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Department of Energy
Washington, DC 20585

May 8, 2000

The Honorable Richard A. Meserve
Chairman
U.S. Nuclear Regulatory Commission
Washington, DC 20555

Dear Mr. Chairman:

Pursuant to the Nuclear Waste Policy Act, Section 113(b)(3), this letter transmits the Twenty-First Semiannual "Site Characterization Progress Report: Yucca Mountain, Nevada." The enclosed report covers the period April 1, 1999 through September 30, 1999. Progress Report 21 is a concise report organized to provide an executive summary and descriptions of site characterization studies, repository design and construction activities, assessment of repository performance, and progress towards near-term programmatic and statutory objectives.

During this reporting period, the *Draft Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada* was released on August 6, 1999. This document assesses the impacts of constructing, operating and monitoring, and eventually closing a monitored geologic repository at Yucca Mountain. The public comment period on the Draft Environmental Impact Statement ended on February 28, 2000. Comments will be considered to the extent practicable beyond that date. These comments will be considered as the Department develops the Final Environmental Impact Statement, which would accompany any Site Recommendation to the President.

During the reporting period, the study of design features and design alternatives was completed, resulting in the selection of a design basis for a possible Site Recommendation and License Application. Substantial resources continue to be applied to ensure that important quality assurance issues are expeditiously resolved and that actions are taken to prevent their recurrence.

The Program's science and engineering work is now focused on completing the analyses and documentation for a Site Recommendation Consideration Report later this year. The Department will hold hearings on a possible site recommendation and request comments from the public, State Governors and legislatures, and affected Native American Tribes and consider these comments in making any recommendation of the site. The Department will also consider preliminary comments from the U.S. Nuclear Regulatory Commission regarding the sufficiency of information for inclusion in a license application. Should the Secretary proceed with a site recommendation and should that recommendation be approved by the President and Congress, the Department will complete the work necessary to submit a license application to the U.S. Nuclear Regulatory Commission in 2002.

We plan to continue to issue future progress reports in this format. Progress Report 22, covering the reporting period of October 1, 1999, through March 30, 2000, is expected to be released in September 2000.

If you wish to discuss any of these matters further, please call me at (202) 586-6842.

Sincerely,

Ivan Itkin, Director
Office of Civilian Radioactive
Waste Management

Enclosure

QA: N/A

SITE CHARACTERIZATION PROGRESS REPORT:

YUCCA MOUNTAIN, NEVADA

April 1, 1999, to September 30, 1999

Number 21

NOTE INSIDE FRONT COVER

The Nuclear Waste Policy Act of 1982, as amended, established the U.S. Department of Energy Office of Civilian Radioactive Waste Management. The Nuclear Waste Policy Act directs the Office of Civilian Radioactive Waste Management to dispose of the nation's high-level radioactive waste and spent nuclear fuel in a geologic repository and prescribes other related activities. The Nuclear Waste Policy Act, as codified in 42 U.S.C. 10133 (b)(3), requires a semiannual report on site characterization progress. Title 10 of the Code of Federal Regulations, Part 60 (10 CFR 60.18(g)), *Disposal of High-Level Radioactive Wastes in Geologic Repositories,* requires the report to:

- Describe the progress of site characterization activities and information developed to date
- Identify decision points reached and schedule modifications
- Describe waste form and waste package research and development
- Identify new issues and plans to resolve these issues
- Discuss any planned studies eliminated because they are no longer necessary to site characterization.

This is the 21st progress report issued by the U.S. Department of Energy. This report provides a summary-level discussion of Yucca Mountain Site Characterization Project progress. Accomplishments this period are presented in a format that identifies important progress achieved and conveys how that progress supports the near-term objectives in the U.S. Department of Energy's schedule. Greater detail is documented in the cited references and in deliverables listed in Appendix A to this report. Readers may request specific U.S. Department of Energy-approved program documents that are listed in Section 7, References, and Appendix A by contacting the Office of Civilian Radioactive Waste Management Information Line at 1-800-225-6972.

This document provides a discussion of recently completed and ongoing activities conducted by the Yucca Mountain Site Characterization Project during the six-month reporting period from April 1, 1999, through September 30, 1999. Some information presented herein is by necessity preliminary, because some deliverables and reports that support the discussions have not been finalized. Projected future deliverables and reports are listed in Appendix B and are noted in the text as works in progress. Appendix C lists the status of milestone reports referenced in previous progress reports commencing with Progress Report 17. A glossary of Yucca Mountain Site Characterization Project-specific terms used in this report is given in Appendix D.

Documentation of Program Change, last published in June 1999 as Revision 01 (CRWMS M&O 1999a), updates site characterization activities in relation to the 1988 *Site Characterization Plan: Yucca Mountain Site, Nevada Research and Development Area* (DOE 1988). Beginning with the reporting period of April 1997 through September 1997, the *Documentation of Program Change* was removed as an appendix to the progress report and published separately as reference material on the Yucca Mountain Site Characterization Project's site characterization program. The U.S. Department of Energy plans to revise this document annually.

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LIST OF FIGURES

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ACRONYMS AND SYMBOLS

ACRONYMS

AMR	analysis and model report
CAR	corrective action report
DBE	design basis event
DOE	U.S. Department of Energy
EDA	enhanced design alternative
EIS	environmental impact statement
ESF	Exploratory Studies Facility
EWDP	Early Warning Drilling Program
FR	Federal Register
FY	fiscal year
IRSR	issue resolution status report
ISM	Integrated Site Model
KTI	key technical issue
LA	license application
MGR	monitored geologic repository
NRC	U.S. Nuclear Regulatory Commission
NWPA	Nuclear Waste Policy Act of 1982, as amended
OQA	Office of Quality Assurance (DOE)
PMR	process model report
PVAR	process validation and reengineering
QA	quality assurance
SNF	spent nuclear fuel
SR	site recommendation
SRCR	site recommendation consideration report
SRR	site recommendation report
SZ	saturated zone
TSPA	total system performance assessment
UZ	unsaturated zone
VA	viability assessment
YMP	Yucca Mountain Site Characterization Project

SYMBOLS

PTn	Paintbrush nonwelded hydrogeologic unit
Tac	Calico Hills Formation
Tpbt1	pre-Topopah Spring Tuff bedded tuff
Tptpll	Topopah Spring Tuff crystal-poor lower lithophysal (zone)
Tptpln	Topopah Spring Tuff crystal-poor lower nonlithophysal (zone)
Tptpmn	Topopah Spring Tuff crystal-poor middle nonlithophysal (zone)
Tptpul	Topopah Spring Tuff crystal-poor upper lithophysal (zone)
Tptpv	Topopah Spring Tuff crystal-poor vitric zone

SECTION 1 – EXECUTIVE SUMMARY

The 21st semiannual report of the Yucca Mountain Site Characterization Project (YMP) summarizes activities from April 1–through September 30, 1999. These activities are focused on evaluating the suitability of Yucca Mountain as a site for permanent geologic disposal of nuclear materials, as directed by the Nuclear Waste Policy Act of 1982, as amended (NWPA). Site characterization, and the semiannual reports describing it, will end when and if the Secretary decides to recommend the Yucca Mountain site for development of a geologic repository.

This progress report documents those Project activities that contributed to completing the near-term programmatic and statutory objectives. These objectives, which are to be completed in the next several years, include completing the environmental impact statement (EIS), developing a possible U.S. Department of Energy (DOE) Secretarial Site Recommendation (SR) to the President, and, if the President's recommendation is approved by Congress, submitting a license application (LA) to the U.S. Nuclear Regulatory Commission (NRC).

Science and engineering work is focused on supporting a decision on an SR. Project work concentrated on three integrated activities: site characterization; engineering design and Exploratory Studies Facility (ESF) construction; and repository performance. Accomplishments during this period and their relation to near-term objectives are summarized briefly below. The near-term objectives and the three integrated activities are presented in more detail in Sections 2–6.

Program Progress and Plans–The most significant accomplishment during this reporting period was completion of the *Draft Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada, Volumes I and II* (draft EIS) (DOE 1999a) in July 1999. This milestone document assesses the impacts of constructing, operating and monitoring, and eventually closing a geologic repository at Yucca Mountain; the potential long-term impacts of repository disposal; the potential impacts of transporting the high-level radioactive waste and spent nuclear fuel (SNF) nationally and in the State of Nevada; and the potential impacts of not proceeding with the Proposed Action (construction, operation, and eventual closure of a geologic repository at Yucca Mountain).

The draft EIS (DOE 1999a) was released to the public on August 6, 1999. The formal Federal Register (FR) Notice of Availability, *Draft Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada, Volumes I and II* (64 FR 44200), was published by DOE on August 13, 1999. The document notes that DOE's preferred alternative is to proceed with the Proposed Action for the disposal of SNF and high-level radioactive waste at Yucca Mountain. The document states that the supporting analyses did not identify any potential environmental impacts that would be a basis for not proceeding with the Proposed Action. The Notice of Availability also states that the natural features of the very dry climate, large distance to the water table, and geology of the site would act to limit the amount of water that entered the repository. The engineered features, including waste packages made from corrosion-resistant material, would inhibit releases of radioactive material, even in the presence of any water that might reach the emplacement area. Limiting the seepage of water into the emplacement drifts is important to maximize waste package performance and minimize the potential release of radioactive material to the environment.

Before the final EIS is issued, the technical analyses supporting the document will be updated as appropriate to reflect the ongoing progress of site studies and to resolve public comments on the draft document. This activity will be integrated with Project work in site testing, design, performance

assessment, and preparation of the SR and LA. After site characterization is complete, the Secretary of Energy will decide, with input from the public, states, Native American tribes, and the NRC, whether to recommend approval of the site to the President. Any recommendation and a comprehensive statement of the basis for the recommendation would then be submitted to the President, as required by the NWPA.

The Project's primary focus is currently on completing the analyses and documentation to support the Secretary's decision whether to recommend the site. The DOE initiated development of the Site Recommendation Consideration Report (SRCR) upon completion of the *Management Plan for the Development of the Yucca Mountain Site Recommendation Report* (CRWMS M&O 1999bw) in April. SRCR and the key references that support it will describe the technical basis for the Secretary's consideration to recommend the site. This will support and encourage participation of interested parties in the hearing process specified in NWPA, under Section 114.

Comments received on the SRCR, as well as additional information available after the report is developed, will be considered in development of the Site Recommendation Report (SRR), which will provide the comprehensive basis for the Secretary's decision. The final EIS, which DOE will publish separately, will accompany the SRR.

While focusing on the SR, the Project also continued to meet with the NRC to gain assurance that the technical work completed to date, and planned, would be sufficient to support the safety case in an LA. In addition, DOE's *Technical Guidance Document for License Application Preparation* was approved and issued (YMP 1999a). The revised document provides guidance to future authors of the potential LA on demonstrating compliance with the NRC's proposed 10 Code of Federal Regulations (CFR) 63, *Disposal of High-Level Radioactive Wastes in a Proposed Geologic Repository at Yucca Mountain* (64 FR 8640). Another accomplishment was development of a working draft LA annotated outline.

The Project continues to apply substantial resources to addressing crosscutting quality assurance (QA) deficiencies identified during the prior reporting period. These deficiencies encompassed data traceability, data qualification, procurement, software qualification, and modeling. The purpose of this work is to make necessary changes at all levels of the program to ensure that important QA issues are resolved and to prevent recurrence of significant QA problems.

The process validation and reengineering (PVAR) activity initiated during the previous reporting period was completed. This work standardized quality-related technical, science, and engineering procedures; provided clearer guidance to end-users; reduced procedure redundancy; established ownership of processes and procedures; and established a more effective training program.

The Project also began development of selected site- and performance assessment-related analyses and documents needed to support an SR and LA. Analysis and model reports (AMRs) will be summarized in nine process model reports (PMRs) that will be primary references to an SR and LA. Each PMR will describe a given process model, including references for submodels, analyses, and abstractions that support development of the model and its use in performance assessment. Documents and analyses developed in conjunction with these PMRs will ensure that information required to comply with QA requirements is, in fact, compliant.

Site Characterization–Site-related work focused in large part on planning for and beginning development of AMRs and PMRs to support the SR and a potential LA. For example, the Integrated Site Model 3.1 (ISM3.1) (CRWMS M&O 1999by) [EARTHVISION CSCI: 30035 V4.0, TBV-692] was completed. Components of the Integrated Site Model are used in fluid-flow, transport, and design-modeling activities, and the ISM is the subject of the first PMR to be completed in Fiscal Year (FY) 2000. Work also continued on preparation for publication of the 1:50,000-scale geologic map of the

site-scale saturated-zone (SZ) flow model area. Seepage into the emplacement drifts is a parameter important to repository design and performance; characterization of seepage into ESF alcoves continued. Monitoring of temperature, relative humidity, and barometric pressure continued in the ESF Main Drift, niches, and the Southern Ghost Dance Fault Alcove (Alcove #7).

Hydrologic bulkheads were completed and closed in June 1999 to isolate part of the Cross Drift from the rest of the Cross Drift and the ESF, which are being ventilated with dry, desert air. This isolation allows monitoring, under conditions of ambient, high relative humidity, to provide data on flow and seepage properties of rock units at the potential repository horizon beneath areas of relatively high infiltration and within the Solitario Canyon fault zone, under conditions similar to those expected for a nonventilated repository. The bulkheads were briefly opened in early September 1999, and no evidence of seeps was noted.

Core samples of the Calico Hills nonwelded hydrogeologic unit from the Busted Butte Test Facility were analyzed for physical properties, saturated hydraulic conductivity, moisture retention, and unsaturated hydraulic conductivity. Phase II testing at Busted Butte was initiated in July 1998 and is anticipated to continue through early spring 2000. Phase II is an expanded version of Phase I, scaled-up spatially and with respect to flow rates, and involves an augmented suite of reactive and nonreactive tracers.

Work related to the SZ included development and calibration of a new site-scale SZ flow and transport model [FEHMN, TBV-569] to be used for the total system performance assessment (TSPA) for the SR (TSPA-SR). Preliminary lithostratigraphic logs for deep Nye County boreholes were developed in support of the Nye County drilling program, based on analyses of drill cuttings. Preliminary geophysical logs were transmitted to Project participants for use in updating regional and site-scale geologic-framework models.

Drilling resumed in borehole USW SD-6 in April at a depth of 2,386 ft (727.2 m). This is the only borehole that penetrates the SZ directly beneath the potential repository. This borehole and several others nearby were instrumented with pressure transducers to monitor drawdown during hydraulic testing. Preliminary analysis of the results of this testing is in progress.

Preliminary geotechnical investigations were conducted for the potential site of the Waste Handling Building. Work also continued on development of seismic-design inputs. A methodology was implemented using available data to determine ground motion inputs for a site at the potential waste emplacement level, for surface-rock sites at Yucca Mountain, and for a surface soil site. Results are being documented in a report planned for the second quarter of FY 2000.

Engineering Design and ESF Construction–Design work continued to focus on supporting the SR. In addition, some LA-related work was performed to ensure sufficient design development to support submittal of an LA, should the site be found suitable and recommended for development. The most important accomplishment related to design was completion of the study of design features and design alternatives. Based on these studies, the Enhanced Design Alternative (EDA) II design (CRWMS M&O 1999az) was selected as the basis for the SR and LA designs. Significant differences between the EDA II design and the viability assessment (VA) (DOE 1998) were identified.

In conjunction with the design decision, DOE decided to pursue further refinement of the design. The sensitivity of postclosure repository performance to uncertainties associated with coupled, thermally driven processes will be examined for preclosure durations of 50 and 125 years. Models that are the basis for evaluation of thermal conditions will be refined to reduce uncertainty. Design options that can increase the efficiency of heat removal also will be evaluated.

The Project continued to develop and refine the documents that establish and form the repository design requirements. This effort included completion of 10 system description documents (CRWMS M&O 1999c–1999k and 1999bx), which defined design bases and criteria for many important structures, systems, and components. In addition, 30 compliance program guidance packages (CRWMS M&O 1999l through 1999ao) were developed to provide regulatory input to both design and licensing documents in support of the LA. The *Monitored Geologic Repository Requirements Document* (YMP 1999b) was updated to add a description of the monitored geologic repository (MGR) concept of a repository that can be kept open for 300 years, add a requirement that the design be capable of accommodating the current inventory projection of SNF and high-level waste, and change the waste inventory to include immobilized plutonium and mixed-oxide SNF.

In support of implementing the new design, the Project continues to define the subsurface repository layout and operations processes. Testing continued on a quarter-scale model emplacement drift and waste package to determine the effectiveness of emplacement drift backfill and drip shields on keeping infiltration from contacting waste packages (see Appendix B, Table B-1, work in progress #9). Planning is underway for additional tests, using different types of backfill in conjunction with the drip shield.

