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TRW

TRW Environmental
Safety Systems Inc.

Management Plan for the Development of a Viability Assessment Document

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Civilian Radioactive Waste Management System

Management & Operating Contractor

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Duke Engineering & Services, Inc.
Fluor Daniel, Inc.
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Sandia National Laboratories
TRW Environmental Safety Systems Inc.
Woodward-Clyde Federal Services
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U.S. Geological Survey

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Management & Operating Contractor

Management Plan for the Development of a Viability Assessment Document

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Management Plan for the Development of a License Application

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1. INTRODUCTION

The Energy and Water Development Appropriations Act, 1997 (U.S. Congress 1996), requires the DOE to complete a viability assessment by September 30, 1998. The viability assessment will identify the remaining significant technical questions regarding the Yucca Mountain site. The viability assessment will include preliminary design concepts for the repository and waste package; an evaluation of the potential performance of the repository in the geologic setting of the mountain; a description and cost estimate of the remaining work needed to prepare a license application; and an updated estimate of the cost of licensing, constructing, and operating a repository of the specified design. The viability assessment also supports the preparation of a site recommendation to the President by the Secretary of Energy, if the site is found to be suitable, and the license application to the NRC.

2. SCOPE OF THE VIABILITY ASSESSMENT DOCUMENT MANAGEMENT PLAN

The scope of this Management Plan is to provide guidance for the development of the Viability Assessment Document. This Management Plan also is intended to assist and guide the Viability Assessment Document authors and support authors during the development of the Viability Assessment Document sections. Specific objectives of this Management Plan include:

- Establish the content and format of the Viability Assessment Document in the form of an annotated outline (Appendix A–Viability Assessment Document Annotated Outline).
- Identify the key staff responsible for preparation of the Viability Assessment Document (Subsection 3.1–Key Staff and Responsibilities).
- Describe the management controls implemented to ensure the Viability Assessment Document, including all technical and acceptance reviews, is completed on schedule (Subsection 3.1–Key Staff and Responsibilities).
- Explain the process to be used by the authors of the Viability Assessment Document to obtain needed information for the Viability Assessment Document (Subsection 3.1–Key Staff and Responsibilities).
- Provide an approved process and procedural guidance for the various stages of the Viability Assessment Document development, including DOE and Civilian Radioactive Waste Management System Management and Operating Contractor (CRWMS M&O) review and comment resolution (Subsection 3.3–Document Review and Comment Resolution).
- Provide a description of the quality assurance (QA) controls used in the preparation of the Viability Assessment Document (Subsection 3.4–QA).
- Provide a description of the Viability Assessment Document preparation and technical review schedule consistent with the 1998 detailed activity schedule (Section 4–Schedule and Milestones).

- Specify the Viability Assessment Document-associated records to be captured and retained in the Mined Geologic Disposal System (MGDS) CRWMS M&O system (Section 5–Records).

Changes to the content of this Plan may be made at the direction of the Manger, Systems Engineering & Integration.

3. VIABILITY ASSESSMENT DOCUMENT DEVELOPMENT

The development of the Viability Assessment Document involves organizing information acquired by the Yucca Mountain Project into a format prescribed by the Viability Assessment Document Annotated Outline (Appendix A).

3.1 KEY STAFF AND RESPONSIBILITIES

The responsibilities of key individuals and organizations involved in the Viability Assessment Document development process are outlined below. Support Authors are identified in Appendix B. This section also provides a description of the management controls implemented to ensure the Viability Assessment Document, including all technical and acceptance reviews, is completed on schedule.

Responsibility Matrix

Activity	Responsibility
Viability Assessment Document Development Lead	Jerry King
Viability Assessment Document Lead Authors	Volume 1: Jerry King Volume 2: Bruce Stanley Volume 3: Robert Andrews Volume 4: Jeff Weaver Volume 5: Robert Sweeney
Document Management and Integration Lead	Steve Fogdall
Technical Publications Management	Sharon Barkin
Training Department	Cindy Sellards
Institutional Integration	Larna Brown
DOE Responsible Leads	Overall VA Document : Tim Sullivan Volume 1: Carol Hanlon (Robert Levich-Site Description) Volume 2: Dan Kane Volume 3: Mark Tynan Volume 4: Carol Hanlon Volume 5: Mitch Brodsky

3.1.1 CRWMS M&O Viability Assessment Document Development Lead

The CRWMS M&O Viability Assessment Document Development Lead is responsible fr day-to-day coordination of CRWMS M&O activities associated with the Viability Asses Document development. The CRWMS M&O Viability Assessment Document Development Lead is responsible for the Viability Assessment Document development process and for providing periodic status updates to DOE and CRWMS M&O management. The CRWMS M&O Viability Assessment Document Development Lead is directly responsible for the development and implementation of the Viability Assessment Document Management Plan.

The CRWMS M&O Viability Assessment Document Development Lead's responsibilities include:

- Serve as the primary interface between the CRWMS M&O and DOE for Viability Assessment Document development.
- Develop the Viability Assessment Document Management Plan.
- Assign Viability Assessment Document authors and establish input due dates.
- Track the Viability Assessment Document development process and provide Viability Assessment Document development status to DOE. The Viability Assessment Document development process is coordinated with the assigned DOE staff specified in the table above.
- Participate in reviews, meetings, and assist with resolution of comments (including CRWMS M&O and DOE in order to develop a coordinated document).
- Direct final consolidation and editing of the Viability Assessment Document prior to delivery to DOE.
- Create and maintain a fully dedicated room that will be used by all document developers to aid in integrating and scheduling.
- Create and submit required records in accordance with AP-17.1Q, *Record Source Responsibilities for Inclusionary Records.*

3.1.2 Viability Assessment Document Lead Authors

The Viability Assessment Document Lead Authors have the overall responsibility for ensuring that Viability Assessment Document chapters or sections are developed in a timely manner.

The Viability Assessment Document Lead Authors responsibilities include:

- Coordinate development of Viability Assessment Document text, coordinate infor reviews, and resolve comments for the Viability Assessment Document.

- Ensure consistency in writing style and that all references in the document follow the requirements specified in Appendix C. The lead author will verify that all references provided in the document are accurate.

- Conduct the combined M&O/YMSCO review of the document using NAP-MG-012 *Development of MGDS Technical Documents Not Subject to QARD Requirements*, as defined in section 3.3.2.

- Submit the completed Viability Assessment Document volumes to the CRWMS M&O Viability Assessment Document Development Lead in accordance with the established Yucca Mountain Project schedule.

- Provide status information as requested by the CRWMS M&O Viability Assessment Document Development Lead.

- Keep the CRWMS M&O Viability Assessment Document Development Lead informed of problems impacting the deliverable due dates.

- Meet bi-weekly with the applicable DOE responsible staff member.

3.1.3 Viability Assessment Document Support Authors

The Viability Assessment Document support authors are responsible for developing Viability Assessment Document chapters and sections. They are responsible for the technical content and schedule of the assigned Viability Assessment Document chapters or sections.

Viability Assessment Document support author responsibilities include:

- Develop Viability Assessment Document text as assigned, coordinate informal reviews, and resolve comments for assigned sections.

- Submit completed Viability Assessment Document sections to the Viability Assessment Document Lead Authors in accordance with the established Yucca Mountain Project schedule.

- Ensue that all references in the document follow the requirements specified in Appendix C.

- Provide status information as requested by the Viability Assessment Document Lead Authors.

- Initiate a working reference list to track and manage the documentary material that will be used and cited in the Viability Assessment Document. This working reference list will be available to the Document Management & Integration Lead at the time the M&O/Yucca Mountain Site Characterization Office (YMSCO) review is started, and will become the reference list for the Viability Assessment Document.

- Commence establishment of the documentation necessary for a records package when the text of the document is first drafted. This documentation must be available to the Document Management & Integration Lead at the time the M&O/YMSCO review started.

3.1.4 Document Management and Integration Lead

The Document Management and Integration Lead will provide two types of support staff who will be responsible for providing the following support to the Viability Assessment Document Support Authors. A document management specialist will provide management of documentary materials, assistance in assembling and managing a records package, and support the Viability Assessment Document Development Lead in interacting between the authors and various support organizations relative to preparing the document. Later, when the document is to be placed in an electronic environment that provides access to the document from the Intranet/Internet, the document management specialist will ensure the conversion of the document occurs and that hypertext linking to the documentary material is accomplished. A second staff member is a web document technician who, under the direction of the document management specialist, will assist in the management of documentary materials, management of any electronic files, and later perform the electronic conversion of the document, including establishing the hypertext links to documentary material.

3.1.5 Document Reviewers

The responsibilities of the Viability Assessment Document reviewers are defined in NAP-MG-012 *Development of MGDS Technical Documents Not Subject to QARD Requirements*. Reviewers can be either CRWMS M&O staff or U.S. Department of Energy (DOE) team leads, or other DOE personnel as assigned by the DOE team leads. The DOE team leads will be involved in the M&O/YMSCO review of the document before it is submitted to DOE for a QAP 6.2 acceptance review. Document reviewer responsibilities include:

- Provide review comments.
- Provide specific recommendations for comment resolution.
- Identify errors in the documents, as well as indicating where additional information is required or desirable.

3.1.6 DOE Team Leads

DOE team leads will work with the CRWMS M&O in drafting, reviewing, and approving these documents. DOE and the CRWMS M&O collectively do planning for the documents by conceptualizing the purpose of the documents, and the information that should be presented in the documents. The CRWMS M&O prepares the draft of the documents, DOE team leads and the CRWMS M&O review the draft of the documents, the CRWMS M&O revises the draf documents to address review comments. DOE will review the final document using a QAP *Document Review* process and then issue it as a DOE document.

3.2 DOCUMENT PREPARATION

The Viability Assessment Document is developed by the CRWMS M&O as an M&O document using NAP-MG-012 *Development of MGDS Technical Documents Not Subject to QARD Requirements.*

The Viability Assessment Document authors begin by understanding the purpose and strategy of the Viability Assessment Document Management Plan, and conceptualizing the layout of the respective sections in accordance with guidance provided in this Management Plan and drafting the document text. Data to be displayed in figures and tables are identified and developed. Strategy for developing the document has been established by numerous management oversight groups such as the Viability Assessment Integration Group, the M&O Operations Managers team, and the Program Review Group.

The authors begin to write proposed text, building upon a planning framework. The authors use the Viability Assessment Document Annotated Outline (Appendix A to this Management Plan) for guidance, and the Viability Assessment Writers Guide (Appendix C) for consistency.

The Viability Assessment Document will be structured and written in "layers" aimed principally, but not exclusively, at different audiences. The executive summary of the document and the overviews and summaries of the individual volumes will be written for a non-technical, lay audience. These parts will avoid the use of technical jargon and will rely heavily on visual explanations. The main text of the document will be written for a more expert audience (including the Nuclear Regulatory Commission and the Nuclear Waste Technical Review Board) but will be structured and written so that a nonexpert audience, with some effort and diligence, can understand it. If required, appendices with technical details may be written for an expert audience.

3.3 DOCUMENT REVIEW AND COMMENT RESOLUTION

Subsection 3.1.5 defines the responsibilities of the CRWMS M&O and DOE reviewers. The draft Viability Assessment Document is reviewed by DOE and the M&O using the review process specified in NAP-MG-012 *Development of MGDS Technical Documents Not Subject to QARD Requirements.*

3.3.1 Document In-Process Reviews

It is expected that the Viability Assessment Document lead and support authors will obtain internal reviews of their respective Viability Assessment Document sections during the writing process. These reviews should verify the technical accuracy of the document, as well as the correctness of the content and format per the Viability Assessment Document Annotated Outline. In addition, CRWMS M&O management will review Viability Assessment Document sections informally.

3.3.2 CRWMS M&O/YMSCO Review

This review is conducted by selected M&O and DOE YMSCO staff. Nevada Site Administrative Line Procedure NAP-MG-012 *Development of MGDS Technical Documents Not Subject to QARD Requirements* is used. Reviewers are chosen by CRWMS M&O and YMSCO management based on qualifications and technical competence in the subject area.

The cognizant Viability Assessment Document lead author transmits draft text to identified CRWMS M&O groups for review. The following review criteria are used to determine the acceptability of the draft Viability Assessment Document text:

- Is the information contained in the document correct?
- Is the Viability Assessment Document easily understood, or could it be clarified or reorganized into a more consistent, logical order?
- Is the level of detail and use of terminology appropriate for the intended audience?
- Is the overall presentation of the information clear, is the information presented complete, and does the information make strategic sense?
- Are all supporting details necessary and sufficient?
- Do the graphics (maps, tables, graphs, etc.) specify the minimum information required?
- Are Viability Assessment Document input sources appropriate, current, correct, and usable?
- Are the data presented clearly so an outside reviewer can reach an independent conclusion?
- Are all assumptions used in the development of the Viability Assessment Document stated explicitly? Are they reasonable?
- Are units of measure consistent, compatible, and appropriate?
- Do existing regulatory or other external commitments affect the Viability Assessment Document content and is the Viability Assessment Document consistent with such commitments?
- If the Viability Assessment Document makes any commitment or addresses a topic of regulatory interest, is it consistent with the Office of Civilian Radioactive Waste Management policy?
- Are there any contradictions between the Viability Assessment Document, DOE orders, regulatory requirements, or commitments?

Reviews will be initiated by having a meeting for the reviewers which explains the purpose of the review, the review criteria, and the structure of the document being reviewed. All comments from reviewers will be collected by selected M&O and DOE department heads so that there is consistency in the comments going to the M&O for resolution. Reviewers may be requested to attend one or more comment resolution meetings where all comments are resolved.

Selected senior CRWMS M&O personnel will review all volumes of the Viability Assessment Document. To facilitate these comprehensive reviews, the time windows for the CRWMS M&O/YMSCO reviews of the different volumes of the Viability Assessment Document have been staggered; see Appendix B.

3.3.3 DOE Review

The DOE will review both the draft sections of the Viability Assessment Document prepared by the CRWMS M&O during the combined M&O/YMSCO review specified in section 3.3.2, and the completed document during the QAP 6.2 acceptance review. This QAP 6.2 review will include DOE Headquarters staff. DOE may use the same review criteria as specified in Subsection 3.3.2 above for the draft sections. After the M&O submits the Viability Assessment Document to DOE, DOE coordinates the distribution of documents for review and comment within the DOE and organizations outside the CRWMS M&O structure, except when DOE delegates this responsibility to the CRWMS M&O. Concurrent with the QAP 6.2 review and comment resolution, a YAP-30.12 publications review of the document will be completed before the document is submitted to DOE for acceptance and approval in accordance with YAP-5.1Q.

3.3.4 MGDS-VA Life Cycle Cost Estimate External Review Process

The DOE selected Foster Wheeler Environmental Corporation to provide the external review team for the MGDS-VA Life Cycle Cost Estimate. The review will be accomplished in parts. Each review part/session will be preceded by an M&O orientation briefing, which will familiarize the external review team with the cost estimate structure and the specific review session data. The orientation briefings will be designed to provide easy navigational guidelines through the cost documentation. Data books will be forwarded to the reviewing personnel during the briefings and interface contacts will be identified. External cost review personnel will interface with the MGDS cost integration manager, who will call for additional support as needed. This external cost review will be conducted per a schedule that will not interfere with production of the Viability Assessment Document.

3.4 QUALITY ASSURANCE

This section describes the Quality Assurance controls used in the preparation of the Viability Assessment Document. An evaluation of this activity was performed using QAP-2-0, *Conduct of Activities*, and writing the Viability Assessment Document has been determined to not be subject to Quality Assurance Requirements Document controls because it is an information document, and a description of work planned to be performed. The Viability Assessment Document Management Plan specifies the process to be used for document preparation, reviews, and records retention. Although the Viability Assessment Document is not important to safety or waste isolation, it will be prepared using sound Quality Assurance principles.

4. SCHEDULES AND MILESTONES

A detailed schedule for development and review of the Viability Assessment Document is contained in Appendix B, as is a matrix defining the support authors and schedules for the various sections.

5. RECORDS

Viability Assessment Document-related records will be submitted to the Records Processing Center as Program records, in accordance with AP-17.1Q. Additionally, Paragraph 5.7.4 of AP-17.1Q specifies that a record source is to submit a list of references to the Records Processing Center and to the Technical Information Center. The Technical Information Center will obtain copies of documents that are not Office of Civilian Radioactive Waste Management records to be included in the Technical Information Center collection.

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VOLUME 1

EXECUTIVE SUMMARY, INTRODUCTION AND SITE DESCRIPTION

EXECUTIVE SUMMARY

The executive summary will be a high-level summary of the Viability Assessment Document. It will be written for a lay audience with no technical expertise and little or no familiarity with the Yucca Mountain Project. Professionally designed graphics will be used liberally to help describe: 1) the history of the repository site-selection process and the governing statutes and regulations, 2) the features of the site and the Yucca Mountain geologic setting that are important to repository design and performance, 3) the preliminary design concepts for the critical elements of the proposed repository and waste package, 4) the probable behavior of the repository in the Yucca Mountain geologic setting relative to overall system performance measures, 5) the remaining work required to complete a license application and the associated costs, and 6) the estimated costs to construct and operate the repository in accordance with the design concepts.

The executive summary will describe the geologic setting and repository design in enough detail to explain to the reader what the repository is and how it is going to protect public health and safety during the period of operations and for the long term.

The executive summary will illustrate the planned capacity of the proposed repository, the estimated potential for expanding the statutory capacity, the existing quantities of spent nuclear fuel and high-level radioactive waste as of 1998, and the amount of additional waste projected to be produced by U. S. nuclear defense activities and civilian nuclear power reactors as functions of time. Waste forms other than spent nuclear fuel and high-level radioactive waste being considered for disposal at Yucca Mountain, and their estimated quantities, will be identified.

The bulk of the Viability Assessment Document necessarily will be based on information available at the beginning of calendar year 1998. To make the document as current as possible, the executive summary will include an epilogue. The epilogue will describe any important, late-breaking programmatic developments, including, as appropriate, testing results, performance assessment results, design changes, and changes in system standards or requirements.

The executive summary will be bound into Volume 1 of the VA Document, but it will also be designed and prepared to be published as a stand-alone document. Footnotes and references will be included to provide traceability and enhance credibility.

OVERVIEW

This section provides an executive-summary-level description of the Introduction and Site Description in this volume of the VA Document. (It differs from the Executive Summary, above, which is for the entire VA Document.)

1.1. INTRODUCTION TO THE VIABILITY ASSESSMENT

1.1.1 SCOPE AND OBJECTIVES OF THE VIABILITY ASSESSMENT

This section will describe the scope and objectives of the Viability Assessment Document, pursuant to the Energy and Water Development Appropriations Act, 1997.

1.1.2 HISTORICAL PERSPECTIVE

This section will briefly describe the history of the civilian radioactive waste management program, including a chronology of the nationwide site identification and selection process, beginning with the 1957 National Academy of Sciences report which suggested underground disposal. The provisions of the Nuclear Waste Policy Act of 1982 and the Nuclear Waste Policy Amendments Act of 1987, with respect to site selection, will be highlighted. The history of Yucca Mountain as a candidate site will be reviewed. This history will include the development by the U. S. Geological Survey of the concept of unsaturated zone disposal and the Survey's recommendation that the Department of Energy consider unsaturated zone disposal at Yucca Mountain.

1.1.3 STATUTORY AND REGULATORY REQUIREMENTS

This section will review the key statutes and regulations that govern the siting, recommendation, licensing, operation, and decommissioning of a repository at Yucca Mountain. The key provisions of the Nuclear Waste Policy Act of 1982, the Nuclear Waste Policy Amendments Act of 1987, and the Energy Policy Act of 1992 will be described. The requirement by the latter that the Environmental Protection Agency promulgate a new health-based standard for Yucca Mountain will be specifically noted, with reference to the National Academy of Science's report on Yucca Mountain standards that Congress requested. This section will review the licensing requirements and process established by the Nuclear Regulatory Commission's regulation, 10 CFR Part 60, *Disposal of High-Level Radioactive Waste in Geologic Repositories*. It will note the latest revision to 10 CFR Part 60, which requires the Department to identify internal and external design basis events. This section will summarize the Department of Energy's general guidelines in 10 CFR Part 960 for recommending repository sites and will provide the status of the Department's proposed rulemaking to update the siting guidelines.

This section will note that the governing statutes and regulations provide for a multi-stage repository development and decision-making process based on the availability of increasingly detailed and complete information about the geologic setting, the design of the repository and waste packages, and the probable long-term behavior of the repository and waste packages in the geologic setting. The location in time of the Viability Assessment will be shown in a timeline that depicts the current schedule for the Environmental Impact Statement, site recommendation, site designation, NRC licensing, construction, waste-emplacement, monitoring, and closure.

1.1.4 SITE CHARACTERIZATION PROCESS

This section will describe the iterative testing-design-performance assessment process that the DOE has employed to investigate the Yucca Mountain site, develop the preliminary design concepts for the repository and waste package, and evaluate the probable behavior of the repository in the Yucca Mountain geologic setting. This process began with reconnaissance-level geologic information about Yucca Mountain and the proposition by the U. S. Geological Survey that the thick unsaturated zone at Yucca Mountain might provide a very favorable environment for deep geologic disposal because of the possibility that waste emplaced in the unsaturated zone would have limited contact with ground water. Following this process, the DOE has explored different design concepts and has conducted several total system performance assessments, each informed by additional information from the materials testing and site investigation programs. This section will provide a figure that illustrates the iterative testing-design-performance assessment process.

