilitates in-depth review of the relevant issues. *Transparency* is achieved when a reader or reviewer has a clear picture of what was done in the analysis, why it was done, and the outcome.

transpiration: The removal of water from the ground by vegetation (roots).

transport: A process that allows substances such as contaminants, *radionuclides*, or *colloids*, to be carried in a fluid from one location to another. Transport *processes* include the physical mechanisms of *advection*, convection, *diffusion*, and *dispersion* and are influenced by the chemical mechanisms of *sorption*, leaching, precipitation, *dissolution*, and complexation.

tuff: A general term for volcanic rocks that formed from fragmented *magma* and fragments of other rocks, and that erupted from a volcanic vent, flowed away from the vent as a suspension of solids and hot gases, or fell from the eruption cloud, and consolidated at the location of deposition. *Tuff* is the most abundant type of rock at the proposed Yucca Mountain repository site. *Welded tuff* is one type.

uncertainty: How much a calculated or measured value varies from the unknown true value. See also *aleatory uncertainty* and *epistemic uncertainty*.

unsaturated zone: The zone between the land surface and the regional water table. Generally, fluid pressure in this zone is less than atmospheric pressure, and some of the voids may contain air or other gases at atmospheric pressure. Beneath flooded areas or in perched water bodies, the fluid pressure locally may be greater than atmospheric.

unsaturated zone flow: The movement of water in the *unsaturated zone*, as driven by capillary, viscous, gravitational, inertial, and evaporative forces.

vadose zone: Synonymous with *unsaturated zone*.

variable: A nonunique property or attribute used to represent the *parameters* or unknowns in an equation or formula.

variably saturated zone: Synonymous with *unsaturated zone*.

variability (statistical): A measure of how a quantity varies over time or space.

vent (geology): The point on the Earth's surface at which *magma* extrudes to form a volcanic eruption. May include geologic deposits or structures associated with the *vent*.

volcanic, volcanic activity, volcanism: Pertaining to extrusive *igneous* activity.

wash: In relation to landforms (geomorphology), a streambed, dry or running, usually in a semi-arid or arid environment.

waste package: The waste form and any containers, shielding, packing, and other absorbent materials immediately surrounding an individual waste container.

watershed: Used to indicate an area of land from which all water falling as precipitation would *flow* toward a single point. *Watershed* is also sometimes used for drainage area (i.e., the area drained by a single stream-river system including the adjacent ridges and hillslopes). The upstream boundaries of *watersheds* are the high points (ridges, etc.) that separate two drainage areas.

welded tuff: A *tuff* deposited under conditions where the particles that make up the rock remain sufficiently hot to weld or sinter together. In contrast to nonwelded *tuff*, *welded tuff* is denser, less porous, and more likely to be *fractured* (which increases *permeability*).

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11. ABSTRACT (200 words or less)

This is volume 4 of the U.S. Nuclear Regulatory Commission (NRC) staff's "Safety Evaluation Report Related to Disposal of High-Level Radioactive Wastes in a Geologic Repository at Yucca Mountain, Nevada." It documents the review and evaluation of the U. S. Department of Energy's (DOE) Safety Analysis Report (SAR), Chapter 3: Research and Development Program to Resolve Safety Questions; Chapter 4: Performance Confirmation Program; and Chapter 5: Management Systems (except for SAR Section 5.4, Expert Elicitation, which is evaluated in SER Volume 3, Repository Safety After Permanent Closure, Chapter 20).

The NRC staff has found, with reasonable assurance, that, except as noted below, DOE has addressed applicable requirements including 10 CFR 63.21, "Content of Application"; 10 CFR 63.121, "Land Ownership and Control"; 10 CFR Part 63, Subpart D, "Records, Reports, Tests, and Inspections"; 10 CFR Part 63, Subpart F, "Performance Confirmation Program"; 10 CFR Part 63, Subpart G, "Quality Assurance"; 10 CFR Part 63, Subpart H, "Training and Certification of Personnel"; and 10 CFR Part 63, Subpart I, "Emergency Planning Criteria." The NRC staff is proposing one condition of construction authorization in this SER Volume related to the description of programs designed to resolve safety questions. The NRC staff finds that DOE has not met the requirements 10 CFR 63.121(a) and 10 CFR 63.121(d)(1) regarding ownership of land and water rights, respectively.

12. KEY WORDS/DESCRIPTORS (List words or phrases that will assist researchers in locating the report.)

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