In repository surface design, the Project completed documents that support development of a revision to the configuration of the Waste Handling Building to support the SRR. Other documents and analyses evaluated the impacts of a modular, phased-construction approach for the Waste Handling Building and described how the Project will deal with the generation and treatment of secondary low-level waste. The Project assessed worker dose during surface facility operations and associated shielding requirements.

The Project also completed *Waste Package Related Impacts of Plutonium Disposition Waste Forms in a Geologic Repository* (CRWMS M&O 1999ap). This study concluded that the ceramic plutonium waste form can be emplaced in the repository at a loading of five plutonium-containing high-level waste canisters per waste package. It also concluded that mixed-oxide SNF can be loaded into the standard waste packages for 12 and 21 commercial, pressurized-water reactor, spent fuel assemblies.

Another important document, *Waste Package Operations FY-99 Closure Methods Report* (CRWMS M&O 1999aq), documented the results of weld closure and nondestructive evaluation work completed on test plates. These test plates will serve as sample plates as part of a residual stress and corrosion-materials testing study. Waste package materials testing and modeling activities were modified to incorporate performance requirements for the EDA II design (CRWMS M&O 1999az). Evaluation of the corrosion resistance of these materials under repository-relevant conditions and work on better defining the chemistry of water drips potentially striking the warm waste package are continuing. Work also continued to support quantifying general corrosion, localized corrosion, microbiologically induced corrosion, stress-corrosion cracking, and hydrogen embrittlement of these materials. The potential amount of spent fuel surface area that is exposed after a waste package failure has been modeled on a per-fuel-rod basis. This modeling, based on an extension of previous spent fuel oxidation, dissolution, and release-rate models, provides the surface area that may be potentially wetted for performance assessment analyses.

ESF and Enhanced Characterization Repository Block design and construction work included completing the designs for the Cross-Over Alcove (Alcove #8) and Niche #5 and beginning excavation of Alcove #8. These alcoves and niches will support site characterization activities related to the evaluation of flow and seepage processes in the potential repository horizon rock layer.

Repository Performance–Repository performance assessment activities continued to focus on three topics: preclosure radiological safety assessment, postclosure performance assessment, and performance confirmation.

For preclosure radiological safety assessment, Revision 10 to *Classification of Permanent Items* (QAP-2-3, Rev 10) was issued. This revision will simplify the QA classification process to make it more consistent with a risk-informed design approach. The five QA classes identified in previous versions were replaced by three quality levels based on safety significance.

Postclosure performance assessment work continued in support of repository design activities. Input calculations were performed in support of the draft EIS (DOE 1999a). The calculations evaluated the potential long-term individual radiological dose from the release of radioactive materials from the Yucca Mountain repository (CRWMS M&O 1999b). A preliminary comparison was made between the performance of the EDA II design (CRWMS M&O 1999az) and the EIS base-case analysis. Preliminary conclusions were that the EDA II design would be effective in reducing the expected annual dose to the average member of the critical group during the first 10,000 years after permanent closure (the proposed period of regulatory concern) as compared to the EIS (and VA [DOE 1998]) base case.

The total system model was revised in preparation for the TSPA-SR. Progress was made on integrating the component models into the comprehensive total system model in preparation for the multirealization probabilistic simulations used to forecast total system performance for both the 10,000-year and 1 million-year time frames. In addition, the *Total System Performance Assessment–Site Recommendation Methods and Assumptions* document (CRWMS M&O 1999ay) was issued. This document presents the overall goals, objectives, scope, methods, approach, and assumptions to be used in development of the TSPA-SR. The document will serve as a communication tool for coordinating the DOE TSPA activities and for informing the NRC staff about those activities for the SR.

Performance confirmation activities are conducted to collect and analyze data to ensure conditions encountered and changes in those conditions are within the limits to be stated in the license. The Performance Confirmation Program began during site characterization and will continue until permanent closure. The program determines whether natural systems, as well as engineered systems and components, are functioning as intended and anticipated. Planned revision of the *Performance Confirmation Plan* (CRWMS M&O 1997) has been rescheduled for March 2000, to incorporate the impact of recent changes on testing and monitoring needs. These changes include the new EDA II design (CRWMS M&O 1999az) and guidance on the expected changes in the U.S. Environmental Protection Agency's *Environmental Radiation Protection Standards for Yucca Mountain, Nevada* (proposed 40 CFR 197 [64 FR 46976]) and regulations proposed by the NRC, *Disposal of High-Level Radioactive Wastes in a Proposed Geologic Repository at Yucca Mountain, Nevada* (proposed 10 CFR 63 [64 FR 8640]). Other changes to be addressed include the revised licensing approach and principal factors for performance, as identified in the draft update of *Repository Safety Strategy: U.S. Department of Energy's Strategy to Protect Public Health and Safety After Closure of A Yucca Mountain Repository* (YMP 1998c) (see Appendix B, Table B-1, work in progress #1).

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SECTION 2 – PROGRESS TOWARD NEAR-TERM OBJECTIVES

During this reporting period, Project activities supported the major near-term objectives prescribed in the NWPA. The first of these objectives was attained with release of the *Draft Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada, Volumes I and II* (DOE 1999a) (draft EIS). This section also describes how the activities discussed in Sections 3–5 of this report relate to the remaining near-term objectives of an EIS, SR, and LA.

Although work is in progress to address both preclosure and postclosure issues to support an SR and LA, the bulk of current work is focused on postclosure issues. The challenge of predicting repository performance over 10,000 years in a complex underground natural environment requires this focus. The Project continued to refine its postclosure safety approach and to update its repository safety strategy. Since Revision 2 of the *Repository Safety Strategy: U.S. Department of Energy's Strategy to Protect Public Health and Safety After Closure of A Yucca Mountain Repository* (YMP 1998c) was issued, design enhancements have been evaluated, and an enhanced, repository-system design concept has been selected. In addition, more information regarding flow and radionuclide transport characteristics of the host rock pertaining to the safety case has been obtained. The repository safety strategy is therefore being updated to take advantage of the additional information and to be applicable to the current design (see Appendix B, Table B-1, work in progress #1).

The updated strategy will identify the factors important to performance of the repository system and the principal factors of the postclosure safety case. The principal factors that have been preliminarily identified are:

- Limited seepage of water into the emplacement drifts
- Performance of the drip shield
- Performance of the waste package
- Solubility limits of dissolved radionuclides in Yucca Mountain water
- Retardation of radionuclide migration in the unsaturated zone (UZ)
- Retardation of radionuclide migration in the SZ
- Dilution of radionuclide concentrations in the geologic setting.

These factors were used to identify the specific testing, performance assessment modeling, and other remaining information needs to complete the postclosure safety case to support the SR process, and, if appropriate, an LA. DOE expects that some work planned in the viability assessment can logically be eliminated or deferred into the performance confirmation program as a result of design enhancements.

A few questions remain regarding each of these factors, and work to address them is underway. Results of this work are expected to be sufficient to provide a postclosure safety case adequate to judge the safety of the system. That safety case will be completed in time to support the SR and LA.

The site characterization program, as defined by the NWPA, ends when and if the Secretary decides to recommend the site to the President. The performance confirmation program, already begun during the site characterization phase, would continue after a site recommendation.

Correction of the crosscutting QA deficiencies that were identified in early 1998 continues to be an important factor in the ability of the Project to meet the schedules for SR and LA. These deficiencies encompassed data traceability, data qualifications, procurements, software qualifications, and modeling. Based on the root-cause determinations completed at the end of the last reporting period, a

number of additional actions to preclude recurrence were identified. All of those actions have been taken with the exception of providing a traceability link for new data in the Office of Civilian Radioactive Waste Management Program Procedures. The remaining action will be completed by the end of October 1999. In addition to the actions to preclude recurrence, the management plan prepared in response to these deficiencies was modified to use an "as-required" approach for determination of the full extent of the deficiencies and correction of deficiencies in each affected work product.

The "as-required" approach uses the nine PMRs (discussed below) and supporting AMRs to establish the data, software, and models needed to support SR and LA. When the data and software needs are identified, priorities consistent with the PMR and AMR schedules are established for the needed verification and qualification efforts. The data and software are then verified or qualified, as appropriate. This entire process was incorporated into procedures primarily developed during the PVAR effort. In addition to data and software verification and qualification efforts, this process ensures the development and verification of adequate traceability for the data being used and verification of procurements affecting data quality, and ensures that models are adequately documented and validated before the output is considered qualified.

The corrective action report (CAR) related to procurement (CRWMS M&O 1998c) was successfully closed in September 1999. All corrective actions for other crosscutting CARs are expected to be completed, with adequate implementation experience to demonstrate effectiveness of the corrective actions, by November 1, 1999. A final verification phase is being scheduled and will be used as a basis for final determination of the adequacy of the corrective actions. If verification identifies satisfactory implementation, the remaining CARs could be closed by the end of 1999.

The PMR development process, conceived during the previous reporting period, began. The process involves developing site- and performance assessment-related analyses and documents needed to support an SR and LA. The various analyses and documents will be summarized in nine PMRs. PMRs are synthesis reports that primarily reference supporting analyses and modeling documentation, documents developed outside the Project, and other key documents (e.g., topical reports and other PMRs). PMRs bring together technical basis information for the various TSPA process models. More detailed technical information will be contained in approximately 120 supporting AMRs.

Each PMR will address the following aspects related to the model:

- Description of the model and submodels
- Abstraction of the model into TSPA
- Relevant data and data uncertainties
- Assumptions and bases
- Model results (outputs)
- Information on code verification and model validation
- Opposing views
- Information necessary to support regulatory evaluations.

The nine reports, to be completed during FY 2000, describe the following process models:

- Integrated site model
- Near-field environment
- Waste package degradation

- Waste form degradation
- UZ flow and transport
- SZ flow and transport
- Engineered barrier system
- Biosphere
- Disruptive events.

Planning for development of the PMRs has been completed. A detailed annotated outline was prepared for each PMR, and a scope statement was prepared for each AMR. During this detailed planning process, a number of AMRs were combined, and development of others was canceled. This effort further supported narrowing focus on the most important activities and processes. Four AMRs have been completed, and the ISM PMR is in the final review process. Because data qualification will be a multiyear process, some data and references appearing in the PMRs will be marked "To Be Validated." The PMRs will need to be revised as additional data qualification work is completed, to support the objective of having all data needed for licensing qualified in time for LA submittal in accordance with Project schedules.

The PVAR process, initiated to facilitate implementation of a sound infrastructure to support a nuclear culture in the Project, was completed. This work resulted in standardized procedures for all program participants and eliminated procedure redundancy for quality-related technical, science, and engineering processes.

The PVAR effort had begun the previous reporting period. All the PVAR procedures were effective by June 30, 1999. A total of 25 quality-affecting technical procedures were implemented, applicable to the DOE, U.S. Geological Survey, and Management and Operating Contractor (including the national laboratories). The effort resulted in 49 procedures being identified for deletion, with more to follow. A "subject-matter expert" was designated for each new procedure. This individual is responsible for working with users to ensure the procedures are technically correct, compliant with applicable requirements, and usable. To further support these objectives, all the procedures were subjected to reviews, and the key integrating procedures were validated. Training was implemented to support the new procedures, and a "lessons learned" process was implemented to help promote continuous improvement in the future.

Other important work in progress addresses defense-in-depth. The Project has evaluated potential repository design concepts to determine the extent to which the natural and engineered barriers work in combination to enhance the resiliency of the repository and to increase confidence that the postclosure performance objectives would be met. This evaluation used the same approach as that used to evaluate the defense-in-depth provided in the VA system design. The evaluation suggested the need for design enhancements to provide one or more additional barriers to decrease the degree of reliance upon the behavior of any single barrier (e.g., waste packages) for waste isolation and containment. The new EDA II design concept (CRWMS M&O 1999az) incorporates a drip shield over the waste package to provide redundancy in preventing exposure of the waste to water.

The assessment of the enhanced design shows that if the waste package and drip shield are each designed to last 10,000 years in the repository environment, the system will likely provide substantial margin in meeting the postclosure performance objectives. These results suggest that the enhanced design will reduce the effects of uncertainties in the factors most important to postclosure performance of the repository system.

2.1 ENVIRONMENTAL IMPACT STATEMENT

The NWPA requires that a final EIS accompany any Secretarial recommendation to the President of the United States [Section 114(f)(1)].

In July 1999, the Project completed the draft EIS (DOE 1999a). This milestone document assesses the following:

- The impacts of constructing, operating and monitoring, and eventually closing a geologic repository at Yucca Mountain
- The potential long-term impacts of repository disposal
- The potential impacts of transporting the high-level radioactive waste and SNF nationally and in the State of Nevada
- The potential impacts of not proceeding with the Proposed Action (construction, operation, and eventual closure of a geologic repository at Yucca Mountain).

The draft EIS (DOE 1999a) was released to the public on August 6, 1999, and the formal Federal Register Notice of Availability (64 FR 44200) was published by DOE on August 13, 1999.

The draft EIS (DOE 1999a) notes that DOE's preferred alternative is to proceed with the Proposed Action to construct, operate and monitor, and eventually close a geologic repository for the disposal of SNF and high-level radioactive waste at Yucca Mountain. The document states that the analyses that support the draft EIS did not identify any potential environmental impacts that would be a basis for not proceeding with the Proposed Action. It adds that DOE has not chosen any preferred transportation mode, corridor, or route. However, DOE has designated the Caliente-Chalk Mountain rail corridor and heavy-haul route as "nonpreferred alternatives."

The document also states that the natural features of the very dry climate, large distance to the water table, and geology of the site would act to limit the amount of water that entered the repository. The engineered features, including waste packages made from corrosion-resistant material, would inhibit releases of radioactive material, even in the presence of any water that reached the emplacement area.

The No-Action Alternative discussed in the draft EIS (DOE 1999a) involves ending characterization activities at Yucca Mountain, with DOE and the commercial utilities continuing to store SNF and high-level waste (Scenarios 1 and 2). One scenario considered is to leave the waste at sites under institutional control for 10,000 years, while the other assumes no effective institutional controls after 100 years.

The draft EIS (DOE 1999a) finds that the short-term environmental impacts of the Proposed Action and the two No-Action Alternative scenarios would be small and would be related to health and safety and socioeconomics. The potential long-term environmental impacts of the Proposed Action and No-Action Alternative Scenario 1 (continued institutional control) would also be small. A 180-day public comment period began with issuance of the draft EIS (DOE 1999a), including meetings both in the local area and elsewhere around the country to receive public comments. The public meetings began in September 1999. Interested persons are encouraged to take part in review of the draft, including federal agencies, Native American tribal organizations, state and local government agencies, public interest groups, industry and utility organizations, and the general

public. As described in the Notice of Availability (64 FR 44200), the DOE has provided several methods for people to express their views.

Before the final EIS is issued, the technical analyses supporting the EIS will be updated as appropriate to reflect the ongoing progress of site studies. Updates will also be made, as needed, to resolve public, agency, or Native American tribal comments on the draft EIS (DOE 1999a). This activity will be integrated with Project work in site testing, design, performance assessment, and preparation of the SR and LA.

2.2 SITE RECOMMENDATION

Following issuance of the draft EIS (DOE 1999a), the next major milestone is the SR. The DOE initiated development of the SRCR upon completion of the *Management Plan for the Development of the Yucca Mountain Site Recommendation Report* (CRWMS M&O 1999bw) in April 1999. The SRCR, which is scheduled to be issued in November 2000, and the key references that support it, will describe the preliminary technical basis for the Secretary's consideration to recommend the site. Although the NWPA [42 U.S.C. 10134(a)(1)] does not require that DOE provide information for public and State review and comment before a possible recommendation, DOE determined that this information should be made available before public hearings on the recommendation. These hearings are required by the NWPA. The information provided in the SRCR is intended to support and encourage participation of interested parties in the hearing process.

Currently, the SRCR is in the early stages of development. While development of the report continues, other activities (as described elsewhere in this report) are focusing on completion of technically defensible documents (e.g., PMRs and system-description documents) that will be the key references supporting the SRCR. The SRCR and its key technical references will demonstrate that the natural and engineered barrier systems are sufficiently understood to support consideration of a site recommendation. They will also address uncertainties in available information and in analyses of system performance. A long-term monitoring program designed to address the remaining uncertainties will also be discussed.

The SRCR, when completed, will contain the following information and would be included in a comprehensive statement of the basis for a recommendation, if the Secretary decides to recommend the site:

- Description of the proposed repository, including preliminary engineering specifications for the facility
- Description of the waste form or packaging proposed for use at the proposed repository, and an explanation of the relationship between such waste form or packaging and the geologic medium of the site
- Discussion of data, obtained in site characterization activities, relating to the safety of the site.

