LAWRENCE LIVERMORE NATIONAL LABORATORY YUCCA MOUNTAIN PROJECT
DECEMBER 1992 TECHNICAL HIGHLIGHTS AND STATUS REPORT
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LAWRENCE LIVERMORE NATIONAL LABORATORY
(LLNL)
YUCCA MOUNTAIN PROJECT (YMP) STATUS REPORT

DECEMBER 1992

EXECUTIVE SUMMARY
(Items Proposed for Reporting in YMPO or OGD Reports)

1) **1.2.2.1 (Waste Package Coordination and Planning).** LLNL hosted a meeting with hydrologists and managers from LLNL, SNL, LBL, the M&O, and YMPO. The assumptions and foundations of T. Buscheck's (LLNL) thermal-hydrological calculations of the SCP-CD and extended dry repository concepts were discussed. A group of hydrologists was formed to benchmark the LLNL calculation using other codes.

2) **1.2.2.2.2 (Hydrologic Properties of the Waste Package Environment).** Hydrothermal calculations of the unsaturated and saturated zones (UZ and SZ) indicate that the bulk permeability threshold for significant UZ dry-out ($\sim 10^{-14} m^2$) is similar to that for significant buoyancy-driven flow in the SZ (10^{-16} to $10^{-13} m^2$). It is possible that UZ heater tests could determine whether SZ fracture properties are conducive to SZ buoyancy flow.

3) **1.2.2.2.2 (Hydrologic Properties of the Waste Package Environment).** Hydrothermal calculations of the unsaturated and saturated zones (UZ and SZ) show that the spatial domain of hydrothermal effects extends at least 1 km below the water table and 15 km radially away from the heat source.

4) **1.2.2.2.2 (Hydrologic Properties of the Waste Package Environment).** Because of the dominance of repository-heat-driven hydrothermal flow, pre-emplacement unsaturated zone groundwater travel time (GWTT) is not a suitability discriminator of the hydrological performance of an extended dry repository. Moreover, conditions that are conducive to deep nonequilibrium fracture flow in the UZ also benefit rapid shedding of condensate away from the boiling zone, thereby promoting effective rock dry-out. Therefore, fast groundwater travel times in the UZ would be indicative of a site that is well suited for an extended-dry repository concept. On the other hand, it is possible (although unlikely) that fractures in the UZ are either too sparse or too poorly connected to promote either deep fracture flow (from meteoric sources) or large-scale dry-out. The absence of large-scale dry-out is not indicative of unsuitable conditions because the same conditions also prevent deep fracture flow from meteoric sources. Therefore, for an extended-dry repository concept, the site could be suitable with either fast or slow groundwater travel time in the UZ.

5) **1.2.2.2.2 (Hydrologic Properties of the Waste Package Environment).** The licensing of a sub-boiling or marginal-boiling repository will be critically dependent on characterizing the highly heterogeneous distribution of fracture and matrix properties as well as the highly spatially and temporally variable distribution of net recharge flux. Licensing will also depend on validity of hydrological models which account for:

1) these very complex variable distributions,
2) the strongly nonlinear dependence of fracture flow on these heterogeneous distributions,
3) how the spatial variability in the heat generation rate among the WPs will drive condensate flow from hotter to cooler WPs (and possibly to the water table), and
4) the impact of hydrothermal-geochemical coupling on the flow and transport properties as well as on the chemistry of water contacting WPs.

Because sub-boiling or marginal-boiling conditions will not mitigate the occurrence of deep nonequilibrium fracture flow from meteoric sources, hydrological assessments of low thermal loading conditions must account for the superposition of naturally occurring episodic fracture flow and repository-heat-driven refluxing for essentially all the time of regulatory concern.

The licensing of an extended-dry repository can be based on three fundamental considerations:
1) the spatial and temporal extent of above-boiling conditions,
2) how closely the dry-out zone corresponds to the zone of above-boiling conditions, and
3) how long it takes the dry-out zone to re-wet back to ambient saturation.

The validation of the performance of the extended-dry concept is greatly facilitated by considering three fundamental hypothesis tests:
1) whether heat conduction dominates heat flow,
2) whether fracture density and connectivity are sufficient to promote rock dry-out due to boiling, and
3) whether the re-wetting of the dry-out zone significantly lags behind the end of the boiling period.

6) **1.2.2.2.2 (Hydrologic Properties of the Waste Package Environment).** Hydrothermal calculations of large-scale in situ heater test geometries indicate that small (~20 W) thermal probes developed by Prof. Danko of the University of Nevada, Reno can be used to accurately determine the in situ rock thermal conductivity and diffusivity.

7) Staff supplied the final version of a white paper by A. Meike entitled "Chemical and Mineralogical Concerns for the Use of Man-Made Materials in the Post-Emplacement Environment" to R. Fish and D. Stahl (M&O). This paper discusses concerns for materials introduced into the ESF.

8) **1.2.2.3.1.1 (Waste Form Testing - Spent Fuel).** A simple gravity feed flow-through system has been successfully tested. The flow rate is controlled by tube diameter and fluid head. Elimination of the pumps saves money and reduces down-time due to leaks and power outages. More lines can be run because the pump space and environment are no longer constraints.