The Viability Assessment represents the next-to-last step, before submittal of a license application, in the iteration of testing, design, and performance assessment. The results of site investigations, design work, and performance assessments conducted to date are summarized in Volumes 1, 2, and 3 of this document, respectively. The remaining work to complete the license application is described in Volume 4. As detailed there, this will involve completion of remaining tests, evaluation of design options and major design alternatives, work to develop the level of detail in the design that is required for the license application, and preparation of the total system performance assessment for the license application. Following submittal of the application, design work will continue, to develop the level of detail in the design that is necessary to begin construction. This post-application design work will be supported by limited, site-specific site investigations (such as geotechnical testing of foundation materials). Confirmatory testing and analysis, as called for by the performance confirmation program, will also be conducted post-application and, if the repository is constructed, will continue until the repository is permanently closed.

This section will refer forward to the License Application Plan for the details of the remaining testing, design, and performance assessment work that will support submittal of the license application. However, because construction of the preclosure safety case and postclosure safety case is the foremost objective of the remaining work and is guiding the next step in the

testing-design-performance process, this introductory section will briefly discuss the bases of the postclosure safety case and preclosure safety case that the DOE is attempting to build. It will also outline the repository safety strategy and how the DOE is using the strategy to develop the postclosure safety case.

Next, this section will identify the "Key Technical Issues" that the NRC staff regards as being the topics that are most critical to repository performance. It will note the DOE and the NRC staff are working to resolve these issues during the prelicensing phase and will refer forward to Vol. 4 for a description of the issue resolution process. It will note that the DOE uses the Key Technical Issues as a completeness check on work related to the long-term performance of the repository to help assure that the work is sufficient to support a successful license application.

Finally, this section will explain that the testing-design-performance assessment process, the repository safety strategy, development of the postclosure safety case, development of the preclosure safety case, and the NRC staff's Key Technical Issues are a unifying set of "discussion threads" that are referred to throughout the VA Document.

1.2. SITE DESCRIPTION

1.2.1 INTRODUCTION

1.2.1.1 Scope and Objectives

This section will briefly review the scope of the Project's site characterization program in meeting requirements of 10 CFR 60. The broad objectives of the program will be described.

1.2.1.2 Site Program Overview

This section will reference the Site Characterization Plan and note that the planned studies have evolved in response to new findings and increased understanding of the site. The overview will include a description of the roles of the U.S. Geological Survey, the national labs, and other organizations. The section will note that the Project's understanding of the geologic setting of Yucca Mountain is based on more than ten years of site investigations.

1.2.2 LOCATION, LAND OWNERSHIP, POPULATION DENSITY, OFFSITE INSTALLATIONS, AND TRANSPORTATION SYSTEMS

This section will describe the geography and demography of the Yucca Mountain site. The section will describe the basis for defining the boundaries of the site and show the relation of the site to man-made and natural features. The section will describe the distribution of population in the vicinity of the site and the reasons for the observed distribution. The

locations of offsite industrial, military, and transportation facilities will also be discussed to provide a basis for evaluating hazards from these facilities.

1.2.3 GEOLOGIC SETTING OF YUCCA MOUNTAIN

This section will summarize the important attributes and processes of the natural system at Yucca Mountain and in the surrounding region. These natural-system attributes and processes will be related to the repository safety strategy and its four key attributes of an unsaturated repository system and its consideration of potential disruptive processes and events, with a forward reference to Volume 4 for the details. The natural-system attributes and processes will also be related to the Principal Factors in Expected Repository Performance, as identified in Volume 3. How the attributes and processes correlate with the Key Technical Issues of the NRC staff will also be noted.

1.2.3.1 Geology

This section will describe the regional geologic and tectonic framework of Yucca Mountain to provide a basis for understanding and interpreting local observations. It will discuss site stratigraphy, structure, and rock properties to demonstrate that an adequate volume of rock exists in which to locate a repository and to establish the setting for hydrologic flow and transport process models. The discussion of geology will note the potential expansion areas for the repository. This section also will discuss volcanic and seismic hazards and their potential to disrupt a repository, natural resources and the relative likelihood that Yucca Mountain will become a site for future resource exploration, and the potential for surficial processes to cause severe erosion.

1.2.3.2 Climatology and Meteorology

This section will describe the climatological and meteorological setting and history of the site, to elucidate the range of future climate parameters that can be expected. It will describe the present climate and meteorology as they relate to infiltration and to preclosure design issues such as atmospheric dispersion processes. Quaternary climate change will be examined to provide insight into climates that may occur in the future.

1.2.3.3 Hydrology

This section will describe the hydrologic system to provide the setting for the description of the engineered barrier system in Volume 2 and to characterize flow paths between the site and the accessible environment. It will discuss surface water hydrology as it relates to understanding the overall hydrologic system, preclosure design issues such as flooding potential, and future water use. It will describe regional flow paths to provide a framework for understanding the local hydrologic conditions at the site and between the site and the accessible environment. Site flow models for the unsaturated zone and saturated zone will

integrate information on the stratigraphy, structure, rock properties, and observed hydrologic parameters to demonstrate an understanding of the site's hydrology.

1.2.3.4 Geochemistry

This section will characterize the geochemical system of the site and surrounding region with respect to the ambient environment for the engineered barrier system and impacts on the transport of radionuclides. Geochemical attributes to be discussed include the mineralogy and petrology of site rocks, the geochemistry of ground water and gas, and geochemical results governing radionuclide mobility. Health-related mineral issues will also be addressed.

1.2.4 INTEGRATED THERMAL SYSTEM RESPONSE

This section will describe the anticipated response of the natural system to thermal loading associated with waste emplacement. The description will include the geomechanical, hydrological, and geochemical aspects of the response for the near-field and altered zone.

1.2.5 SUMMARY

This section will provide a brief summary of the results of the site characterization program as they relate to the postclosure repository safety strategy and the preclosure and postclosure safety cases. Plans for additional testing between the viability assessment and the license application will be briefly noted, with appropriate reference to the License Application Plan (Volume 4) for detailed discussion.

APPENDIX 1A. GLOSSARY

This appendix is a glossary of technical and other special terms used in this volume of the Viability Assessment Document.

APPENDIX 1B. ACRONYMS, ABBREVIATIONS, AND SYMBOLS

This appendix lists and defines acronyms, abbreviations, and symbols used in this volume of the VA Document.

APPENDIX 1C. REFERENCES

This appendix provides the reference information for this volume of the VA Document. In addition to a full bibliographic citation for each reference, it provides a Records Information System accession number, Technical Information Center catalog number, or Data Tracking Number, as applicable, for every reference.

VOLUME 2

PRELIMINARY DESIGN CONCEPT FOR THE REPOSITORY AND WASTE PACKAGE

OVERVIEW

This section provides an executive-summary-level description of the material in this volume. All major aspects and critical elements of design are described, along with a high-level description of design development, construction and operations.

2.1. INTRODUCTION

This section provides a general lead-in that sets the stage for Volume 2. It is anticipated that this Volume will be 200-300 pages in length. It includes the scope and objectives and a brief description of the critical elements of the repository and waste package design.

2.1.1 SCOPE AND OBJECTIVES

This section describes the intent of the document and provides the reader with an understanding of what he will learn from reading it. The section describes the extent of completeness and notes that the level of detail of design of different design items is different for items in different "bins," as discussed in the next subsection.

2.1.2 CRITICAL ELEMENTS OF REPOSITORY AND WASTE PACKAGE DESIGN

This section identifies the critical elements of the repository and waste package design. It introduces the binning process and very briefly describes the roles of the repository and waste package in the repository safety strategy and the postclosure and preclosure safety cases. It will identify the major areas that were emphasized during VA design for TSPA input and cost estimating, and that are necessary for completeness of presentation to show an integrated systems engineering approach.

2.2. DESIGN PROCESS

2.2.1 GENERAL DESIGN PROCESS

This section presents the process used by design in developing and selecting technical alternatives and options in the engineering process. A general description of the integrated process is given, which addresses the interdependence of site investigation, design and

performance assessment. This description also includes mention of the review process for design, including the roles of the Consulting Board and other independent reviewers. Some attention is also given to the configuration management of the design products and design input.

A brief discussion is provided on historical alternatives and their solutions that appear in previous design phases such as the Advanced Conceptual Design (ACD). The reader is directed to the ACD report for more detail. The description continues to outline flow of design development from VA to LA, dealing specifically with the methods for consideration of design alternatives (e.g., thermal loading, waste package design and materials), and the plans for selecting the preferred design and documenting that process of selection. Forward references are provided to Section 2.5.4 for descriptions of EBS design options and to Section 2.8 for descriptions of major design alternatives. Post-LA design phases will be briefly described.

This section notes that the design being presented was developed under an NRC approved quality assurance (QA) program and key QA requirements that are applied in the design process.

This section also identifies the design issues that are tracked for resolution during the Viability Assessment design phase. Each issue is described, along with an explanation of significance, interfaces, effects on Viability Assessment, ties to Total System Performance Assessment, the MGDS cost estimate and License Application planning, and finally the status and results of closure for the Viability Assessment. A summary of each issue resolution is captured in this section, and, where appropriate, pointers are given to indicate where these results are reflected in the design product documentation.

2.2.2 NUCLEAR SAFETY ANALYSES

This section will lay the framework for what items are important to preclosure radiological safety and waste isolation based on the analyses to date, and what parameters are key to these determinations. The determinations made to date will be summarized, and analytical results will be listed as they apply to major design systems for VA. This section will list design basis events and discuss the systematic approach used to identify the same. It will discuss the results of analyses of the design basis events and the associated consequences. It will reference Section 4.3.2 for a description of the remaining work in this area before submittal of a license application.

2.2.3 DESIGN PRIORITIZATION

A description of the methods used to prioritize design is presented. The binning process is outlined, with explanation and examples of the reasoning and results. Rationale is given for the prioritization of work based on the resulting bin category of the systems being designed,

along with the influence from other project sectors to provide needed information to modeling, reports, and other designs. Each bin is defined in terms of impact to radiological safety or importance to waste isolation, and to the time-phased degree of detail to be expected for the design of systems falling within that category.

2.3. DESIGN BASES

This section describes the bases for the MGDS design. It includes the driving requirements, primary assumptions, and specific allocated functions.

2.3.1 DRIVING REQUIREMENTS

This section identifies the technical baseline requirements that were met in the design of the MGDS for Viability Assessment. These include the project Level II baseline controlled requirements as well as the various codes, standards, government orders and regulatory guidance. The project level requirements documents are the Repository Design Requirements Document and the Engineered Barrier Design Requirements Document. These requirements documents include design, operation, and decommissioning requirements to the extent that they impact the physical development of the repository. The basis for each of these requirements has been documented in the records package material for each of these requirements. The interfaces between other CRWMS Projects are also included in these baseline documents. During the course of the design development, these requirements documents have been interpreted, updated, and supported with an M&O controlled assumptions document. These requirements also support the MGDS level functions at both the Repository and Engineer Barrier levels.

2.3.2 PRIMARY ASSUMPTIONS

This section identifies and describes the "major" and non-major assumptions used in the development of the MGDS Viability Assessment design. The basis for each assumption will be provided as well as the approach to substantiate each assumption. The relationship between each assumption and the Viability Assessment Issues are also identified.

The top-level project assumptions used for the MGDS Viability Assessment design were documented and controlled in the M&O's Controlled Design Assumptions (CDA) document. This document contains the high level Key Assumptions that impact multiple areas of the design. In addition, it includes assumptions to interpret, modify and supplement technical baseline requirements, provide quantified values for technical data and to identify design concepts for surface, subsurface and waste package designs to assure a completely integrated disposal system. Each of the Viability Assessment issues is summarized in this document and the reference concept as well as all selected alternative concepts are supported by the Controlled Design Assumptions document.

2.3.3 ALLOCATED POSTCLOSURE FUNCTIONS

This section identifies and describes the functions that the MGDS must perform to successfully contain and isolate waste from the accessible environment. This section further identifies the relationship of parent and sibling functions and their allocation to the physical system. The basis for each function and allocation will be provided.

Functional analyses have been performed for both the CRWMS Program level and the MGDS Project level elements. The functional analysis for the MGDS provides a decomposition of repository and waste package functions and the allocation of these functions to a physical architecture. This leads to the development of requirements captured in the Project baselined requirements documents or the System Description Documents in the case of lower level requirements. A concise description, the identification of input and output interfaces, and an allocation to the physical architecture is provided for each function at each of the respective system element levels.

2.3.4 PRECLOSURE GOALS AND OBJECTIVES

This Section will state the goals and objectives of the Preclosure Radiological Safety program. This discussion will tie in the 10 CFR 60.136, *Preclosure Controlled Area*, and 10 CFR 20, *Standards for Protection Against Radiation*, criteria for Preclosure Radiological Safety (these should be the items important to the health and safety of the public and workers). The reader will be given enough information to understand how the overall design responds to these goals.

2.3.5 SITE CHARACTERISTICS

This Section describes the site in sufficient detail to provide the reader a general understanding of the site and what, if any, influence or impact it has on the design. The author will recognize that a more detailed site description is included in Volume 1. The design will demonstrate integration with the site's geologic and environmental features presented in this section. This includes the general setting, physical characteristics, meteorology, stratigraphy, and structural geology.

2.3.6 PHYSICAL DATA

This section generally describes the physical data used in MGDS design and identifies the sources of the data. Those site data which have significant influence on the design will be noted in this section. This section is not intended to be a recitation of the Reference Information Base (RIB) or Technical Data Base. Much of the numerical information utilized in the Viability Assessment design process is captured in the *Controlled Design Assumptions* document, and may appear in Section 3.3.2. Repetition will be minimized as practical by cross-reference.

2.4. REPOSITORY DESIGN

This section describes the repository design in sufficient detail to provide the reader a general understanding of the repository and how the design addresses the various design requirements. This includes physical data used, repository surface facilities, repository subsurface facilities, and closure and decommissioning issues. A point is made to state that the use of demonstrated technology for waste receipt and handling is utilized throughout the design.

Physical data utilized in the course of the design will be provided as appropriate. There will, however, be no overlap with Section 2.3, *Design Bases.*

Repository surface facility descriptions include an overall site plan with significant features called out. Text will describe the general nature of each feature. More significant features, such as the Waste Handling Building, will be described in greater detail. Mention is made of nuclear standards used in the design of certain SSCs classified as Bin 2 and 3 systems.

An overall repository subsurface layout is included, which has the major features of the subsurface called out. Each feature will be described and discussed. Overall descriptive information, including total area required, total length of tunneling, and total excavated volume and tonnage is provided.

The M&O has retained and interacted extensively with a panel of industry experts termed the "Repository Design Consulting Board." The Board has provided comments and insight into many areas of the design, including the underground excavation processes, the surface waste handling functions, the waste package design, and the waste package materials testing program. Where appropriate, this advice has been incorporated into subsequent design analyses and was utilized in the Viability Assessment design. Areas of significant Board input are discussed in this section.

2.4.1 REPOSITORY SURFACE FACILITIES

This section describes the operational areas, major facilities, and site support systems that comprise the Repository Surface Facility. Sufficient detail is provided to demonstrate that the design solutions satisfy the allocated requirements. A separate subsection for each major facility and system is provided. Appropriate figures are provided.

An introductory discussion centering on the overall site plan describes, in general terms, the significant features of the surface design. The radiologically controlled area (RCA), as well as Balance of Plant area, are called out in the site plan and generally described.

A more detailed discussion of significant facilities is provided, with each structure discussed in a separate subsection. The Waste Handling Building (WHB) is discussed in the most detail, as it is the largest and most complex surface structure. Other facilities, including the

Waste Treatment Building (WTB) and the Carrier Preparation Building (CPB), will be described to a level of detail commensurate with the design effort applied.

The Balance of Plant area will be described in overview terms. It has not been the focus of significant design effort. Discussion will be limited to the primary functions that will be provided.

2.4.2 REPOSITORY SUBSURFACE FACILITIES

This section describes the major elements of the Repository Subsurface Facilities and describes the major design considerations. Sufficient detail is provided to demonstrate that the design solutions satisfy the allocated requirements and that the subsurface facilities perform their allocated functions. A separate subsection for each major element and design consideration is provided. Appropriate figures are provided.

An introductory section, centered around a figure of the subsurface layout, defines the various features of the facility. Its total excavation requirements, length and duration of excavation and emplacement operations, and overall construction sequences are described.

The waste emplacement process is described, including interfaces with the surface WHB. The method of subsurface waste transportation is described, as well as the subsurface waste package transfer operation at the emplacement drift entrance. The method of emplacement using the gantry concept is also described.

The subsurface ventilation system is defined. Figures show the configuration of the system over the construction period, the period of simultaneous development and emplacement, and the caretaker period. The concept of two separate and independent flow networks, each with dedicated fans, is presented.

The repository ground control systems planned for both the main access drifts and the emplacement drifts are described. In the case of the emplacement drifts, two distinct systems are discussed, as there are multiple options still under consideration.

2.4.3 CLOSURE AND DECOMMISSIONING

This section describes closure and decommissioning activities. The process of decontamination and decommissioning of the surface facilities is discussed. The subsurface decommissioning process also is defined. Removal of non-permanent items, placement of backfill in the main drifts, and placement of seals and plugs in the ramps and shafts are discussed. Reclamation of site surface disturbances will be addressed conceptually.

2.5. ENGINEERED BARRIER SYSTEM DESIGN

This section describes the Engineered Barrier System design and the various components that comprise the Engineered Barrier System in sufficient detail to provide the reader a general understanding of the design and how it addresses the design requirements. This includes an overview of the Engineered Barrier System, waste package components and design, and Engineered Barrier System repository components and features, and testing programs for waste package materials and waste forms.

2.5.1 WASTE PACKAGE COMPONENTS AND DESIGN

This section describes the major components of waste packages and designs in sufficient detail to demonstrate how the design solutions satisfy the allocated requirements and how the waste packages perform their allocated functions. Major design considerations are discussed, including design basis events and design basis fuel. This section will address waste types (e.g., CSNF, Department of Energy SNF, Navy, HLW, and Pu). A separate subsection for each major waste package, its components, the design, and design consideration is provided. Appropriate figures are provided.

2.5.2 UNDERGROUND PORTION OF THE ENGINEERED BARRIERS SYSTEM DESIGN

This section describes the design of Engineered Barrier System components other than waste packages in sufficient detail to demonstrate how the design solutions satisfy the allocated requirements and how the underground barriers perform their allocated functions. These functions will be placed into the context of the repository safety strategy (which is briefly described in Volume 1 and detailed in Volume 4). A separate subsection for each major Engineered Barrier System component is provided. Appropriate figures are provided, along with text that specifically addresses release standards, either in the context of criteria or interim performance standards as appropriate.

The emplacement drift openings, in their capacity as engineered barriers, are discussed. Measures taken to preserve, or limit deterioration of, their properties as engineered barriers are discussed. Any features included specifically to enhance the performance of the barrier are defined.

The drift invert is the third portion of the underground facility portion of the Engineered Barrier System. The Viability Assessment design concept for the materials and configuration of the invert, and its interface with the Waste Package support pier and pedestal, are discussed.

2.5.3 WASTE PACKAGE MATERIALS AND WASTE FORMS TESTING PROGRAMS

This section describes the waste package materials and waste forms testing and modeling programs supporting the materials selection process, Engineered Barrier System development, and the performance analysis activities. A separate subsection for each major element of the program is provided. The discussions relate the testing programs to the Principal Factors in Expected Repository Performance (identified in Volume 3) and to the repository safety strategy. Results from the testing program are provided either in summary, reference, or both, to the extent to which results are available and interpreted for practical application.

2.5.4 ENGINEERED BARRIER SYSTEM DESIGN OPTIONS

Design options being evaluated to enhance the performance of the Engineered Barrier System include emplacement drift backfill; drip shields over the waste packages, with backfill; and ceramic coating of the waste packages, with backfill. This section discusses the process used to evaluate these specific design options with respect to their rôles in the repository safety strategy and, specifically, with respect to their capabilities to delay breaching of the waste package, slow the release of radioactive materials from the waste package, and retard the release of radioactive materials from the Engineered Barrier System. This section will include a forward reference to Section 3.3.3.3 for the PA implications of the design options.

This section specifically discusses how the Backfill Emplacement System would place backfill in the emplacement drifts, if backfill is required for waste isolation. This section discusses the backfill material, the equipment needed to prepare, transport, and emplace (stow) the backfill in the emplacement drifts, and the overall backfill operations. Discussion on the backfill operations covers design features such as remote handling control systems and operational measures such as drift cooling that would be necessary for dealing with heat and radioactivity in active emplacement drifts.

2.6. CONCEPTS FOR CONSTRUCTION AND OPERATION

This section describes the MGDS from a construction and operational perspective. An overview will be provided of the operational requirements and the integration of the requirements into the design and then the operation itself. The discussion will include the interactive process that will occur between the construction function and the operation function over 10 to 20 years of building while operating, and will describe the integration of the operation of newly built facilities into ongoing operations.

2.6.1 MGDS CONSTRUCTION

This section describes the principal activities required to construct the MGDS. Each major construction step is described in a separate subsection. Discussion continues to incorporate interactive process between construction and operation.

2.6.1.1 through 2.6.1.x Principal Activities in MGDS Construction

Each principal activity is identified and briefly described to provide a broad overview of construction phase components. Subsections of this chapter will be developed to describe the construction activities and sequencing for the MGDS construction. Descriptions will center on the systems that are defined for the MGDS, and will be presented individually and comprehensively to demonstrate some detail, and an overall construction sequence. Individual systems that require special construction activities will include generalized descriptions of those activities.