This information tracks certain requirements of the NWPA [42U.S.C. 10134(a)(1)(A), (B), and (C)]. Comments received on the SRCR, as well as additional information available after the SRCR was developed, will be considered in development of the SRR. The SRR will provide the comprehensive basis for the Secretary's decision to recommend. In addition to the updated SRCR information, the SRR will contain the views and comments of the Governor and Legislature of any state, or the governing body of any affected Native American Indian tribe, as determined by the Secretary,

together with the response of the Secretary to such views [NWPA, 42 U.S.C. 10134(a)(1)(F)]. It will also include other information that the Secretary considers appropriate [NWPA, 42 U.S.C. 10134(a)(1)(G)] and any impact report submitted under Section 116(c)(2)(B) by the State of Nevada [NWPA, 42 U.S.C. 10134(a)(1)(H)].

Preliminary NRC comments concerning the extent to which the at-depth site characterization analysis and the waste form proposal for the site seem to be sufficient for inclusion in any LA (NWPA, 42 U.S.C. 10134 (a)(1)(E)) will also be included with the SRR. As required by NWPA, 42 U.S.C. 10134 (a)(1)(D), the final EIS, which DOE will publish separately, will accompany the SRR.

2.3 LICENSING

Although near-term work will continue to focus on supporting the Secretary's decision whether to recommend the site, the Project is continuing interactions with the NRC to ensure that YMP activities are consistent with NRC's expectations for submittal of a high-quality repository LA, should the Yucca Mountain site be recommended to and approved by the President and Congress. On February 22, 1999, the NRC published its proposed licensing criteria specific to Yucca Mountain. The proposed regulations, *Disposal of High-Level Radioactive Wastes in a Proposed Geologic Repository at Yucca Mountain, Nevada*, (proposed 10 CFR 63 [64 FR 8640]) would significantly change the NRC's approach to evaluating repository performance.

The new proposed regulations are risk-informed and performance-based. They also require use of multiple barriers to provide defense-in-depth against releases of radioactive materials and to enhance confidence that repository performance objectives will be met. The NRC would leave in place its existing generic regulations as 10 CFR 60 but would indicate that those regulations neither apply nor may be the subject of litigation in any NRC licensing proceedings for a repository at Yucca Mountain.

On June 30, 1999, the DOE submitted written comments to the NRC on the proposed regulations. The letter conveying the comments (Barrett and Klein 1999) noted that the DOE strongly endorses NRC's use of risk-informed, performance-based licensing criteria (proposed 10 CFR 63 [64 FR 8643]). It also stated that elimination of subsystem performance objectives and siting criteria allows both DOE as applicant and NRC as regulator to place emphasis on key technical issues (KTIs) related to health and safety aspects of repository performance. The letter stated that DOE believes the proposed rule is a major improvement over 10 CFR 60 in terms of allowing DOE appropriate flexibility in determining how best to satisfy the performance criteria and allowing the NRC to focus on the results of the performance assessment analysis as the primary basis for decision making. The letter forwarded comments DOE believed would improve several risk-informed, performance-based aspects of the proposed rule.

Interactions with the NRC continue to focus on the NRC's 10 KTIs and on the associated NRC issue resolution status reports (IRSRs) that provide a framework for addressing KTIs. The NRC identified the KTIs as the topics the NRC considers most important to performance of a repository at Yucca Mountain. This reporting period, the YMP reviewed, analyzed, and developed comments on three NRC IRSRs (NRC 1999a–1999c). In addition, NRC and DOE met on issues related to the IRSR on TSPA and integration and to the IRSR on container life and source term.

The DOE and NRC also conducted public meetings on other important subjects. Subjects addressed included disposal criticality, thermal testing, and engineered barrier system testing, among others. These meetings provided appropriate forums for discussion of technical issues that will need to be

resolved before licensing. In general, DOE and NRC participants assessed the meetings as beneficial, and in some cases, as among the most useful since the NRC/DOE interactions began several years ago.

In addition to the 10 technical exchanges and Appendix 7 meetings, two quarterly QA/management meetings were conducted during this reporting period. Interactions with the Advisory Committee on Nuclear Waste and the Nuclear Waste Technical Review Board continued to provide an opportunity for DOE to explain various technical and programmatic aspects of the YMP and gain understanding of external issues and concerns.

A working draft LA annotated outline was developed. This activity had the objectives of putting into place the appropriate processes for developing the LA and allowing potential authors practice in developing draft LA text. Having met these objectives and facing competing priorities, this activity was terminated after a rough draft was developed. The draft text will be used as applicable to support SR, and it will be used to support LA development in FY 2001.

2.4 KEY PLANNED ACTIVITIES THROUGH SEPTEMBER 30, 2000

Key site characterization studies, design and construction, performance, and programmatic activities planned for FY 2000 (October 1, 1999–September 30, 2000) will include the following:

Progress Toward Near-Term Objectives

- Completing the first versions of PMRs to support an SR.
- Obtaining and responding to public comments on the draft EIS (DOE 1999a) and continuing development of the final EIS.
- Continuing development of an SRCR. This is the Project's top priority for FY 2000.
- Completing preparation for commencing development of an LA, should the site be recommended to the President. This work will include developing appropriate administrative-control processes or revising existing processes as needed to support licensing.
- Updating the repository safety strategy to reflect new site information, evaluations of design alternatives and options, updated model abstractions, the proposed 10 CFR 63 (64 FR 8640), and the proposed U.S. Environmental Protection Agency standard.
- Revising the *Technical Guidance Document for License Application Preparation* (YMP 1999a) to incorporate additional regulatory analyses, other new information, and the expected issuance of the NRC's final site-specific regulations in the proposed 10 CFR 63 (64 FR 8640).
- Transmitting to the NRC the DOE comments from reviews of the NRC IRSRs (NRC 1999a–1999c) to support resolution of issues, questions, and concerns raised in the IRSRs.
- Participating in Appendix 7 meetings to facilitate progress towards agreement on KTIs.
- Identifying and qualifying Q-data necessary to support SR and LA.

Site Characterization

- Issuing a Topical Report regarding seismic design and initiate review with the NRC.
- Revising the *Yucca Mountain Site Description* (CRWMS M&O 1998b), currently planned for completion early in the third quarter of FY 2000.
- Collecting SZ hydrogeological data in previously untested areas through the Alluvium Testing Complex and in conjunction with the Nye County Phase II Early Warning Drilling Program, in support of the IRSR on unsaturated and saturated flow under isothermal conditions.
- Conducting fluid-inclusion studies to address concerns raised by the Nuclear Waste Technical Review Board and the State of Nevada.
- Continue collecting drift-scale thermal test data and conducting thermal-testing workshops that relate to the IRSR on thermal effects on flow.
- Documenting and qualifying input data for ISM3.1. The model is anticipated to undergo validation during FY 2000.
- Completing Phase II testing of flow and transport in the Calico Hills Formation at the Busted Butte Test Facility in support of the IRSR on unsaturated and saturated flow under isothermal conditions.
- Conducting saturated and unsaturated flow and transport testing in Atomic Energy of Canada, Ltd., Laboratories on blocks of the Calico Hills Formation removed from the Busted Butte Test Facility, in support of the IRSR on unsaturated and saturated flow under isothermal conditions.
- Conducting systematic borehole characterization of fracture properties and seepage characteristics in the lower lithophysal.
- Testing in Niche #5 to address flow and seepage processes in the lower lithophysal (Tptpll) potential repository horizon rocks.
- Testing in Alcove #8 to address flow, matrix diffusion, and seepage processes in upper lithophysal (Tptpul) rocks and middle nonlithophysal (Tptpmn) potential repository horizon rocks.

Engineering Design and Construction

- Completing Pilot-Scale Tests #1, #3, #4 and #5 to support study of performance of engineered barrier system concepts.
- Initiating design of backfill and drip shield.
- Testing of bench-scale thermal, hydrological, and chemical coupled heated columns to simulate temperature and chemical behavior of water circulating through a column of potential invert and backfill materials.

- Testing in the ESF to evaluate the drainage capacity of rock in the emplacement drifts.

- Continuing to define and describe the Waste Handling Building configuration needed to support development of the SRCR.

- Updating the Project requirements document (YMP 1999b) to integrate DOE's Interim Guidance (Dyer 1999) to the proposed 10 CFR 63 (64 FR 8640) and requirement changes resulting from the EDA II (CRWMS M&O 1999az) and *License Application Design Selection Report* (CRWMS M&O 1999ba) effort (see Appendix B, Table B-1, work in progress #3).

- Updating the Project description (see Appendix B, Table B-1, work in progress #5) to capture performance criteria associated with the EDA II selection (CRWMS M&O 1999az). The *Monitored Geologic Repository Concept of Operations* (CRWMS M&O 1999bb) will be updated to provide an operational description of the repository operations based on the SR design (see Appendix B, Table B-1, work in progress #6).

- Continuing development of the waste package design, including design analysis reports for waste package designs that will serve as the technical basis document for the SRCR. A methodology report will be developed to provide a written reference of the design approach for thermal, structural, and shielding processes for the waste package design. Corrosion testing of Alloy 22, Ti-Gr 7, and 316 stainless steel will continue.

- Continuing excavation of Alcove #8 and Niche #5 to support ongoing testing activities.

- Providing spent fuel and glass data and models to evaluate waste form degradation rates for different design options and to support performance assessment. Studies to characterize the initial condition of Zircaloy fuel rods will continue.

Performance Assessment

- Developing TSPA-SR Rev. 00 analyses to support the SRCR, including nominal scenario and disruptive events (primarily volcanism), with a separate stylized analysis for human intrusion, and comparing dose rates to compliance criteria. The TSPA-SR calculations will incorporate the most up-to-date component models, and latest design and site data.

- Completing AMRs to support TSPA-SR Rev. 00.

- Revising the *Performance Confirmation Plan* (CRWMS M&O 1997) to incorporate the impact of recent changes to repository design and the repository safety strategy (YMP 1998c).

- Documenting, checking, reviewing, and revising data (e.g., To Be Verified [TBV] data, unqualified data, etc.), and resolving comments on Analysis/Model Reports.

- Providing input and documentation to and resolving comments on Process Model Reports.

- Issuing Rev. 01 of AMRs and supporting issuance of Rev. 01 of PMRs.

- As part of TSPA-SR development, analyzing and producing screening arguments for features, events, and processes for all topics to support SR. Producing documentation to support TSPA-SR and updating the features, events, and processes database.

- Conducting analyses and developing abstractions on stress corrosion cracking models for waste package and drip shield, incorporating key aspects of manufacturing and stress remediation of welds, especially waste package closure welds. Improving abstractions for general corrosion and localized corrosion (pitting and crevice) of waste package and drip shield materials under repository conditions. Improving approach to quantifying treatment of uncertainty and variability of corrosion degradation processes of waste packages and drip shields in the repository.

- Completing verification of computer code for waste package degradation analysis (WAPDEG CSCI: 30048 V3.09 TBV-568).

- Developing new cladding degradation model using new data. Incorporating new degradation rates for commercial SNF, defense SNF, and high-level waste into TSPA-SR and TSPA-LA.

- Evaluating the solubility of neptunium, americium, uranium and technetium as a function of pH, total carbonate, and temperature, and adjusting solubility distributions for other important radioisotopes.

- Supporting update of the repository safety strategy by providing analytical support, as requested, including sensitivity analyses and barrier neutralization analyses.

SECTION 3 – SITE CHARACTERIZATION

This section summarizes progress on selected site characterization activities for this period.

3.1 GEOLOGIC INVESTIGATIONS

Integrated Site Model–The Integrated Site Model 3.1 (ISM3.1) (CRWMS M&O 1999by) [EARTHVISION CSCI: 30035 V4.0, TBV-692] was completed, with incorporation of the Geologic Framework Model, version GFM3.1 and updates of rock properties and mineralogical models with data from boreholes USW SD-6 and USW WT-24. Components of ISM3.1 are used in fluid flow, transport, and design-modeling activities. Documentation and qualification of input data for ISM3.1 are anticipated to be completed during FY 2000; report documentation of ISM3.1 as a PMR is scheduled for completion in early FY 2000. It is anticipated that the model will undergo validation during FY 2000 (see Appendix B, Table B-1, work in progress #10).

Site Description–An effort was initiated to update the *Yucca Mountain Site Description* (CRWMS M&O 1998b). The revision will address new results obtained during FY 1998 and FY 1999 and will provide more detailed traceability for the information presented. In addition, organization of the report is being modified to better present the results. The revision is currently planned for completion early in the third quarter of FY 2000.

Geologic Field Investigations–Work continued on preparation for publication of the 1:50,000-scale geologic map of the site-scale saturated-zone flow model area. Preliminary digital versions of the map and cross-sections were transmitted to the site-scale, SZ modeling group to support timely completion of modeling activities.

Work on the short-trace-length fracture study continued with analysis of data from the small-scale fracture study and preparation of collected and reviewed data for submittal to the Project technical data system. The short-trace-length fracture study consisted of 6 horizontal traverses and 18 vertical traverses in the Enhanced Characterization Repository Block Cross Drift. Initial results indicated that fracture densities along the small-scale fracture traverses (13–26 fractures per meter) were very similar to those previously predicted on the basis of original rock quality designation (known as RQD) values calculated for the Cross Drift. Preliminary cluster analysis of the data has been conducted. Fracture sets have been distinguished only by orientation at this early stage of analysis.

Project geologists completed final technical review of the unpublished manuscript titled *Geology of the ECRB Cross Drift, Stations 0+00 to 27+81, Exploratory Studies Facility, Yucca Mountain Project, Yucca Mountain, Nevada*. Review and correction of full-periphery geologic maps continued after determination that the heat-dissipation-probe holes and some samples had been incorrectly plotted on the full-periphery maps.

Preliminary lithostratigraphic logs for deep Nye County boreholes were developed in support of the Nye County drilling program, based on analyses of drill cuttings. Unreviewed, preliminary geophysical logs were transmitted to Project participants for use in updating regional and site-scale geologic-framework models.

3.2 ALTERED-ZONE AND NEAR-FIELD ENVIRONMENT

Near-Field Environment–Work included the following tests: Plug Flow Reactor tests of rock-water interaction, alteration at high temperature and humidity, column evaporation to study the evaporation

processes, and batch evaporation to study the chemical compositions of concentrated Well J-13 water and concentrated synthetic Topopah Spring Tuff pore water. Well J-13 water and concentrated J-13 water were studied because these have been used in performance assessment evaluations and long-term corrosion testing. Synthetic Topopah Spring Tuff pore water was used in the study because of the difficulties of collecting samples of pore water from unsaturated rock. In the Plug Flow Reactor tests, J-13 water flowed through a column of crushed tuff at controlled temperatures and flow rates. The water and the solid were sampled and analyzed. Two runs of the Plug Flow Reactor were completed. The water and solid samples of the runs have been analyzed. Batch evaporation of J-13 water and the pore water to concentrations of 100× and 1,000× were conducted, with and without the presence of Topopah Spring Tuff. The water and solid from those tests have been analyzed. The Plug Flow Reactor tests and the Batch Evaporation tests have been reported in Dibley and Knauss (1999) and Rosenberg, Dibley et al. (1999) and Rosenberg, Knauss et al. (1999).

Thermal Tests–The unpublished milestone report, *Single Heater Test Final Report*, REV 00 ICN 0 was completed and submitted. It was accepted with conditions that require providing proper software documentation, including version numbers, and editorial corrections with minor impact to the report's conclusions. REV 00 ICN 1 of this report addresses these conditions (CRWMS M&O 1999bd). Driftwall temperatures in the Drift Scale Test have exceeded 180°C after approximately 22 months of heating. Water and gas samples from the Drift Scale Test continue to be collected and analyzed in the laboratory. Most recent measurements were presented and discussed in the Thermal Testing Workshop in Las Vegas in April 1999. Installation of packers in the two lowermost SEAMIST (Science Engineering Associates Membrane In Situ Sampling Technique) holes, so that water samples from the lower part of the test block can be collected, is underway. Post-test coring of the Large Block Test was completed. The mineralogical and petrologic analyses of the pre-test cores was completed. The mechanical properties of the pre- and post-test cores have been measured. Post-test mineralogical analyses will be completed in FY 2000. A report to document fractures in the Large Block Test neared completion (see Appendix B, Table B-1, work in progress #8). Thermal-hydrological simulation of the Single Heater Test, the Drift Scale Test, and the Large Block Test employing the active fracture model is underway for the Thermal Test Thermal-Hydrological AMR. Activities for the next 6-month period include completing installation of the packers in the two SEAMIST holes, continuing active testing, passive monitoring, laboratory analyses, and modeling. Thermal test workshops are scheduled in October 1999 and January 2000.