9) The approved test matrix for flow-through testing with spent fuel specimens at PNL consists of twenty separate tests with a total of seventeen different test conditions. Eighteen of the tests have been completed. Preliminary results have

also been obtained for the remaining two test conditions, but these tests are being repeated because the results are inconsistent with the others.

10) The final two geochemical code user manuals entitled "EQPT, A Data File Preprocessor for the EQ3/6 Software Package, User's Guide and Related Documentation, Version 7.0, Part II" and "EQ6, A Computer Program for Reaction Path Modeling of Aqueous Geochemical Systems: Theoretical Manual, User's Guide and Related Documentation, Version 7.0, Part IV" by T. Wolery, and S. Daveler were approved by YMPO and will be published in January.

1.2.1 SYSTEMS ENGINEERING

1.2.1.1 Systems Engineering Coordination and Planning

No significant activities.

1.2.1.5 Special Studies

No significant activities.

1.2.1.6 Configuration Management

LLNL-YMP reviewed its controlled documents to determine the impact of ADN92/145, Surface Based Testing Facility Requirements Document (technical baseline), Rev. 8 and found that no LLNL-controlled documents were affected.

1.2.2 WASTE PACKAGE

1.2.2.1 Waste Package Coordination and Planning

Responses to review comments on the Preliminary Near Field Environment Report were submitted to YMPO on December 7.

B. Viani participated in the December Geochemistry Integration Task (GIT) meeting held by teleconference.

1.2.2.2 Waste Package Environment

1.2.2.2.1 Chemical and Mineralogical Properties of the Waste Package Environment

Discussions were held regarding PACS workscope statements for WBS elements.

The paper by W. Glassley entitled "Validation of Hydrogeochemical Codes Using the New Zealand Geothermal System" was submitted to YMPO. After approval, it will be published in the proceedings of the CEC Natural Analog Working Group meeting that was held in Toledo, Spain on October 5-9, 1992.

W. Glassley attended the AGU meeting in San Francisco December 7-8, 1992.

1.2.2.2.2 Hydrologic Properties of the Waste Package Environment

The first draft of a Study Plan for the Near Field Environment Hydrology Task is in the technical editing process.

Model Calculations

Work continued to conduct and analyze the preliminary scoping calculations of the hydrothermal performance of the repository, using the RIB Version 4 thermal conductivity data, and using the new model which represents hydrothermal flow in the upper 1000 m of the saturated zone (SZ) as well as within the unsaturated zone (UZ). As mentioned in the past few months, the treatment of the water table is critical to the calculated hydrothermal flow in both the UZ and SZ. After about 100 yrs, the water table begins to experience a temperature buildup, ΔT. Even for 20 kW/acre, the water table temperature rise is substantial and persists for tens of thousands of years. For 30 yr old fuel emplaced at 20 kW/acre, the water table peaks at 46.9°C (ΔT = 16.5°C) at 6900 yr, and remains above 40°C for over 26,000 yr. For 114 kW/acre, 30 yr old fuel, the water table peaks at 95°C at 830 yr, remains above 90°C for 670 yr, and remains above 70°C for over 12,000 yr. Even 250 m below the water table (475 m below the repository center), ΔT is quite substantial, with a maximum temperature rise of 11, 22, and 23°C for APDs of 20, 57, and 114 kW/acre, respectively.

For the cases with fractures, it was found that after 5000 yr, the isotherms of the temperature buildup in the saturated zone show significant deviations relative to what would be expected for heat-conduction-dominated heat flow. These deviations do not arise from the convection of repository heat; instead they are caused by the convection of hotter water from below (hotter because of the geothermal gradient). Because a constant-property boundary is maintained 1 km below the water table and liquid flow is both entering and leaving this boundary, the convection cells are not within a closed loop. Consequently, the boundary effect prevents cooler water that enters the boundary from cooling the warmer water leaving the boundary. Thus, this boundary effect may be introducing additional heat that would not have occurred had the finite extent of the convection cell been fully represented in the model. On the other hand, the close proximity of a constant-temperature boundary to significant temperature changes has the tendency of artificially lowering temperatures. It is not clear whether the net impact of these two effects causes an overall increase or decrease of heat in the upper 1000 m of the SZ. Several cases were analyzed with no fracture flow (effectively causing heat flow to be entirely dominated by heat conduction) and found negligible differences (relative to the cases with significant fracture flow) in heat flux crossing the water table (i.e., from the UZ to the SZ). Therefore, the boundary effects which occur 1 km below the water table do not affect UZ temperatures. It should be noted that very little data exists concerning the vertical extent of connected fracture networks in the SZ and that thermal property data below the PPw unit is lacking in the RIB. It is planned to continue the study of hydrothermal flow in the SZ, utilizing all available sources of thermal property data.

The sensitivity of buoyancy-driven SZ flow to bulk permeability, k_b, was also examined. The k_b threshold for significant buoyancy-driven flow effects occurs somewhere in the range $10^{-16} < k_b < 10^{-13}$ m^2. In previous work, it was found that the

threshold k_b for significant dry-out effects occurs in approximately the same range (k_b~$10^{-14}m^2$). Although there are different phases (liquid vs gas-phase) involved in these convective processes, it is interesting to note that approximately the same threshold k_b applies. It is possible that for hydrostratigraphic units which occur both below and above the water table at Yucca Mountain, heater testing in the SZ could be used to determine whether fracture densities and connectivities are sufficient to promote significant dry-out (due to boiling) in the UZ. Conversely, heater testing in the UZ would indicate whether the fracture properties are conducive to SZ buoyancy flow.