2.6.2 MGDS OPERATION

This section describes the principal activities required to operate the MGDS and covers both the surface and subsurface facilities. The surface facilities, located at the North Portal, include the rail terminal for receiving waste, the waste handling and waste treatment building, and offices, maintenance facilities, and associated structures necessary to operate the surface complex. The subsurface facilities include the underground openings, emplacement equipment, and control and monitoring systems for emplacement operations. The major operational step for the surface and subsurface facilities are described in a separate subsection. The subsurface description addresses the various pre-emplacement construction phases, emplacement, development operations that proceed concurrently with emplacement, monitoring and maintenance operations on completion of waste emplacement, retrieval, backfill, and closure. Discussion continues on the interactive processes between surface and subsurface operations, and operations and construction.

2.6.2.1 through 2.6.2.x Principal Activities in MGDS Operations

Each principal activity is identified and briefly described to provide a broad overview of operations phase components. Principal activities described in individual subsections may include: waste emplacement, waste retrieval, development interface activities, monitoring and control, backfill and closure. The organization of subsections will be developed to provide a clear and complete presentation.

2.7. DESIGN FLEXIBILITY CONSIDERATIONS

This section discusses the flexibility of the repository design. It demonstrates sensitivity to

potential changes in requirements or technical data by showing a plan that considers these potential changes. It addresses "what-if" situations that are unknown, but plausible.

2.7.1 CAPACITY

Spare Capacity - Unexpected geologic conditions could cause parts of the planned emplacement area to be unusable. Some contingency must be provided to account for this eventuality. The amount of planned contingency is defined, and its location shown.

Capacity changes - Though currently limited by statute to 70,000 MTU, the repository could ultimately be required to accommodate either more or less waste. Discussion and figures, as needed, are provided to show how the facility can adjust to these possibilities.

2.7.2 WASTE ACCEPTANCE RATE

Changes in Waste Acceptance Rate - The current 24-year emplacement schedule, with a gradual buildup from 300 MTU in year 1 to 3000 MTU in year 5, is the basis of the Viability Assessment design. The impact of changes to the basic schedule will be addressed qualitatively to indicate the impact to the system.

2.8. MAJOR ALTERNATIVES

This approximately 30-page section qualitatively describes major design alternatives that the DOE is evaluating. These major design alternatives may include smaller drift sizes, smaller waste packages, lower thermal loads, higher thermal loads, deferred closure, rod consolidation, engineered barrier system enhancements, and others. The alternatives to be discussed in this section are currently being selected, and will be available for author use at the time of text generation. A forward reference will be provided to the License Application Plan (Volume 4) for the plans for evaluating major design alternatives after the Viability Assessment and reaching closure before submittal of the license application. Rough cost estimates for the major design alternatives will be provided in a companion document, separate from this Viability Assessment Document, and will not be included in the limited life cycle cost estimate in Volume 5.

2.9. SUMMARY

This section summarizes the main points of the previous sections and briefly describes what remains to be done in future design phases. It reiterates how the current repository and waste package design relates to the bases of the preclosure and postclosure safety cases that the DOE is attempting to build. The text points to Volume 4 (License Application Plan & Costs) for a more detailed description of the work to be accomplished between VA and LA and the reasons for doing the work.

APPENDIX 2A. GLOSSARY

This appendix is a glossary of technical and other special terms used in this volume of the Viability Assessment Document.

APPENDIX 2B. ACRONYMS, ABBREVIATIONS, AND SYMBOLS

This appendix lists and defines acronyms, abbreviations, and symbols used in this volume of the VA Document.

APPENDIX 2C. REFERENCES

This appendix provides the reference information for this volume of the VA Document. In addition to a full bibliographic citation for each reference, it provides a Records Information System accession number, Technical Information Center catalog number, or Data Tracking Number, as applicable, for every reference.

VOLUME 3

TOTAL SYSTEM PERFORMANCE ASSESSMENT

OVERVIEW

This section presents an executive-level-summary of the material in this volume.

3.1. INTRODUCTION

This section will be a "primer" on the performance assessment process. The objective will be to describe how and why performance assessment analyses are applied in a general sense. This chapter is approximately 10 pages in length.

3.1.1 SCOPE AND OBJECTIVES

This section describes the purpose of this volume of the VA Document and outlines for the reader what he or she will get out of reading it.

3.1.2 DEFINITION OF PERFORMANCE ASSESSMENT AND TOTAL SYSTEM PERFORMANCE ASSESSMENT

This section will define and describe how the authors of this report use the terms "performance assessment" and "total-system performance assessment."

3.1.3 PHILOSOPHY OF PERFORMANCE ASSESSMENT

This section will include a brief discussion of the philosophy of why the process of performance assessment is used (both in the U.S. and in the international community). It will also discuss the applications of performance assessment and total system performance assessment as the only tool that integrates all of the elements of the repository system into a "single" representation. The objective will be to show how this integrated representation facilitates prioritizing information collection and development for site characterization and design activities, and allows evaluation of long-term performance to assess compliance of the entire system with regulatory criteria. This section will also describe how the results of any particular Performance Assessment analysis should be interpreted, noting the uncertainties associated with projecting performance over the long time periods of concern.

3.1.4 GENERAL APPROACH

This section will discuss how performance assessment is performed for the Yucca Mountain Project and for other programs and applications. This will include a general discussion of the abstraction approach utilized in the total system performance assessment that was conducted for the viability assessment. This section will note the use of peer review panels and other external reviews to assure the completeness and objectivity of the abstractions.

3.1.5 GENERAL METHODOLOGY

This section will discuss the general methodology used for Performance Assessment for Yucca Mountain Project and other programs and applications. This will include a discussion of the software used and the methods employed to assure the analyses are traceable and transparent.

3.2. YUCCA MOUNTAIN TOTAL SYSTEM PERFORMANCE ASSESSMENT

The objective of this section will be to demonstrate how the general philosophy, approach, and methodology described in Chapter 1 has been specifically applied to Yucca Mountain. This chapter is approximately 25 pages in length.

3.2.1 OBJECTIVES OF TOTAL SYSTEM PERFORMANCE ASSESSMENT-VIABILITY ASSESSMENT

This section will discuss how Total System Performance Assessment-Viability Assessment is expected to be a "dry run" for the analyses used to support the license application. It will include a discussion of the incorporation of feedback from the Total System Performance Assessment Peer Review Panel and other external reviews to be incorporated into the development and implementation of the Total System Performance Assessment-License Application. It will also include a discussion of how Total System Performance Assessment-Viability Assessment provides guidance for what information is needed from site characterization and design activities to adequately support the development of models underlying the Total System Performance Assessment-License Application.

3.2.2 APPROACH

This section will discuss how the analyses for Total System Performance Assessment-Viability Assessment are constructed. It will include an overview of how the system components are defined, how and why the system is divided into components, how the appropriate suite of analyses is defined, why and how the general form of abstractions is developed, and how they are recombined into a total-system model in a manner that ensures consistency among the model assumptions.

3.2.2.1 Components of the Yucca Mountain Repository System

This will be an overview of all of the components in the repository system and the sequence in which Performance Assessment views these components to develop the framework for the Performance Assessment analyses. It will also provide a brief synopsis of how the Yucca Mountain system is expected to behave with reference to the detailed site description in Volume 1 and the engineered components in Volume 2. This section will note that the Yucca Mountain repository system can be described in terms of 19 principal factors that affect the expected performance of the repository and will list the factors. It will correlate these Principal Factors in Expected Repository Performance to the previously described components of the repository system. It will note that the Principal Factors have provided a focus for the site investigations, described in Section 1.2, and the waste package materials and waste form testing programs, described in Section 2.5.3, and provide a focus for future work, as described in Sections 4.2 and 4.3 of the License Application Plan.

3.2.2.2 Development and Screening of Scenarios

This section will discuss how the specific suite of features, events, and processes are selected for analysis. It will include a discussion of the criteria for selecting or screening out components or elements of the components for the Total System Performance Assessment-Viability Assessment.

3.2.2.3 Development of Abstractions

This section will discuss why and how abstractions are generally developed for the Total System Performance Assessment-Viability Assessment and will also describe the form of the abstractions (response surfaces, look-up tables, 3D computer models, etc.).

3.2.2.4 Combining the Components into a Total-System Representation

This section will discuss in a general way how the various components are combined into the total system tool.

3.2.2.5 Differences from Previous Yucca Mountain Project Total System Performance Assessments

This section will briefly discuss lessons learned from previous Performance Assessment exercises and will describe how the representations of the system have evolved over the past years.

3.2.3 METHODOLOGY

3.2.3.1 Development and Utilization of Process Model Information

This section will include a description of the general process of defining and developing the process model information used in the Performance Assessment process. It will primarily focus on the process of identifying and prioritizing appropriate information and analyses as used during the abstraction/testing workshops.

3.2.3.2 Information from Expert Elicitations

This section will briefly describe the expert elicitation process, list the elicitations that were used for the Total System Performance Assessment-Viability Assessment, and describe how information was generally incorporated for the components.

3.2.3.3 Form of the Abstracted Models

This section will present the form of the abstractions provided by each component for the Total System Performance Assessment-Viability Assessment calculations.

3.2.3.4 Architecture of Total System Performance Assessment Models and Codes

This section will briefly describe the configuration and architecture of the codes used to run the Total System Performance Assessment-Viability Assessment (the details supporting this section will be written in the Total System Performance Assessment-Viability Assessment Technical Bases Document).

3.2.3.5 Application of Sensitivity Analyses

This section will briefly discuss how and why sensitivity analyses are performed and how the Total System Performance Assessment-Viability Assessment was modified to reflect information gained by this exercise. It will also provide, in tabular form, the suite of sensitivity analyses most important to construction of the "final" Total System Performance Assessment-Viability Assessment (the details supporting this section will be written in the Total System Performance Assessment-Viability Assessment Technical Bases Document).

3.2.3.6 Treatment of Alternative Conceptual Models and Uncertainty

The importance and the treatment of alternative conceptual models and of uncertainty and variability will be contained in this section (the details supporting this section will be written in the Total System Performance Assessment-Viability Assessment Technical Bases Document).

3.2.4 DESCRIPTION OF BASE CASE

The base case consists of a series of conceptual models describing the relevant processes potentially impacting total system performance, which have been abstracted and combined in a total system model capable of being run for multiple realizations. This section will describe the key elements of each of these abstracted models.

3.3. RESULTS

This section will present the results of the Total System Performance Assessment-Viability Assessment "base case". It will also present the suite of probabilistic analyses used to evaluate the uncertainty in the predicted response of the system. It will identify the four key attributes of an unsaturated repository system that are critical to containing waste and protecting public health and safety, which have been incorporated into the Repository Safety Strategy. This chapter is approximately 60 pages in length.

3.3.1 RESULTS OF DETERMINISTIC ANALYSIS OF THE REFERENCE DESIGN

This section will present the results of the base case analysis. It will show a "deterministic" result for the "expected value" distributions. It is expected to include intermediate results and a time history of dose. It may also show the concentration versus time for different spatial locations (i.e., engineered barrier system, unsaturated zone, saturated zone). A number of graphical methods will be used to show how the various components and their contribution can be traced to the final result (dose). Examples of the types of graphical results that may be used to illustrate how the "base case" is predicted to behave include:

- dose vs time plot (total plus all radionuclides) at 20 kilometers
- concentration vs time plot at 20 kilometers
- table of biosphere dose conversion factors
- saturated zone concentration vs space (two dimensional or three dimensional at 10,000 yrs) for base case unsaturated zone release
- mass breakthrough at base of unsaturated zone vs time (total and all 6 individual regions of saturated zone)
- unsaturated zone concentration (two dimensional vertical) (or particle density) at base of unsaturated zone at 10,000 yrs
- unsaturated zone concentration (two dimensional vertical) (or particle density) in unsaturated zone at 10,000 yrs
- mass breakthrough at edge of engineered barrier system vs time (total and all 6 individual unsaturated zone regions)
- engineered barrier system concentration (two dimensional vertical) (or particle density) at edge of engineered barrier system for all 6 regions at 10,000 yrs

- mass breakthrough at edge of Engineered barrier system vs time for different waste package types
  - (CSNF vs DHLW vs N-reactor; drips vs no drips vs drips in long term average climate)
- mass distribution (or concentration) in engineered barrier system at 10,000 yrs
- fraction of waste packages with drips for all 6 regions
- Waste package failure (first pit) vs time for different waste package types
- Waste package failure (first patch) vs time for different waste package types
- Waste package failure (cumulative area exposed) vs time for different waste package types
- T and RH and Sw distribution in drifts vs time for different waste package types
- spatial distribution of T and RH across repository
- seepage vs percolation distribution
- spatial distribution of drips across repository
- spatial distribution of percolation flux at repository horizon (present day)
- spatial distribution of percolation flux at repository horizon (long term average climate)
- temporal distribution of climate
- spatial distribution of infiltration rate (present day)
- spatial distribution of infiltration rate (long term average climate)

3.3.2 RESULTS OF PROBABILISTIC ANALYSES OF THE REFERENCE DESIGN

This section will present the range of possible base case results associated with key parameter uncertainties in the abstracted models used in TSPA-VA. The results will be presented as a family of dose rate versus time plots for hundreds of realizations. On this plot will also be illustrated the mean, median, 5th percentile and 95th percentile dose rate versus time plots (where the statistics are based on the peak dose rate over the time of evaluation). In addition, various scatter plots will be used to graphically depict the most significant parameters affecting the long term performance assessment. Statistical evaluation of the results will include various regression analyses to assist in identifying the key parameters.

3.3.3 RESULTS OF SENSITIVITY ANALYSES

3.3.3.1 Alternative Conceptual Models

This section will present the range of possible total system performance results caused by uncertainties in the conceptual models used to describe the behavior of the repository system. Various measures of performance will be evaluated, including dose rate versus time, peak dose rate, and time of peak dose rate. While these alternative models could be weighted and the results of separate realizations combined in an overall measure of uncertainty, the current plan is to focus on the "expected" models and to evaluate the sensitivity of the results to one-at-a-time changes in the models. Only those models which are deemed important to system performance will be varied. The bases for the variations will be described in Chapter 4.

3.3.3.2 Disruptive Features, Events and Processes

The possibility of low probability disruptive features, events and processes affecting the evaluation of system performance will be discussed in this section. This section will focus on both the probability of these disruptive scenarios occurring as well as the consequences on long-term performance if they do occur. Both the conditional consequences (i.e., assuming the scenario occurred) and the weighted consequences (taking into account the probability of the scenario) will be illustrated and discussed. This section will note that consideration of disruptive processes and events is part of the Repository Safety Strategy.

3.3.3.3 Design Options

Engineered barrier system design options are to be evaluated in the Viability Assessment. This section will capture the effects of these design options using the base case models. The potential benefits of the design options to address the potential consequences associated with the uncertainty in conceptual models will also be presented. This will include, for example, choosing the more conservative (i.e., leading to higher peak dose rates) albeit low probability models with the design option to depict how more robust designs can be used to ameliorate the effects of such uncertainties.

3.3.4 DISCUSSION

3.3.4.1 Comparison of Results with other Yucca Mountain TSPAs

This section will compare the results of TSPA-VA with recently completed performance assessments of Yucca Mountain completed by DOE contractors (TSPA-95 and TSPA-93), the NRC (IPA-3, assuming it is completed by April, 1998, and IPA-2), EPA (if their technical bases for revision to 40 CFR 191 is completed), and EPRI (IMARC-3). This will be a summary of the individual analyses, as the details of each are beyond the scope of this presentation.

3.3.4.2 Key Attributes of the Natural and Engineered Barriers

This section will summarize the key attributes of the natural and engineered barriers comprising the repository system that significantly affect the long term performance of the system. These are the Key Attributes embodied in the Repository Safety Strategy. This section will utilize the sensitivity and uncertainty analyses presented in Sections 3.3.2 and 3.3.3. This section will also discuss the Key Attributes with respect to the NRC's Key Technical Issues. The Key Attributes and the Principal Factors will be used as a basis for the discussion in Volume 4 on the information needs for developing more robust analyses for the License Application.

3.4. DEVELOPMENT OF TOTAL SYSTEM PERFORMANCE ASSESSMENT COMPONENT MODELS

In Sections 4.1-4.9 below, the technical foundation of the components of the Yucca Mountain repository total system model will be presented. In each of these sections, a brief discussion of the following information will be included: the inputs and assumptions obtained from the process model developers that formed the basis for Total System Performance Assessment model development, the important issues identified by the workshops and the method of treating the issues, the selection of analyses from the scenario screening process, the linkage of each individual component with other components that either provided input or received output from that component, a discussion of the types of sensitivity analyses performed and their results, a discussion of the form of information provided to the Total System Performance Assessment modelers, a synopsis of the importance of the component to overall performance, and a discussion of information needs for Total System Performance Assessment-License Application. The details supporting this section will be written in the Total System Performance Assessment-Viability Assessment Technical Bases Document. This chapter is approximately 150 pages in length.

3.4.1 UNSATURATED ZONE FLOW

3.4.1.1 Technical Bases

This section will describe the bases for the defensibility of the model used to describe unsaturated zone flow.

3.4.1.2 Initial Selection of Important Issues

This section will describe the significant issues and uncertainties associated with the current understanding of unsaturated zone flow.

3.4.1.3 Evaluation of Important Issues and Importance to Performance

This section will describe the relevance of the significant issues associated with unsaturated zone flow to the predictions of post closure performance. This will include sensitivity analyses conducted on the unsaturated zone flow model within the context of Total System Performance Assessment-Viability Assessment and other relevant quantitative and qualitative discussion of the potential consequences associated with these uncertainties.

3.4.1.4 Development of Information Needs

Based on the sensitivity analyses performed and related discussion of the relevance of the uncertainty to the prediction of long term performance, this section will summarize the bases for the need for additional information to enhance the licensing argument. This section will

provide forward reference to Volume 4 for discussion of the work that is planned to address the information needs.

3.4.2 THERMOHYDROLOGY

3.4.2.1 Technical Bases

This section will describe the bases for the defensibility of the model used to describe thermohydrology.

3.4.2.2 Initial Selection of Important Issues

This section will describe the significant issues and uncertainties associated with the current understanding of thermohydrology.

3.4.2.3 Evaluation of Important Issues and Importance to Performance

This section will describe the relevance of the significant issues associated with thermohydrology to the predictions of post closure performance. This will include sensitivity analyses conducted on the thermohydrology model within the context of Total System Performance Assessment-Viability Assessment and other relevant quantitative and qualitative discussion of the potential consequences associated with these uncertainties.

3.4.2.4 Development of Information Needs

Based on the sensitivity analyses performed and related discussion of the relevance of the uncertainty to the prediction of long term performance, this section will summarize the bases for the need for additional information to enhance the licensing argument. This section will provide forward reference to Volume 4 for discussion of the work that is planned to address the information needs.

3.4.3 NEAR-FIELD GEOCHEMISTRY ENVIRONMENT

3.4.3.1 Technical Bases

This section will describe the bases for the defensibility of the model used to describe the near field geochemistry environment.

3.4.3.2 Initial Selection of Important Issues

This section will describe the significant issues and uncertainties associated with the current understanding of near field geochemical environment.

3.4.3.3 Evaluation of Important Issues and Importance to Performance

This section will describe the relevance of the significant issues associated with near field geochemical environment to the predictions of post closure performance. This will include sensitivity analyses conducted on the near field geochemical environment model within the context of Total System Performance Assessment-Viability Assessment and other relevant quantitative and qualitative discussion of the potential consequences associated with these uncertainties.

3.4.3.4 Development of Information Needs

Based on the sensitivity analyses performed and related discussion of the relevance of the uncertainty to the prediction of long term performance, this section will summarize the bases for the need for additional information to enhance the licensing argument. This section will provide forward reference to Volume 4 for discussion of the work that is planned to address the information needs.

3.4.4 WASTE PACKAGE DEGRADATION

3.4.4.1 Technical Bases

This section will describe the bases for the defensibility of the model used to describe waste package degradation.

3.4.4.2 Initial Selection of Important Issues

This section will describe the significant issues and uncertainties associated with the current understanding of waste package degradation.

3.4.4.3 Evaluation of Important Issues and Importance to Performance

This section will describe the relevance of the significant issues associated with waste package degradation to the predictions of post closure performance. This will include sensitivity analyses conducted on the waste package degradation model within the context of Total System Performance Assessment-Viability Assessment and other relevant quantitative and qualitative discussion of the potential consequences associated with these uncertainties.

3.4.4.4 Development of Information Needs

Based on the sensitivity analyses performed and related discussion of the relevance of the uncertainty to the prediction of long term performance, this section will summarize the bases for the need for additional information to enhance the licensing argument. This section will provide forward reference to Volume 4 for discussion of the work that is planned to address the information needs.

3.4.5 WASTE FORM ALTERATION AND RADIONUCLIDE MOBILIZATION

3.4.5.1 Technical Bases

This section will describe the bases for the defensibility of the model used to describe waste form alteration and radionuclide mobilization.

3.4.5.2 Initial Selection of Important Issues

This section will describe the significant issues and uncertainties associated with the current understanding of waste form alteration and radionuclide mobilization.

3.4.5.3 Evaluation of Important Issues and Importance to Performance

This section will describe the relevance of the significant issues associated with waste form alteration and radionuclide mobilization to the predictions of post closure performance. This will include sensitivity analyses conducted on the waste form alteration and radionuclide mobilization model within the context of Total System Performance Assessment-Viability Assessment and other relevant quantitative and qualitative discussion of the potential consequences associated with these uncertainties.

3.4.5.4 Development of Information Needs

Based on the sensitivity analyses performed and related discussion of the relevance of the uncertainty to the prediction of long term performance, this section will summarize the bases for the need for additional information to enhance the licensing argument. This section will provide forward reference to Volume 4 for discussion of the work that is planned to address the information needs.

3.4.6 UNSATURATED ZONE TRANSPORT

3.4.6.1 Technical Bases

This section will describe the bases for the defensibility of the model used to describe unsaturated zone transport.