3.3 SITE UNSATURATED ZONE FLOW AND TRANSPORT

Exploratory Studies Facility Alcove and Niche Studies–Characterization of seepage into ESF alcoves and niches continued. Monitoring of temperature, relative humidity, and barometric pressure continued in the ESF Main Drift, niches, and in the Southern Ghost Dance Fault Alcove (Alcove #7). Water-potential data were collected from 51 heat dissipation probes in the rock mass surrounding Alcove #7 and from 8 surface-based, heat dissipation probes in the soil within and adjacent to the Ghost Dance fault zone. Water-potential monitoring in the rock mass surrounding Niche #1 continued with 21 heat dissipation probes.

Ongoing ESF tracer-infiltration experiments in the Upper Tiva Canyon Alcove (Alcove #1) were designed to study the effects of the El Niño precipitation events as an analogue to infiltration, deep percolation, fast pathways, and seepage in certain units of the Topopah Spring Tuff (e.g., the middle nonlithophysal [Tptpmn] as found in Alcove #7) under similar conditions. Through September 1999, 51,319 gal (194,242 L) of water have been applied to a 910 ft^2 (83.7 m^2) area of land surface above the alcove since resumption of the test in February 1999. The equivalent amount of water expressed as inches of rainfall applied to the area would be 91.4 in. (2,321 mm); this amount of water is about 15 times greater than present-day average annual precipitation in the Yucca Mountain area. Since March 6, 1999,

when seepage into the alcove began, approximately 4,915 gal (18,603 L) of water have been collected in the alcove. From May 18 through June 28, 1999, a lithium-bromide tracer was added to the infiltration water in an attempt to determine the travel time of water from the land surface to the alcove, which is approximately 32 m (105 ft) below land surface. On June 26, 1999, a small spike of the tracer may have been detected in the alcove, but shortly thereafter, tracer concentrations returned to background levels. On July 1, 1999, however, the tracer was detected again in water seeping into the alcove. Tracer concentrations increased to a maximum on July 7, 1999, and then declined to background levels by July 15, 1999. Through September 1999, no additional tracer has been detected in water seeping into the alcove. Preliminary qualitative analysis of the tracer-infiltration experiments seems to indicate that, once steady-state flow conditions are established, the travel time from the land surface to the alcove is approximately 3–4 weeks. These steady-state flow rates will provide a basis for model predictions of the drift-to-drift infiltration experiment. All of this information will be used to assist in understanding the conditions that could produce seepage into any mined drift. A report titled *Results from Geothermal Logging, Air and Core-Water Chemistry Sampling, Air-Injection Testing and Tracer Testing in the Northern Ghost Dance Fault, Yucca Mountain, Nevada, November 1996 to August 1998* (see Appendix B, Table B-1, work in progress #7) underwent review and was submitted and approved in September for publication as a Water Resources Investigation Report. According to the report, geothermal logging of the horizontal borehole drilled prior to excavation of Alcove #6 identified a temperature decrease of 0.1°C near the Ghost Dance fault. The temperature decrease could indicate movement of cooler air or water, or both, down the fault, or it may be due to drilling-induced cooling. In situ pneumatic-pressure monitoring indicated that the permeability of the tuff is relatively high and that the barometric pressure changes were transmitted from the ground surface to depth through the Ghost Dance fault. Values of carbon dioxide and $\delta^{13}C$ (an analysis of the isotopic variation of carbon in a sample compared to a standard) from gas samples indicated that air from the underground drill room had penetrated the tuff, supporting the concept of a well-connected fracture system. Uncorrected carbon-14 age estimates from gas samples ranged from 2,400 to 4,500 years. Tritium levels in borehole core water indicated that the fault might have been a conduit for the transport of water from ground surface to depth during the last 100 years. Air-injection testing indicated that the permeability of the 4-m-wide, intensely fractured fault zone is two to three times greater than the permeability of the footwall and the hanging-wall zones. Cross-hole convergent-tracer tests yielded longitudinal-dispersivity values ranging from 0.06 to 2.63 m (0.2 to 8.63 ft) and indicated that the transport porosity of all three zones are about the same, averaging approximately 0.013. Particle tracking, using a discrete-fracture model, identified flow paths that were as much as six times longer than the linear distance, accounting at least in part for the large transport-porosity values in the footwall and hanging-wall zones.

In efforts to determine percolation flux through the repository block from isotopic data, additional samples of pore water were analyzed for $^{234}U/^{238}U$ (i.e., the ratio of uranium-234 to uranium-238) from the Paintbrush nonwelded hydrogeologic unit (PTn) in ESF Alcove #3 and from sites within the welded Topopah Spring Tuff. Uranium isotopic values for these samples of pore water remained consistently lower than those of fracture minerals, perched water, or water from the shallow SZ beneath Yucca Mountain. Therefore, matrix water likely is isolated from fracture water responsible for fracture minerals and may not constitute a substantial contribution of recharge to the SZ. In addition, preliminary calculations were begun to estimate the amounts of recoil ^{234}U that may become available to percolating water as it flows downward below the PTn within the fracture network. "Recoil ^{234}U" is ^{234}U produced at a systematic rate on grain surfaces from the spontaneous decay of ^{238}U within the grain by slight displacements of ^{234}Th (thorium-234) after ejection of an alpha particle.

Enhanced Characterization of the Repository Block–Efforts continued to evaluate percolation flux across the repository horizon in the ESF. Before the hydrologic bulkheads were closed in June 1999, temperature and relative humidity only were measured at Cross Drift Station 24+75 (2,475 m [8,118 ft]), where the ventilation-system intake was located, and in the vent line at Cross Drift Station 0+00 (0 m

[0 ft]), where ventilation air exited the Cross Drift. Measurements of air temperature, relative humidity, and air-movement in both the Cross Drift tunnel and ventilation system were used to calculate the amount of water vapor removed from the Cross Drift by the ventilation system. Water potential in the rocks surrounding the Cross Drift was monitored with 103 heat dissipation probes installed in 2-m (6.6-ft)-deep drill holes at 25-m (82-ft) intervals from Cross Drift Station 0+50 (50 m [164 ft]) to Station 26+00 (2,600 m [8,528 ft]) and with 20 heat dissipation probes installed at other locations in the Cross Drift. Measured water potentials continued to indicate that the rock mass surrounding the Cross Drift is wetter (i.e., the potentials are higher) and that the moisture is more uniformly distributed than expected.

Other ongoing work in the Enhanced Characterization Repository Block Cross Drift includes:

- Systematic sampling
- Geologic mapping and small-scale fracture mapping
- Fracture-mineral geochemistry and geochronology
- The $^{36}Cl/Cl$ (the ratio of chlorine-36 to chloride in a sample) analyses of systematic and feature-based samples
- Moisture monitoring
- Hydrologic bulkhead studies.

These tasks were initiated in late FY 1998 and FY 1999 and will be completed in FY 2000, with the exception of moisture monitoring and the bulkhead studies, which will continue. The hydrologic bulkheads (Figure 3-1) were completed and closed in June 1999. This study involves isolating the back of the Cross Drift from the rest of the tunnel, which is being ventilated with dry, desert air. This isolation allows long-term hydrologic monitoring under conditions of ambient high relative humidity. This will provide data on flow and seepage properties of the lower lithophysal (Tptpll) and lower nonlithophysal (Tptpln) potential repository horizon rock units beneath areas of relatively high infiltration and within the Solitario Canyon fault zone under conditions similar to a closed (nonventilated) repository. Since the bulkheads were closed, the rock has returned to close to ambient water potential of about −1 bar (equivalent to greater than 99 percent relative humidity). Heat dissipation probes, which previously showed evidence of rock drying under ventilation, now show evidence of rewetting. The bulkheads were opened in early September 1999, and no evidence of seeps was noted.

Excavation and drilling at the Cross Over Alcove (Alcove #8, Figure 3-1) was started in late FY 1999 and will continue in early FY 2000, with testing to follow in FY 2000 to address flow, matrix diffusion, and seepage processes, at the scale of tens of meters, in upper lithophysal (Tptpul) and middle nonlithophysal (Tptpmn) potential repository horizon rocks. The configuration of the ESF and Cross Drift in the area of Alcove #8 and ESF Niche #3 provides a unique opportunity to conduct a large-scale test in fractured, welded Topopah Spring Tuff. The characteristics of these units will also provide important data to support understanding of the lower lithophysal (Tptpll) and lower nonlithophysal (Tptpln) rocks, which make up the majority of the potential repository horizon. Excavation and drilling at Niche #5 (Figure 3-1) is planned to begin in early FY 2000 with testing to follow in FY 2000 to address flow and seepage processes in the lower lithophysal (Tptpll) potential repository horizon rocks. Systematic borehole characterization of fracture properties and seepage characteristics in the lower lithophysal also will commence in FY 2000.

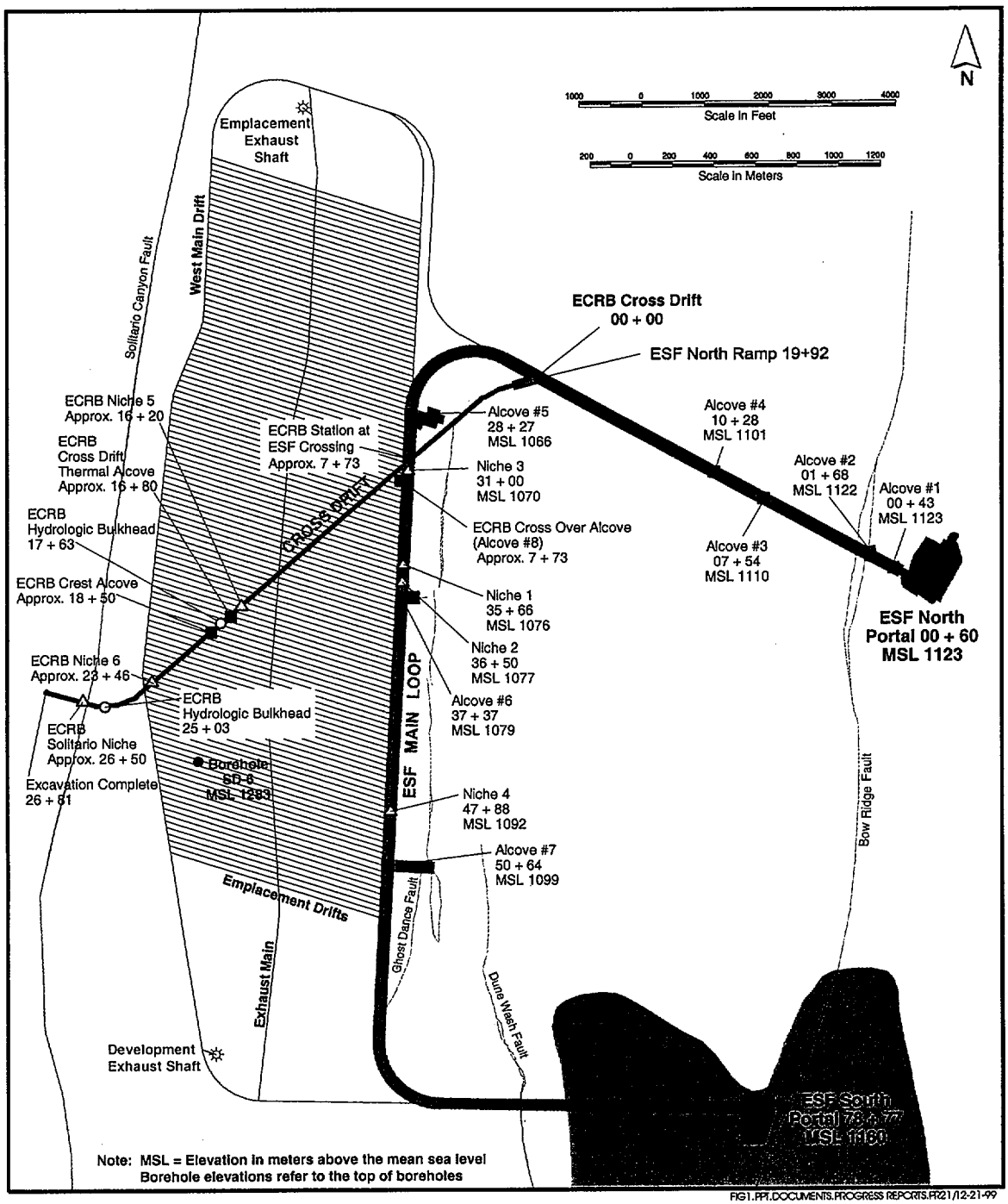

Figure 3-1. Exploratory Studies Facility, Showing Main Loop and Enhanced Characterization of the Repository Block Cross Drift

Cross Drift testing planned for FY 2001 and beyond also includes:

- The Cross Drift Thermal Test in the lower lithophysal (Tptpll) potential repository horizon in the planned Cross Drift Thermal Alcove
- Flow and seepage testing in the planned Niche #6 (lower nonlithophysal, Tptpln)
- Hydrologic testing underneath the high infiltration area (in the planned Crest Alcove)
- Borehole testing of the Solitario Canyon fault zone.

Unsaturated Zone Modeling–Work continued on the first draft of an AMR describing and documenting the coupled net-infiltration–surface-water flow-routing model. The infiltration AMR is a component of the unsaturated –zone (UZ) flow and transport PMR and provides the upper boundary condition for the site-scale flow and transport model. A preliminary analysis of infiltration-model uncertainty and interpretations of modeling results was completed. A snow-cover and snowmelt module also was developed. Preparations for submittal of model software QA documentation and development of a user's manual continued. The new, composite, future-climate input data sets for the infiltration model were developed to represent the three climate states that are expected during the next 10,000 years: a modern climate state, a warmer-than-modern monsoon-climate state, and a glacial-transition state. Based on the climate record near Yucca Mountain and on solar and orbital forcing functions, the modern climate state should persist for the next 600 years. The monsoon climate state should persist for the following 1,400 years, and the glacial-transition state should persist for more than the following 8,000 years. Each climate state is represented by appropriate values for mean annual temperature and mean annual precipitation, which control evapotranspiration and have a major impact on net infiltration. Integrated calibration of the new net-infiltration model, which uses a layered root-zone system algorithm, was completed using a combination of measured water-content profiles and available stream-flow data.

Draft sections of the Geochemistry AMR on strontium-isotope pore-water analyses, fracture-mineral data, and interpretations with respect to flow paths and percolation rates were prepared. Geochemical modeling software (PHREEQC CSCI: 10068-2.0-00 V2.0) used to obtain carbon-14 residence times for perched water and to correct perched-water ages was submitted for technical review. Numerous core samples were transported from the Sample Management Facility to Denver for pore-water extraction and hydrochemical and isotopic analysis. Samples included rock core from boreholes USW WT-24, USW SD-6, ESF South Ramp borehole SRWS M-150, and USW SD-9. Documentation was completed for the data package that was titled "Analysis of Carbon Isotopes of Pore Water from ESF-NR-Moist Study #13, USW WT-24, USW NRG-7A and USW SD-7 Extracted from Core by Core Compression and CO_2 Distillation."

Field-Scale Unsaturated Zone Transport Test at Busted Butte–Core samples of the Calico Hills nonwelded hydrogeologic unit from the Busted Butte Test Facility (see Figure 3-2) were analyzed for physical properties, saturated hydraulic conductivity, moisture retention, and unsaturated hydraulic conductivity. The Busted Butte underground study site is being used to measure properties for the nonwelded vitric rocks at the base of the Topopah Spring Tuff (crystal-poor, vitric units Tptpv2, Tptpv1) and the top of the Calico Hills Formation (Tac). These units are similar to those that underlie the potential repository.