Also considered was the sensitivity of the model results to the radial boundary (that assumes the initial pressure, temperature, and saturation distribution remain constant) located at a radial distance 15 km from the repository center. While this boundary has no impact on hydrothermal flow in the UZ, a small amount of liquid flows into and out of the outer radial boundary in the SZ during the first 50,000 yr. However, this effect does not affect buoyancy-driven flow at radial distance less then 13 km. In future work, the radial distance to the outer constant-property boundary and the depth to the lower constant-property boundary will be increased. In general, the analysis indicates that the spatial domain that must be accounted for in the model extends at least 1 km below the water table and at least 15 km radially away from the center of the repository, indicating the extensive spatial extent of repository-heat-driven hydrothermal flow effects.

For high areal mass loadings (AMLs), (resulting in long-term boiling and sub-ambient saturation conditions), liquid-phase flux is much greater than the net recharge flux associated with pluvial climatic conditions. The higher liquid flux is associated with vapor flow and condensate drainage during the boiling period and with re-wetting the dry-out zone during the post-boiling period. Even for low AMLs (resulting in insignificant dry-out due to boiling), repository-heat-driven hydrothermal flow will dominate SZ flow and will also dominate local flow conditions through much of the UZ. This is not to say that episodic nonequilibrium fracture flow from meteoric sources is not important. For sub-boiling conditions, while episodic events occur, fracture flow is likely to be the dominant source of liquid flux along preferential pathways connected to meteoric sources. Overall, however, repository-heat-driven hydrothermal flow is likely to be the main contributor of gas- and liquid-phase flow in the UZ. Therefore, the most important hydrological consideration in determining whether the Yucca Mountain site is suitable for the emplacement of heat-producing, high-level nuclear waste is how heat moves fluid that is already present at Yucca Mountain; the impact of water that has yet to infiltrate is of secondary importance for high AMLs and is, at best, of equal importance for low AMLs.

Because of the dominance of repository-heat-driven hydrothermal flow, pre-emplacement unsaturated zone groundwater travel time (GWTT) is not a suitability discriminator of the hydrological performance of an extended dry repository. Moreover, conditions that are conducive to deep nonequilibrium fracture flow in the UZ also benefit rapid shedding of condensate away from the boiling zone, thereby promoting effective rock dry-out. Therefore, fast groundwater travel times in the UZ would be indicative of a site that is well suited for an extended-dry repository concept. On the other hand, it is possible (although unlikely) that

fractures in the UZ are either too sparse or too poorly connected to promote either deep fracture flow (from meteoric sources) or large-scale dry-out. The absence of large-scale dry-out is not indicative of unsuitable conditions because the same conditions also prevent deep fracture flow from meteoric sources. Therefore, for an extended-dry repository concept, the site could be suitable with either fast or slow groundwater travel time in the UZ.

The licensing of a sub-boiling or marginal-boiling repository will be critically dependent on characterizing the highly heterogeneous distribution of fracture and matrix properties as well as the highly spatially and temporally variable distribution of net recharge flux. Licensing will also depend on validity of hydrological models which account for:

1) these very complex, variable distributions,
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The validation of the performance of the extended-dry concept is greatly facilitated by considering three fundamental hypothesis tests:

1) whether heat conduction dominates heat flow,
2) whether fracture density and connectivity are sufficient to promote rock dry-out due to boiling, and
3) whether the re-wetting of the dry-out zone significantly lags behind the end of the boiling period.

In addressing these hypotheses, it must be asked whether hydrothermal-geochemical-geomechanical coupling effects can be conservatively accounted for by bounding analyses. The use of these hypothesis tests can greatly focus the critical characterization, modeling, laboratory and in situ testing activities required in building robust licensing arguments. The validation of these hypotheses will profoundly reduce the impact of hydrogeologic uncertainty and variability on the predictability of total system performance.

The most conclusive means of testing these hypotheses involves large-scale in situ heater tests at various hydrostratigraphic intervals of the UZ. In situ heater tests will also be extremely useful in determining whether temperature rise, condensate

flow, and buoyancy-driven SZ flow can drive geochemical changes that significantly alter properties within the engineered and natural barrier systems. Critical performance issues involving hydrothermal-geochemical-geomechanical coupling cannot be entirely resolved either in the laboratory or through modeling. Moreover, critical hydrological performance issues cannot be entirely resolved by ambient property measurements conducted during site characterization. Therefore, in situ heater tests at various hydrostratigraphic intervals (above as well as below the repository horizon) will be critical to addressing such issues.