3.4.6.2 Initial Selection of Important Issues

This section will describe the significant issues and uncertainties associated with the current understanding of unsaturated zone transport.

3.4.6.3 Evaluation of Important Issues and Importance to Performance

This section will describe the relevance of the significant issues associated with unsaturated zone transport to the predictions of post closure performance. This will include sensitivity analyses conducted on the unsaturated zone transport model within the context of Total System Performance Assessment-Viability Assessment and other relevant quantitative and qualitative discussion of the potential consequences associated with these uncertainties.

3.4.6.4 Development of Information Needs

Based on the sensitivity analyses performed and related discussion of the relevance of the uncertainty to the prediction of long term performance, this section will summarize the bases for the need for additional information to enhance the licensing argument. This section will provide forward reference to Volume 4 for discussion of the work that is planned to address the information needs.

3.4.7 SATURATED ZONE FLOW AND TRANSPORT

3.4.7.1 Technical Bases

This section will describe the bases for the defensibility of the model used to describe saturated zone flow and transport.

3.4.7.2 Initial Selection of Important Issues

This section will describe the significant issues and uncertainties associated with the current understanding of saturated zone flow and transport.

3.4.7.3 Evaluation of Important Issues and Importance to Performance

This section will describe the relevance of the significant issues associated with saturated zone flow and transport to the predictions of post closure performance. This will include sensitivity analyses conducted on the saturated zone flow and transport model within the context of Total System Performance Assessment-Viability Assessment and other relevant quantitative and qualitative discussion of the potential consequences associated with these uncertainties.

3.4.7.4 Information Needs

Based on the sensitivity analyses performed and related discussion of the relevance of the uncertainty to the prediction of long term performance, this section will summarize the bases for the need for additional information to enhance the licensing argument. This section will provide forward reference to Volume 4 for discussion of the work that is planned to address the information needs.

3.4.8 BIOSPHERE

3.4.8.1 Technical Bases

This section will describe the bases for the defensibility of the model used to describe biosphere.

3.4.8.2 Initial Selection of Important Issues

This section will describe the significant issues and uncertainties associated with the current understanding of the biosphere.

3.4.8.3 Evaluation of Important Issues and Importance to Performance

This section will describe the relevance of the significant issues associated with the biosphere to the predictions of post closure performance. This will include sensitivity analyses conducted on the biosphere model within the context of Total System Performance Assessment-Viability Assessment and other relevant quantitative and qualitative discussion of the potential consequences associated with these uncertainties.

3.4.8.4 Development of Information Needs

Based on the sensitivity analyses performed and related discussion of the relevance of the uncertainty to the prediction of long term performance, this section will summarize the bases for the need for additional information to enhance the licensing argument. This section will provide forward reference to Volume 4 for discussion of the work that is planned to address the information needs.

3.4.9 DISTURBED SCENARIOS (VOLCANISM, SEISMICITY, AND NUCLEAR CRITICALITY)

3.4.9.1 Technical Bases

This section will describe the bases for the defensibility of the models used to describe disturbed scenarios.

3.4.9.2 Initial Selection of Important Issues

This section will describe the significant issues and uncertainties associated with the current understanding of disturbed scenarios.

3.4.9.3 Evaluation of Important Issues and Importance to Performance

This section will describe the relevance of the significant issues associated with disturbed scenarios to the predictions of postclosure performance. This will include sensitivity analyses conducted on the disturbed scenarios models within the context of Total System Performance Assessment-Viability Assessment and other relevant quantitative and qualitative discussion of the potential consequences associated with these uncertainties.

3.4.9.4 Development of Information Needs

Based on the sensitivity analyses performed and related discussion of the relevance of the uncertainty to the prediction of long term performance, this section will summarize the bases for the need for additional information to enhance the licensing argument. This section will provide forward reference to Volume 4 for discussion of the work that is planned to address the information needs.

3.5. SUMMARY

This section will provide a brief summary of the results of Total System Performance Assessment-Viability Assessment as they relate to the postclosure repository safety strategy and the postclosure safety case. Plans for additional performance assessment work between the viability assessment and the license application will be briefly noted and a forward reference will be provided to Volume 4, License Application Plan and Costs, where the plans and rationales for the work will be detailed.

APPENDIX 3A. GLOSSARY

This appendix is a glossary of technical and other special terms used in this volume of the Viability Assessment Document.

APPENDIX 3B. ACRONYMS, ABBREVIATIONS, AND SYMBOLS

This appendix lists and defines acronyms, abbreviations, and symbols used in this volume of the VA Document.

APPENDIX 3C. REFERENCES

This appendix provides the reference information for this volume of the VA Document. In addition to a full bibliographic citation for each reference, it provides a Records Information System accession number, Technical Information Center catalog number, or Data Tracking Number, as applicable, for every reference.

VOLUME 4

LICENSE APPLICATION PLAN AND COSTS

OVERVIEW

This section will provide an executive-summary-level description of the contents of Volume 4.

4.1 INTRODUCTION

4.1.1 SCOPE AND OBJECTIVES

This section will state that the purpose of Volume 4 is to identify the remaining work required to complete a license application, to explain what requirements or needs the remaining work will address, and to provide a cost estimate and schedule for the remaining work.

4.1.2 APPROACH TO IDENTIFYING THE REMAINING WORK

This section will outline the DOE's approach to identifying the remaining work required to complete a license application. This will be a short section that describes the overall framework, with details provided in following sections.

The DOE has identified the remaining work in three broad categories: technical work, pre-licensing steps required by statute and regulation, and necessary support services.

The remaining technical work encompasses natural environment investigations, design activities, and performance assessments that are needed to construct a postclosure safety case, construct a preclosure safety case, and develop other technical information needed for the license application. Details are provided in Sections 4.2 and 4.3.

The pre-licensing steps required by statute and regulation include preparation of an Environmental Impact Statement and other environmental compliance activities, preparation for and issuance of a Site Recommendation, and a number of other pre-licensing activities. The specifics of work in these categories are described in Section 4.4.

Necessary support services include field construction and operations activities, and other support activities, detailed in Section 4.5.

4.2 TECHNICAL WORK NEEDED TO COMPLETE THE LICENSE APPLICATION

This section will describe what additional natural environment investigations, design activities, and performance assessments are planned between this Viability Assessment and submittal of a License Application, and why. It will be a summary-level narrative, with details of the work plans provided in Section 4.3.

4.2.1 OVERVIEW OF APPROACH FOR IDENTIFYING NEEDED TECHNICAL WORK

This section will provide an overview of the approach that the DOE is employing to identify technical work that is needed to complete a license application. At the highest level, the approach is to identify work needed to: 1) develop a postclosure safety case; 2) develop a preclosure safety case, and 3) provide any other technical information that is needed to complete the LA. This section will describe the five bases of the postclosure safety case, with reference to the Repository Safety Strategy document and forward reference to Section 4.2.2 for details. It will list the two bases of the Preclosure Safety Case, with forward reference to Section 4.2.3 for details. It will reference Section 4.2.4 for details of the other needed technical work.

This section will note that the remaining natural environment investigations, design activities, and performance assessment work is founded on the results of the site investigations (summarized in Volume 1), the preliminary design concepts for the repository and waste package (Volume 2), and the most recent total system performance assessment (Volume 3). It will note that this remaining work represents a continuation of, and convergence of, the iterative testing-design-performance assessment process that was described in Section 1.1.4.

This overview will also discuss the timing for accomplishing the needed technical work in terms of key decisions that must be made before completing a license application. These key decisions will be listed here. The key decisions will include the decision whether to incorporate design options and the decision whether to switch to a major design alternative.

4.2.2 TECHNICAL WORK NEEDED TO CONSTRUCT THE POSTCLOSURE SAFETY CASE

This section will describe the bases of the postclosure safety case that were introduced in Section 4.2.1. As explained in the document, *Repository Safety Strategy: U.S. Department of Energy's Strategy to Protect Public Health and Safety After Closure of a Yucca Mountain Repository, Revision 1*, the postclosure safety case is a rationale that will be used in the License Application to show that the repository system will contain and isolate waste sufficiently to protect public health and safety. The postclosure safety case will include these five bases:

- Estimates of expected repository performance
- Consideration of disruptive processes and events
- Margins of safety and defense in depth
- Understanding from relevant natural analogs
- Performance confirmation

These five bases are intended to provide *reasonable assurance* that a repository at Yucca Mountain would meet the overall system performance objectives in 10 CFR 60.112 and the requirements in §60.113 for performance of particular barriers after permanent closure.

The following five subsections describe the work required to develop each basis of the postclosure safety case.

4.2.2.1 First Basis - Estimates of Expected Repository Performance

Estimates of expected repository performance in the geologic setting of Yucca Mountain are the first basis of the postclosure safety case. The quantitative results of the total system performance assessment that will be conducted for the license application will be compared directly to the quantitative (presumably, dose-based) postclosure performance standard, and this comparison will be a key consideration in the NRC's determination of whether there is reasonable assurance that a repository at Yucca Mountain would meet the postclosure performance requirements.

This subsection will describe the work planned between VA and LA to refine current estimates of expected repository performance. It will introduce and motivate this planned work by explaining the categorization scheme that the DOE has employed for the work in this area, and the approach that was used in identifying the work. The categorization scheme is based on nineteen Principal Factors in Expected Repository Performance and four Disruptive Processes and Events. The work identification approach utilizes a Repository Safety Strategy, as discussed below.

4.2.2.1.1 Principal Factors of Expected Repository Performance

This section will reference Section 3.2.2.1 and reiterate that the total system performance assessments described in Volume 3 are based on a conceptual model of how meteoric water would enter the top of the MGDS--the top of Yucca Mountain--gravitate downward to the repository horizon, interact with the engineered barrier system, carry some of the inventory of radionuclides to the accessible environment, and, eventually, create exposure pathways to members of the public living nearby. This conceptual model can be described in different ways, but one useful way is to disaggregate it into 19 processes and environmental conditions called the "Principal Factors of Expected Repository Performance":

- Climate
- Net water infiltration

- Water seepage into drifts (including thermal effects)
- Water drips onto waste packages
- Humidity in drifts
- Corrosion-allowance-material corrosion
- Galvanic protection
- Corrosion-resistant-material corrosion
- Water seepage into waste packages
- Cladding degradation
- Waste-form degradation
- Radionuclide transport within waste packages
- Colloid formation and radionuclide transport
- Radionuclide transport out of waste packages
- Radionuclide transport through inverts
- Radionuclide transport through the unsaturated zone below the repository
- Radionuclide mixing and dilution in the saturated zone
- Radionuclide dilution during pumping
- Biosphere model

An explanatory paragraph or sentence will be provided for each Principal Factor.

4.2.2.1.2 Disruptive Processes and Events

This section will reiterate the three disruptive processes and events that are considered in the disturbed TSPA scenarios (Section 3.4.9). These are:

- Tectonics and seismicity
- Volcanism
- Nuclear criticality

It will provide the basis for adding a fourth disruptive process or event,

- Human interference

and will explain how this process/event category is being handled apart from the TSPA work.

4.2.2.1.3 The Repository Safety Strategy

The DOE has developed a Repository Safety Strategy to focus the remaining technical work related to expected repository performance and the potential for disruptive processes and events to perturb the expected performance. The Repository Safety Strategy proposes reliance on several key attributes of the natural and engineered barriers in the repository system and it considers the potential disruptive processes and events described in the previous section. It postulates testable hypotheses regarding the key attributes and the disruptive processes and

events; the remaining natural environment investigations, design activities, and performance assessment work is designed to test these hypotheses.

The key attributes have been identified through insights gained from a series of interim total system performance assessments and from information obtained from materials testing, site investigations, and design studies. The key attributes are those which appear to contribute significantly to containing waste and limiting doses to nearby members of the public *and* which appear to be quantitatively demonstrable. There are four key attributes in the Repository Safety Strategy:

- Limited water contacting waste packages
- Long waste package lifetimes
- Slow rate of release from the waste form
- Concentration reduction during transport

The testing of each hypothesis regarding a key attribute or a disruptive process or event requires specific additional information about one or more Principal Factors in Expected Repository Performance or one or more Disruptive Processes and Events. The resulting information needs are the basis for the planned remaining natural environment investigations, design activities, and performance assessment work. An example is given in the next section.

4.2.2.1.4 Work Planned to Refine Estimates of Expected Repository Performance

This section will summarize the work that the DOE has planned to refine its estimates of expected repository performance, which constitute the first basis of the postclosure safety case. This work will be described in terms of the Principal Factors of Expected Repository Performance and the Disruptive Processes and Events, as just described.

An example of the plans to refine the estimates of expected repository performance is the work planned for the Principal Factor, "radionuclide transport through the unsaturated zone below the repository." This factor needs to be better understood to determine the degree to which the radionuclide concentrations will be reduced during transport from the repository horizon to the accessible environment--the fourth Key Attribute in the Repository Safety Strategy. The field testing for this factor includes the tracer test in a tunnel at the Busted Butte analog site, as described in the work statement for Work Package 12342215M3, UZ Transport & Lab Sorption Studies:

> Phase I testing in FY 1998. This testing involves the sequenced point source injection of eight boreholes separated in space and time along tunnel walls, and includes overcoring and field and laboratory characterization of the test. Transport scoping calculations and calibration activities will occur in parallel. The duration of this activity will be 5 months. In addition, construction will be completed for the Phase II testing. This construction includes preparation of the large in-situ test block at the

base of the tunnel (right rib) at the same time of the Phase I testing (left rib).

Phase II testing in FY 1999. This testing involves the simultaneous injection of conservative and reactive tracers at the top of the test block over an area of approximately 8m x 8m. This phase includes associated field and laboratory characterization activities in min/pet and geochemistry and transport modeling activities (i.e., scoping calculations, predictive modeling exercises and model calibration). The activity also includes a partial mineback of the test block and associated 3-D mapping of the ingress of the tracers into the block.

Phase III testing to address coupled effects and higher infiltration rates (associated with potential future climate scenarios) will be conducted in the out years (FY 2000 to FY2002) and will be based on the information obtained in the Phase I and Phase II testing.

This example will be shortened and summarized for inclusion in this section, but it illustrates the key source of information for the work plans to be described here.

The work descriptions here will note the dependence of the total system performance estimates to decisions on design options and design alternatives and that related work plans will evolve as the repository design evolves.

The authors of this section may consult a number of documentary sources for the information needs associated with the Principal Factors. These include proceedings of the PA abstraction workshops, PA Peer Review reports, published plans to resolve design issues, outstanding Design Input Requests (from the PA organization to Design) that have been generated under QA Procedure QAP-3-12, "TBD's" and "TBV's" in the Conceptual Design Assumptions Document, the Repository Design Data Needs document, and the draft MGDS Test and Evaluation Plan. Another important source of information needs will be the process-model-development information needs that are identified in Volume 3 (Sections 3.4.4.1 through 3.4.4.8). Those sections will be prepared concurrently with this volume, but the authors of those sections will be asked to contribute to this section, as well. Regardless of the source of the information need, the work descriptions will reflect work that is described in the Multi-Year Planning System.

4.2.2.2 Second Basis - Consideration of Disruptive Processes and Events

Consideration of potential disruptive processes and events is the second basis of the postclosure safety case. An understanding of what processes and events could perturb the nominal performance of the repository, and the magnitude of the potential disturbance, is important to achieving reasonable assurance that a repository would perform satisfactorily in the geologic setting of Yucca Mountain. There are four potential disruptive processes and events that appear to be relevant at Yucca Mountain:

- Tectonics and seismicity
- Volcanism
- Human interference
- Nuclear criticality

As described in the previous section, the consideration of disruptive processes and events is part of the Repository Safety Strategy and its associated hypotheses. Hypotheses regarding these potential disruptive processes and events provide a framework for identifying and prioritizing work that needs to be accomplished between this Viability Assessment and submittal of a License Application. The planned work associated with the disruptive processes and events will be summarized here.

4.2.2.3 Third Basis - Margins of Safety and Defense in Depth

Margins of safety in the expected performance of items that are important to waste isolation and defense in depth in the overall Mined Geologic Disposal System are two related means of contributing to reasonable assurance that the repository will meet postclosure performance standards. Margins of safety refer to extra capacity that is incorporated into design items such that the postclosure performance of the repository is expected to be better than what is required by the performance standard. Various approaches to defense in depth, including multiple barrier systems, increase confidence by assuring that the overall system will perform satisfactorily even if a particular subsystem falls short of its performance expectation. Multiple barriers also contribute to the overall margin of safety. Margins of safety and defense in depth are key considerations in the identification of engineered barrier system design features and design options.

The information needs and planned work related to margins of safety in expected performance and defense in depth will be described here. This section will reiterate the elements of the design process described in Section 2.2.1 that pertain to evaluating and deciding on design options and design alternatives. It will reference the EBS design options that are described in Section 2.5.4 and which would provide extra defense in depth and extra margins of safety, as indicated by the corresponding PA sensitivity studies reported in Section 3.3.3.3. The companion document on major design alternatives (being prepared concurrently) will also be a source for this section.

4.2.2.4 Fourth Basis - Understanding from Relevant Natural Analogs

Understanding from relevant natural analogs will also contribute to reasonable assurance that the repository will meet postclosure performance standards. Natural analogs refer to natural geologic systems in which chemical isolation and transport phenomena over hundreds of thousands and millions of years can be studied directly. Such studies support the identification and evaluation of processes that are relevant to repository performance and the evaluation of models of repository performance. While natural analog studies have limitations, including the incomplete geologic record, difficult assessment of initial and boundary conditions, partial or imperfect analogy, and nonunique interpretations, they have the unique advantage of permitting direct study of relevant processes and phenomena over the long time and extended space scales that are applicable to repository performance. Analog studies, therefore, are important part of the information base that contributes to confidence in estimates of long-term repository behavior. Remaining natural analog studies (if any) will be described here.

4.2.2.5 Fifth Basis - Performance Confirmation

Performance confirmation is the final element of the postclosure safety case. As required by regulation, performance confirmation involves the confirmation that subsurface conditions encountered and changes in those conditions during construction and waste emplacement are within the limits assumed in the licensing review, and confirmation that the natural and engineered systems and components of the repository are functioning as intended and anticipated. Establishment of a baseline for the performance confirmation program started during site characterization, and the program must continue until permanent closure. The purpose of performance confirmation is to provide additional assurance that the repository will meet postclosure performance standards before the final decision is taken to close and decommission the facility. The needs of the performance confirmation program are another consideration in the identification of the work remaining to license application.

This section will refer to the Performance Confirmation Plan and will briefly describe any testing, design, or performance assessment work between now and the license application submittal that serves the performance confirmation program.

4.2.3 TECHNICAL WORK NEEDED TO CONSTRUCT THE PRECLOSURE SAFETY CASE

The DOE is developing the preclosure safety case to demonstrate compliance with the objectives in §60.111 for performance of the geologic repository operations area through permanent closure. This section will present the two bases of the preclosure safety case that the DOE is developing, identify the related technical information needs, and summarize the associated technical work that is required to complete a license application.

4.2.3.1 Use of Demonstrated Technology and Accepted Design Criteria

The first basis of the preclosure safety is use of demonstrated technology and accepted design criteria. This section will explain how the DOE is maximizing the use of existing NRC regulatory guidance in its design of structures, systems, and components that are related to radiological safety and, in areas where NRC guidance is not available, maximizing the use of accepted industry codes, standards, and professional practices. This section will reference the design process descriptions in Volume 2.

Work between VA and LA that is related to use of demonstrated technology and accepted design criteria is expected to be characterized as a continuation of current practice described in Volume 2. Any special design efforts that are planned to identify applicable NRC guidance or design criteria will be identified.

4.2.3.2 Systematic Safety Classification of Design Items and Identification of Design-Basis Events

The second basis of the preclosure safety case is systematic safety classification of design items and identification of design-basis events. This section will describe the requirement in 10 CFR 60 to identify design basis events and will summarize the nuclear safety analysis process that is detailed in Section 2.2.2. This section will identify the scope of work remaining between VA and LA in the safety classification of design items and in the identification of design basis events.

4.2.4 OTHER TECHNICAL WORK NEED TO COMPLETE THE LICENSE APPLICATION

The DOE is developing all other technical information needed to satisfy the requirements in §60.21 for the content of the License Application for Construction Authorization. This section will capture any natural systems investigations, design activities, and performance assessment work that is needed as input to a complete license application, apart from that work that is needed to complete the preclosure and postclosure safety cases. An example is the Balance-of-Plant design effort. It will also capture technical work that is required for environmental compliance, development of the EIS, and development of the site recommendation.

4.3 TECHNICAL WORK PLANS

Section 4.2 summarized the planned technical work between VA and LA in terms of the postclosure safety case, the preclosure safety case, and other technical information that is required to complete a license application. Section 4.3 provides a more comprehensive (but still summary-level) description of this work, and presents it in organizational categories that

can be directly related to the M&O's Multi-Year Planning System and to the costs between VA and LA that are presented in Section 4.6, below. The work descriptions in this section will tie the planned work to the information needs that are described in Section 4.2, and there will be sufficient explanation so it is clear that the work is reasonably likely to satisfy the need. The work descriptions will also note where the work addresses a Key Technical Issue of the NRC and contributes to the issue resolution process described in Section 4.4.3.3.1.

4.3.1 NATURAL ENVIRONMENT INVESTIGATIONS

This section will summarize the site/natural environment activities between Viability Assessment and submittal of a License Application that are planned to satisfy the information needs identified in Section 4.2. The specific activities in this area will come from the Multi-Year Planning system. When the author has researched the Planning system, the author will group the major work activities by organizing principles that make sense for the body of work being described. These will be categories that can easily be mapped to the Multi-Year Planning System. These organizing principles may become the basis for subsections. As an example, the author may determine that the following organizing principles for the natural environment investigations apply:

- Geologic features, natural processes, and disruptive events.
- Testing and modeling groundwater flow above the water table (infiltration, percolation, and climate change).
- Testing and modeling groundwater flow below the water table.
- Radionuclide transport modeling and testing (Busted Butte).
- Near-field environment, coupled process, thermal testing.