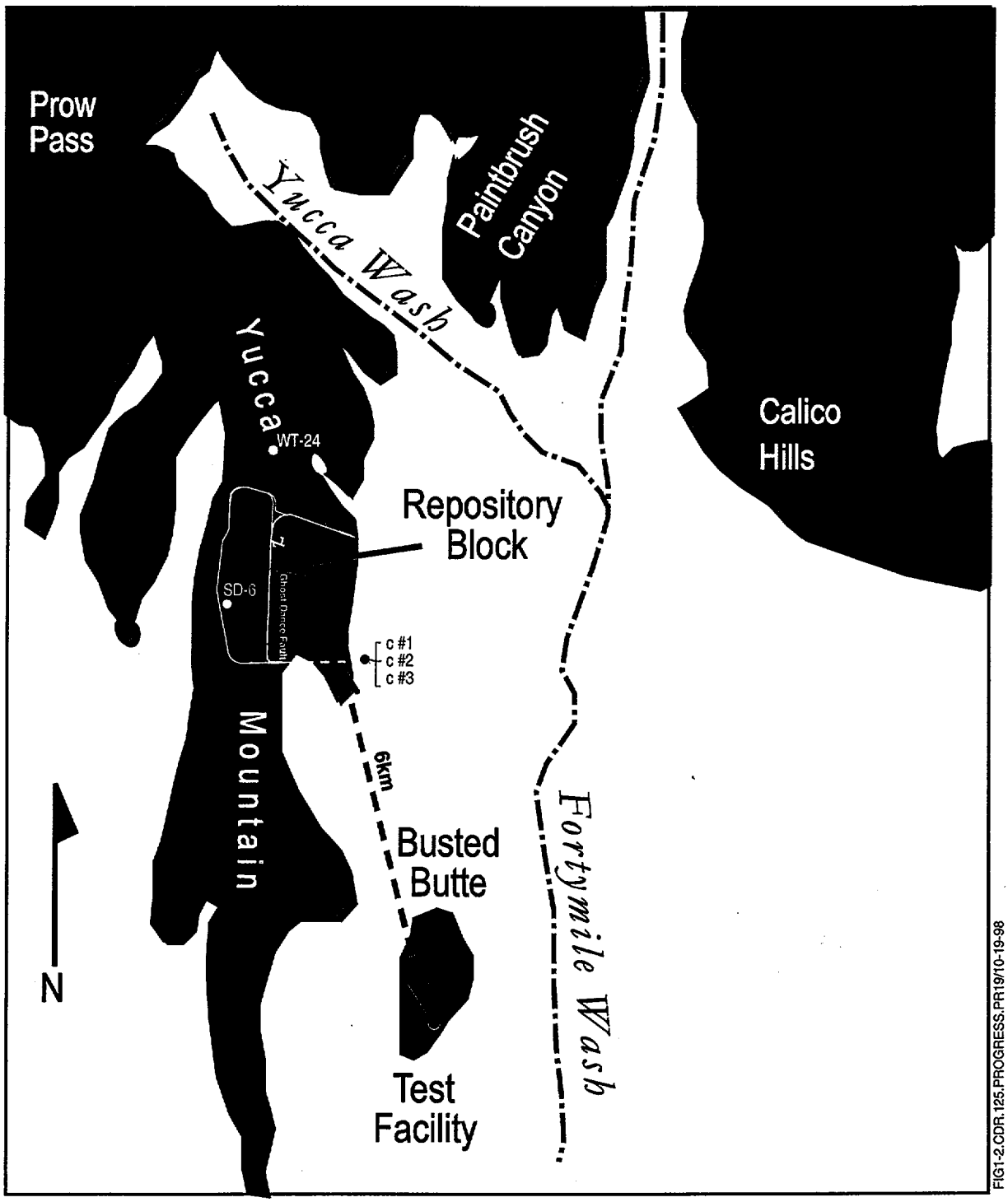

Figure 3-2. Location of Test Facilities, Yucca Mountain, Nevada

Results of the matrix-property analyses indicate that the porosity of Tptpv2 at Busted Butte is much higher than in boreholes USW SD-7 and USW SD-12, or the compilation of all surface-based borehole samples. Similarly, saturated hydraulic conductivity of the Tptpv2 at Busted Butte is 1,000 to 10,000 times greater than that in the boreholes. Although porosity of the Tptpv1 and the pre-Topopah Spring Tuff bedded tuff (Tpbt1) rocks is higher at Busted Butte than in all the surface-based boreholes, the saturated hydraulic conductivity is about one-tenth of that in the boreholes, suggesting some alteration not evident in the physical-property measurements. Although porosity of the vitric Calico Hills Formation at Busted Butte is about the same as in the boreholes, saturated hydraulic conductivity at Busted Butte is about 100 times greater than in the boreholes, also suggesting a difference in degree of alteration. Moisture-retention data and saturated hydraulic conductivity were used successfully to predict unsaturated hydraulic conductivity, which is a critical parameter for the site-scale unsaturated-zone flow and transport model. Results indicate significant small-scale variability between the various samples.

Phase II testing was initiated in July 1998 and is anticipated to continue through early spring 2000. Phase II is an expanded version of Phase I, scaled-up spatially and with respect to flow rates, and involves an augmented suite of reactive and nonreactive tracers. Phase II is underway within an in situ 10 x 10 x 7-m (33 x 33 x 23-ft) test block, with access along two adjacent faces. Tracer solution is being continuously injected at 77 discrete points located along 8 parallel, 10-m (33-ft) boreholes arranged in two horizontal planes. Injection rates range from 1 to 50 mL (0.03 to 1.7 fluid oz) per hour at each point. Porewater samples are collected regularly using approximately 250 sorbing-paper collection pads emplaced using an inflatable inverting membrane system into 12 horizontal and inclined 10-m (33-ft) collection boreholes, oriented perpendicular to the injection boreholes. Injection and collection boreholes are arranged to provide injection-to-collection fluid travel distances ranging from 0.15 to 7 m (0.49 to 23 ft).

The Phase II tracer mixture includes nonreactive and reactive tracers, nonreactive and slightly reactive fluorescent dyes, reactive metals and rare earths, and synthetic colloidal tracers. This suite of tracers will provide flow and transport information corresponding to the range of potential contaminants that could exit the repository. The tracer mixture is prepared in synthetic porewater, designed to mimic local porewater chemistry. Five different fluorobenzoic acids are used to label different injection boreholes in order to determine the degree of lateral mixing and provide an estimate of unsaturated, transverse dispersivity under a range of saturation conditions.

Early results show that nonreactive tracer breakthrough for short travel distances occurred within 1 month of the start of the test; within 6 months, most of the collection boreholes were showing nonreactive tracer breakthrough. Analysis of the different fluorobenzoic acids shows clear evidence of lateral mixing between the injection and collection zones.

A 1-ft-cube (0.3-m-cube) block was removed from the Calico Hills Formation (Tac) section at Busted Butte for research conducted at Atomic Energy of Canada, Ltd. These scientists will conduct radionuclide transport tests on this block in their facilities in Canada. The tests are designed to complement the field transport testing at Busted Butte and ongoing laboratory studies. Planning for the removal of two additional 1-m (3.3-ft) cubes of Busted Butte Calico Hills rock for saturated and unsaturated flow and transport testing at Atomic Energy of Canada, Ltd., has been completed. Excavation of the blocks is expected to be completed in early FY 2000. Testing will be initiated in FY 2000.

3.4 SITE SATURATED ZONE FLOW AND TRANSPORT

The following details the Saturated Zone Process Model Report progress (see Section 2 for a discussion of PMRs and AMRs):

1. Six AMRs were drafted.

2. Two AMRs neared completion. These include S0010, Development of Flow Boundary Conditions, and S0030, Probability Distribution for Flowing Interval Spacing.

3. Data feeds for all SZ AMRs have been completed.

4. Analyses for all SZ characterization AMRs have been completed.

Nye County Drilling Program–Planning is completed to drill Phase II of the Nye County Early Warning Drilling Program (EWDP). EWDP Phase II drilling is intended to provide hydrogeological data in the area between the boreholes drilled by the YMP in the immediate vicinity of the potential repository and the Phase I holes previously drilled by Nye County to the south of Yucca Mountain along U.S. Highway 95. Phase II will characterize the SZ and alluvial aquifer along the flow paths from beneath the potential repository to the NRC-proposed, 20-km (12.4-mile) compliance boundary. Data gathered will provide flow and transport parameters for the SZ flow and transport model.

The DOE incorporated information and data from the EWDP (including lithology, water-level data, hydraulic test results, alluvium sorption measurements, hydrochemistry data, and Eh/pH data) into the DOE models of the SZ (the hydrogeologic framework model, the SZ site-scale flow and transport model, and the regional model).

Planning for the Alluvium Testing Complex is complete. The Alluvium Testing Complex will be a set of test wells (three or more) completed in the saturated alluvium along the flow paths downgradient from the potential repository. The wells will be located within 100 m of each other. Testing will be similar to tests done in the C-well complex and include aquifer characterization and tracer tests. The Alluvium Testing Complex will serve to test the conceptual model of flow and transport in alluvium. Results will be incorporated into the SZ flow and transport model.

Saturated Zone Flow and Transport Modeling–The new site-scale SZ flow and transport model [FEHM V2.000, 10031-2.00-00], which will be used for future TSPAs, has been calibrated, and development is complete.

The regional and site-scale models linkage was completed. Lateral fluxes were extracted from the regional model [MODFLOW V2.3, TBV-569] and were used as boundary conditions to the site-scale model. Recharge to the site-scale model was obtained from the UZ model for areas where the two models overlap, the Fortymile Wash recharge study, and the regional model for the rest of the model domain.

Borehole USW SD-6–Drilling resumed in borehole USW SD-6 in April 1999 at a depth of 2,386 ft (727.2 m) after a whipstock (a steel wedge that was grouted in the hole above the stuck drill pipe) was installed to allow sidetrack drilling around an obstruction in the original borehole. The whipstock deflected the drill bit about 3 degrees, allowing the hole to be sidetracked and drilled to the planned depth near the original borehole. The sidetrack hole was drilled from about 2,386 to 2,808 ft (727.2 to 855.8 m) below land surface. The sidetrack was designated as USW SD-6ST1, and all data collected from the sidetrack borehole have been referenced accordingly. Borehole SD-6ST1 is the only borehole that penetrates the SZ directly beneath the potential repository (see Figure 3-1). Borehole USW SD-6ST1 was

drilled to a total depth of 2,808 ft (855.8 m), ending in the Bullfrog Tuff of the Crater Flat Group (i.e., the lower volcanic aquifer). Depth to water in the borehole in late April 1999 was 2,508 ft (764.4 m) below land surface, with a water table elevation of about 2,392 ft (729 m) above mean sea level.

Borehole USW SD-6ST1 and several nearby boreholes were instrumented with pressure transducers to monitor drawdown during hydraulic testing. The observation boreholes were USW H-4 (about 1.7 km east of SD-6ST1), USW H-5 (about 1.4 km north), USW H-6 (about 1.4 km west), and USW WT-2 (about 1.1 km east-southeast). About 30 separate pretest pumping episodes were conducted at discharge rates ranging from 16 to 76 gal per minute (1.0 to 4.8 L/s) prior to hydraulic testing to develop the borehole and determine the optimal pumping rate. Formal hydraulic testing occurred in June when borehole USW SD-6ST1 was pumped for 20,350 minutes (about 2 weeks) at an average rate of 16 gal per minute (1.0 L/s). Maximum drawdown in the borehole during the test was about 163 ft (49.7 m). Water-level recovery in borehole USW SD-6ST1 occurred very rapidly, requiring only 60 minutes from pump shut-off. No drawdown was observed in any of the observation boreholes. Preliminary interpretations of the hydraulic test indicate that the permeability of the water-bearing fractures encountered in borehole SD-6ST1 is very low, as evidenced by very low specific capacity (pumping rate divided by water-level decline).

Because of the rapid recovery following 2 weeks of pumping the aquifer, it seems that only secondary fractures with very low permeability were penetrated by borehole USW SD-6ST1. Although the secondary fractures may be in hydraulic connection with some primary fractures, the volume of water that these secondary fractures could transmit was not enough to dewater the primary fracture system. Consequently, any transmissivity estimates determined from this hydraulic test will not be indicative of the primary fracture system. The rapid recovery in the borehole indicates that only a small portion of the aquifer was dewatered during pumping and a significant cone of depression never developed around the borehole.

Saturated Zone Hydrochemical Sampling–A data package containing results of dissolved-ion and isotopic analyses of saturated-zone water samples was completed and submitted to the Technical Data Base (Level 4 milestone SPH471M4). The analyses were conducted using water samples collected from domestic and irrigation wells in Amargosa Valley and from boreholes UE-25 c#2, UE-25 WT#3, and UE-25 WT#17 at Yucca Mountain. Additional saturated-zone water samples were collected from borehole USW SD-6ST1, the Nye County Early Warning Drilling Program boreholes, and wells in the northern Amargosa Valley for analysis of major ions and strontium and uranium isotopes. Hydrochemical and isotopic data are being used to help determine flow paths in the SZ downgradient from the potential repository.

3.5 SEISMIC HAZARDS AND DESIGN

Geotechnical Site Investigations–Preliminary geotechnical investigations were completed for the potential site of the Waste Handling Building (CRWMS M&O 1999bc). The investigations included drilling one new borehole (UE-25 RF#13), downhole seismic logging of the borehole, laboratory testing of the dynamic response of samples from the borehole, and characterization of soil samples from the borehole. These data, along with other available data, allowed preliminary characterization of subsurface conditions, estimation of a shear-velocity profile at the site, and estimation of foundation design parameters.

Work also continued on development of seismic design inputs. A methodology was implemented using available data to determine ground-motion inputs for a site at the potential waste emplacement level, for surface rock sites at Yucca Mountain, and for a surface soil site. Results are being documented in a report that is planned for completion in the second quarter of FY 2000.

SECTION 4 – DESIGN AND EXPLORATORY STUDIES FACILITY CONSTRUCTION

The Project continued to develop and refine the documents that establish and form the repository design requirements and support the license application. This effort included completion of the following:

- Revision 00 of 10 system description documents (CRWMS M&O 1999c–1999k and 1999bx).
- The revision to *Monitored Geologic Repository Concept of Operations* (CRWMS M&O 1999bb). The revision reflects the transition to EDA II (Wilkins et al. 1999).
- Incorporation of the *Monitored Geologic Repository Requirements Document* (YMP 1999b) into the DOE Level-II technical baseline. Changes incorporated in the document included: (1) adding a description of the monitored geologic repository (MGR) concept, which results in a repository that can be kept open for 300 years; (2) adding a requirement that the design be capable of accommodating the current inventory projection of SNF and high-level waste; and (3) changing the waste inventory to include immobilized plutonium and mixed-oxide SNF.
- Preparation of five technical reports (CRWMS M&O 1999az and 1999bs–1999bv) in support of the License Application Design Selection effort.
- Development of 30 compliance program guidance packages (CRWMS M&O 1999l–1999ao) that served as regulatory input to design and licensing documents in support of the license application. Of these packages, 17 were engineering packages for input to the system description documents and 13 were nonengineering topical packages.
- The Document Change Notice DCN01 of *Monitored Geologic Repository Project Description Document*, Revision 00, (CRWMS M&O 1999bg) neared completion at the end of FY 1999. Revision 00, DCN 01, reflects the transition of the repository conceptual design from that presented in the VA to EDA II, according to the Wilkins/Heath letter (Wilkins et al. 1999).

4.1 REPOSITORY

The Project completed the study of design features and design alternatives. Based on these studies, EDA II (Wilkins et al. 1999) was selected as the basis for an SR and LA reference design. Significant differences between the EDA II design and Volume 3 of the *Viability Assessment of a Repository at Yucca Mountain* (DOE 1998) VA design include:

- The drift spacing will be 81 m center-to-center. The wide drift spacing is expected to promote drainage of thermally mobilized water and increase the independence of individual drifts.
- The ground support in the repository will be carbon steel (steel sets and/or rockbolts and mesh). Thick concrete was eliminated as the primary ground-support material due to pH control issues; however, cementitious grout will be used to anchor rockbolts.
- A carbon steel frame will be used to construct the invert that will support the waste packages. A granular material will be used as ballast. Elimination of concrete in the invert reduces uncertainties associated with radionuclide transport.

- Waste packages will be closely spaced along the emplacement drifts (line loading). Line loading should produce a more uniform temperature distribution along the drifts and reduce cost of excavations, drip shields, and backfill.

- A metal drip shield will be placed over the waste packages just prior to closing the repository. Drip shields will be designed to divert water around the waste packages for at least 5,000 years.

- Granular backfill will be placed over the drip shield just before closing the repository. Backfill is expected to help protect the drip shield and keep water from contacting the waste packages.

- The waste package will be a two-layer cylindrical shell consisting of an approximately 5-cm-thick inner barrier of stainless steel (Alloy 316L) and an approximately 2-cm-thick outer barrier of corrosion resistant Alloy 22 material.

- The design will permit the repository to be kept open, with only routine maintenance, for approximately 125 years from initiation of waste emplacement, which is approximately the time necessary for the ventilation system to remove sufficient heat to keep the drift walls below boiling (96°C at the elevation of the potential repository) following closure.

- The design will permit the repository to be closed during the period from 50 years to approximately 125 years from the start of waste emplacement. The design will not preclude keeping the repository open, with appropriate maintenance and monitoring, for 300 years after initiation of waste emplacement. A decision on when it is appropriate to close the repository will be made in the future, based on information and considerations at that time.

- The sensitivity of the postclosure performance of the repository system to uncertainties associated with coupled, thermally driven processes will be examined for preclosure durations of 50 and 125 years.

- The models that are the basis for evaluation of thermal conditions will be refined to reduce unnecessary conservatism. Design options that can increase the efficiency of heat removal also will be evaluated.