Work continued on the hydrothermal calculations of large-scale in situ heater tests with a focus on analyzing the feasibility of using small thermal probes (approximately 20 W) for determining the thermal conductivity and diffusivity of the rock in the vicinity of the heaters. This work is being done in collaboration with Professor G. Danko of the Mackay School of Mines at the University of Nevada, Reno. The ability of the thermal probes to detect the effects of heat conduction and convection for a range of conditions is being tested. These include ambient conditions prior to heating, conditions during the transition from sub-boiling to boiling, conditions during boiling with gravity-driven refluxing effects, and above-boiling conditions (the dry-out zone). The preliminary results show that the thermal probe can very accurately determine the in situ thermal properties of the rock. This in situ measurement technique will be extremely useful in validating the applicability of laboratory-based measurements for determining the in situ thermal properties in the UZ and SZ. It is planned that the LLNL Large Block Test thermal probes will be tested.

Laboratory Experiments

Work continued to measure electrical resistivity as a function of moisture content of Topopah Spring tuff samples from U3hg-1 and GU-3 holes at room temperature. Four samples with different thicknesses were prepared from each rock type for the measurements. The purpose of the measurement is to generate calibration curves of electrical resistivity of Topopah Spring tuff samples with respect to moisture content so that laboratory and field determined resistivity can be interpreted in terms of degree of water saturation. A gold electrode was deposited on the flat surfaces of cylindrical disc samples and two-electrode electrical resistance measurements were done on each of the four samples. The measurements in the drying phase have been started.

Work continued on the investigation of the different imbibition rates of water into a rock sample when the sample is either in a vapor environment or in liquid water. To understand the mechanism of the imbibition, capillary tubes of various inside diameters (ID) were put in a constant humidity chamber which will be set at various levels of humidity. The imbibition rate of water into each capillary tube will be determined. The smallest ID of the capillary tubes so far obtained was about 100 microns, and these tubes were too large for the tubes to retain any moisture when they were put in a 95 - 98% relative humidity environment.

Meetings

The following papers were presented in the AGU Fall meeting in San Francisco, December 8-11, 1992.

1) "Electrical Resistivity of Topopah Spring Tuff as a Function of Water Saturation", by J. Roberts and W. Lin, and

2) "Suction Potential, Imbibition, and Relative Permeability of Topopah Spring Tuff", by W. Lin, J. Nitao, and J. Roberts.

The paper by D. Wilder entitled "Alternative Strategies - A Means for Saving Money and Time on Yucca Mountain" was submitted to YMPO for approval. The paper will be presented at the International High Level Radioactive Waste Management Conference in Las Vegas, April 26-30, 1993.

1.2.2.2.3 Mechanical Attributes of the Waste Package Environment

Study Plan 8.3.4.2.4.3, Geomechanics of the Near Field Environment, was transmitted to the Regulatory Integration Branch, OSC, HQ and to the NRC. Minor corrections and other associated documentation including discussion of Open Item 17 from the NRC SCA were also prepared and forwarded.

S. Blair attended the AGU meeting in San Francisco December 7-11, 1992.

1.2.2.2.4 Engineered Barrier System (EBS) Field Tests

The first draft of the Study Plan for the Engineered Barrier System Field Tests is in internal review.

W. Lin attended the AGU meeting in San Francisco December 8-11, 1992.

Large Block Test (LBT)

The first draft of the scientific investigation plan for the Large Block Test is 50% complete. W. Lin and J. Blink met with Sandia National Laboratories personnel on December 1, 1992 at the Fran Ridge and Busted Butte sites to investigate the cutting of blocks. W. Lin has completed preliminary QA grading for the Large Block Tests.

W. Lin, D. Wilder and J. Blink (LLNL) met in Las Vegas on December 8 with LANL, M&O, and YMPO staff to discuss ESF heater test schedules and test layout.

1.2.2.2.5 Characterization of the Effects of Man-Made Materials on Chemical & Mineralogical Changes in the Post-Emplacement Environment

Staff supplied the final version of a white paper by A. Meike entitled "Chemical and Mineralogical Concerns for the Use of Man-Made Materials in the Post-Emplacement Environment" to R. Fish and D. Stahl (M&O). This paper discusses concerns for materials introduced into the ESF.

1.2.2.3 Waste Form and Materials Testing

1.2.2.3.1 Waste Form

1.2.2.3.1.1 Waste Form Testing - Spent Fuel

Spent Fuel Dissolution

During the process of fabricating additional stainless steel cells and associated system components at LLNL, a simple gravity-feed flow-through system was successfully tested. It was noted that previous lines had dripped effluent even when the pumps were turned off. The same effect was discovered by colleagues who had used similar systems for glass dissolution studies. By removing the pump and relying only on the inside diameter of the outlet tubing and the "head" between the buffer solution and the sampling outlet, the buffer flow-rate through the cell was controlled to a range similar to the pump system. This "pumpless" system was also verified on the operating oxygen-sensor test bed. Eliminating the pumps has several advantages. Pumps are expensive and subject to leaks and power outages. More lines can be run simultaneously because the number, space and gas environment of the peristaltic pumps are no longer factors. Additional room temperature, reduced oxygen runs using gravity-feed stainless steel setups have begun.

The approved test matrix for flow-through testing with spent fuel specimens at PNL consists of twenty separate tests with a total of seventeen different test conditions. Eighteen of the tests have been completed. Preliminary results have also been obtained for the remaining two test conditions, but these tests are being repeated because the results are inconsistent with the others.

