

LESSONS LEARNED DURING THE YUCCA MOUNTAIN SAFETY EVALUATION REPORT DEVELOPMENT

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1.0 Introduction

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, which denied DOE's motion in June 2010. During this time period, Congress reduced funding for the NRC's review of the application, with no funds appropriated for Fiscal Year 2012. On September 30, 2010, DOE's Office of Civilian Radioactive Waste Management ceased operations and assigned the remaining Yucca Mountain-related responsibilities, such as site closure, to other offices within DOE. In October 2010, the NRC staff began orderly closure of its Yucca Mountain activities. In September 2011, the Commission was evenly divided on whether to overturn or uphold the Atomic Safety and Licensing Board's decision denying DOE's motion to withdraw its application. The Commission directed the 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. The staff also completed its orderly closure of its Yucca Mountain Activities by September 30, 2011 (e.g., issued three Technical Evaluation Reports as part of the staff's knowledge management records of its technical review of the DOE license application). In August 2013, the U.S. Court of Appeals for the District of Columbia Circuit issued a decision granting a writ of mandamus and directed 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 license application.

In January 2015, the NRC staff completed the development of the SER for a potential repository at Yucca Mountain, Nevada (NUREG-1949). The SER details the NRC staff's review of DOE's license application and supporting information consistent with NRC regulations and the Yucca Mountain Review Plan (YMRP). The DOE's license application for a potential repository at Yucca Mountain represents a first-of-a-kind facility, and the staff's review is the first to implement the requirements and guidance in 10 CFR Part 63 and the YMRP.

Although the NRC staff's review began in 2008, significant technical work was conducted before this with respect to preparation for a risk-informed, performance-based review of a potential repository at Yucca Mountain. For more than twenty years prior to receipt of the license application, the NRC conducted technical and regulatory analyses in support of conducting a review of a license application seeking an authorization to construct a repository at Yucca Mountain. For example, during this time period the NRC (including the NRC's contractor the Center for Nuclear Waste Regulatory Analyses [CNWRA]): (i) developed the capability to conduct a performance assessment (e.g., Initial Demonstration of the NRC's Capability to Conduct a Performance Assessment for a High-Level Waste Repository – NUREG-1327, published in 1992); (ii) conducted analyses to support development of regulations for Yucca Mountain (Preliminary Performance-Based Analyses Relevant to Dose-Based Performance Measures for a Proposed Geologic Repository at Yucca Mountain – NUREG-1538, published in 2001); (iii) conducted numerous technical analyses and evaluations related to a potential repository at Yucca Mountain supporting issue resolution (e.g., Integrated Issue Resolution

Status Report – NUREG-1762, Rev. 1, published in 2005); and participated in numerous public technical exchanges with DOE. All of this effort assisted the staff in its preparations to conduct an efficient and effective review.

Many factors, including the long history of pre-licensing efforts, the first-of-a-kind nature of the facility, the complexity of the application, and the need for a large multi-disciplinary review team, made the development of the SER for the Yucca Mountain application challenging for the NRC staff. The staff therefore sees value in compiling information that may help in future review activities.

In this report, the NRC staff identifies aspects of the review that, in the staff's view, were especially effective in contributing to an efficient review (i.e., lessons learned) and provides recommendations that it considers generally applicable to SER development for any type of activities. The lessons learned discussed in this report focus on the activities associated with the development of the five-volume Yucca Mountain SER and cover the time period during the development of the SER beginning in 2008 and ending in 2015. This report identifies lessons learned associated with the SER process (procedures and approaches for conducting the review) in Section 2.0, regulations and guidance used during the review in Section 3.0, and document development tools (e.g., use of a SharePoint type framework) in Section 4.0.

2.0 SER Process

Lessons learned and recommendations for the SER process cover the management of the project (Topic 1) and integration of the contributions from the many members of the technical staff into the SER (Topic 2).

TOPIC 1: Project Management

Strong project management and leadership were critical to the timely completion of a quality SER. Assignment of a project manager for each SER Volume, as well as an overall SER project manager, was important for successful coordination and completion of the SER. In particular, the project managers: (i) ensured early identification of issues to management where assistance was needed; (ii) ensured chapter teams had the resources they needed to perform assigned tasks; (iii) kept management fully informed on progress and status; (iv) ensured team members were aware of the schedule and expectations; (v) held weekly progress meetings to ensure consistency among the different volumes, and timely identification and resolution of issues; and (vi) assisted and convened meetings as necessary to assist chapter completion. Project managers, review staff, and management communicated well throughout the SER development process to ensure timely completion of the SER.