As an activity is presented, the author will reference the work to the information needs presented in Section 4.2. (All technical work should tie to at least one information need in Section 4.2.) In addition, the author will note if planned work relates to a Nuclear Regulatory Commission Key Technical Issue, and, if so, how.

4.3.2 DESIGN WORK

This section will summarize the design activities between Viability Assessment and submittal of a License Application that are planned to obtain the information identified in Section 4.2. Design activities are defined here to include the waste package materials and waste forms testing programs. The identification of specific activities in this area will come from the Multi-Year Planning System (MYPS). (This assumes that work to address major design alternatives will be included in the MYPS before the Viability Assessment Document is

issued.) This section will also describe activities to resolve the issue related to DOE waste and the Nuclear Waste Policy Act definition of "Metric Tons of Uranium." When the author has researched the Planning system, the author will group the major work activities by organizing principles that can easily be mapped to the MYPS. These organizing principles may become the basis for subsections. As an activity is presented, the author will reference the work to information needs presented in Section 4.2, if applicable. Similarly, work related to a Nuclear Regulatory Commission Key Technical Issue, if any, will be noted with a brief description of how the work will help resolve the issue.

4.3.3 PERFORMANCE ASSESSMENT WORK

This section will summarize the performance assessment activities between Viability Assessment and submittal of a License Application that are planned to obtain the information identified in Section 4.2. This work will include activities to bring the performance assessment work under the formal nuclear quality assurance program. The identification of specific activities in this area will come from the Multi-Year Planning system. When the author has researched the Planning system, the author will group the major work activities by organizing principles. These organizing principles may become the basis for subsections. As an activity is presented, the author will reference the work to information needs for the bases for the safety case presented in Section 4.2, if applicable. Similarly, work related to a Nuclear Regulatory Commission Key Technical Issue, if any, will be noted with a brief description of how the work will help resolve the issue.

4.4 STATUTORY ACTIVITIES

In addition to the technical activities required to support performance assessment, design, or testing, a substantial body of other work is needed to comply with statutory requirements. The purpose of this section is to summarize the other statutory work needed between Viability Assessment and submittal of a License Application. The identification of specific activities in this area will come from the Multi-Year Planning system. Work related to a Nuclear Regulatory Commission Key Technical Issue will be noted with a brief description of how the work will help resolve the issue consistent with the approach presented by the Nuclear Regulatory Commission staff in the Issue Resolution Status Reports.

The discussion of statutory activities will be grouped per the following subsections.

4.4.1 ENVIRONMENTAL IMPACT STATEMENT AND ENVIRONMENTAL COMPLIANCE

Volume 1 described the statutory requirement for the Environmental Impact Statement. This section will summarize Environmental Impact Statement and environmental compliance activities needed between Viability Assessment and License Application. The identification

of specific activities in this area will come from the Multi-Year Planning system. The schedule for the EIS will be identified.

4.4.2 SITE RECOMMENDATION

Volume 1 described the statutory requirement for the Site Recommendation. This section will summarize the Site Recommendation work needed between Viability Assessment and submittal of a License Application. The identification of specific activities in this area will come from the Multi-Year Planning system. This section will refer to the plan prepared which gives details related to the site recommendation activities. Where the Site Recommendation fits into the schedule for the overall site characterization and licensing process will be identified.

4.4.3 LICENSING

This section describes the licensing work leading up to and directly supporting development of the License Application document.

4.4.3.1 Licensing Activities

Licensing activities included in this section will focus on the resolution of regulatory and technical issues with the Nuclear Regulatory Commission before completion of the License Application, interactions with the Nuclear Regulatory Commission and other regulatory agencies, regulatory guidance to the development of information systems to support the licensing process, conduct of reviews of the draft chapters for the License Application, preparation of the documentation necessary to support the License Application, and finally development of the License Application.

Licensing work to be described specifically will include support for development of the Nuclear Regulatory Commission Electronic Docket and Information Systems; technical and regulatory reviews to determine the adequacy of technical reports as licensing documentation; and regulatory reviews of potential changes to the regulatory framework and of design products.

Management of the Project technical data management system will be described, including development, operation and maintenance of the Automated Technical Data Tracking system, Reference Information Base, and the Geographic Nodal Information Study and Evaluation System. The efforts planned to qualify data will be specifically discussed.

4.4.3.2 License Application Status and Schedule

This section will be a brief discussion of what has been accomplished in the way of preparing for a license application. Accomplishments such as topical reports, working draft license

application, and interactions will be presented. This section will contain a summary schedule for the preparation of the license application.

4.4.3.3 Nuclear Regulatory Commission Interactions

This section will present the Project's approach to actively engage the Nuclear Regulatory Commission now that we are in the process of proceeding with a License Application. It will clearly present the early and frequent discussions with the NRC during the Viability Assessment process.

4.4.3.3.1 Key Technical Issues

This section will describe the process for resolving the Nuclear Regulatory Commission's Key Technical Issues. It will identify the Key Technical Issues and their subissues. It will note that the site description in Volume 1, the design description in Volume 2, and the TSPA presentation in Volume 3 reference the Key Technical Issues as they are applicable. It will note that the work descriptions in Sections 4.2 and 4.3 directly relate to the Key Technical Issues. A "road map" will be provided for the NRC that points them to the different places in the Viability Assessment Document where their various Key Technical Issues have been addressed.

4.4.3.3.2 Communications

This section will discuss the lines of communications available between the Nuclear Regulatory Commission and the Department of Energy. Both formal interactions, such as the Management Meetings, and less formal interactions such as Nuclear Regulatory Commission On-Site Representative meetings will be discussed. The series of regularly scheduled meetings expected with the Nuclear Regulatory Commission will be highlighted. A discussion of not-regularly-scheduled meetings with the Nuclear Regulatory Commission which will be held as needed to facilitate Nuclear Regulatory Commission review of Project information will be included. A discussion of public participation will also be included as will the plans to keep these lines of communications open. This discussion will highlight the Nuclear Regulatory Commission's current and continuing role in inviting participation by the public in Nuclear Regulatory Commission/Department of Energy interactions.

4.5 SUPPORT ACTIVITIES

4.5.1 FIELD CONSTRUCTION AND OPERATIONS ACTIVITIES

The purpose of this section is to summarize the field construction and operations activities needed between Viability Assessment and submittal of a License Application. The identification of specific activities in this area will come from the Multi-Year Planning system.

4.5.2 OTHER SUPPORT ACTIVITIES

This section will describe planned work in other support areas. These areas include information systems, configuration management, project management and control, institutional affairs, training, and administrative and support services. This section includes discussion of financial and technical assistance, lease scoring, escalation, contractor fees, and management reserve.

4.6 COSTS

This section will provide a summary-level cost estimate similar in detail to Table 4 of the May 1996 Program Plan. These costs are obtained from the Project's Multi-Year Planning system. The costs will be grouped by the years FY 1999, 2000, 2001 and 2002, including a total for all years. The costs will be grouped to facilitate comparison with the Administration's FY 1999 Congressional Budget Request for the Yucca Mountain Project.

4.7 SCHEDULE

This section will provide an overall schedule for the key work activities presented here. This schedule will be at a level of detail similar to Figure 8 of the May 1996 Program Plan. This schedule will come from the Project's Multi-Year Planning system.

APPENDIX 4A. GLOSSARY

This appendix is a glossary of technical and other special terms used in this volume of the Viability Assessment Document.

APPENDIX 4B. ACRONYMS, ABBREVIATIONS, AND SYMBOLS

This appendix lists and defines acronyms, abbreviations, and symbols used in this volume of the Viability Assessment Document.

APPENDIX 4C. REFERENCES

This appendix provides the reference information for this volume of the Viability Assessment Document. In addition to a full bibliographic citation for each reference, it provides a Records Information System accession number, Technical Information Center catalog number, or Data Tracking Number, as applicable, for every reference.

VOLUME 5

COSTS TO CONSTRUCT AND OPERATE THE REPOSITORY

OVERVIEW

This section presents an executive-level-summary description of the contents of this volume of the Viability Assessment Document.

5.1. INTRODUCTION

This volume will present the estimated costs which begin with license application (LA) and reflect the cost relating to complete repository and engineered barrier designs, the construction and operation phases, and the closure and decommissioning of the repository. The costs will be consistent with the concepts for the reference repository and engineered barrier system designs and for several engineered barrier system design options, described in Volume 2 of this document. Costs assumptions that govern the MGDS-VA costs are presented in this document.

5.1.1 SCOPE AND OBJECTIVES

The document will present the estimated cost to construct and operate a repository, and closure and decommission the repository which is based on the concept for the repository and engineered barrier segments as described in Volume 2. The cost estimate horizon presented herein begins with submittal of a License Application, and reflects the cost to complete the repository and engineered barrier designs, to construct and operate the repository, and to close and decommission the repository. Cost assumptions that will govern the MGDS-VA cost estimates are presented in this document.

This section also provides the description of the cost estimate and its relation to the other Viability Assessment volumes. This section defines the purpose of the document in response to language in the FY 97 budget legislation.

5.1.2 ASSUMPTIONS

This section provides a detailed list of assumptions not documented in other Program or project controlled documents that are required to facilitate this estimate. The assumptions that will be contained in the MGDS-VA Life Cycle Cost Document are as follows:

A. All estimated costs will be presented in constant FY 1998 dollars.

B. There will be no co-located interim storage facility at the repository.

5.1.2.1 Multi-Year Planning

This section will provide assumptions related to the development and evaluation cost and will include specific assumptions for the following elements of work:

- Systems Engineering, Waste Package and Repository
- Core Science
- Regulatory
- Exploratory Studies Facility and Test Facilities
- Information Management
- Related Program Elements

5.1.2.2 Repository Assumptions

This Section Will Include Global Repository Assumptions. Specific element detailed will be specified in the following subsections:

5.1.2.2.1 General

A. The retrieval operations cost will be excluded from the overall funding allocation assessment.

B. No backfill will be used in the emplacement drifts, in the reference repository design. All other drifts, shafts and ramps will be backfilled and sealed during the closure phase of the repository. Design options will be costed that include emplacement-drift backfill alone, backfill in combination with drip shields, and backfill in combination with ceramic waste package coating, as described in Volume 2.

C. Potential repository expansion areas are excluded.

5.1.2.2.2 Schedule

A. The Major Milestones will be met and accomplished within the schedule as listed in Table 1-1.

Table 1-1. Major Milestones

Milestone	Date (FY)
Submit License Application	3/1/2002
Construction Authorization	2005
License to Receive and Emplace Waste	2010
Submit License to Close Repository	2057
License to Decommission and Close Repository	2059

B. Repository construction will commence upon the Nuclear Regulatory Commission issuance of authorization for construction.

C. Long lead procurement will begin in FY 2004.

D. The construction of the repository surface facilities will be completed during or before 2010.

E. Sufficient underground construction to support initial waste emplacement operations will be completed by 2010.

F. Waste emplacement will commence upon the Nuclear Regulatory Commission issuance of a license to receive and emplace waste.

G. Repository closure will commence upon the Nuclear Regulatory Commission issuance of a license to decommission and close the repository.

H. Repository Life Cycle Cost Phases will commence as scheduled and listed in Table 1-2.

Table 1-2. Schedule and Duration of Each of the Repository Life Cycle Cost Phases

Phase	Duration (FY)
Post License Application Development and Evaluation	04/2002 - 2010
Pre-emplacement Construction	2005 - 2010
Emplacement Operation (Including underground construction)	2010 - 2033
Caretaker Operations	2034 - 2059
Closure and Decommissioning	2060 - 2066

5.1.2.2.3 Waste

A. The repository design capacity will be 70,000 metric tones of initial uranium (MTU) or the equivalent as per the *Nuclear Waste Policy Amendments Act of 1987*. The nuclear waste breakdown by source is listed in Table 1-3.

Table 1-3. Assumed Waste Sources & Their Respective Quantities

Source	Quantity
Commercial Spent Nuclear Fuel (SNF)	63,000 MTU
DHLW (8,314 canisters are assumed the equivalent of 4,667 MTU)	8,314 Canisters
U.S. Department of Energy (Department of Energy)-owned SNF	2,333 MTHM

B. Annual waste shipments to the repository will not exceed 3,000 MTU commercial SNF, and 400 MTU of combined Department of Energy SNF and DHLW.

C. The basis for the waste stream design and cost is defined in Appendix L of the *Waste Quantity Mix and Throughput Study Report* (CRWMS M&O 1997).

D. A DHLW disposal container design that contains five DHLW canisters and one Department of Energy SNF basket will be used in this cost estimate.

E. Canisters of Pu will be placed in DHLW type waste packages.

5.1.2.2.4 Performance Confirmation

A. Performance confirmation activities will commence in 1998 and terminate with the License to Decommission and Close Repository milestone. The scope of this estimate starts with the License Application submittal.

B. Performance confirmation activities will collect data sufficient to verify the repository performance prediction, and sufficient to support the submittal of the License Application to close the repository.

C. Waste package recovery will not be required in support of performance confirmation activities.

D. Performance confirmation monitoring will be automated to the fullest extent possible. It will be configured to perform automated analysis and will determine and report any deviation from expected values.

5.1.3 REPOSITORY LIFE CYCLE COST OVERVIEW

The repository Life Cycle Cost (LCC) analysis presented in this document is a limited LCC analysis because the definition of life starts in 2002. This definition is mandated for the MGDS-VA estimate in H.R.3816 and is adhered to in this report. The total repository LCC presented here, therefore, will not include $2,401 million (year of expenditure) of historical costs nor will it include License Application Plan costs. A summary of annual distribution of costs over the life cycle will also be provided in this section. The section will provide a repository cost summaries and discussion of results. The graphical cost summaries will provide a breakdown for each of the repository elements.

5.1.4 BASIS OF ESTIMATE

This section provides definition of the estimates in various project areas. It will identify all relevant documents that contain data used in the development of the estimates. The author will reference other Volumes as appropriate.

The estimate basis for the costs presented in the document will be consistent with the repository design and operations as identified in the following technical basis documents:

- Mined Geologic Disposal System Requirements, Department of Energy/RW-0404P, Revision 2, DCN 02.
- Draft Waste Acceptance Criteria Document June 27,1997.
- Mined Geologic Disposal System Architecture, REV 00 Draft A.
- Preliminary Mined Geologic Disposal System Concept of Operations, B00000000-01717-4200-00004 REV 00.
- Mined Geologic Disposal System Viability Assessment Test and Evaluation Plan Report, B00000000-01717-5705-00058 REV 00 DRAFT.
- Reference Design Description for a Geologic Repository, B00000000-01717-5707-00002 REV 01.
- Performance Confirmation Plan, B00000000-00841-4600-00002 REV 00, Draft B.
- Project Cost and Schedule Baseline, YMP/CM-0015, REV 13.
- Controlled Design Assumptions Document, B00000000-01717-4600-00032 REV 04, ICN 1.

5.1.5 QUALITY CONTROLS

This section describes the level of quality assurance (N/Q) and lists governing documents/procedures.

5.2. REPOSITORY LIFE CYCLE SCHEDULE

5.2.1 MAJOR LIFE CYCLE COST MILESTONES

This section provides the list of milestones and defined schedules that support the cost estimate. These will include:

- Life Cycle cost Phases
- Construction schedules:
  1. Surface
  2. Subsurface
- Performance confirmation (test schedules)

5.2.2 LIFE CYCLE COST PHASES

This section provides the definition of the costs included in the following cost phases:

- Licensing Phase - Primarily Development and Evaluation costs
- Pre-Emplacement Construction
- Emplacement Operations (includes subsurface continued construction)
- Caretaker Operations
- Closure and Decommissioning activities

5.3. ESTIMATING TECHNIQUE

Various cost estimating techniques will be employed in the development of this cost analysis. These techniques will be selected on the basis of the design maturity. Estimates for the most mature designs will be based on a bottoms-up estimate, while the conceptual designs with a lower maturity level capacity will utilize a factoring technique, as well as factoring and scaling costs from earlier estimates. An overview of the estimating techniques utilized in this work will be provided in Table 3-1.

The following table is an example and will be updated per the Viability Assessment estimate process.

Table 3-1. Cost Estimating Technique Applications

Estimate Element	Bottoms-up	Capacity Factoring	Scaling	Comments (Costs Based On)
Development and Evaluation	✔		✔	
Surface Facilities	✔	✔		
Subsurface Facilities	✔	✔		Nevada Test Site Labor Agreements
Disposal Containers	✔			Supplier Quotes
Performance Confirmation		✔	✔	ESF Testing & Site Characterization

* Program Cost Estimate

5.3.1 REFERENCE DATABASES

This section will provide the definition of database usage as well as exceptions, if any. This section will also define modifying factors, if used, for the following items: Labor hours, material prices, machinery costs, construction (above and below surface).

5.3.2 COST MODELS DESCRIPTIONS

This section will provide pictorial and verbal description of the models and each of the contributing modules to include the following:

5.3.2.1 Repository Integrated Life Cycle Cost Model

The Repository Integrated LCC Model is a spreadsheet with multiple pages, each containing various levels of estimate details. This LCC model interfaces with and integrates data inputs generated by the cost models at the surface and subsurface design organizations, as well as multi-year planning estimates, and cost estimates for the performance confirmation program. This integration process produces the total repository LCCs. A description of the content of each of the model pages is provided below as they appear, in order, in the model:

a. Macros—This page contains all macros created to support the computation, formatting, and printing of the various levels of estimate details.

b. Rates—This page contains the tables of escalation rates used to convert reference data to the constant dollar value, as defined for this report, as well as the year of expenditure annual cost breakdown.

c. MGDS—This page contains the detailed summary by line item of all costs for each

cost account for all the project elements. Various cost summaries are also incorporated.

d. D & E—This page contains a summary of the Development and Evaluation costs. The sources of the Development and Evaluation costs are: the cost to complete the license application processes (FY 1998 - April 2002) from the License Application Plan; and the cost to complete the design and readiness to waste receipt (May 2002 - 4th FY 2010) from the Long Range Plan Multi-Year Baseline.

e. Surface —This page contains the interface tables which facilitate the interface with the Surface Facilities Module. All data is listed by cost account and by operation period.

f. Subsurface —This page contains the interface tables which facilitate the interface with the Subsurface Facilities Module. All data is listed by cost account and by operation period.

g. Waste Package—This page contains tables of anticipated waste stream arrivals by year for each of the waste types to be emplaced in the repository, and the unit costs for each waste package type. All waste package cost computations are performed on this sheet of the model.

h. Perf Confirm—The cost estimate details of the Performance Confirmation program are presented on this page.

I. Annual—This page is the summary annual cost profile over the repository life cycle which is tabulated in this page both in constant dollars and in year of expenditure dollars.

j. Past Estimates—This page facilitates comparisons with historical estimates, the 1995 Total System Life Cycle Cost, and the 1997 Program Cost Estimate.

The model configuration will be illustrated in Figure 3-1.

5.3.2.2 Subsurface Facility Cost Model

The subsurface development and operation costs were developed using the Morrison-Knudsen Long Term Operation Estimating System. The model configuration, data flow, and module interfaces will be depicted in Figure 3-2. Assumption used for implementation of this estimating system will be listed in Appendix 5D.

5.3.2.2.1 Introduction

Cost estimates for long-term operations require a different approach from those used for short-

term construction projects. Long-term operations require an estimating system that allows the estimator to develop cash flows for varying periods of time. The estimate format has to allow for the development of daily operation expenses, as well as initial procurement and replacement costs for plant and equipment. The estimating system must account for costs relating to environmental impact studies necessary to support major projects.

To organize the estimate and track the large volume of information that must be processed, the estimators for Morrison-Knudsen developed a series of interactive spreadsheets. These spreadsheets were initially developed by Morrison-Knudsen's estimating staff in the mining group to produce estimates for their contract mining operations. They have also been used to estimate the related costs for several major feasibility studies. This system is designed to develop an operating cost center for each major operating subsurface facility/operation element as well as related purchase and replacement cost schedules.

The following is a list of the various spreadsheets by name and function:

Labor—The Labor spreadsheet is used to compute craft labor costs per shift using the project labor agreements, statutory payroll taxes and insurance. The labor rates are indexed to allow the estimator to import them into the Crew spreadsheet using simple alpha-numeric codes.

Equipor—The Equipor spreadsheet is used to tabulate and analyze the equipment operating costs for use in the estimate. This spreadsheets allows the estimator to adjust costs from Morrison-Knudsen's historical base, the published rates from the Dataquest Service, the Army Corps of Engineers, and other sources. This spreadsheet allows the estimator to adjust the selected operating costs to reflect the project costs for labor, fuel and power. The costs are indexed to allow the estimator to import the operating costs into the Crew spreadsheet using simple alpha-numeric codes.

Materials—The Materials spreadsheet provides the estimator with a system that tabulates permanent material costs, applicable sales taxes, and freight costs. This spreadsheet is indexed to allow the estimator to import material costs into the Crew spreadsheet using simple alpha-numeric codes.

Supplies—The Supplies spreadsheet is similar to the Materials spreadsheet and allows the estimator to tabulate consumable supply costs. This spreadsheet is also indexed using simple alpha-numeric codes.

Sequence—The Sequence spreadsheet is used by the estimator to develop an operating schedule for each cost center. The spreadsheets will track operating days and other useful key quantities for use in the Takeoff spreadsheet.