The Project is continuing to define the subsurface repository layout and operations processes. The revised design of waste packages and their spacing in the emplacement drifts will require a new handling and transport concept, because the waste packages can no longer be picked up and transported by lifting the ends. The requirement for continuous ventilation and removal of 70 percent of the heat generated during the preclosure period requires further study to determine the volume of ventilation air and number of additional shafts needed for ventilation.

Testing is continuing on a quarter-scale model emplacement drift and waste package to determine the effectiveness of emplacement drift backfill and drip shields on keeping seepage from contacting waste packages (see Appendix B, Table B-1, work in progress #9). In support of the pilot-scale engineered-barrier Phase II tests, Project hydrologists collected hydrologic and properties data on materials being evaluated for potential use as backfill in waste-emplacement drifts. Pilot Scale Test #3, which uses a drip shield to divert water from the waste package, was begun. A drip shield fabricated of 304 stainless steel has been installed over the model waste package. How the waste packages respond to heat is being monitored. Planning is underway for Pilot Scale Tests #4 and #5. These tests will use the EDA II design of the drip shield, using different types of backfill.

In repository surface design, the Project completed two summaries, *Waste Handling Building Reconfiguration Summary* (CRWMS M&O 1999bh) and *Non-Standard Waste Material Handling Summary* (CRWMS M&O 1999bi). These documents will be used to support development of a revision to the configuration of the Waste Handling Building. This revised configuration will be the basis for development of the SR report. The Project completed a technical report, *Modular Design/Phased Construction Alternative Evaluation Report* (CRWMS M&O 1999at), and a calculation, *Witness Model Results and Forecasts for Modular Design of Surface Facilities* (CRWMS M&O 1999bj). These documents will serve to evaluate the impacts of a modular, phased construction approach for the Waste Handling Building. The Project completed two analyses, *Secondary Low-Level Waste Generation Rate Analysis* (CRWMS M&O 1999bk) and *Secondary Low-Level Waste Treatment Strategy Analysis* (CRWMS M&O 1999bl). These documents describe how the Project will deal with the generation and treatment of secondary low-level waste. The Project revised the analysis, *Waste Handling Operations-Dose Assessment* (CRWMS M&O 1999bm), and completed the calculation, *Shielding and Dose Assessment for the Surface Handling Facilities in Support of the LA Features and Alternatives Design* (CRWMS M&O 1999bn). These documents provide an assessment of worker dose during surface facility operations and associated shielding requirements.

4.2 WASTE PACKAGE

The Project completed the *Supplement to the Disposal Criticality Analysis Methodology* topical report (CRWMS M&O 1998be). This report describes plans for collecting additional information to support the analysis methodology presented in the DOE's *Disposal Criticality Analysis Methodology Topical Report* (YMP 1998b) submitted to NRC for review in January 1999. Three calculations supporting this deliverable were completed (CRWMS M&O 1999bo–1999bq).

The Project completed the *Preclosure Criticality Analysis Process Report* (CRWMS M&O 1999bf). This report proposes an approach to preclosure criticality analysis similar to that developed in the topical report for analyzing postclosure criticality. It also contains deterministic aspects appropriate for the preclosure period.

The Project completed the *Waste Package Related Impacts of Plutonium Disposition Waste Forms in a Geologic Repository* (CRWMS M&O 1999ap). The study documented that the ceramic plutonium waste form can be emplaced in the repository at a loading of five plutonium-containing, high-level waste canisters per waste package and that the mixed-oxide SNF can be loaded, depending on the assembly burnup, into the standard, commercial, 12 or 21 pressurized-water reactor waste packages.

The Project completed the *Waste Package Operations FY-99 Closure Methods Report* (CRWMS M&O 1999aq) documenting results of the weld closure and nondestructive examination work completed on test plates. These test plates will serve as sample plates as part of the residual stress corrosion materials testing study. The Project completed the *Waste Package Fabrication Process Report* (CRWMS M&O 1999ar). This document was revised to identify various methods of manufacturing that may be used to fabricate the disposal container for the EDA II design.

The waste package materials testing and modeling activities were modified to incorporate performance requirements for the EDA II design. For the waste package, this design consists of a thin outer barrier made of highly corrosion resistant nickel-chromium-molybdenum Alloy 22 (UNS N06022) surrounding a thicker inner barrier made of a modified Type 316 L stainless steel (UNS S31603). The stainless steel serves primarily as a physical, mechanical barrier to provide bulk to the waste package. The enhanced design also uses a drip shield made of Ti-Gr 7 (UNS R52400). Evaluation of the corrosion resistance of these materials under repository-relevant conditions is continuing. Work continues on improving the definition of the chemistry of water drips striking the warm waste package. Work also continues in

quantifying general corrosion, localized corrosion, microbiologically induced corrosion, stress corrosion cracking, and hydrogen embrittlement of these materials. The amount of spent fuel surface area that is exposed after a waste package failure has been modeled on a per fuel rod basis. This modeling, based on an extension of previous spent fuel oxidation, dissolution, and release rate models, provides the surface area that potentially may be wetted for performance assessment analyses.

4.3 EXPLORATORY STUDIES FACILITY

The Project is continuing testing activities that require continued operation and maintenance of the ESF and Busted Butte. The designs for the Cross Over Alcove (Alcove #8 located at Station 7+98 [798 m (2,618 ft)] of the Cross Drift) and Niche #5 (located at Station 16+20 [1,620 m (5,315 ft)] of the Cross Drift) were completed. The excavation of Alcove #8 was started.

SECTION 5 – REPOSITORY PERFORMANCE

During this reporting period, the Project accomplished several advances in developing the topics of preclosure radiological safety assessment, postclosure performance assessment, and performance confirmation. Advances in these topics are described in the following sections.

5.1 PRECLOSURE RADIOLOGICAL SAFETY ASSESSMENT

Revision 10 to the procedure *Classification of Permanent Items* (QAP-2-3, Rev. 10) was issued. This revision will simplify the QA classification process to make it more consistent with a risk-informed design approach. Three quality levels based on safety significance replaced the five QA classes identified in previous versions.

The document that provided the QA classification of structures, systems, and components, *Classification of the Preliminary MGDS Repository Design* (CRWMS M&O 1998a), was superseded by a separate analysis for each of the 60 MGR systems. The classification of items identifies the administrative, design, and operational features required to meet radiological safety (preclosure) or waste isolation (postclosure) functions. The newly issued analyses incorporate current system information based on the MGR architecture, the system description documents, the preliminary results of DBE analysis associated with revised radionuclide release fractions, and the applicable requirements of the interim guidance (Dyer 1999) pending issuance of the proposed 10 CFR 63 (64 FR 8640). These analyses will provide the basis for revision (see Appendix B, Table B-1, work in progress #2) of the current MGR *Q-List* (YMP 1998a). The new *Q-List* will result in a more realistic classification for structures, systems, and components based on their importance to safety.

The *DOE SNF Screening Dose Analysis* (CRWMS M&O 1999as), the *DOE High-Level Vitrified Waste Dose Calculation* (CRWMS M&O 1999au), the *Preliminary Selection of MGR Design Basis Events* (CRWMS M&O 1999av), the *Plutonium/High-Level Vitrified Waste Canister - DBE Offsite Dose Calculation* (CRWMS M&O 1999aw), and the *MGR Event Tree Analysis for Cask, Canister, and Container Drop Events* (CRWMS M&O 1999ax) were issued. These documents supported DBE analyses, including analyses of DOE SNF, high-level waste glass, and immobilized plutonium (can-in-canister). These calculations provide input to determination of the radioactive consequences of the selected DBEs, which bound all surface and subsurface DBEs.

Meetings were held with the NRC to discuss preclosure radiological safety methods for determination of DBEs, radiological consequences resulting from those events, methodologies for DBE categorization, consequence analysis, QA classification, and QA grading.

5.2 POSTCLOSURE PERFORMANCE ASSESSMENT

The focus for this reporting period has been on the following activities:

- Planning and development of AMRs including submittal of technical development plans, technical change requests, and other forms as required.

- Developing and incorporating improvements in performance assessment component models in response to comments on the TSPA, Volume 3 of the *Viability Assessment of a Repository at Yucca Mountain* (DOE 1998). In addition, data gathered after completion of the TSPA-VA were included, and the models were revised to accommodate changes created by adoption of EDA II in the *License Application Design Selection Report* (CRWMS M&O 1999ba).

- Participating in a DOE/NRC Technical Exchange on TSPA for Yucca Mountain in San Antonio, Texas, in May 1999 and a DOE/NRC Appendix 7 meeting in Las Vegas, Nevada, in September 1999 on features, events, and processes.

- Developing the *Total System Performance Assessment–Site Recommendation Methods and Assumptions* document (CRWMS M&O 1999ay).

Postclosure performance assessment activities included implementation of corrective actions necessary to close out QA deficiencies. Corrective actions included developing a database of models and a model tree depicting the relationship of various models , reviewing and identifying software, and reviewing and qualifying data. In addition, actions were implemented to resolve Deficiency/Corrective Action Report-Response, LVMO-99-D-053 (DOE 1999b) that documents deficiencies in procedure AP-3-10Q, Analyses and Models. A performance-based audit, Audit Report M&O-ARP-99-002 of the Civilian Radioactive Waste Management System Management and Operating Contractor at Las Vegas, Nevada and Albuquerque, New Mexico, May 3 through May 14, 1999 (DOE 1999c) was performed to evaluate the effectiveness of TSPA in providing evidence of the ability of the repository to meet regulatory safety criteria. It was determined that critical process steps relative to TSPA activities have been effectively implemented (DOE 1999c).

The *Draft Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada, Volumes I and II* (draft EIS) was issued in July 1999 (DOE 1999a). This document was supported by input calculations to evaluate the potential long-term individual radiological dose from release of radioactive materials from the Yucca Mountain repository (CRWMS M&O 1999b). Technical assistance for the draft EIS was a continuation of earlier work to calculate the total, long-term individual dose to receptors at distances of 5 km (3.1 miles), 20 km (12.4 miles) (used in TSPA-VA), 30 km (18.6 miles), and 80 km (49.7 miles) from the repository at 10,000 and 1 million years after repository closure.

A preliminary comparison of EDA II and the EIS base-case analysis of repository performance at a thermal load of 60 metric tons heavy metal per acre with dose calculation at 20 km (12.4 miles) from the repository has been prepared in conjunction with preparations for the TSPA-SR document and the final EIS. Preliminary indications are that the dose from the previous base-case design would be greater than the EDA II case earlier during postclosure, but that the doses would be equivalent 300,000 years after repository closure. The conclusions from the preliminary indications were that EDA II design is effective in reducing the expected annual dose to the average member of the critical group during the first 10,000 years after permanent closure. The period of regulatory concern is 10,000 years.

The total system model was revised in preparation for the TSPA-SR. This included incorporation of the VA models to the new version of the total system simulator, developing an automated database capability for controlling input to the total system simulator, and designing a parallel computation capability for faster run times. Progress was made on integrating the SR component models into the SR comprehensive total system model in preparation for the multirealization, probabilistic simulations used to forecast total system performance for the 10,000- and 1 million-year time frames. Several features of the performance assessment component models have changed since TSPA-VA because of acquisition of new data, modifications based on recommendations of external review groups, and adoption of the EDA II repository and waste package designs. In general, this has led to more conservative assumptions in the various models.

Workshops on Waste Package (SL972M4) and In-drift Geochemical Environment/Engineered Barrier System Transport (SL950M4) were conducted during the report period. Note that the In-drift

Geochemical Environment/Engineered Barrier System Transport activity was called the Near-Field Geochemical Environment in past reports.

The workshops were held to evaluate important issues and aid in work planning. They addressed issues identified in NRC IRSR acceptance criteria, performance assessment peer review comments, and other technical reviews of TSPA.

Work in the natural systems included reviewing the NRC IRSRs for evolution of the near-field environment (NRC 1999a) and unsaturated and saturated flow under isothermal conditions (NRC 1999b).

For waste package and drip shield degradation, efforts continue to improve the waste package degradation (WAPDEG) (WAPDEG CSCI: 30048 V3.09 TBV-568; MKHISTORY V1.0, CSCI: 30080 V1.0 TBV-568; and Post 308, TBV-568) computer model to analyze waste package degradation and to bring the code into full QA compliance. The waste package degradation and total system performance calculations that supported the *License Application Design Selection Report* (CRWMS M&O 1999ba) were completed and approved.

The National Spent Nuclear Fuel Program issued an updated radioisotope inventory in August 1999 for waste form, cladding, and colloids. The TSPA-VA used an inventory developed for the 1988 *Site Characterization Plan: Yucca Mountain Site, Nevada Research and Development Area* (DOE 1988). Data from the updated radioisotopic inventory will be incorporated for use in the TSPA-SR and the TSPA-LA. Data used for degradation rates of waste form and solubility of neptunium, americium, uranium, and technetium were also improved. The AMR Colloid Associated Concentration Limits (ANL-WIS-MD-000012) neared completion, and a new abstraction for colloid generation from waste form degradation was developed.

Disruptive events work included reviewing the igneous activity IRSR (NRC 1999c). Technical support for concepts and data relevant to the consequences of a volcanic vent through the repository are being improved through ongoing work, including waste particle size determinations and the behavior of waste packages in a magmatic environment. The potential for separation of drip shield overlaps during an earthquake will be studied as part of the engineered barrier system activities.

The SZ AMR on flow boundary conditions (SNL 1999) was completed. This AMR provides the basis for the conceptual model for infiltration and recharge to the 3-dimensional (3-D) saturated zone flow and transport model. Lateral boundaries were determined in addition to implementation of recharge as specified-flux boundary conditions in the SZ site-scale model. The SZ AMR on probability distribution for flowing interval spacing (ANL-NBS-MD-000003) was completed. This AMR provides a key parameter for matrix diffusion that is included in the new 3-D site-scale model. The new 3-D site-scale flow and transport model was presented to the NRC at a meeting held August 6, 1999, at Los Alamos National Laboratory.

New UZ models are under development for fracture matrix interaction. These models affect advective and diffusive transport in fractured rock. In addition, a new model for the problem of colloid transport is being developed at a more detailed level to account for kinetic sorption interactions, filtration and resuspension mechanisms, and size exclusion in fracture and matrix exchange. The results of the new colloid model will be incorporated into the particle-tracking transport algorithm developed for TSPA-VA. A more detailed model for release from waste emplacement drifts to the UZ transport model is also being developed. Sensitivity studies are in progress concerning the effects of fault displacement on UZ flow and transport. A comparison between the particle-tracking algorithm and direct-solution method for UZ transport is also in progress. Documentation of these activities has not been finalized.

5.3 PERFORMANCE CONFIRMATION

Performance confirmation activities are conducted to collect and analyze data to ensure conditions encountered and changes in those conditions are within the limits to be stated in the license application. This program began during site characterization and will continue until permanent closure. The program determines whether natural systems, as well as engineered systems and components, are functioning as intended and anticipated.

The planned revision of the *Performance Confirmation Plan* (CRWMS M&O 1997), which will incorporate the impact of recent changes, has been rescheduled for March 2000. The plan revision will incorporate the following factors in a reassessment of testing and monitoring important to postclosure performance:

- A revised repository design resulting from the *License Application Design Selection Report* process (CRWMS M&O 1999ba)
- Guidance on the expected changes in applicable regulations (i.e., the proposed 10 CFR 63 [64 FR 8640])
- Revised licensing approach and principal factors for performance as described in the *Repository Safety Strategy: U.S. Department of Energy's Strategy to Protect Public Health and Safety After Closure of a Yucca Mountain Repository* (YMP 1998c) and its update (see Appendix B, Table B-1, work in progress #1).

SECTION 6 – EPILOGUE

Since the close of the reporting period, several important developments have occurred on the Project, including:

- Design and Construction

  - The design of the potential repository is an evolving process. Recent thermal calculations indicate that the use of backfill in the emplacement drifts may have an adverse impact on the temperature of the drift wall. Consequently, the use of backfill in the reference design is being reevaluated.

  - The *Monitored Geologic Repository Project Description Document* (CRWMS M&O 1999bg), *Monitored Geologic Repository Concept of Operations* (CRWMS M&O 1999bb), and the *Monitored Geologic Repository Requirements Document* (YMP 1999b) have been and issued.

  - Sixteen compliance program guidance packages were developed for future issuance. These consist of 14 engineering packages and 2 nonengineering topical packages.

  - Drift-Scale Heater Test reevaluations resulted in a recommendation to continue the heating as originally planned rather than terminating the heating portion of the test.

- Performance Confirmation

  The DOE developed a top-level strategy for developing and implementing the performance confirmation program. Fundamental elements of the strategy consist of the following:

  - The performance confirmation program must be clearly identifiable and traceable to the regulatory requirements.

  - The program will be further defined and focused by using the repository safety strategy, TSPA, contributing PMRs and AMRs, and DOE commitments made during licensing negotiations.