The effects of air oxidation on spent fuel dissolution rates have been measured and reported for one flow-through test condition using ATM-105 fuel (BWR fuel with burnup ~31 MWd/kgM and fission gas release ~0.6%). To supplement this work, preparations are being made to perform flow-through tests with ATM-106 fuel (PWR fuel with burnup ~48 MWd/kgM and fission gas release ~18%) in both oxidized (O/M ~2.4) and unoxidized forms. Portions of both oxidized and unoxidized fuel have been delivered to the PNL Bldg. 325 hot cells where test specimen preparation will begin in early January 1993.

Equipment that will allow the BET surface areas of spent fuel test specimens to be measured is being installed in the PNL Bldg. 355 hot cells. Installation will be completed and BET measurements of specimens with known surface areas will begin in early January 1993.

Spent Fuel Oxidation

Dry Bath Testing

An interim examination of the drybath samples was conducted at PNL. No unusual results were measured. The lifting bale on one crucible of fuel in Bath 4, operating at 130°C, broke. The bale was removed and weighed. Since the sample was one of six duplicates, it will be left in the dry bath until the tests are completed, then

reweighed. Routine maintenance is being done on the system. This is requiring more times each year as the system components age. The system was originally designed to operate for about two years, but has been extended to operate for seven years.

1.2.2.3.1.2 Waste Form Testing - Glass

R. Stout visit ANL on December 4 to review progress of ongoing activities.

D-20-27 Unsaturated Testing of WVDP and DWPF Glass

The N2 tests (SRL actinide-doped glass) continue with no sampling period occurring this month. These tests have been in progress for 352 weeks. The N3 tests (ATM-10, a West Valley actinide-doped glass) continue and have been in progress for 270 weeks.

1.2.2.3.2 Metal Barriers

The paper by G. Henshall entitled "Modeling Pitting Corrosion Damage of High-Level Radioactive-Waste Containers, with Emphasis on the Stochastic Approach" was approved by YMPO and will be published in January as an LLNL informal report.

1.2.2.3.3 Other Materials

This WBS element has not been funded in FY93.

1.2.2.3.4 Integrated Testing

1.2.2.3.4.1 Integrated Radionuclide Release: Tests and Models

Determination of Elemental Profiles in Rocks, Minerals, and Glasses using the Ion Microscope

Single crystals of clinoptilolite that were contacted with 1 N Na, Ca were mounted in stainless steel rings using epoxy in preparation for secondary ion mass spectroscopy (SIMS) analysis.

Work continued on autoradiography technique development.

Preliminary samples were selected and a preliminary experimental protocol for elevated temperature cation exchange measurements on clinoptilolite was developed.

Interactions of Actinide-bearing Solutions with Rock Core Samples

An isoparaffinic solvent (ISOPAR-H) was found to be compatible with materials in the flow-through apparatus and will be used for applying confining pressure to the core.

The saw-cut fracture was found to provide too much resistance to flow. The core was removed from the jacket and gold spacers (1 mil) were placed between the core halves. Initial tests suggest that flow rates were adequate at the differential pressures expected to be used in the experiment.

The deionized (Milli-Q) water used for making input solutions for the flow tests was examined using Transmission Electron Microscopy (TEM). It was found that small (<0.2 μm) particles of silica were present in the unfiltered water. All water used in the initial flow tests was filtered through 0.015 μm membrane filters to prevent introduction of colloidal silica.

1.2.2.3.4.2 Thermodynamic Data Determination

No significant activities.

1.2.2.3.5 Nonmetallic Barrier Concepts

This WBS element has not been funded in FY93.

1.2.2.4 Design, Fabrication, and Prototype Testing

1.2.2.4.3 Container/Waste Package Interface Analysis

This WBS element has not been funded in FY93.

1.2.3 SITE INVESTIGATIONS

1.2.3.1 Site Investigations Coordination and Planning

This WBS element has not been funded in FY93.

1.2.3.2 Geology

1.2.3.2.1.2.1 Natural Analogue of Hydrothermal Systems in Tuff

This WBS element has not been funded in FY93.

1.2.3.4 Geochemistry

1.2.3.4.2 Geochemical Modeling

The final two geochemical code user manuals entitled "EQPT, A Data File Preprocessor for the EQ3/6 Software Package, User's Guide and Related Documentation, Version 7.0, Part II" and "EQ6, A Computer Program for Reaction Path Modeling of Aqueous Geochemical Systems: Theoretical Manual, User's Guide and Related Documentation, Version 7.0, Part IV" by T. Wolery, and S. Daveler were approved by YMPO and will be published in January.

The draft Software Requirements Specification (SRS) for Version 8 of EQ3/6 was revised in response to informal review comments and submitted to the Task Leader

for formal review and approval. Work continued to revise the corresponding draft Software Design Documentation (SDD). More detail is being added.

A 486 PC was received and installed this month. This will be used as a second host platform for EQ3/6 (the first is a Sun SPARCstation). A Lahey F77L EM/32 Fortran compiler was ordered this month for use on the 486. It is expected to provide significantly improved error detection than the compiler on the SPARCstation.