LESSON LEARNED 1:

Strong project management was necessary and critical for timely completion of a quality SER. Good communication among management and project managers and the technical staff was essential for ensuring timely resolution of issues. Project managers, review staff, and management benefited from early and frequent review and agreement on a detailed schedule and expectations for the development of the SER.

RECOMMENDATION 1:

Meetings of all staff and management (i.e., “all-hands meetings”) should be held on a regular basis to: (i) ensure a consistent understanding of schedules and expectations, (ii) share current information, and (iii) provide opportunities to identify and discuss generic issues.

TOPIC 2: Integration of Contributions from Multiple Authors

Many of the chapters of the SER, particularly in Volume 2 on the safety of pre-closure operations, were developed with contributions from a number of authors with specific areas of expertise (e.g., electrical components, seismicity and structural design, fire protection, radiation safety). Multiple contributions often resulted in variation in writing styles. During development of all of the SER volumes, staff used a chapter “champion” approach that gave responsibility to a single author (i.e., the chapter champion). The chapter champion revised and integrated an SER chapter to improve consistency across the chapter and improve the readability and clarity (e.g., helped ensure chapter read more like a “single” author, level of technical details was commensurate with the significance of the review topic, and technical terminology was used consistently).

Once the chapter champion completed initial efforts to compile a chapter, the draft chapter was made available to both the staff who contributed to the chapter as well as staff responsible for

review of the chapter (e.g., OGC staff). Availability of the draft chapter proved to be a useful mechanism for generating discussions among all relevant staff that promoted identification of issues, which contributed to timely resolution (e.g., meetings for discussion of the issues among the appropriate staff). In particular, frequent discussion both within NMSS and with OGC allowed for staff to voice opinions and be engaged throughout the review and drafting process.

Additionally, each SER chapter and volume was reviewed for consistency between the chapters in an SER volume and between SER volumes. Integration and consistency was improved by having a limited number of staff reading and editing multiple chapters in a volume and having a single branch chief reviewing all of the chapters in a volume. Further, Volume 5 of the SER served as a “wrap-up” volume for the review, and all contributing staff and management were asked to review Volume 5 for consistency and integration with the other four SER Volumes. This approach was effective for raising and resolving issues within and between the SER chapters and volumes.

LESSON LEARNED 2:

Development of SER chapters involving a variety of technical disciplines benefited from having a chapter champion with strong writing skills to integrate the review inputs from all the contributors into the chapter to ensure: (i) consistency of writing styles, including use of technical terminology, (ii) clarity in describing the review and the basis for conclusions, and (iii) the level of technical detail was commensurate with the significance of the review topic. SER chapters benefited from review and discussion by all relevant staff. This review and discussion improved clarity and consistency and also allowed for early identification of issues, which contributed to timely resolution.

Integration and consistency within and between SER volumes was part of the SER development schedule (e.g., including time for a small team to evaluate integration and consistency within an SER Volume; time for all staff to review the overall conclusions of the review). SER Volume 5 provided a summary and wrap-up of the review that assisted with consistency and integration among all the SER volumes.

RECOMMENDATION 2:

Chapter champions should have strong writing and communications skills. Meetings of the chapter review team should be held on a regular basis to: (i) ensure a consistent understanding of schedules and expectations, (ii) share current information, and (iii) provide opportunities to identify and discuss chapter issues. Chapter champions for chapters within a volume should be in close communication with each other to maintain consistency in style and ensure proper coordination of information among chapters.

3.0 Regulations and Guidance

Lessons learned and recommendations for the regulations and guidance cover the safety review focus (Topic 3) and the clarity of the SER (Topic 4).

TOPIC 3: Focused Review

The risk-informed, performance-based regulations at 10 CFR Part 63 provide requirements that focused the staff's review on the barriers important to waste isolation (i.e., post-closure safety) and structures, systems, and components important to safety (i.e., pre-closure safety). The YMRP was developed to provide guidance for the staff to evaluate DOE's license application. The YMRP was first published more than 10 years before the license application was submitted (and the last revision, revision 2, was published nearly five years before application submittal); therefore, interim staff guidance was used to supplement the YMRP in areas that would benefit from further review guidance. For example, guidance about the requirements regarding the post-closure performance period after 10,000 years was developed after the YMRP was published. Recognizing that prior to receiving a license application it can be difficult to determine precisely which topical areas will need more details to support a risk-informed, performance-based review approach, guidance should be written in a manner that does not inappropriately restrict a risk-informed approach (e.g., provide for a detailed review regardless of the risk significance) and thus decrease review efficiency and effectiveness.