Takeoff—The Takeoff spreadsheet is used to tabulate labor shifts, equipment operating hours, consumable supply quantities, and permanent material quantities. This spreadsheet is

designed to link directly to the input sections of the Crew spreadsheet. The Takeoff and Crew spreadsheets are formatted to allow transfer of data from the Takeoff spreadsheet into the Crew spreadsheet. The Takeoff spreadsheet interfaces with the four basic cost sheets listed above using alpha-numeric codes. The Takeoff spreadsheet is also programmed to provide detailed summaries required for environmental impact studies.

Crew—The Crew spreadsheet is the key spreadsheet where the Takeoff is combined with the cost elements from above to produce an annual operating cost. This spreadsheet is linked to the labor, equipment operating cost, material and supply spreadsheets. Simple alpha-numeric codes are used to call out the required cost elements. This provides the ability to modify the cost input for a basic cost element in one place and update the entire estimate. Printing of all the work sheets is required to create configuration cost documentation. The Crew spreadsheet is designed to import data into the Summary spreadsheet and Bigsum spreadsheet. The Crew spreadsheets and various types of summary spreadsheets must be formatted with identical operating periods.

Summary—The Summary spreadsheet is designed to import data from all the Crew spreadsheets and to provide several types of useful operating cost summaries. These include Total Direct Project Cost by Cost Center, a Repair and Service Labor Cost by Cost Center, Total Labor by Cost Center by Year, Total Supplies by Cost Center by Year, Total Materials by Cost Center by Year, and Total Direct Cost by Cost Center by Year. In addition, a Detailed Annual Summary of Direct Costs by Cost Centers is available. For documentation and checkout printing data from the various Crew spreadsheets is provided.

Bigsum—The Bigsum spreadsheet is similar to the Summary spreadsheet in that it is designed to import data from the Crew spreadsheets. The Bigsum spreadsheet has the added capability of providing the estimator two additional columns: one for direct input of capital costs for equipment, and the second column for the direct input of subcontract costs. The Bigsum spreadsheet also allows the estimator to apply an unlimited number of markup factors that can be programed to allow for overhead costs, contractors fees, contingency allowances, program costs, and any other type of factored costs. The Bigsum spreadsheet can be used as a final summary sheet providing a series of cost summaries. The Bigsum spreadsheet is also formatted for use as an intermediate summary to provide data for the Grandsum spreadsheet described below.

Grandsum—The Grandsum spreadsheet is used to provide additional summarizing capacity. The Grandsum spreadsheet can read the totals from the Bigsum spreadsheets and other Grandsum spreadsheets. The Grandsum spreadsheet also allows the estimator to apply additional markup factors if necessary. This spreadsheet provides a wide range of cost summary printouts as well as copies of the input data from the intermediate summaries. This provides a strong audit trail, and simplifies checkout and development of the final cost summaries.

Hourssum—The Hourssum spreadsheet is used to tabulate and summarize the equipment operating hours by type of equipment by year. This spreadsheet is designed to import data from the various Crew spreadsheets to summarize the equipment operating hours. The Hourssum spreadsheet uses the alpha-numeric coding to identify and tabulate the total operating hours for the various types of equipment. This information is used in the Replace spreadsheet to determine when capital equipment replacements are required.

Replace—The Replace spreadsheet is used to compute the replacement schedule for a piece of capital equipment. This spreadsheet uses the equipment hours from the Hourssum spreadsheet, the number of pieces of equipment required by year, and the estimated life of the equipment to calculate a replacement schedule. This information is used in the Replsum spreadsheet to develop a capital equipment purchase and replacement schedule.

Replsum—The Replsum spreadsheet is used to tabulate the output from the Replace spreadsheets and to provide a unified equipment purchase and replacement schedule. This schedule is imported into the Purchase spreadsheet to develop a capital equipment cost schedule.

Purchase—The Purchase spreadsheet is used to develop a purchase and replacement cost schedule for capital equipment. This spreadsheet is formatted to assist the estimator in tabulating the purchase cost for the various pieces and developing allowances for sales tax and freight costs. These costs are extended against the purchase and replacement schedule imported from the Replsum spreadsheet to develop the annual cost for capital equipment.

Labsum—The Labsum spreadsheet is used to tabulate a schedule of direct operating shifts per year by labor classification, using the labor sheet index codes. This spreadsheet imports the labor input summaries from either the Takeoff spreadsheets or the Crew spreadsheets and provides a detailed manpower summary.

Matrlsum—The Matrlsum spreadsheet is used to tabulate a schedule of permanent material quantities used per year by type of material using the material index codes. This spreadsheet imports the material input summaries from either the Takeoff spreadsheet or the Crew spreadsheet and provides a detailed permanent material consumption summary.

Suplysum—The Suplysum spreadsheet is used to tabulate a schedule of expendable supply quantities used per year by type of supply using the supply index codes. This spreadsheet imports the supply input summaries from either the Takeoff spread or the Crew spreadsheet and provides a detailed supply consumption summary.

Esupcost—The Esupcost spreadsheet is used to tabulate a schedule of annual equipment related supply costs. This list includes electric power, diesel fuel, gasoline, lubricants and filters, repair parts, cable and teeth, outside repairs, and shop costs. This spreadsheets imports the equipments operating hours from the Hourssum spreadsheet and extends them against data

from the Equipor spreadsheet. This provides a basis for fuel and other supply usage estimates for use in the environmental impact studies and sizing facilities.

CAES—The CAES program, Computer Aided Estimating System, is Morrison-Knudsen's preparatory estimating program. This program is used to develop the estimates for the short term work items that would fit a hard money fixed price construction contract. It is similar to several commercial estimating programs.

The spreadsheets listed above were developed as a series of small modules that build into a final summary. The use of small linked modules allows the estimator and designer to check their work as they build the estimate. The small modules also provide a more stable estimating system, and can be checked as they are developed.

These spreadsheets are formatted to print the estimator identification, the date, the time of day, and the file name, including the path, which helps to establish an audit trail through the estimate.

5.3.2.3 Surface Facility Cost Model

The surface design group cost estimating system is spreadsheet-based and configured as will be shown in Figure 3-3. Assumptions used in surface cost estimate will be listed in Appendix 5C.

5.3.3 SITE SPECIFIC COST DATA

This section will provides a description of unique data, data sources, and modification process, if any.

- Utility costs
- Transportation costs

This section will reference Appendix I for the data details.

5.4. REPOSITORY LIFE CYCLE COST SUMMARY

The lower level details for each system element will be reported by cost account and operating period for the following system elements.

5.4.1 LIFE CYCLE COST BY PERIOD AND PROJECT ELEMENT

This section will provide the Repository life cycle cost summary by repository element and by cost phase.

5.4.2 ANNUAL DISTRIBUTION OF LIFE CYCLE COST

This section will provide the repository annual life cycle costs profile by element.

5.4.3 CAPITAL AND OPERATING COST DISTRIBUTION OF THE LIFE CYCLE COSTS

This section will provide the summary of repository capital and operating and maintenance costs by repository element.

APPENDIX 5A. TOTAL REPOSITORY DETAILED LIFE CYCLE COST SUMMARY

This appendix and appendices 5B-I below will provide lower level details of the estimate for the subject program element. The data will be tabulated by cost account and the period in which the investment will occur.

Appendix 5A will provide a detailed cost summary by cost account and life cycle phase as follows:

Table A-1 Surface Facilities
Table A-2 Subsurface Facilities
Table A-3 Disposal Containers and Performance Confirmation

APPENDIX 5B. DEVELOPMENT AND EVALUATION COST SUMMARY

This appendix will provide the detail for the Development and Evaluation (D&E) costs incorporated into the life cycle estimate. However, since this estimate life begins in April 2002, the values incorporated into this estimate will be less than the total D&E costs. Table B-1 is the historical and near term budget estimate for the Yucca Mountain Project. Table B-2 shows the development and evaluation cost summaries, historical, license application costs, and pre-emplacement costs.

In past the cycle cost analyses for the repository the development and evaluation funding was assumed to end at the time of waste emplacement. Current evaluation suggests that some functions funded by development and evaluation budget are likely to continue through most repository life cycle these will be incorporated into the estimate.

APPENDIX 5C. SURFACE FACILITIES COST ESTIMATE DETAILS

5C.1 DESIGN ASSUMPTIONS

The section will list of design assumptions driving cost estimate

5C.2 COST ESTIMATING ASSUMPTIONS

The major cost estimating assumptions that are used to develop this analysis will be provided below:

5C.3 LIFE CYCLE COST ESTIMATE SUMMARY will provide detail table(s)

APPENDIX 5D. SUBSURFACE FACILITIES COST ESTIMATE DETAILS

5D.1 DESIGN ASSUMPTIONS

This section will provide specific design assumptions used as a basis for this estimate.

5D.1.2 COST ESTIMATING ASSUMPTIONS

This section will provide the list of assumptions.

5D.2 LIFE CYCLE COST ESTIMATE SUMMARY

A summary of the LCCs for the subsurface repository cost accounts will be provided in Table D-1. Each major cost account will be described briefly in Subsection D.2.2 below. The life cycle phases will be described in Subsection D.2.3.

APPENDIX 5E. WASTE PACKAGE FABRICATION COST ESTIMATE DETAILS

5E.1 DISPOSAL CONTAINER COSTS

The Disposal Container (DC) costs are based on unit costs estimated for each of the DC designs described in the *VA Design Document*, and the waste stream defined in Appendix 5L of the *Waste Quantity, Mix and Throughput Study Report*. Disposal container types, numbers and costs will be described in Table E-1. The reference waste stream will be provided in Table E-2. The summary of the detailed unit cost estimates will be presented in Table E-3.

A summary of the cost of disposal containers for commercial SNF by year of emplacement and by type of disposal container will be provided in Table E-4.

Table E-5 will provide the annual quantities of disposal containers for each SNF type in the Department of Energy's inventory to be emplaced at the repository. The costs of the disposal containers will be identified in Table E-5 and will be presented in Table E-6.

Table E-7 will provide an annual summary of disposal containers and costs by the waste source.

APPENDIX 5F. PERFORMANCE CONFIRMATION COST ESTIMATE DETAILS

5F.1 UNDERGROUND GEOLOGIC OBSERVATIONS, MAPPING, SAMPLING AND LAB TESTING

Key estimating assumptions to be provided in this section.

5F.2 SURFACE BASED UNSATURATED ZONE HYDROLOGY

Key estimating assumptions to be provided in this section.

5F.3 FULL SCALE THERMAL INSTRUMENTATION & TESTING WITH BOREHOLES IN TEST ALCOVES

Key estimating assumptions to be provided in this section.

5F.4 LARGE SCALE LONG DURATION THERMAL TEST

Key estimating assumptions to be provided in this section.

5F.5 UNDERGROUND FAULT ZONE HYDROLOGIC INSTRUMENTATION AND TESTING

Key estimating assumptions to be provided in this section.

The Performance Confirmation activities by test and year will be summarized in Table F-1 through Table F-4.

5F.6 OTHER SITE TESTING

Key estimating assumptions to be provided in this section.

APPENDIX 5G. COMPARISON TO PREVIOUS LIFE CYCLE COST ESTIMATES

This section will provide a list of historical estimates to be used in cost comparisons and will provide graphical comparisons (bar charts) and description of cost differences and reasons for each.

APPENDIX 5H. LABOR RATE DATABASE

Table(s) to be provided.

APPENDIX 5I. GLOSSARY

This appendix is a glossary of technical and other special terms used in this volume of the Viability Assessment Document.

APPENDIX 5J. ACRONYMS, ABBREVIATIONS, AND SYMBOLS

This appendix lists and defines acronyms, abbreviations, and symbols used in this volume of the Viability Assessment Document.

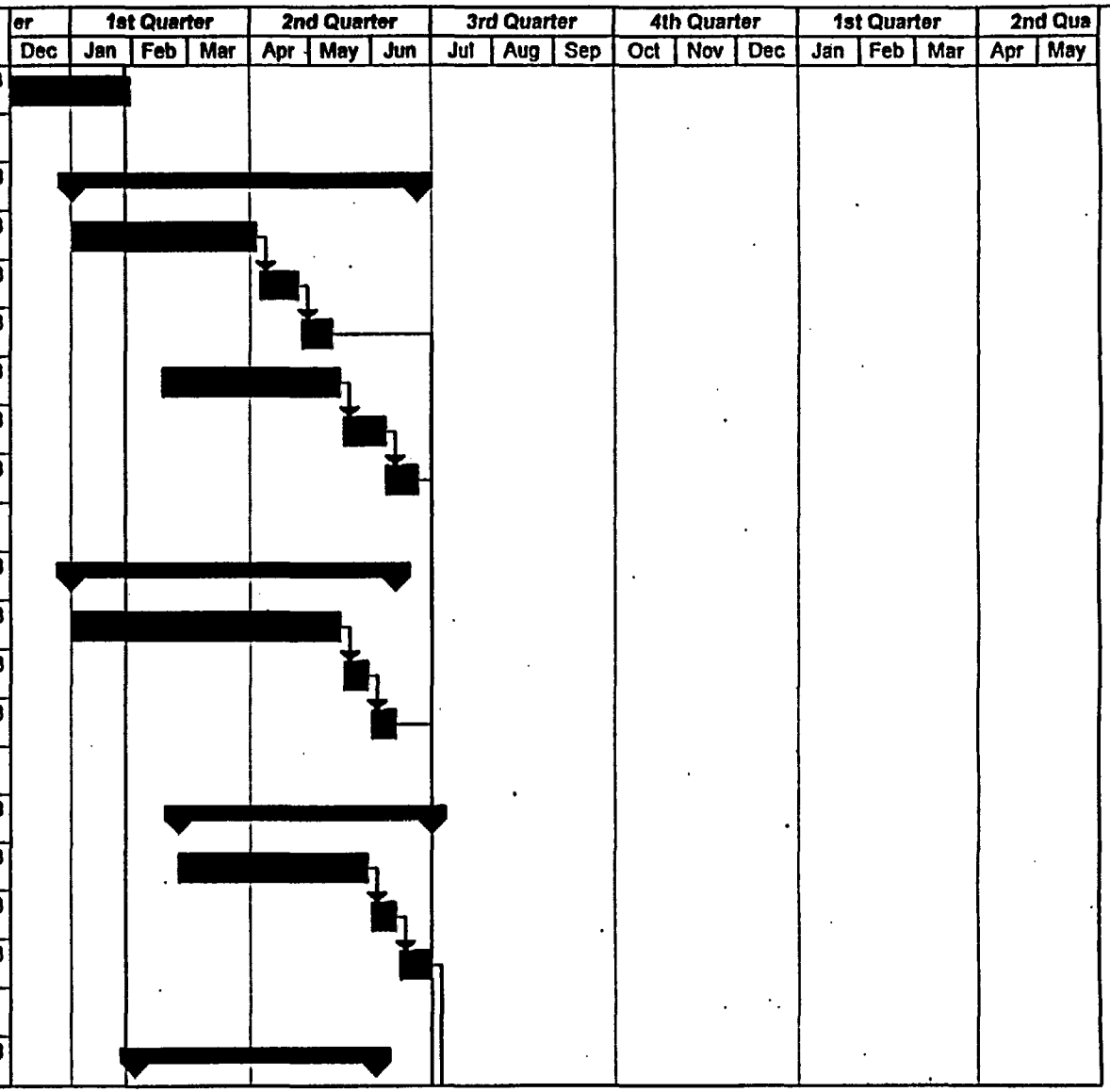
APPENDIX 5K. REFERENCES

This appendix provides the reference information for this volume of the Viability Assessment Document. In addition to a full bibliographic citation for each reference, it provides a Records Information System accession number, Technical Information Center catalog number, or Data Tracking Number, as applicable, for every reference.

APPENDIX B - DETAILED SCHEDULES

VA Document Preparation Schedule

Task Name	Start	Finish
Prepare Consolidated VA Mgt. Plan	12/1/97	1/30/98
Volume 1--ES, Intro & Site Description	1/2/98	6/23/98
Prepare draft (w/o exec. summ.)	1/2/98	4/3/98
Conduct M&O/YMSCO review	4/6/98	4/24/98
Incorporate & confirm resolutions	4/27/98	5/11/98
Prepare executive summary	2/16/98	5/15/98
M&O/YMSCO review of Exec. Summ.	5/18/98	6/7/98
Incorporate & confirm resolutions	6/8/98	6/23/98
Volume 2--VA Design	1/1/98	6/12/98
Prepare draft VA design product	1/1/98	5/15/98
Conduct M&O/YMSCO review	5/18/98	5/29/98
Incorporate & confirm resolutions	6/1/98	6/12/98
Volume 3 TSPA-VA	2/24/98	6/30/98
Draft TSPA-VA document	2/24/98	5/29/98
Conduct M&O/YMSCO review	6/1/98	6/12/98
Incorporate & confirm resolutions	6/15/98	6/30/98
Volume 4--LA Plan and Costs	2/2/98	6/2/98

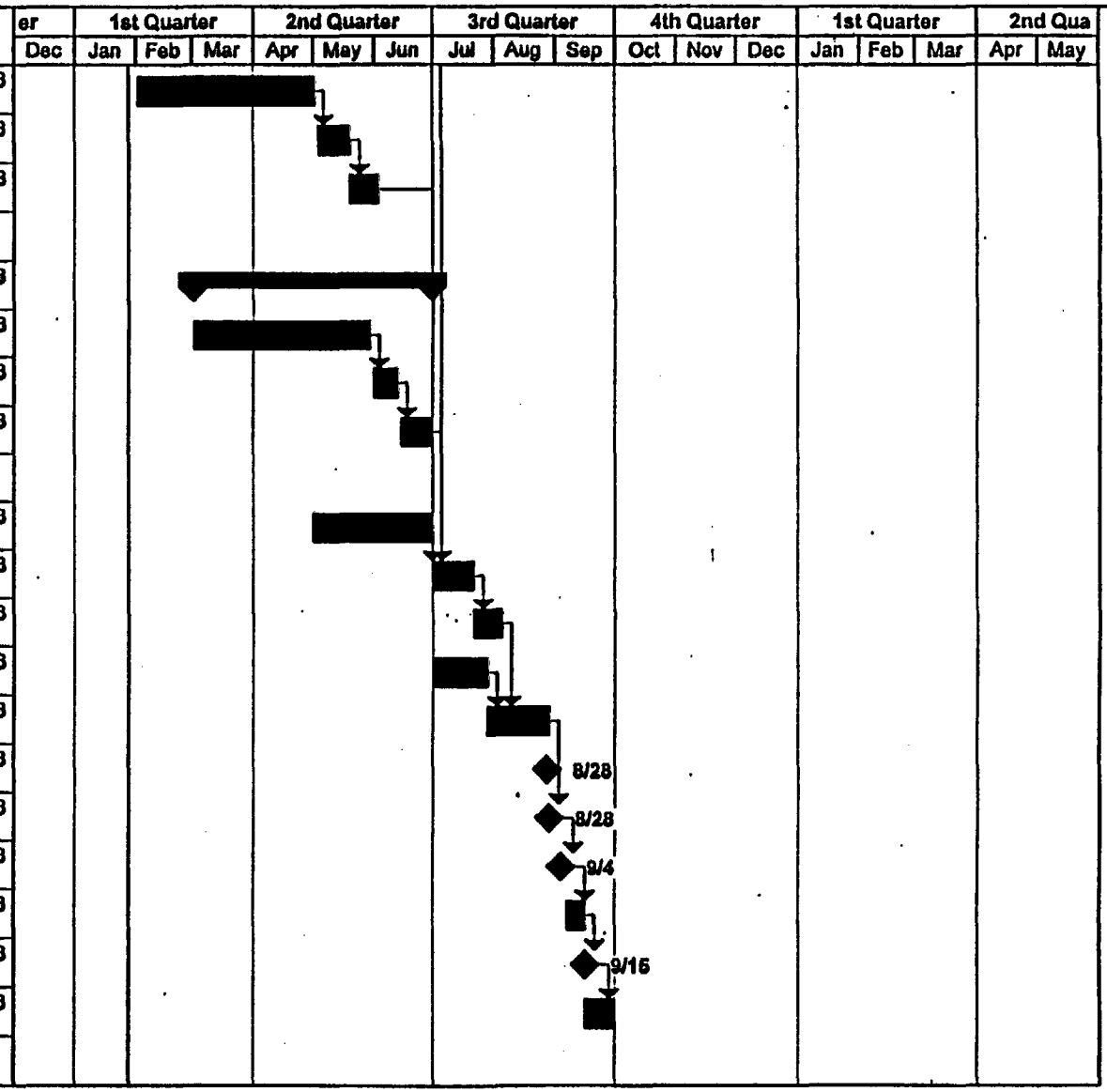


Project: VA Document
Date: 1/28/98
Prepared by: Jerry King

Task
Progress
Milestone
Summary
Rolled Up Task
Rolled Up Milestone
Rolled Up Progress

VA Document Preparation Schedule

Task Name	Start	Finish
Prepare draft LA Plan	2/2/98	5/1/98
Conduct M&O/YMSCO review	5/4/98	5/19/98
Incorporate & confirm resolutions	5/20/98	6/2/98
Volume 5--Costs to Construct & Operate	3/2/98	6/30/98
Prepare draft VA cost document	3/2/98	5/29/98
Conduct M&O/YMSCO review	6/1/98	6/12/98
Incorporate & confirm resolutions	6/15/98	6/30/98
Pull parts together into one document	5/1/98	6/30/98
Conduct DOE-wide QAP 6.2 review	7/1/98	7/21/98
Incorporate & confirm resolutions	7/22/98	8/4/98
Conduct YAP 30.12 review	7/1/98	7/28/98
Finalize VA document	7/29/98	8/28/98
Complete technical record for VA (M2)	8/28/98	8/28/98
YMSCO accepts VA (M2)	8/28/98	8/28/98
OCRWM accepts VA (M1)	9/4/98	9/4/98
DOE HQ concurrence	9/7/98	9/15/98
"Camera-ready" copy to Secretary	9/15/98	9/15/98
Secretarial review	9/16/98	9/30/98