T. Wolery met with I. Puigdomenech of the NEA Data Bank on December 7 to discuss the state of EQ3/6 development.

1.2.3.10 Altered Zone Characterization

Funding is expected for this WBS element after FY92 underrun funds are redistributed.

1.2.5 REGULATORY

1.2.5.1 Regulatory Coordination and Planning

This WBS element has not been funded in FY93.

1.2.5.2 Licensing

1.2.5.2.2 Site Characterization Program

The author's response to review comments of the following Study Plans have been reviewed and accepted by LLNL reviewers:

1) Study Plan 8.3.1.15.1.8, "In Situ Design Verification",
2) Study Plan 8.3.1.3.6.2, "Diffusion", and
3) Study Plan 8.3.1.12.2.1, "Meteorological Data Collection at the Yucca Mountain Site".

1.2.5.3 Technical Data Management

1.2.5.3.4 Geologic and Engineering Materials Bibliography of Chemical Species (GEMBOCHS)

The transfer of the GEMBOCHS database and software library from the local Sun 3/260 server (node s33 of the local Sun network) to a new, dedicated Sun SPARCstation2 (node s60) was completed. INGRES/Windows 4GL was installed on node s60. This package represents the gateway to future development of mouse-driven GEMBOCHS software.

DBAPP was monitored such that anyone having a log-in account on the local Sun network can now run this code and review GEMBOCHS data from their own account. Addition, deletion, or modification of these data remains password-restricted to GEMBOCHS staff members.

CNGBOCHS and the associated CNGREQ database were restructured such that each research group (GEMBOCHS, EQ3/6, etc.) using this automated change-request system now maintains its own independent set of change requests and associated data.

J. Johnson attended the quarterly meeting of the YMP-TDB Administrators Working Group in Las Vegas on December 2.

1.2.5.3.5 Technical Data Base Input

No significant activities.

1.2.5.4 Performance Assessment

1.2.5.4.2 Waste Package Performance Assessment

Waste Package Subsystem Model software requirements analysis is continuing using the prototype code PANDORA 1.1. Revisions to the PANDORA code and users manual in response to reviewer comments are in progress. L. Lewis modified computational procedures in the prototype code to allow longer analysis time spans (>10,000 years) for application to higher areal-power density repository design scenarios.

W. Halsey attended the NRC Working Group on Performance Assessment and the NRC/DOE Technical Exchange on Performance Assessment held in Washington, D.C., December 14-15.

W. Halsey provided input to the M&O for the paper entitled "Performance Assessment/Regulatory Compliance, Cost Evaluation Study".

1.2.9 PROJECT MANAGEMENT

1.2.9.1 Management and Coordination

1.2.9.1.2 Technical Project Office Management

W. Clarke and J. Blink attended the TPO meeting in Las Vegas on December 11.

W. Clarke and J. Blink met with R. Levich and T. Ricketts in Las Vegas on December 2 to discuss the International program.

W. Clarke and J. Blink met with W. Simecka, N. Elkins, H. Kalia, and H. Benton in Las Vegas on December 2 for the ESF layout discussions. W. Clarke and J. Blink also met with D. Stahl, H. Benton, R. Fish and T. Doering of the M&O to discuss materials and design issues.

J. Blink attended the Quality Integration Group meeting in Las Vegas on December 9 and the Early Decision Committee meeting on December 10.

1.2.9.2.2 Participant Project Control

The November FTE report was submitted to YMPO, and the November actual schedule progress and costs were submitted via PACS workstation. The Cost Plan was updated to include November actuals. Adjustments were made for FY92 carryover funds.

The revision of the LLNL account structure was completed to match and support the FY93 PACS database. The PACS database was revised to reflect new activities in altered zone, hydrology and man-made materials. The new work is funded by FY92 carryover allocations. Several workscopes were adjusted to incorporate descriptions and dates for third level milestones. Also, several existing accounts were combined into fewer summary accounts for the FY93 PACS baseline.

A request was submitted to YMPO to convert FY93 operating funds to capital funds to purchase equipment identified in the FY93 PACS planning cycle. The total amount of the conversion request is $547.8k. Work is in process to prepare the capital acquisition plan for four computer systems which exceed 15k. While these systems were identified in the PACS planning base, LLNL did not submit the acquisition plans to support the Information Resource Management (IRM) requirements.

A new Contractor Work Breakdown Structure (CWBS) was submitted to YMPO. The document supports LLNL's Mission 2001 plan.

J. Podobnik attended a Project Control Steering Committee (PCSC) meeting in Las Vegas. Two participants (including LLNL) presented October performance measurement data. Committee members decided to curtail future presentations since there are several issues that are more relevant to the Committee's charter that require near-term attention. In addition, several problems were discussed that concern perceived deficiencies in the project's control system. The PCSC decided to dedicate the next meeting to address concerns and develop a workplan for resolution.

A response was initiated to an extensive GAO questionnaire that addresses the entire Nuclear Waste Fund for the past four years. The response will be completed by January 5.

1.2.11 QUALITY ASSURANCE

1.2.11.1 Quality Assurance Coordination and Planning

No significant activities.

1.2.11.2 Quality Assurance Program Development

Work continued on the activities to implement the new QARD and complete LLNL-YMP implementing documents.