  The testing strategy represents an efficient approach for defining and implementing the requirements of the performance confirmation program. The performance confirmation program defines a larger overall integrated test program that satisfies multiple requirements and test objectives.

- Quality Assurance Issues

  - A traceability link for new data was provided in November 1999. This procedural change completed the last remaining action to preclude recurrence based on the root cause determinations associated with the crosscutting QA deficiencies.

  - As a result of Quality Assurance audits on the PMRs for the Integrated Site Model, Waste Package Degradation, and Biosphere, there was insufficient evidence of corrective action implementation to close the deficiencies related to data defensibility, software, modeling, and data traceability.

- The audit teams concluded that the PVAR processes are effectively implemented for PMR development and that newly identified deficiencies are not significant.

- Site Characterization

  - Completed coring of chlorine-36 validation boreholes in the ESF in support of additional work on "bomb-pulse" localities.

  - Completed removal of blocks from the Busted Butte Facility for flow and transport tests to be conducted by Atomic Energy of Canada, Ltd.

  - The *Single Heater Test Final Report* (CRWMS M&O 1999bd) was issued.

  - Excavation of Niche #5 in the Enhanced Characterization Repository Block commenced.

  - Saturated Zone AMRs S0010 and S0030 were completed.

  - Unsaturated Zone AMR U0000 was completed.

  - Three Integrated Site Model AMRs were completed. The Integrated Site Model PMR was completed and submitted to DOE for review and acceptance.

- Site Recommendation

  DOE draft regulation for a new 10 CFR 963 was published in the Federal Register November 30, 1999, for public comment (64 FR 67054). Two public hearings were held February 2 and 3, 2000, in Las Vegas, Nevada, and Pahrump, Nevada, respectively. DOE's proposed suitability criteria and methodology are based on the NRC's recently proposed regulation 10 CFR 63 (64 FR 8640) for licensing a nuclear waste repository at Yucca Mountain.

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LV.NS.JLY.06/99-026. Las Vegas, Nevada: TRW Environmental Safety Systems, Inc. ACC: MOL.19990622.0126.

YMP (Yucca Mountain Site Characterization Project) 1998a. *Q-List*. YMP/90-55Q, Rev. 5. Las Vegas, Nevada: Yucca Mountain Site Characterization Office. ACC: MOL.19980513.0132.

YMP 1998b. *Disposal Criticality Analysis Methodology Topical Report*. YMP/TR-004Q, Rev. 0. Las Vegas, Nevada: Yucca Mountain Site Characterization Office. ACC: MOL.19990326.0395.

YMP 1998c. *Repository Safety Strategy: U.S. Department of Energy's Strategy to Protect Public Health and Safety After Closure of A Yucca Mountain Repository*. YMP/96-01, Rev. 2. Las Vegas, Nevada: U.S. Department of Energy, Office of Civilian Radioactive Waste Management. ACC: MOL.19980727.0001.

YMP 1999a. *Technical Guidance Document for License Application Preparation*. YMP/97-03, Rev. 1. Las Vegas, Nevada: Yucca Mountain Site Characterization Office. ACC: MOL.19991025.0118.

YMP 1999b. *Monitored Geologic Repository Requirements Document*. YMP/CM-0025, Rev. 3, DCN 01. Las Vegas, Nevada: U.S. Department of Energy, Office of Civilian Radioactive Waste Management. ACC: MOL.19990429.0228.

7.2 CODES, STANDARDS, REGULATIONS, AND PROCEDURES

10 CFR (Code of Federal Regulations) 60. *Disposal of High-Level Radioactive Wastes in Geologic Repositories*. Readily available.

64 FR (Federal Register) 8640. *Disposal of High-Level Radioactive Wastes in a Proposed Geologic Repository at Yucca Mountain*. Proposed Rule: 10 CFR 63. Washington, D.C.: U.S. Government Printing Office. TIC: 242725.

64 FR 44200. *Draft Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada, Volumes I and II*. Notice of Availability. August 13, 1999. Washington, D.C.: U.S. Government Printing Office. TIC: 245888.

64 FR 67054. *Office of Civilian Radioactive Waste Management; Nuclear Waste Repositories; Yucca Mountain Site Suitability Guidelines*; Proposed Rule 10 CFR 963. Readily available.

Nuclear Waste Policy Act of 1982, as amended. 42 U.S.C. 10101 et seq. Washington, D.C.: U.S. Government Printing Office. TIC: 241722.

AP-3.10Q Rev 1, ICN 1. *Analyses and Models*. Las Vegas, Nevada: U.S. Department of Energy, Office of Civilian Radioactive Waste Management. ACC: MOL.19991019.0467.

QAP-2-3, Rev. 10. *Classification of Permanent Items*. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19990316.0006.

APPENDIX A

LIST OF COMPLETED YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT DELIVERABLES

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Table A-1. List of Completed Yucca Mountain Site Characterization Project Deliverables (April 1, 1999, to September 30, 1999)		
Document Control Number	**Deliverable Number**	**Title and Revision**
20025	BM207BM3	Computer Security Policy and Procedures and Computer Protection and Privacy Plan Approvals
20420	SLSR50M3	Annotated Outline of the Site Recommendation Report (Volume 1) and Site Recommendation Volume 2: 10 CFR 960 Compliance Evaluation
20547	BM207CM3	Planning Procedure for IT Capital Investments
20718	SS128BM3	Annual Report on Compliance with Programmatic Agreement on Historic Sites
20719	SLTDBM3	Submittals and Incorporations into the Technical Data Management System
20720	SLTDNM3	GIS CD Update
20790	SPQ303M3	Geology/Hydrology Environmental Baseline File; Rev. 01; YDAR # 20790
20820	SSH14JM3	Letter Report: 2nd Qtr FY99
20854	RPA451M3	License Application Design Selection Report; Rev. 01
20858	SEB135M3	Environmental Impact Statement Cost Summary Report
20878	SS983BM3	Underground Injection Control (UIC) Permit UNEV89031 First Quarter Report for 1999
20905	SL29KM3	Quarterly Interactions Summary Report Second Report Quarter - Fiscal Year 1999
20985	SLSR5M3	Comment Response to the Final Report: Peer Review of the Total System Performance Assessment - Viability Assessment (TSPA-VA); Rev. 01
20995	SS128NM3	Socioeconomic Monitoring Program Quarterly Employment Data Report January 1999 through March 1999
20998	SS128CM3	Annual Inventory of Collected Archeological Materials
21074	SS1281M3	Ambient Air Monitoring Report Monitoring Period 31: January - March 1999
21098	SLPR20M3	Submit PR 20 to YMSCO AMs for Review
21142	SS128FM3	Annual EPCRA Section 313 Report
21176	RPA140M3	Secondary Low-level Waste Treatment Strategy Analysis
21238	SS128PM3	Socioeconomic Monitoring Program Procurement Data Report October 1, 1998 to March 31, 1999
21239	RPA118M3	Modular Design/phased Construction Alternative Evaluation Report
21441	SLD105M3	Level of Design Detail Necessary for the License Application for Construction Authorization
21445	SP327KM3	Preliminary Geotechnical Investigation for Waste Handling Building, Yucca Mountain Site Characterization Project

Table A-1. List of Completed Yucca Mountain Site Characterization Project Deliverables (April 1, 1999, to September 30, 1999) (Continued)		
Document Control Number	**Deliverable Number**	**Title and Revision**
21448	RPA106M3R1	Repository Surface Design Engineering Files Report
21512	SS985M3	Site Environmental Report for Calendar Year 1998
21561	SLPRCMM3	Site Characterization Progress Report: Yucca Mountain, Nevada, October 1, 1998 to March 31, 1999
21573	BM207DM3	IT Architecture Baseline
21674	SLTDCM3	3rd Quarter Status of Data Submittals and Incorporations into the Technical Data Management System
21715	BM9500M3	Submit Initial FY00 YMP Plan Update YMSCO
21747	SL9051M3	Repository Design Feed to TSPA
21873	SS983CM3	Quarterly Underground Injection Control (UIC) Permit Report
22060	SL29LM3	Quarterly Interactions Summary Report - Third Quarter Fiscal Year 1999
22176	SL915M3	Total System Performance Assessment – Site Recommendation Methods and Assumptions
22221	SSH14KM3	Letter Report: 3rd Quarter FY99
22265	SSJ29M3	Public Comment Response Process Plan and Guidance Manual
22341	SS128OM3	Socioeconomic Monitoring Program Quarterly Employment Data Report April 1999 through June 1999
22351	BM205OM3	M&O Year 2000 Business Continuity Plan
22363	SS985AM3	Environmental Regulatory Compliance Plan
22381	SS128JM3	Ambient Air Monitoring Report Monitoring Period 32: April-June 1999
22456	SS19DM3	Distribute DEIS
22772	SL36X3M3	Technical Guidance Document for License Application Preparation; Rev. 01
22818	SSH14NM3	Selected Ground-water Data for Yucca Mountain Region, Southern Nevada and Eastern California, through December 1998

APPENDIX B

LIST OF FUTURE YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT DELIVERABLES AND STATUS OF WORKS IN PROGRESS

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Table B-1. List of Future Yucca Mountain Site Characterization Project Deliverables			
Work in Progress Number	**Document or Deliverable ID Number**	**Proposed Title**	**Expected Completion Date**
Future Deliverables PR 21 Listings			
1	YMP/96-01	Repository Safety Strategy, Rev. 03	11/30/99
2	YMP/90-55Q	MGR Q-List, Rev. 06	03/31/00
3	SEDA0BM3	"Monitored Geologic Repository Requirements Document" Update	10/29/99
4	SEDA09M3	Update QL-1 SDDs – Letter Report	01/10/00
5	SEDA03M3	Monitored Geologic Repository Project Description Document Design Description Update – Letter Report	03/31/00
6	SEDA04M3	"Monitored Geologic Repository Concept of Operations Update	03/31/00
7	SP3515M3	Milestone Report Ghost Dance Fault Testing	12/12/99
8	UCRL-ID-133846	Fracture Characterization of the Large-Block Test, Fran Ridge, Yucca Mountain, Nevada	03/31/00
9	BBD000000-01717-5700-00001	Engineered Barrier System–Pilot Scale Testing Preliminary Results	03/31/00
10	SP32P4M3	Report: Integrated Site Model 3.1; Addendum to ISM3.0 Report	12/13/99

Table B-2. Status of Works in Progress from Previous Progress Reports			
Work in Progress Number	**Document or Deliverable ID Number**	**PR 20 Listings**	**Expected Completion Date**
1	B00000000-01717-4600-00123	License Application Design Selection Report, Rev. 01 (CRWMS M&O 1999ba)	05/28/99 **Final**
2	BBD000000-01717-5700-00001	Engineered Barrier System–Pilot Scale Testing Preliminary Results (carried forward to Appendix B, Table B-1, work in progress #9)	03/31/00
3	B00000000-01717-5700-00031	Annotated Outline of the Site Recommendation Report, Volume 2: 10 CFR 960 Compliance Evaluation	04/09/99 **Final**
4	B00000000-01717-4601-00002	Management Plan for the Development of the Yucca Mountain Site Recommendation Report	04/09/99 **Final**
5	SP9904M3	Large Block Test Final Report – Revised, results incorporated in Near-Field Environment Process Model Report	03/03/00
6	Number TBD	Unsaturated Zone Flow and Transport Model. Rev. 0	04/28/00
7	SPV248M3	Report: Saturated Zone Flow & Transport Model for Site Recommendation/License Application – Revised, Saturated Zone Process Model Report	01/28/00
8	SS19DM3	Distribute Draft EIS	07/30/99 **Final**
9	SL916M3	Draft EIS	03/15/99 **Final**
10	SLSTRBM3	Submit Seismic Topical Report (STR) III for QAP 6.2/YAP-30.12 Reviews	11/08/99 Revised 05/08/00
11	B00000000-01717-1705-00003	Monitored Geologic Repository Project Description Document	10/29/99
12	SEA282M3	Performance Confirmation Plan, Revision 1	07/30/99 Revised 01/31/00

Table B-2. Status of Works in Progress from Previous Progress Reports (Continued)			
Work in Progress Number	**Document or Deliverable ID Number**	**PR 20 Listings**	**Expected Completion Date**
13	SL915M3	TSPA-Site Recommendation/License Application Methods and Assumptions Document	06/30/99 Revised 09/03/99 **Final**
14	SP32P4M3	Report: ISM3.1; Addendum to ISM3.0 Report (carried forward to Appendix B, Table B-1, work in progress #10)	12/13/99
15	SPG42GM3	Geology of the Enhanced Characterization of the Repository Block Drift	08/16/99 Revised 10/29/99
16	SPG258M3	Preliminary Geologic Map for Saturated Zone Site Area	05/28/99 Revised 10/29/99
17	Number TBD	Data Submittal to Technical Database for Nye County	09/30/00
18	SPG452M3	Geometry and Characteristics of Fault Zones at Yucca Mountain	09/30/99 Revised 12/30/99
19	SP387CM4	Analysis and Model Report for Natural Resources	09/30/99
20	Number TBD	Seismicity for Fiscal Year 1999	09/30/00
21	BAB000000-01717-5700-00005	Single Heater Test Final Report	09/30/99
22	SPH372M4	Cross-drift Moisture Monitoring Data Package to RPC/TDB	09/30/99
23	BCB000000-01717-5705-00016	Preliminary Geotechnical Investigation for Waste Handling Building, Yucca Mountain Site Characterization Project, REV 00	06/10/99 **Final**
24	B00000000-01717-5700-00025	Evolution of the Monitored Geologic Repository Reference Design	06/30/99 **Final**
25	BCBD00000-01717-5705-00002	Cask/Canister Cooldown System Technical Report	02/16/99 **Final**

Table B-2. Status of Works in Progress from Previous Progress Reports (Continued)			
Work in Progress Number	**Document or Deliverable ID Number**	**PR 20 Listings**	**Expected Completion Date**
26	BCBD00000-01717-5705-00007	Waste Handling Equipment Development Test and Evaluation Study	09/28/98 **Final**
27	B00000000-01717-0210-00064	Thermal-Hydrology Modeling of a Modified Waste Emplacement Mode Concept: Borehole Emplacement	09/30/99 **Final**
28	B00000000-01717-0210-00054	Thermal-Hydrology Modeling of the Blending of Waste Alternative Designs	09/30/99 **Final**
29	B00000000-01717-0210-00055	Thermal-Hydrology Modeling of the Niche Pattern Modified Waste Emplacement Mode Alternative Design	09/30/99 **Final**
30	B00000000-01717-0210-00056	Thermal-Hydrology Modeling of the Pre-Closure Ventilation Alternative Designs	09/30/99 **Final**
31	B00000000-01717-0210-00057	Thermal-Hydrology Modeling of the Post-Closure Ventilation Alternative Designs	09/30/99 **Final**
32	B00000000-01717-0210-00058	RIP Input Tables from WAPDEG for LA Design Selection: Continuous Post-Closure Ventilation Design - Closed "Bowtie" Layout	09/30/99 **Final**
33	B00000000-01717-0210-00065	RIP Input Tables from WAPDEG for LA Design Selection: Continuous Post-Closure Ventilation Design - Open Loop	09/30/99 **Final**
34	B00000000-01717-0210-00077	RIP Input Tables from WAPDEG for LA Design Selection: Modified Waste Emplacement Mode Design - Horizontal Borehole	09/30/99 **Final**
35	B00000000-01717-0210-00076	RIP Input Tables from WAPDEG for LA Design Selection: Modified Waste Emplacement Mode Design - Vertical Borehole	09/30/99 **Final**
36	B00000000-01717-0210-00044	RIP Input Tables from WAPDEG for LA Design Selection: Modified Waste Emplacement Mode Design - Alcove	09/30/99 **Final**
37	B00000000-01717-0210-00037	RIP Input Tables from WAPDEG for LA Design Selection: Drip Shield and Quartz Backfill	09/30/99 **Final**
38	B00000000-01717-0210-00040	RIP Input Tables from WAPDEG for LA Design Selection: 50 Year Pre-Emplacement Aging	09/30/99 **Final**
39	B00000000-01717-0210-00042	RIP Input Tables from WAPDEG for LA Design Selection: Blending of Waste	09/30/99 **Final**
40	B00000000-01717-0210-00045	RIP Input Tables from WAPDEG for LA Design Selection: Continuous Pre-Closure Ventilation	09/30/99 **Final**