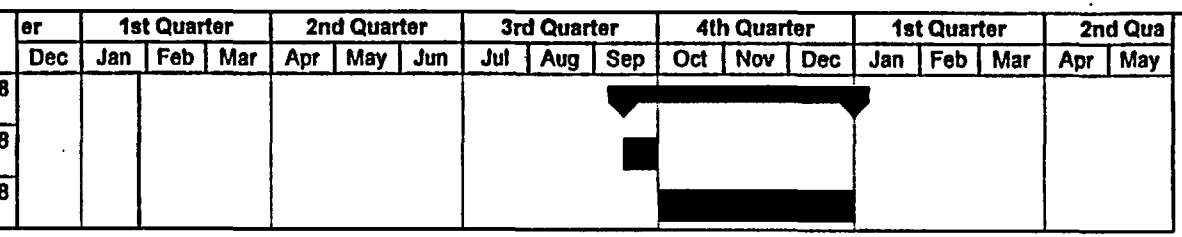


Project: VA Document
Date: 1/28/98
Prepared by: Jerry King

Task
Progress
Milestone
Summary
Rolled Up Task
Rolled Up Milestone
Rolled Up Progress

VA Document Preparation Schedule

Task Name	Start	Finish
Place document on Web	9/15/98	12/31/98
Transfer document to web server	9/15/98	9/30/98
Establish HTML links	10/1/98	12/31/98



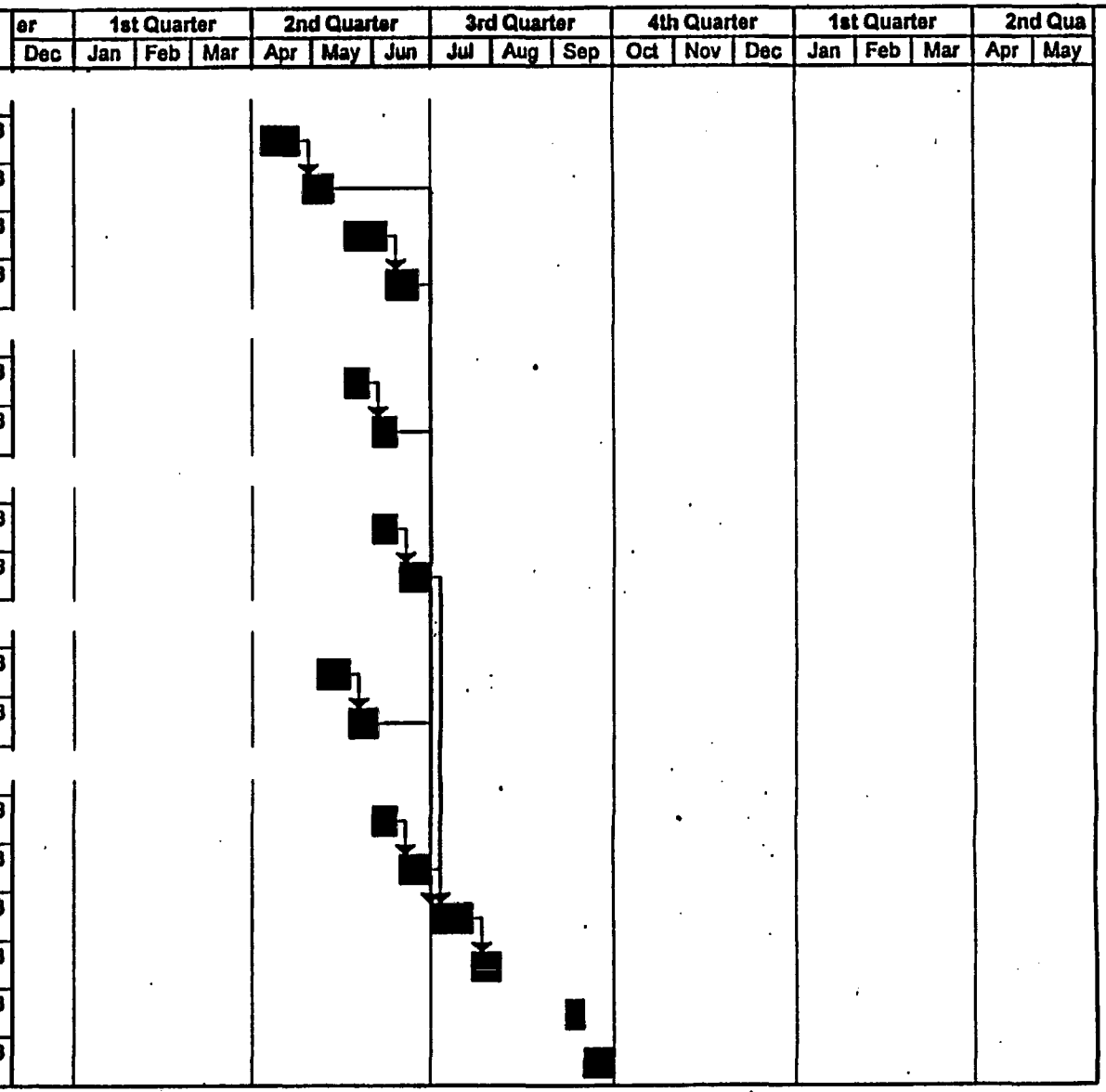
Project: VA Document
Date: 1/28/98
Prepared by: Jerry King

Task
Progress
Milestone
Summary
Rolled Up Task
Rolled Up Milestone
Rolled Up Progress

REVIEW WINDOWS

VA Document Preparation Schedule

Task Name	Start	Finish
Volume 1--ES, Intro & Site Description		
Conduct M&O/YMSCO review	4/6/98	4/24/98
Incorporate & confirm resolutions	4/27/98	5/11/98
M&O/YMSCO review of Exec. Summ.	5/18/98	6/7/98
Incorporate & confirm resolutions	6/8/98	6/23/98
Volume 2--VA Design		
Conduct M&O/YMSCO review	5/18/98	5/29/98
Incorporate & confirm resolutions	6/1/98	6/12/98
Volume 3 TSPA-VA		
Conduct M&O/YMSCO review	6/1/98	6/12/98
Incorporate & confirm resolutions	6/15/98	6/30/98
Volume 4--LA Plan and Costs		
Conduct M&O/YMSCO review	5/4/98	5/19/98
Incorporate & confirm resolutions	5/20/98	6/2/98
Volume 5--Costs to Construct & Operate		
Conduct M&O/YMSCO review	6/1/98	6/12/98
Incorporate & confirm resolutions	6/15/98	6/30/98
Conduct DOE-wide QAP 6.2 review	7/1/98	7/21/98
Incorporate & confirm resolutions	7/22/98	8/4/98
DOE HQ concurrence	9/7/98	9/15/98
Secretarial review	9/16/98	9/30/98



Project: VA Document
Date: 1/8/98
Prepared by: Jerry King

Task
Progress
Milestone
Summary
Rolled Up Task
Rolled Up Milestone
Rolled Up Progress

APPENDIX B - DETAILED SCHEDULES

SUPPORT AUTHOR DEVELOPMENT SCHEDULE
VOLUME 1 - EXECUTIVE SUMMARY, INTRODUCTION, AND SITE DESCRIPTION

Vol. 1 Section	Support Authors	Start Drafting	Prelim. Draft Complete	Start M&O / YMSCO Review	Complete M&O / YMSCO Review	Start QAP 6.2 Review	Complete QAP 6.2 Review
Exec. Summary	John Burns Tom Cotten Jerry King	2/16/98	4/30/98	5/18/98	6/12/98	7/1/98	8/4/98
1.1. Introduction							
1.1.1 Scope and Objectives	John Burns Jerry King	2/16/98	3/16/98	4/6/98	5/11/98	7/1/98	8/4/98
1.1.2 Historical Perspective	John Burns	2/16/98	3/16/98	4/6/98	5/11/98	7/1/98	8/4/98
1.1.3 Statutory and Regulatory Requirements	Ken Ashe	2/16/98	3/16/98	4/6/98	5/11/98	7/1/98	8/4/98
1.1.4 Site Characteri-zation Process	Larry Rickertsen, Jerry King	2/16/98	3/16/98	4/6/98	5/11/98	7/1/98	8/4/98
1.2. Site Description							
1.2.1 Introduction	Richard Quittmeyer, David Fenster	2/23/98	3/20/98	4/6/98	5/11/98	7/1/98	8/4/98
1.2.2 Location, Land Ownership, Population Density, Offsite Installations, and Transportation Systems	Quittmeyer, Bryan	2/23/98	3/20/98	4/6/98	5/11/98	7/1/98	8/4/98
1.2.3 Geologic Setting of Yucca Mountain	Quittmeyer, Fenster, Stuckless, Forester, Dudley, Gilles, Davis, Eckhardt	2/23/98	3/20/98	4/6/98	5/11/98	7/1/98	8/4/98

Vol. 1 Section	Support Authors	Start Drafting	Prelim. Draft Complete	Start M&O / YMSCO Review	Complete M&O / YMSCO Review	Start QAP 6.2 Review	Complete QAP 6.2 Review
1.2.4 Integrated Thermal System Response	Quittmeyer, Revelli, Wilder	2/23/98	3/20/98	4/6/98	5/11/98	7/1/98	8/4/98
1.2.5 Summary	Quittmeyer	2/23/98	3/20/98	4/6/98	5/11/98	7/1/98	8/4/98

SUPPORT AUTHOR DEVELOPMENT SCHEDULE
VOLUME 2 – VA DESIGN

Volume 2 Section	Support Author	Start Drafting	Prelim. Draft Complete	Start M&O/ YMSCO Review	Complete M&O/ YMSCO Review	Start QAP 6.2 Review	Complete QAP 6.2 Review
OVERVIEW	Dan McKenzie	3/16/98	4/30/98	5/18/98	5/29/98	6/1/98	6/12/98
2.1 Introduction	Dan McKenzie	1/1/98	4/30/98	5/18/98	5/29/98	6/1/98	6/12/98
2.2 Design Process	Dan McKenzie Dealis Gwyn Sam Rindskopf	1/1/98	4/30/98	5/18/98	5/29/98	6/1/98	6/12/98
2.3 Design Bases	Sam Rindskopf (Systems) Bob Elayer (Repository)	1/1/98	4/30/98	5/18/98	5/29/98	6/1/98	6/12/98
2.4 Repository Design	Bob Saunders Chris Gorrell Jeff Steinhoff Matt Gomez Mark Fortsch (Repository)	2/2/98	4/30/98	5/18/98	5/29/98	6/1/98	6/12/98
2.5 Engineered Barrier System Design	Kathryn Knapp J. Cogar Mal Taylor Yming Sun (WP Design/ Repository)	2/2/98	4/30/98	5/18/98	5/29/98	6/1/98	6/12/98
2.6 Concepts for Construction and Operation	Bob Saunders Jeff Steinhoff Matt Gomez (Repository)	2/2/98	4/30/98	5/18/98	5/29/98	6/1/98	6/12/98
2.7 Design Flexibility	Dan McKenzie Steven Meyers (Repository)	3/16/98	4/30/98	5/18/98	5/29/98	6/1/98	6/12/98

Volume 2 Section	Support Author	Start Drafting	Prelim. Draft Complete	Start M&O/ YMSCO Review	Complete M&O/ YMSCO Review	Start QAP 6.2 Review	Complete QAP 6.2 Review
2.8 Major Alternatives	Dan McKenzie Steve Meyers	3/16/98	4/30/98	5/18/98	5/29/98	6/1/98	6/12/98
2.9 Summary	Dan McKenzie Steve Meyers K. Knapp	3/16/98	4/30/98	5/18/98	5/29/98	6/1/98	6/12/98
References and Appendices	All Authors (All Dept.)	3/16/98	4/30/98	5/18/98	5/29/98	6/1/98	6/12/98

SUPPORT AUTHOR DEVELOPMENT SCHEDULE
VOLUME 3 - TOTAL SYSTEM PERFORMANCE ASSESSMENT

Volume 3 Section	Support Authors	Start Drafting	Prelim. Draft Complete	Start M&O/ YMSCO Review	Finish M&O/ YMSCO Review	Start QAP 6.2 Review	Complete QAP 6.2 Review
OVERVIEW	Andrews, Dockery	3/1/98	5/10/98	6/1/98	6/30/98	7/1/98	8/4/98
3.1. Introduction	Dockery, Andrews	3/1/98	5/10/98	6/1/98	6/30/98	7/1/98	8/4/98
3.1.1 Scope & Objectives	Dockery	3/1/98	5/10/98	6/1/98	6/30/98	7/1/98	8/4/98
3.1.2 Definition of PA and TSPA	Dockery	3/1/98	5/10/98	6/1/98	6/30/98	7/1/98	8/4/98
3.1.3 Philosophy of PA	Dockery	3/1/98	5/10/98	6/1/98	6/30/98	7/1/98	8/4/98
3.1.4 General Approach	Dockery	3/1/98	5/10/98	6/1/98	6/30/98	7/1/98	8/4/98
3.1.5 General Methodology	Dockery	3/1/98	5/10/98	6/1/98	6/30/98	7/1/98	8/4/98
3.2. Yucca Mountain TSPA	Andrews, Dockery	3/15/98	5/15/98	6/1/98	6/30/98	7/1/98	8/4/98
3.2.1 Objectives	Andrews, Dockery	3/15/98	5/15/98	6/1/98	6/30/98	7/1/98	8/4/98
3.2.2 Approach	Sevougian, Wilson	3/15/98	5/15/98	6/1/98	6/30/98	7/1/98	8/4/98
3.2.3 Methodology	Sevougian, Wilson	3/15/98	5/15/98	6/1/98	6/30/98	7/1/98	8/4/98
3.2.4 Description of Base Case	Sevougian, Wilson	3/15/98	5/15/98	6/1/98	6/30/98	7/1/98	8/4/98
3.3. Results	Wilson, Sevougian	3/15/98	5/15/98	6/1/98	6/30/98	7/1/98	8/4/98
3.3.1 Deterministic Analysis of Reference Design ("Base Case")	Wilson, Sevougian	3/15/98	5/15/98	6/1/98	6/30/98	7/1/98	8/4/98
3.3.2 Probabilistic Analysis of Reference Design	Sevougian, Wilson	3/15/98	5/15/98	6/1/98	6/30/98	7/1/98	8/4/98

Volume 3 Section	Support Authors	Start Drafting	Prelim. Draft Complete	Start M&O/ YMSCO Review	Finish M&O/ YMSCO Review	Start QAP 6.2 Review	Complete QAP 6.2 Review
3.3.3 Sensitivity Analysis	McNeish, Gauthier, Sevougian, Wilson, MacKinnon	3/15/98	5/15/98	6/1/98	6/30/98	7/1/98	8/4/98
3.3.4 Discussion	Andrews, Dockery, Wilson	3/15/98	5/15/98	6/1/98	6/30/98	7/1/98	8/4/98
3.4. Component Models of the TSPA	Wilson, McNeish, Gauthier, Sevougian	2/20/98	4/30/98	6/1/98	6/30/98	7/1/98	8/4/98
3.4.1 Unsaturated Zone Flow	Ho, Wilson	3/1/98	4/30/98	6/1/98	6/30/98	7/1/98	8/4/98
3.4.2 Thermohydro logy	Francis, Itamura, Wilson	3/6/98	5/5/98	6/1/98	6/30/98	7/1/98	8/4/98
3.4.3 Near-field Geochemistry Environment	Sassani, Sevougian	3/6/98	5/5/98	6/1/98	6/30/98	7/1/98	8/4/98
3.4.4 Waste Package Degradation	Lee, McNeish	3/15/98	5/10/98	6/1/98	6/30/98	7/1/98	8/4/98
3.4.5 Waste Form Alteration And Radionuclide Mobilization	Halsey, Stockman, McNeish	3/15/98	5/10/98	6/1/98	6/30/98	7/1/98	8/4/98
3.4.6 Unsaturated Zone Transport	Houseworth, Sevougian	2/15/98	4/30/98	6/1/98	6/30/98	7/1/98	8/4/98
3.4.7 Saturated Zone Flow And Transport	Arnold, Parsons, Gauthier	3/15/98	5/10/98	6/1/98	6/30/98	7/1/98	8/4/98
3.4.8 Biosphere	Smith, Aguilar, Gauthier	3/25/98	5/15/98	6/1/98	6/30/98	7/1/98	8/4/98
3.4.9 Disruptive Processes and Events	Barnard, Barr, Swift	4/1/98	5/15/98	6/1/98	6/30/98	7/1/98	8/4/98

Volume 3 Section	Support Authors	Start Drafting	Prelim. Draft Complete	Start M&O/ YMSCO Review	Finish M&O/ YMSCO Review	Start QAP 6.2 Review	Complete QAP 6.2 Review
3.5. Summary	Wilson, Sevougian, Gauthier, McNeish, Andrews, Dockery, Barnard	5/1/98	5/15/98	6/1/98	6/30/98	7/1/98	8/4/98

SUPPORT AUTHOR DEVELOPMENT SCHEDULE
VOLUME 4 - LICENSE APPLICATION PLAN AND COSTS

Volume 4 Section	Support Authors	Start Drafting	Prelim. Draft Complete	Start M&O/ YMSCO Review	Complete M&O/ YMSCO Review	Start QAP 6.2 Review	Complete QAP 6.2 Review
Overview	J. Weaver L. Rickertson	4/1/98	4/15/98	5/4/98	5/19/98	7/1/98	8/4/98
4.1.1 Scope and Objectives	J. Weaver	3/1/98	3/15/98	5/4/98	5/19/98	7/1/98	8/4/98
4.1.2 Approach to Ident. Work	L. Rickertson (Voegele, King)	2/15/98	3/15/98	5/4/98	5/19/98	7/1/98	8/4/98
4.2 Tech Work for LA	L. Rickertson T. Cotton	2/15/98	3/15/98	5/4/98	5/19/98	7/1/98	8/4/98
4.3.1 Natural Env. Invest.	R. Quittmeyer	2/15/98	3/15/98	5/4/98	5/19/98	7/1/98	8/4/98
4.3.2 Design Work	B. Stanley K. Knapp S. Meyers	2/15/98	3/15/98	5/4/98	5/19/98	7/1/98	8/4/98
4.3.3 Perf. Assess.	B. Mann	2/15/98	3/15/98	5/4/98	5/19/98	7/1/98	8/4/98
4.4.1 EIS & Environment. Compliance	K. Prince	2/15/98	3/15/98	5/4/98	5/19/98	7/1/98	8/4/98
4.4.2 Site Recommend.	K. Ashe	2/15/98	3/15/98	5/4/98	5/19/98	7/1/98	8/4/98
4.4.3.1 Licensing Activities	N. Chappell K. Prince S. Bodnar	2/15/98	3/15/98	5/4/98	5/19/98	7/1/98	8/4/98
4.4.3.2 License Application Status and Schedule	M. Scott	2/15/98	3/15/98	5/4/98	5/19/98	7/1/98	8/4/98
4.4.3.3.1 KTI's	T. Crump P. Hammond	2/15/98	3/15/98	5/4/98	5/19/98	7/1/98	8/4/98
4.4.3.3.2 NRC Communicat.	P. Hammond	2/15/98	3/15/98	5/4/98	5/19/98	7/1/98	8/4/98
4.5.1 Field Construction and Oper.	I. Cottle	2/15/98	3/15/98	5/4/98	5/19/98	7/1/98	8/4/98
4.5.2 Other Support Activities	M. Weaver IPL's	2/15/98	3/15/98	5/4/98	5/19/98	7/1/98	8/4/98
4.6 Costs	M. Weaver	3/15/98	4/1/98	5/4/98	5/19/98	7/1/98	8/4/98
4.7 Schedule	M. Weaver	3/15/98	4/1/98	5/4/98	5/19/98	7/1/98	8/4/98