Change Notice 6.0-3-1 (Document Control) and QP 18.0 Revision 4 (Audits) were completed and distributed.

1.2.11.3 Quality Assurance Verification

1.2.11.3.1 Quality Assurance Verification - Audits

CAR-LLNL-023 was completed, verified, and transmitted to YMPO.

A due date extension was requested from YMPO for CARs YM-92-064 and YM-92-065 resulting from Audit YMP-92-21.

1.2.11.3.2 Quality Assurance Verification - Surveillance

Surveillance S93-02 (Instrument Calibration Program) was completed and issued.

Surveillance S93-03 (Document Control and Records) was performed.

CARs-LLNL-008 and -018 were completed, verified, and transmitted to YMPO.

CARs YM-092-066, -067, and -068 were closed and verified by YMPO.

LLNL's response to CAR YM-93-017 resulting from YMQAD Surveillance YMP-SR-92-028 was transmitted to YMPO.

A response was made to OCRWM's request for information regarding distribution of YMP controlled procedures at LLNL.

1.2.11.4 Field Quality Assurance/Quality Control

This WBS element has not been funded in FY93.

1.2.11.5 Quality Assurance - Quality Engineering

Support was continued for the Waste Form Characterization area.

1.2.12 INFORMATION MANAGEMENT

1.2.12.2 Records Management

1.2.12.2.2 Local Records Center Operation (LRC)

Document Control issued three new revision under controlled distribution. Routine follow-up for receipt acknowledgments continues.

1.2.12.2.3 Participant Records Management

A total of 179 items were logged into the LLNL-YMP tracking system. This includes 18 records/records packages that were processed through to the CRF. Seven action items were closed.

Work continues on cross-referencing 1991 records from database to microfilm. This activity is anticipated to be complete by mid-February.

1.2.12.2.5 Document Control

LLNL received no funding under this WBS. Work performed to complete LLNL's obligation in this WBS is funded under WBS 1.2.12.2.2.

1.2.13 ENVIRONMENT, SAFETY AND HEALTH

1.2.13.1 Environment, Safety and Health Coordination and Planning

No significant activities.

1.2.15 SUPPORT SERVICES

1.2.15.2 Administrative Support

No significant activities.

1.2.15.3 Yucca Mountain Site Characterization Project (YMP) Support for the Training Mission

Eleven different self-study assignments were issued, and eleven people were trained to these assignments. Currently, there are 68 participants on the project whose training is tracked.

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JAN 22 3 23 PM '00

WBS 1.2.9.1
QA N/A

DIST: Gertz
CC: Blanchard
CC: Dixon
CC: Clarke
CC: Simecka
CC: Dyer
CC: Brodsky
CC: Jones, S
CC:

REC'D IN YMP 1/22/93

January 14, 1993

TWS-EES-13-01-93-027

Mr. Carl P. Gertz, Project Manager
Yucca Mountain Site Characterization Project Office
US Department of Energy
P.O. Box 98608
Las Vegas, NV 89193-8608

Dear Mr. Gertz:

SUBJECT: HIGHLIGHTS OF THE LOS ALAMOS MONTHLY ACTIVITY REPORT—DECEMBER 1992

Attached are the highlights of the Los Alamos Monthly Activity Report for December 1992. This internal document describes our technical work; however, the report has not received formal technical or policy review by Los Alamos or the Yucca Mountain Site Characterization Project. Data presented in this document represent work progress, are not referenceable, and are not intended for release from the US Department of Energy. If you have changes to our distribution list, please call Susan Klein at (505) 667-0916.

Sincerely,

Julie A. Canepa

Julie A. Canepa

SHK/elm

Attachment: a/s

Cy w/att:
M. B. Blanchard, YMPO, Las Vegas, NV
W. L. Clarke, LLNL, Livermore, CA
W. R. Dixon, YMPO, Las Vegas, NV
J. R. Dyer, YMPO, Las Vegas, NV
N. Z. Elkins, EES-13/LV, MS J900/527
L. D. Foust, CRWMS, M&O/TRW, Las Vegas, NV
L. R. Hayes, USGS, Denver, CO
V. F. Iorii, YMPO, Las Vegas, NV
S. H. Klein, EES-13, MS J521
M. Martin, M&O/TRW, Las Vegas, NV
A. R. Pratt, EES-13, MS J521
L. Shephard, SNL, Albuquerque, NM
W. Simecka, YMPO, Las Vegas, NV
M. Voegele, SAIC, Las Vegas, NV
RPC File (2), MS M321
TWS-EES-13-File, MS J521

Cy w/o att.:
CRM-4, MS A150

ENCLOSURE 2

December 1992
Highlights from Los Alamos

WBS 1.2.3.1

Five papers were presented at scientific conferences this month. Four papers were presented at the Symposium on the Scientific Basis for Nuclear Waste Management XVI at the Materials Research Society Fall Meeting, 30 November–4 December.