The risk-informed, performance-based approach in 10 CFR Part 63 and the YMRP focused the staff's review on those topics relied on for safety. For example, the regulations require the applicant to evaluate and identify performance of the repository with respect to post-closure safety (e.g., identification and evaluation of features, events, and processes important to performance; demonstration of performance of the natural and engineered barriers that are relied on for meeting the post-closure safety limits) and pre-closure safety (e.g., hazard identification and evaluation; demonstration of performance of the structures, systems, and components important to safety). This assisted the staff in focusing on those attributes of the repository that DOE relied on for safety. Thus, the staff was able to use both the information in the license application and its own knowledge and experience to focus the review, consistent with the regulations, on whether DOE had appropriately identified the safety-relevant attributes and demonstrated the performance of the barriers important to waste isolation and the structures, systems, and components important to safety.

Communication among the reviewers was critical for ensuring a common understanding of performance of the repository to be used throughout the review. (Note: meetings described under Topic 1 as well as the project-wide Yucca Mountain team meetings described under Lesson Learned 3 provided opportunities for communication on the understanding of repository performance.)

LESSON LEARNED 3:

The risk-informed, performance-based approach allowed staff to focus its review on the safety relevant attributes of the repository. The staff's approach was supported by regulations and guidance documents that implemented principles of a risk-informed, performance-based review. Reviewers should have a common understanding of repository performance. Communication is key to reaching this understanding. This was best supported through regular meetings where key issues and topics were openly discussed as needed. The project-wide Yucca Mountain

team meeting was convened on a regular basis beginning during pre-licensing and continued during the review. Staff and managers made it a high priority to attend.

RECOMMENDATION 3:

Risk-informed, performance based regulations and review plans are essential elements for ensuring the rigor of the review is commensurate with the risk-significance. It is important that the review plan provides flexibility for implementing a risk-informed, performance-based approach. Development of a common understanding of facility performance among the reviewers through all-hands meetings is also important.

TOPIC 4: Clarity of the SER

The YMRP was generally developed following the order and format of the regulatory requirements in 10 CFR Part 63 (i.e., the review methods and acceptance generally track the progression of 10 CFR Part 63); however, as described below, slightly different guidance was developed in the YMRP for the pre-closure review relative to the post-closure review.

The post-closure review of model abstraction in the YMRP was divided into 14 sections that represented distinct aspects of the post-closure performance (e.g., degradation of engineered barriers and radionuclide transport in the unsaturated zone) and the acceptance criteria were applied to each section. This post-closure approach provided a framework for developing the safety review in sections that were somewhat 'stand-alone' topics. Alternatively, the YMRP pre-closure review approach, divided the review into a smaller number of sections based on specific regulatory requirements (e.g., identification of hazards and initiating events and identification of event sequences) that applied to multiple buildings needed for repository operations (e.g., wet handling facility, canister receipt and closure facility, and the aging pad). As draft chapters were completed and reviewed, a number of reviewers expressed the view that it was at times difficult to follow the pre-closure discussion due to the variety of operations and buildings discussed throughout the individual SER sections. An alternative could have been to document the safety review with a separate section for building(s) with distinct activities and performance characteristics (e.g., wet handling facility) instead of a section for a specific regulatory requirement that addressed a variety of buildings and activities. This would have provided readers with 'stand-alone' sections similar to the post-closure approach that documented 14 distinct aspects of post-closure performance.

LESSON LEARNED 4:

All stakeholders benefit when the SER is clearly written and easy to follow. Although the YMRP was written to ensure that all the regulatory requirements are addressed, the order and format of the review plan may not represent the clearest way to document the staff's review.

RECOMMENDATION 4:

Although the SER can follow the exact order and format of the review plan, it is important to consider, early in the process, whether an alternative order and format could improve the clarity and readability of the SER.

4.0 Document Development Tools

Lessons learned and recommendations for the document development tools cover how computer/electronic capabilities were used to assist the SER development across various locations and authors (Topic 5) and access to the license application and its references (Topic 6).

TOPIC 5: SER Development by Many Authors in Varied Locations

Development of the safety review documents was performed using a SharePoint¹ framework maintained and managed by the CNWRA. The SharePoint framework allowed multiple staff in multiple locations to have access to the SER documents during the development process. Additionally, the SharePoint framework was used for other documents that improved the efficiency of the review (e.g., master reference list). Having dedicated support staff to maintain timely access to SharePoint, as well as the ability to restrict access to documents as they were being finalized, also enhanced the efficiency of document handling and assured version control.

LESSON LEARNED 5:

Development of the SER within a SharePoint framework and a single point for management of the framework effectively supported the efficiency of the review across a variety of locations and authors by ensuring timely access for authors and reviewers to current versions of SER.

RECOMMENDATION 5:

Dedicated and timely information technology support is needed for control and maintenance of a SharePoint type framework to ensure continued availability of SER documents to the staff.