Table B-2. Status of Works in Progress from Previous Progress Reports (Continued)			
Work in Progress Number	**Document or Deliverable ID Number**	**PR 20 Listings**	**Expected Completion Date**
41	B00000000-01717-0210-00038	RIP Input Tables from WAPDEG for LA Design Selection: Line Loading	09/30/99 **Final**
42	B00000000-01717-0210-00049	RIP Input Tables from WAPDEG for LA Design Selection: Waste Package CRMs	09/30/99 **Final**
43	B00000000-01717-0210-00059	RIP Input Tables from WAPDEG for LA Design Selection: Waste Package CRMs – 2 cm Alloy 22	09/30/99 **Final**
44	B00000000-01717-0210-00039	RIP Input Tables from WAPDEG for LA Design Selection: Richard's Barrier	09/30/99 **Final**
45	B00000000-01717-0210-00047	RIP Input Tables from WAPDEG for LA Design Selection: Canistered Assemblies	09/30/99 **Final**
46	B00000000-01717-0210-00060	RIP Input Tables from WAPDEG for LA Design Selection: Alluvium Surface Modification	09/30/99 **Final**
47	B00000000-01717-0210-00061	RIP Input Tables from WAPDEG for LA Design Selection: Repository Horizon Elevation – 2-Level AML 50% and Near Maximum	09/30/99 **Final**
48	B00000000-01717-0210-00062	RIP Input Tables from WAPDEG for LA Design Selection: Higher thermal Loading	09/30/99 **Final**
49	B00000000-01717-0210-00069	RIP Input Tables from WAPDEG for LA Design Selection: Enhanced Design Alternative I	09/30/99 **Final**
50	B00000000-01717-0210-00070	RIP Input Tables from WAPDEG for LA Design Selection: Enhanced Design Alternative II	09/30/99 **Final**
51	B00000000-01717-0210-00071	RIP Input Tables from WAPDEG for LA Design Selection: Enhanced Design Alternative IIIa	09/30/99 **Final**
52	B00000000-01717-0210-00078	RIP Input Tables from WAPDEG for LA Design Selection: Enhanced Design Alternative IIIb	09/30/99 **Final**
53	B00000000-01717-0210-00072	RIP Input Tables from WAPDEG for LA Design Selection: Enhanced Design Alternative IV	09/30/99 **Final**
54	B00000000-01717-0210-00073	RIP Input Tables from WAPDEG for LA Design Selection: Enhanced Design Alternative V	09/30/99 **Final**
55	B00000000-01717-5705-00128	Environmental Impact Statement Performance Assessment (for Disposal of Commercial and DOE Waste Inventories at Yucca Mountain)	6/30/99 Revised 03/15/99 **Final**

Table B-2. Status of Works in Progress from Previous Progress Reports (Continued)			
Work in Progress Number	**Document or Deliverable ID Number**	**PR 20 Listings**	**Expected Completion Date**
56	BCB000000-01717-1705-00034	Performance Confirmation Data Acquisition/Monitoring System Description Document	07/16/99 **Final**
57	BCA000000-01717-5705-00007	Analysis of Clearance Envelopes for Emplacement Drift Operating Equipment and Space Envelopes for Test Coupons within the Emplacement Drift	08/09/99 **Final**
		PR 19 Listings	
9	SP32E1M3*	Report: Prow Pass Reactive Tracer Test - Revised as Flow Calibrations AP-3.10Q	04/01/99 **Revised** 03/31/00
10	SP32E7M4*	Report: Prow Pass Reactive Tracer Test - Revised as Flow Calibrations AP-3.10Q	02/12/99 **Revised** 03/31/00
18	SLSR5M3	Performance Assessment Peer Review Panel	05/28/99 **Final**
20	SEAA21M3	Criticality Analysis of Pu Waste Forms in a Geologic Repository	09/30/99 **Final**
21	SEA1A9M3	Design Basis Events Analysis of Immobilized Pu Waste Form	09/30/99 **Final**

* Results to be incorporated into AMR UZ 0100, UZ and SZ Transport Properties

APPENDIX C

STATUS OF MILESTONE REPORTS REFERENCED IN PREVIOUS PROGRESS REPORTS

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APPENDIX C
STATUS OF MILESTONE REPORTS REFERENCED IN PREVIOUS PROGRESS REPORTS

This appendix lists YMP documents referenced in previous progress reports (Progress Reports 17 to date) as Level 4 milestone reports and indicates a current status (i.e., a final, published reference; publication pending; or no change). This list will be updated in each progress report; documents will be carried forward until final disposition.

These documents are developed for the YMP primarily by the national laboratories and U.S. Geological Survey. The versions originally presented as Level 4 milestone reports for use by the YMP may differ from the final published documents. This appendix provides readers the opportunity to obtain final, published technical documents when available.

Table C-1. Status of Milestone Documents Referenced in Progress Reports 17 to Date

As referenced in:	Current Status
Progress Report 17	
Buscheck, T.A.; Shaffer, R.J.; and Nitao, J.J. *Pretest Thermal-Hydrological Analysis of the Drift Scale Test at Yucca Mountain.* Level 4 Deliverable SP 9321M4. Livermore, California: Lawrence Livermore National Laboratory.	MOL.19980507.0359
Bussod, G.Y.; Robinson, B.A.; Vaniman, D.T.; Broxton, D.E.; and Viswanathan, H.S. *UZ Transport Test Plan*, Rev. 1. Yucca Mountain Project Milestone SP341SM4. Los Alamos, New Mexico: Los Alamos National Laboratory.	MOL.19981006.0254
Conic, J.L.; Robinson, B.A.; Triay, I.R.; Bussod, G.Y. 1997. *Direct Characterization of Transport Parameters in Near-Field and Engineered Backfill/Invert Materials.* Yucca Mountain Project Milestone SP341NM4. Los Alamos, New Mexico: Los Alamos National Laboratory.	Superseded by AMRs/PMRs
Efurd, D.W.; Runde, W.; Tait, C.D.; Banar, J.C.; Reonsch, F.R.; Palmer, P.D.; and Clark, D.L. 1996. *Measured Solubilities And Speciation Of Neptunium And Plutonium In J#13 Ground Water.* Yucca Mountain Project Milestone 3411. Los Alamos, New Mexico: Los Alamos National Laboratory.	Superseded by AMRs/PMRs
Efurd, D.W.; Runde, W.; Janecky, D.J.; and Tait, C.D. 1997. *Delivery Solubility Models And Experiments.* Yucca Mountain Project Milestone SP341FM4. Los Alamos, New Mexico: Los Alamos National Laboratory.	MOL.19981028.0280
Fabryka-Martin J.T.; Flint, A.L.; Sweetkind, D.S.; Wolfsberg, A.V.; Levy, S.S.; Roach, J.; and Wolfsberg, L.E. in prep. *Evaluation of Flow and Transport Models of Yucca Mountain, based on Chlorine-36 Studies for FY97.* Milestone Report SP2224M3. Los Alamos, New Mexico: Los Alamos National Laboratory.	MOL.19980204.0916

Table C-1. Status of Milestone Documents Referenced in Progress Reports 17 to Date (Continued)	
As referenced in:	**Current Status**
Progress Report 17	
Feighner, M.A.; Daley, T.M.; Gritto, R.; and Majer, E.L. in prep. *Report on CDP Reflection Image and Subsurface Structure Along Lines B and C: US-16 VSP.* Milestone Report SP3B2BM4. September 30, 1997.	MOL.19971208.0338
Flint, A.L.; Hevesi, J.A.; and Flint, L.E. *Conceptual and Numerical Model of Infiltration for the Yucca Mountain Area, Nevada.* Milestone Report 3GUI623M, DTN: GS960908312211.003. Submitted for publication as a Water-Resources Investigations Report. Denver, Colorado: U.S. Geological Survey.	MOL.19970409.0087;TIC: 242974
French, D.E., *Assessment of Hydrocarbon Resources of the Yucca Mountain vicinity, Nye County, Nevada.* Unpublished independent consultant's report prepared for Civilian Radioactive Waste Management System Management and Operating Contractor, Billings, Montana. Level 4 Deliverable #SPTAM4.	Superseded by AMRs/PMRs
Huang, J. 1997. *Thermal Embrittlement of Carbon Steels in Canistered Waste Disposal Containers.* WP60508 Milestone report for CRWMS M&O, DOE. Livermore, California: Lawrence Livermore National Laboratory.	MOL.19980114.0092
Meijer, A. 1996. *Conceptual Model of Ground Water Chemistry.* Yucca Mountain Project Milestone Report 3098. Los Alamos, New Mexico: Los Alamos National Laboratory.	MOL.19980924.0158
Paces, J.B.; Marshall, B.D.; Whelan, J.F.; and Neymark, L.A 1997a. *Progress Report on Unsaturated Zone Stable and Radiogenic Isotope Studies*, Milestone Report SPC23FM4. Denver, Colorado: U.S. Geological Survey.	MOL.19990107.0150; TIC 238068
Paces, J.B.; Whelan, J.F.; Forester, R.M.; Bradbury, J.P.; Marshall, B.D.; and Mahan, S.A. 1997c. *Summary of Discharge Deposits in the Amargosa Valley*, Milestone Report SPC333M4. 52 pp. Denver, Colorado: U.S. Geological Survey.	MOL.19981104.0151
Runde, W.; Palmer, P.D.; and Tait, C.D. 1997. *Characterization of NP_2O_5 and NpO_2.* Yucca Mountain Project Milestone SP341WM4. Los Alamos, New Mexico: Los Alamos National Laboratory.	MOL.19990104.0082
Sweetkind, D.S.; Fabryka-Martin, J.T.; Flint, A.L.; Potter, C.J.; and Levy, S.S. 1997a. *Evaluation of the Structural Significance of Bomb-Pulse ^{36}Cl at Sample Locations in the Exploratory Studies Facility, Yucca Mountain, Nevada.* Milestone Report SPG33M4. Denver, Colorado: U.S. Geological Survey.	Superseded by AMRs/PMRs

Table C-1. Status of Milestone Documents Referenced in Progress Reports 17 to Date (Continued)	
As referenced in:	**Current Status**
Progress Report 17	
Thompson, R. and Anderson, K., in prep. *Post Climate Characteristics During the Last Glacial Based on Quantitative Analysis of Packrat Midden Data [Working Title].* U.S. Geological Survey Administrative Report. Denver, Colorado: U.S. Geological Survey.	Thompson, R.S; Anderson, K.H., and Bartlein, P.J. 1999. *Quantitative Paleoclimatic Reconstructions from Late Pleistocene Plant Macrofossils of the Yucca Mountain Region.* U.S. Geological Survey Open-File Report 99-338. Denver, Colorado: U.S. Geological Survey. MOL/TIC TBD.
Thompson, J.L., ed. *Laboratory and Field Studies Related to the HD Hydrologic Resources Management Program, October 1, 1996 to September 30, 1997.* Los Alamos National Laboratory Technical Report. Los Alamos, New Mexico: Los Alamos National Laboratory. In review.	Superseded by AMRs/PMRs
Triay, I.R.; Conic, J.; Romero, D.; Cotter, C.; and Anderson, J. 1997b. *Actinide Transport Through Intact Tuff Under Varying Degrees of Saturation.* Yucca Mountain Project Milestone Report SP341JM4. Los Alamos, New Mexico: Los Alamos National Laboratory.	MOL.19981006.0282
Woodward-Clyde Consultants. *Water Resources Assessment, Yucca Mountain Project.* Unpublished consultant's report prepared for CRWMS M&O. Level 4 Deliverable #SPT72BM4. Denver, Colorado: Woodward-Clyde Consultants.	Superseded by AMRs/PMRs
Progress Reports 18-20	
None	None

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APPENDIX D

GLOSSARY

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APPENDIX D
GLOSSARY

NOTE: Many of the following definitions are YMP-specific.

Glossary Item	Definition or Explanation
Air-Injection Tests	Tests conducted to determine the permeability of fault zones in and around the emplacement area.
Alcove	Underground excavations made to the sides of drifts or ramps of the ESF or Cross Drift and used as sites for in situ testing of ambient rock characteristics or thermal perturbations of those characteristics.
Altered Zone	Generally, regions of rock surrounding waste emplacement areas that have temperatures sufficiently high to prevent liquid water from existing in pores and fractures.
Analysis and Model Report	A report that documents the technical underpinnings used to defend the applicability of the model for its intended purpose of evaluating the postclosure performance of the potential Yucca Mountain Repository System.
Aquifer	A water-bearing layer of permeable rock that is capable of yielding groundwater to supply wells and springs.
Backfill	Material placed in the emplacement drifts to refill the drift after waste packages are placed in the drift and prior to closing the repository.
Ballast	Heavy granular material used to fill and give stability to the inverts.
Borehole	A hole bored or drilled to investigate subsurface features.
Characterization	A study done to investigate (i.e., to determine the character or quality) and describe an item or process.
Colloid	A substance consisting of particles, dispersed throughout another substance, that are too small for resolution with an ordinary light microscope but are incapable of passing through a semipermeable membrane.
Cross Drift	The west-southwest trending excavation extending from near the base of the north ramp of the ESF through the main trace of the Solitario Canyon fault.
Defense In Depth	The use of multiple barriers (i.e., several natural and engineered barriers) to provide a series of barriers for the repository such that if one barrier were to be breached, the next would contain the radioactive waste.
Design Alternative	A design that involves important changes to the fundamental concepts on which the VA design was based.
Design Feature	Enhancements to design that can be easily incorporated within multiple alternative designs.
Drift	Mining terminology for a horizontal underground passage.
Drip Shield	A sheet of impermeable material placed above a waste package to prevent water from seeping into the drift and dripping onto the waste package.
Emplacement Area	That part of the geologic repository in which radioactive waste would be placed.

Glossary Item	Definition or Explanation
Engineered Barrier System	Those engineered features of the geologic repository that contribute to containing radioactive wastes and preventing or delaying them from escaping the geologic repository. Engineered barriers are items such as waste packages and drip shields.
Enhanced Repository Design Alternative	Combinations of one or more design alternatives and design features that fit logical principles derived from the objectives for repository design.
Fault Zone	An area composed of many small, closely spaced rock fractures that show evidence of movement, or such an area composed of breccia or fault gouge.
Geologic Repository	A facility designed for underground disposal of spent nuclear fuel and high-level radioactive waste.
Invert	Structure placed in the bottom of drifts (round tunnels) to provide a flat, rather than rounded, floor surface.
Model	A depiction of a system, phenomenon, or process including any hypotheses required to describe the system or explain the phenomenon or process. The depictions may be conceptual or numerical.
Natural Barrier System	Those natural features of the geologic repository that contribute to containing radioactive wastes and preventing or delaying them from leaving the geologic repository. Natural barriers are items such as the rocks above and below the emplacement area.
Near-Field Environment	The zone of environmental conditions that directly impacts the waste package container materials and the waste form.
Niche	A relatively shallow excavation in the side of a drift where scientific experiments can be conducted.
Perched Water	Small bodies of water held above the water table and supported by a relatively impermeable layer of rock.
Performance Confirmation	Assessment activities to confirm that the repository is performing as expected.
Permeability	Measurement of the degree to which a given material or substance will permit the passage of air or water.
Postclosure	The time after the repository is closed (contrast with preclosure).
Preclosure	The time before the repository is closed (contrast with postclosure).
Probability Distribution	A mathematical representation of the chance that some event will occur, or the variation among possible outcomes.
Process Model Report	A report that documents a synthesis of the necessary and sufficient technical information that the Project will be relying upon to support its site suitability evaluation and the licensing safety case pertaining to a particular process model.
Quality Assurance	All those planned and systematic actions necessary to provide adequate confidence that the geologic repository and its subsystems or components will perform satisfactorily.

Glossary Item	Definition or Explanation
Recharge	Water that flows into an aquifer and replaces, or recharges, water that is lost from the aquifer by pumping or natural discharge.
Repository Block	The geologic structure (i.e., block of rock) inside of which the emplacement area would be constructed.
Repository Horizon	The stratigraphic horizon in which the potential repository might be constructed.
Root Cause Determination	A process used to determine the cause of problems or mistakes and to prevent those problems or mistakes from arising in the future.
Saturated Zone	The subsurface zone below the water table in which all void space is filled with water at a pressure greater than the pressure of the atmosphere.
Sensitivity Studies	Studies of models to determine the magnitude of differences in the results of the models that result from small changes to the input values. These studies determine how sensitive the results of the model are to small changes in the inputs and permit researchers to determine the input factors that most affect the results.
Unsaturated Zone	The volume of earth below the ground surface, and above the water table, in which the void space contains water at less than atmospheric pressure and air at atmospheric pressure.
Vitric	Any glassy, pyroclastic material containing at least 75 percent glass.
Waste Form	A generic term that refers to radioactive materials and any encapsulating or stabilizing matrix.
Waste Package	An engineered containment vessel, made of corrosion-resistant materials, in which radioactive material can be stored.
Water Table	The top of the saturated zone below which the rocks are saturated with water, and above which the rocks are not saturated (i.e., the interface between the saturated and unsaturated zones).

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