SUPPORT AUTHOR DEVELOPMENT SCHEDULE
VOLUME 5 – COSTS FROM LICENSE APPLICATION TO DECOMMISSIONING

Volume 5 Section	Support Authors	Start Drafting	Prelim. Draft Complete	Start M&O / YMSCO Review	Complete M&O / YMSCO Review	Start QAP 6.2 Review	Complete QAP 6.2Review
Overview	Sweeney	3/2/98	5/15/98	6/1/98	6/12/98	7/1/98	8/4/98
5.1.	Sweeney	3/2/98	4/25/98	6/1/98	6/12/98	7/1/98	8/4/98
5.1.1	Sweeney	3/2/98	4/25/98	6/1/98	6/12/98	7/1/98	8/4/98
5.1.2	Sweeney	3/2/98	4/25/98	6/1/98	6/12/98	7/1/98	8/4/98
5.1.3	Sweeney	3/2/98	4/25/98	6/1/98	6/12/98	7/1/98	8/4/98
5.1.4	Sweeney	3/2/98	4/25/98	6/1/98	6/12/98	7/1/98	8/4/98
5.1.5	Sweeney	3/2/98	4/25/98	6/1/98	6/12/98	7/1/98	8/4/98
5.2.RLCS	Morag	4/1/98	5/15/98	6/1/98	6/12/98	7/1/98	8/4/98
5.2.1	Morag	4/1/98	5/15/98	6/1/98	6/12/98	7/1/98	8/4/98
5.2.2	Morag/Steiger	4/1/98	5/15/98	6/1/98	6/12/98	7/1/98	8/4/98
5.3.Estim.Tech	Morag	3/2/98	4/25/98	6/1/98	6/12/98	7/1/98	8/4/98
5.3.1	Morag/Steiger/ Shoemaker	3/2/98	4/25/98	6/1/98	6/12/98	7/1/98	8/4/98
5.3.2	Morag/Steiger/ Shoemaker	3/2/98	4/25/98	6/1/98	6/12/98	7/1/98	8/4/98
5.3.3	Morag	3/2/98	4/25/98	6/1/98	6/12/98	7/1/98	8/4/98
5.4. LCCS	Morag	4/1/98	5/15/98	6/1/98	6/12/98	7/1/98	8/4/98
Appendix 5A	Morag	5/1/98	5/15/98	6/1/98	6/12/98	7/1/98	8/4/98
Appendix 5B	Weaver	4/1/98	4/25/98	6/1/98	6/12/98	7/1/98	8/4/98
Appendix 5C	Meyers/ Shoemaker	4/1/98	4/25/98	6/1/98	6/12/98	7/1/98	8/4/98
Appendix 5D	Steiger/ McKenzie	4/1/98	4/25/98	6/1/98	6/12/98	7/1/98	8/4/98
Appendix 5E	Morag/Cogar/ Benton	4/1/98	4/25/98	6/1/98	6/12/98	7/1/98	8/4/98
Appendix 5F	Thomson/ Scotese	4/1/98	4/25/98	6/1/98	6/12/98	7/1/98	8/4/98
Appendix 5G	Morag	4/1/98	4/25/98	6/1/98	6/12/98	7/1/98	8/4/98
Appendix 5H	Morag	4/1/98	4/25/98	6/1/98	6/12/98	7/1/98	8/4/98

Volume 5 Section	Support Authors	Start Drafting	Prelim. Draft Complete	Start M&O / YMSCO Review	Complete M&O / YMSCO Review	Start QAP 6.2 Review	Complete QAP 6.2Review
Appendix 5I	Shoemaker/ Steiger	4/1/98	4/25/98	6/1/98	6/12/98	7/1/98	8/4/98
Appendix 5J	Sweeney	4/1/98	5/15/98	6/1/98	6/12/98	7/1/98	8/4/98
Appendix 5K	Sweeney	4/1/98	5/15/98	6/1/98	6/12/98	7/1/98	8/4/98
Appendix 5L	All Authors	4/1/98	5/15/98	6/1/98	6/12/98	7/1/98	8/4/98

APPENDIX C - VIABILITY ASSESSMENT DOCUMENT WRITERS GUIDE

VIABILITY ASSESSMENT DOCUMENT WRITER'S GUIDE

1. INTRODUCTION

This document provides the lead authors of the Viability Assessment document with guidance related to the mechanics of the document. The mechanics and structure for preparing the Viability Assessment document are explained in Sections 1, 2, and 3, and style guidance is contained in Section 4. Adherence to the guidance presented herein by all authors will result in a more uniform appearance of the Viability Assessment document, and management of the process to prepare and review the Viability Assessment document will be streamlined. This document represents an information source that outlines what is expected from authors in terms of structure and format of text. This Writer's Guide and documents that it references will serve as the only guide for the Viability Assessment document structure, format, and style. Style issues not addressed by the Writer's Guide should be referred to the *Technical Publications Management department.*

The Writer's Guide does not contain guidance on content or high-level organization of the Viability Assessment document or level of detail to be provided in the Viability Assessment document. The basic organization of the Viability Assessment document is provided in Appendix A to the Management Plan for the Development of a Viability Assessment document.

The Writer's Guide assumes the document will be developed using word processing and graphics software and printed in hard copy. Additional instructions are provided to address when the document is published electronically. (See Chapter 5 of this appendix.)

2. VIABILITY ASSESSMENT DOCUMENT STRUCTURE

2.1 DOCUMENT STRUCTURE

The basic organization of presentation of material in the Viability Assessment document is provided in Appendix A. The document structure of the Viability Assessment document is hierarchical, starting with a general subject at the top, leading to more specific subjects at the lower levels that support the higher-level topic.

2.1.1 Sections

Each volume will contain a table of contents, which will be consistent with the table of contents for the Viability Assessment Document Annotated Outline in Appendix A. It also will show additional subsections created by section authors at greater levels of

indention than levels provided in Appendix A. Each volume also will contain a list of figures and a list of tables, which will be developed by the lead authors.

2.1.2 Sections and Subsections

Within each section, authors will use subsections to organize text. Organizing the document into subsections implements a philosophy of dividing topics into units that can be broken out individually for review.

2.1.2.1 Subsections

A subsection is a unit of text residing at the second level of indention (e.g., 1.1, 1.2). Subsections are numbered sequentially within each section using the section number followed by a period and then the sequential number. Subsection numbers and titles are limited to those provided in Appendix A, unless a different organization is approved in writing by the Viability Assessment Product Development Lead.

Subsection headings consist of the subsection number, an indent, subsection title, and two hard carriage returns. All second-level headings are bolded, upper case, and left justified. If the subsection title takes more than one line, subsequent lines are aligned with the beginning of the first word of the first line. Text is placed flush left. New subsection headings begin on a new page. References appear as specified in Appendix A.

2.1.2.2 Subsections

Subsections also reside at the third and lower levels of indention. These subsections are numbered using three or more digits separated by periods (e.g., x.x.x, x.x.x.x) depending on the level of indention.

Subsections should be created as follows:

2.1.1
2.1.1.1

The subsection structure for the Viability Assessment document will be consistent with Appendix A, although authors may create more subsections.

Subsection numbering is limited to the fourth level of indention (e.g., 2.1.1.1). If an author feels it necessary, further division of text beyond the fourth level of indention can be accomplished by one of the following options:

- Using zero-level of indention, per Subsection 2.1.2.4 (preferred).

- Obtain permission from the Viability Assessment Product Development Lead to use further levels of indention.

It is noted that in past documents of this type, flexibility in subsection indention has led to substantial inconsistency between subsections completed by different authors. Although there are no hard rules for when to create new subsections, the following general guidance will be used by the Viability Assessment Product Development Lead when considering the authorization of new subsections:

- Minimize indention below the fourth level (x.x.x.x). In spite of the difficulty with topics such as site characteristics, minimization beyond the fourth level is a goal.

- Do not create a new subsection if the section consists of one or two paragraphs. If it is necessary to further detail the topic, use zero level of indention titles. (See below).

- Ensure that the lower level subsection logically expands upon the higher level subsection.

- Use zero level of indention titles to relate text to items that are best described in a list.

Subsection headings consist of the section number, an indent, section title, and two hard carriage returns. All subsection headings are bolded and typed in initial capital letters. Subsection heading numbers line up with the first word of the second-order heading. If the subsection title takes more than one line, then subsequent lines are aligned with the beginning of the first line. One line of space should be left between a paragraph ending a subsection and the heading of the next subsection.

2.1.2.3 Lists

Lists should use bullets, with the bullets at the left margin. Do not use numbered lists unless it is necessary to indicate order. Lists can include complete sentences; however, if each list item becomes a lengthy paragraph, the preferred style might be a series of subsections rather than a list. A list should be used to mention a series of items that are an integral part of a discussion. For example, if an author is writing a paragraph and wants to define three new terms, a list format could be used to name the terms and provide a definition for each. Discretion of the author is used to determine whether each item should be discussed separately and formatted as a subsection.

2.1.2.4 Zero Level of Indention

In some instances, it is desirable to delineate information for a more logical presentation. Although subsections are an alternative, excessive use tends to clutter and complicate the document. The zero level of indention is an alternative that provides an opportunity to delineate information and minimize clutter.

A zero level of indention heading contains no section number. The heading text is terminated with a period and two spaces. The heading text, which is bolded and left justified, is embedded within the first paragraph of the zero-level subsection. The first letter of each word in the subsection title is upper case. Because zero-level subsections are not numbered, they do not appear in the table of contents. The following illustrates a zero level of indention heading:

Example:
Characteristics of Earthquake Ground Motions at Yucca Mountain. To date, earthquake ground motions at Yucca Mountain have been estimated using attenuation.....

3. VIABILITY ASSESSMENT DOCUMENT TEXT FORMAT

3.1 MARGINS

Text will have 1-inch left, right, top, and bottom margins. All header and/or footer text is located between the edge of the paper and the margins.

3.2 JUSTIFICATION

All text will be fully justified.

3.3 SPACING

The document will be single-spaced with a double space separating each paragraph. Paragraphs will not be indented.

3.4 FONT SELECTION

The font used for the Viability Assessment document is Times New Roman font, 12 point type.

3.6 PAPER SIZE

All text pages will use standard 8 ½ x 11- inch paper, although pages for figures and tables may be larger than 8 ½ x 11 provided that:

- The bound side does not exceed 11 inches
- The finished copy when folded does not exceed 8 ½ x 11 inches.

3.7 PAGE NUMBERING

Pages will be numbered with the section number followed by a hyphen and a sequential number within the section. Page numbers will be placed in the footer at the bottom center of the document in 10-point type.

Text pages will be double-sided. Each section will begin with a new page and will begin on the front side of a sheet of paper. Pages without text will be labeled: "INTENTIONALLY LEFT BLANK" in the center of the otherwise blank page.

Table and figure pages will be single-sided. Blank reverse page sides of figures and tables do not require and should not have notations such as the one in the previous paragraph.

3.8 FIGURE AND TABLE NUMBERING

Figures and tables are numbered sequentially in the same manner as the page numbering scheme described in Section 3.7. In other words, the first figure in Section 2.2 is labeled "Figure 2.2-1." Figures and tables are numbered separately, each numbering sequence starting with the numeral 1.

3.9 FIGURES AND MAPS

All text provided in figures must be legible. The preferred electronic format for figures and maps is Corel Draw, although Powerpoint and WordPerfect Graphics are acceptable. Contact Technical Publications Management for further guidance. All maps proposed for inclusion in the Viability Assessment document must be processed through M&O Technical Data Management. The preferred projection is Universal Transverse Mercator. However, if considered necessary, permission may be obtained from M&O Technical Data Management to use a different projection.

3.10 TABLES

All text provided in tables must be legible. Contact Technical Publications Management for guidance on format. Tables that contain quality data must be clearly identified as such.

3.11 HEADERS AND FOOTERS

Footers will be inserted by Technical Publications Management. The footer will include the Viability Assessment document number in the lower left corner. If the page is in draft form, the footer will so indicate by "DRAFT, xx/xx/xx." where xx/xx/xx is the date of the draft. Both the

document number and the date will be in 10-point type. The header will specify the volume number.

3.12 REFERENCES

References cited in text should be formatted in accordance with the M&O Publishing Guide. The following requirements shall be adhered to:

- All reference material must be approved documents. Draft documents will not be referenced.

- References must be traceable to the source and must be available in the records system. All references not already in the Reference Information System (RIS), Technical Information Center (TIC), or the Technical Data Management System (TDMS) must be submitted to those systems prior to DOE acceptance of the final document.

- All references are required to have an RIS or TIC number or a data tracking number. Data tracking numbers are required for reference to data or models in the GENISES or Reference Information Base (RIB) databases. These identifiers as to location of the references are to be included at the end of the complete reference description in the reference section of the section in which the reference is cited.

- Global reference to a source document should only be used when the entire document was used as a source. Citations must include specific reference as to page, paragraph, figure, etc. when appropriate.

3.13 CROSS-REFERENCING

Cross-referencing is encouraged to reduce the amount of duplicate information and to minimize the chance of presenting contradictory information. The lead author who cross-references with another author's material will:

- Inform the other lead author of the existence of the cross-reference

- Verify during final preparation of the section for submittal that the cross-reference to the other author's work is still valid and correctly numbered.

3.14 UNITS OF MEASUREMENT

Although the units of the International System of Units (SI) are becoming more common in the United States, most readers do not understand them. Therefore, measurements expressed in the SI will be expressed in both SI and English units, first by SI and immediately followed by the English equivalent in parentheses, with the following exceptions.

- In citing units from references, the convention used in the reference is followed, with conversions to the other type of unit given in parentheses.

- For measurements commonly expressed in English units, such as the diameter of pipes, English units are used without conversion to SI units.

- Quantities on maps, such as elevations, given in English units are not converted to SI quantities.

Certain quantities may customarily be expressed in mixed units, such as English and SI, as in the case of metric tons heavy metal per acre. Although this practice is undesirable and should be avoided, the author may choose to use mixed units if use is predominant and if the use of other units would not add clarity or assist in understanding the meaning of the quantity.

3.15 NUMBERS

All numbers that appear before units of measurement are written as figures.

Units of measurement are abbreviated when preceded by a numeral (e.g., 50 cm) but spelled out when standing alone (e.g., "the concentration, measured in milligrams per liter").

If the number preceding a unit is one or less, the unit is written in the singular; write "0.5 meter."

In expressing a range or series of measurements, do not repeat the units; write "40 to 50°C" and "5 and 10 rem," or "40, 60, or 90 cm."

Numbers in text are spelled out if they are fewer than 10 or if they begin a sentence. If any number in a series is greater than 10, the entire series is written as figures.

Fractions standing alone are spelled out, "two-thirds of the site." Fractions that are not spelled out are best expressed as decimals rather than fractions, (e.g., 3.75 rather than 3 3/4).

Avoid changing units unnecessarily when reporting different amounts of the same quantity, for example, changing units of radiation dose from rem to millirem in a discussion.

3.16 OTHER NUMERIC CONVENTIONS

In text, spell out units of measurement except for temperatures; write "812 watts," "600 picocuries per square meter," and "50°C." When temperature is expressed in kelvins, no degree sign is used (e.g., 300 K).

The degree sign (°) also is used for angles, compass directions, longitude, and latitude. The percent sign (%) is used for percents.

Standard abbreviations for units of measure are to be used. The abbreviations are not followed by a period. If the abbreviation is derived from the name of a person (i.e., W. K.), it is upper case; otherwise it is lowercase (i.e., m, g, s, in., ft) with the exception of liter. The standard prefixes of scientific notation such as "m," "c," or "k" for "milli," "centi," and "kilo" are lowercase, with the exception of "giga" and "mega" which are upper case (G and M, respectively).

References to geologic age are ma (mega annum) or ka (kilo annum), equivalent to "million years before present" or "thousand years before present," respectively. My and ky refer respectively to "million years" and "thousand years."

The abbreviations for liter, hour, minute, and second are L, h, min, and s, respectively. If one part of a compound measurement is not a unit, the word, "per" rather than a slash (/) is used to denote division (e.g., 5,000 kg per load). If the unit is the second part, it is not abbreviated (e.g., 300 particles per second).

When the measure is a compound unit designating the multiplication of one unit by another, the multiplication is indicated by a hyphen (e.g., g-cm, W-s), division by the slash symbol (e.g., J/mole-K, kcal/m-s-K). Measurements that are cubed or squared are written with exponents (e.g., 10 m^3, 8.34 x 10^{-8}).

In reference to radioisotopes in text, write cesium-137 instead of ^{137}Cs. In tables write Cs-137. Tables use the superscript form only when there is no room for the longer form. WordPerfect version 6.1 can accommodate Greek letters.

3.17 EQUATIONS

Equations will be created using the Microsoft Word equation editor, using the default settings for the type size and font. Equations will be in italics to set them off from regular text. Equations will be numbered according to section number. For example, the first equation in Section 1 will be numbered (EQ 1-1) and will be right justified next to the margin, aligned as closely as possible to the first line of the equation.

4. STYLE

The potential readership of the Viability Assessment document will include engineers, scientists, lawyers, Congressional staff members, members of the general public, and others. Since the Viability Assessment document will report complex technical subjects and phenomena, the writers' challenge will be to present these ideas in terms that any interested reader can understand. The use of jargon and complex technical expressions should be minimized; they

should be accompanied by explanations when they are used. Readers will be aided by presentation of material in a logical, linear progression. A topic sentence at the beginning of each paragraph will assist in establishing this structure.

In addition, the Viability Assessment document authors should follow the additional guidance below:

- Use active rather than passive voice wherever possible to produce a stronger and more assertive document.
- Use short declarative sentences; break up large sections.
- Avoid superlatives and exaggeration. A dry, slightly understated position is more defensible.
- Be certain of the facts.

4.1 COMPOUND WORDS

The DOE practice, in the *Site Characterization Plan* and elsewhere, has been to write "fresh water," "salt water" without a hyphen, but to hyphenate when used as unit modifiers, such as "salt - water flow." Groundwater should be one word in all usages.

Hyphenate strings of modifiers. For example, write "host-rock strength," "a northwest-trending structural trend," or "five high-strength 1-inch-diameter rock bolts" When the strings of hyphenated modifiers are long, they should be broken by the use of prepositional phrases.

4.2 SYNTAX

Writers must be particularly alert to syntax and choice of verbs to avoid inadvertently undermining the completed work. There is a spectrum of certainty implicit in writers' syntax. Writers should use a word that fits the intended meaning, but should seek to make syntax choices using "high confidence words when possible:

Low Confidence Words–May, maybe, might, could be, seem, appear, suggest, imply, infer, deduce, expect, assume, conceivable, probably, likely, possibly

High Confidence Words–Illustrates, concludes, shows, resolves, states, demonstrates, indicates, establishes, documents, proves.

"Relatively" and "significant" are words that confuse and must be used sparingly, if at all. "The impacts are relatively harmless." The reader must ask, "Relative to what?" "The U-series dating technique is significantly better than the U-trend technique." The reader must ask, "Significant

according to what standard?"

4.3 WORDS THAT OFTEN CAUSE TROUBLE

Troublesome words that often occur include:

- "All," "never," and "none" are words that should be used with caution because their use may overstate a fact or conclusion.

- Avoid the use of "maximize," "minimize," "optimize" and similar words whose meanings are subject to excessively wide interpretation.

- "Data," "media," "phenomena," and "criteria" are plural forms. The corresponding singular forms are "datum," "medium," "phenomenon," and "criterion."

- The words "offsite" and "onsite," written as single words, are used as adjectives, not as adverbs. "The plans call for onsite processing" is acceptable. "Processing is performed onsite" is not acceptable; a phrase like "at the site" must replace "onsite."

- The adverbial phrase "under way," written as two words meaning "in progress" or "in motion." The single word "underway" occurs more rarely; it is an adjective meaning "occurring while in motion."

- "Alternative" means "a choice between two or more things." "Alternate" means "succeeding by turns," such as, every other day, or to move in position from one side to the other.

- "Due to" is not used in adverbial prepositional phrases by the most careful writers; it is not a substitute for "because of." Use it only when "due" clearly modifies a noun. "The machine broke due to improper oiling" is not acceptable; "a failure due to improper oiling" is acceptable.

- The phrase "the maximum individual" appears in regulations on exposure to radiation. Although it cannot always be avoided, its use is objectionable, not only because it is graceless but also because it does not mean what it seems to mean: few readers will guess that the "individual" is not necessarily a person. Like other technical phrases, this one must be carefully defined if it must be used. Once defined, it can be avoided by the use of a less jarring phrase like "the maximum individual dose."

- Do not use the slash symbol (/) to mean "and." The slash should be used only to denote division in units of measurement. Do not use "and/or."

4.4 VOGUE AND VAGUE WORDS

Some words and phrases are in such common use among writers of Program documents that they are often used imprecisely or even with no meaning at all.

- "Anticipate." This word is not a synonym for "expect."

- "Based on. ..." This phrase frequently appears without anything to modify, as in "Based on the reported data, the committee concluded that no action was necessary." Make sure the phrase modifies something if it must be used.

- Bureaucratic jargon. Careful readers tumble over officialese as "prior to," "implement," "viable," "at this point in time," and a proliferation of "-ize" and "-wise" suffixes, Some of these words and phrases have precise meanings, but they are pretentious. Do not use them.

- "Conservative." Writers often use this word to describe analyses designed intentionally to overestimate risks or adverse impacts. When the word is used to describe an analysis, it requires explanation by pointing out explicitly which parts of the analysis produce the overestimates. Giving such a complete a definition of the word, however, usually removes the need for it.

- "Consider" and "factor." These words are vague, although "factor" does have a precise meaning in mathematics. Writers use them to mean "criterion," "design specification," or something to think about.

- "Facility." This word usually conveys little information; define it more clearly.

- "Ologies." The indiscriminate use and coining of words ending in "ology" leads to imprecise writing. In careful use, the suffix is reserved for words that express the theory or study of something. "Technology," a fuzzy word that usually means "methods" or "techniques" should be avoided. Do not write "the hydrology of the site;" write "the water flowing through the site" or "the hydraulic system at the site" or another phrase that conveys the meaning. Do not use "methodology" to mean "methods."

- "Orders of magnitude." This phrase is almost incomprehensible to people who do not use technical jargon frequently. Write "one ten-thousandth of x" or 10,000 times smaller than x" instead of "four orders of magnitude smaller than x."

4.5 TEXT STYLE

The Technical Publications Management department should be consulted on issues related to text style such as capitalization and punctuation.

5. ELECTRONIC DOCUMENT PUBLISHING

Should the Viability Assessment document be published electronically rather than on paper, the following guidance applies:

- Subsection 2.1.2.1, "Sections": References, figures and tables may be hypertext linked instead of in the section.
- Section 3.7, "Page Numbering": In an electronic environment, there may be no page numbers or "intentionally left blank" statements.
- Section 3.9, "Figures and Maps": Guidance for electronic formatting of figures will be provided separately.
- Section 3.10, "Tables": Guidance for electronic formatting of tables will be provided separately.
- Section 3.11, "Headers and Footers": Electronic format may not allow headers and footers.
- Section 3.16, "Other Numeric Conventions": Greek letters and equations may need to be typed in a word processing application and copied as bit maps.