TOPIC 6: Access to the License Application and Its References

The NRC staff review and SER development was assisted by the availability of the license application and its references using multiple electronic means, such as NRC's Agencywide Document Access Management System (ADAMS). In addition, many commonly-referenced documents (including the License Application, the NRC Requests for Additional Information (RAI) responses, and the set of key references identified by DOE and provided with its application) were available to staff on organized local servers at both NRC and CNWRA. As multiple technical staff were involved with the development of the SER it was critical that all relevant documents were identified and easily accessible. This was particularly important given the volume of documents involved: the License Application alone was 1.5 gigabytes in electronic form (and filled a standard bookshelf when printed), and the 196 key references identified by DOE totaled an additional 49 gigabytes in electronic form.

¹ SharePoint is a web application platform used to store, track, and manage electronic documents and centralized access is typically provided via an intranet portal. The access for certain tasks (e.g., editing and revising documents) is often controlled by passwords or other access controls.

LESSON LEARNED 6:

Electronic document libraries, such as NRC's ADAMS, ensured the staff timely access to relevant documents.

RECOMMENDATION 6:

Dedicated and timely information technology support is needed for control and maintenance of electronic libraries to ensure continued availability of documents to the staff.

5.0 Conclusion

Overall, the staff identified the following lessons learned that contributed to effective and efficient SER development: (i) strong project management, including early identification of issues to management where guidance was needed; (ii) chapter champions (technical staff with overall responsibility for completion, clarity, and accuracy of a specific chapter) that integrated the staff contributions (e.g., sections and sub-sections of a chapter) into a specific chapter; (iii) the risk-informed, performance-based approach was supported through regular meetings where issues and topics were openly discussed; (iv) the order and format of the review plan may not be the clearest way to document the staff's review; (v) the use of a SharePoint framework ensured timely access to the SER documents; and (vi) electronic document libraries provided access to the license application and its references, including all the DOE responses to NRC RAIs. In addition, certain aspects of the regulations and guidance improved the efficiency of the review by providing a risk-informed, performance-based approach that focused the review on those attributes of the repository commensurate with the safety significance.

Based on the lessons learned, the following recommendations are made: (i) regular all-hands meetings are useful for ensuring consistent understanding of schedules and expectations for the SER, and for discussion of generic issues; (ii) chapter review team meetings are useful for sharing technical information and discussion of chapter issues; (iii) all-hands meetings are useful for ensuring a common understanding of facility performance and providing opportunities to discuss and clarify repository performance characteristics; (iv) the review plan should provide flexibility in implementing a risk-informed, performance-based approach, as appropriate; (v) early in the SER development process, it is useful to consider how the order and format of the SER affects clarity and readability; (vi) dedicated information technology support is needed for control and maintenance of a SharePoint type framework to ensure continued availability of the SER documents to staff; and (vii) dedicated information technology support is needed for control and maintenance of electronic document libraries to ensure continued availability of documents to staff.

Table 1 presents key aspects of the lessons learned and recommendations for SER development. The lessons learned and recommendations documented in this report are provided as information for NRC staff and managers of future review projects. Many of the conclusions in this report are not specific to review of a deep geologic repository. The lessons learned and recommendations have applications in other types of review activities.

Table 1 Lessons learned and recommendations based on the SER development.

Topic #	SER Development Topics	Lessons Learned	Recommendations
1 (process)	Project management	Good communication across all levels to assist in early identification of issues to management, timely resolution of issues, and understanding and agreement for schedule and expectations	All-hands meetings should be held on a regular basis to ensure common understanding and discuss generic issues
2 (process)	Integration of contributions from multiple authors	Chapter champions used to integrate inputs and lead discussions in resolving issues	Chapter champion should have strong writing and communication skills; should hold regular chapter meetings to share information and discuss chapter issues
3 (guidance)	Focused review	Risk-informed, performance-based regulations and guidance help focus safety reviews on repository characteristics with safety significance	All-hands meetings should be held to ensure common understanding of facility performance; the review plan should provide flexibility in implementing a risk-informed, performance-based approach
4 (guidance)	Clarity of the SER	Order and format affects the clarity and readability of the SER	Early in the process, it is useful to consider how the order and format of the SER affects clarity and readability
5 (tools)	SER development by many authors over varied locations	SharePoint framework ensured timely access for authors and reviewers to the SER	Dedicated information technology support is needed for control and maintenance of a SharePoint type framework to ensure continued availability of SER documents to staff
6 (tools)	Access to the License Application and its references	Electronic document libraries (e.g., ADAMS) ensured timely access to documents	Dedicated information technology support is needed for control and maintenance of electronic document libraries to ensure continued availability to staff