> S. Levy, "Surface-discharging hydrothermal systems at Yucca Mountain -- examining the evidence." (WBS 1.2.3.2.1.1.2)
>
> D. E. Morris, C.D. Tait, S. A. Ekberg, and P. D. Palmer, "Speciation of Plutonium in Carbonate Media." (WBS 1.2.3.4.1.3)
>
> P. S. Z. Rogers, A. M. Meijer, and K. H. Kung, "Sorption Characteristics of Yucca Mountain Tuffs as a Function of Particle Size." (WBS 1.2.3.4.1.2.3)
>
> I. R. Triay, M. A. Ott, A. J. Mitchell, and C. M. Overly, "Transport of Neptunium through Yucca Mountain Tuffs." (WBS 1.2.3.4.1.4)

One paper was presented at the fall meeting of the American Geophysical Union, 7-11 December.

> J. Poths, "Surface Exposure Ages and Noble Gas Components of Volcanic Units at the Lathrop Wells, Nevada Volcanic Center." (WBS 1.2.3.2.3.1A)

WBS 1.2.3.2.1.1.1 (Mineralogy/Petrology)

The study plan for Mineralogy, Petrology, and Chemistry of Transport Pathways is being revised to address changes in ESF design, in procedures for this task, and in requirements for study plans. Minor modifications were also made to reflect NRC and auditor comments.

To determine the nature and extent of intergrowth with other minerals, calcite fragments were studied using scanning electron microscopy and x-ray diffraction. Results of these studies were incorporated in a paper entitled "Calcite Deposits in Fractures at Yucca Mountain, Nevada," which will be presented at the 1993 International High Level Radioactive Waste Management Conference (Las Vegas, April 26-30, 1993). This paper summarizes petrographic, major-element, and trace-element

studies on fracture calcites in both unsaturated and saturated portions of drill cores USW G-1, USW G-2, USW GU-3/G-3, and USW G-4.

WBS 1.2.3.2.3.1.(Volcanism)

We received a memorandum from the U. S. Geological Survey, which documented the formal naming of the Lathrop Wells volcanic center in 1987; therefore, we will not change the name to the Cind-R-Lite center, as previously reported.

We received isotopic data from the University of Colorado on Sr, Nd, and Pb for basalt samples from Black Cone, Hidden Cone, and Little Black Peak Cone volcanic centers and interpret them as follows: Isotopic and trace element data for three eruptive units of the Little Black Peak Cone show no significant variations and are consistent with previous interpretations, which state that this center is monogenetic (formed in a single eruptive cycle). Isotopic data for Hidden Cone show little variability, but there are large variations in the concentrations of Sr, Sm, and Nd. Isotopic and trace element data from the northern and southern flows at Black Cone are consistent with previously reported INAA data. Since Sr and Nd isotopic ratios are lower for the southern flow compared with the northern flow, and concentrations of Sr, Nd, and Sm are slightly higher for the south flow, this new data support the interpretation that the northern and southern flow were derived from separate magma batches.

WBS 1.2.3.3.1.2.2 (Water Movement)

The revised study plan for the Water Movement Test was returned to the YMPO for verification of comment resolution. A comment resolution meeting is scheduled for January.

Sample processing began for nine additional cuttings samples from USW UZ-N-54 and N-55. They will be submitted to Lawrence Livermore National Laboratory for chlorine-36 analysis in January. Collection of cutting samples for ^{36}Cl analysis from UZ16 continued this month. Collection from USW UZ-N61, one of the Phase 2 neutron boreholes, also began this month.

WBS 1.2.3.3.1.3.1 (C-Well Reactive Tracer Test)

A paper on flow and transport through fractures prepared for the1993 International High-Level Radioactive Waste Management Conference was completed. The authors used surface-profile data taken with a noncontact laser profilometer to determine the aperture distribution within a natural fracture and found the surfaces and apertures to be isotropic. They also found that the aperture spatial correlation varied over different areas of the fracture, with some areas being much more correlated than others. The fracture surfaces did not have a single fractal dimension over all length scales, which implied that they were not self-similar. Resolution aperture data (0.5- and 0.05-mm spacing

between points, respectively) over the same subset of the fracture domain suggests that the spacing between the aperture data points must be less than the correlation length to obtain accurate predictions of fluid flow and tracer transport.

WBS 1.2.3.4.1.2.1 (Sorption)

Staff developed a plan to study the effects of organic coatings on radionuclide sorption; K. Kung, a clay organic chemist, is leading this research. Our objective is to determine the interfacial geochemical reactions that dominate the transport of radionuclides when organic materials are sorbed onto mineral surfaces. As a result of this work, we will also generate new data to improve the current sorption models used to predict mobility of radionuclides in the presence of organics.

WBS 1.2.3.4.1.2.3 (Sorption Models)

A paper for presentation at the International High-Level Radioactive Waste Management conference was completed. It presented results of experiments to determine the dependence of sorption on sample grinding and on pre-conditioning with water of various compositions. The major conclusions were (1) Sorption Rd's for representative Yucca Mountain tuffs, determined from batch measurements, do not depend on sample grinding for size fractions larger than about 65 μm. Thus previous batch measurements, which used predominantly 63-500 μm or 75-500 μm size ranges for the crushed samples, should not contain (non-conservative) errors due to sample grinding. (2) Water composition influenced the sorption behavior of the studied radionuclides, Sr, Cs, and Np; in particular, Np sorption onto zeolitized tuff decreased by over a factor of three when the tuff was pretreated with J-13 water containing added Ca and Mg.

Although optical-microscopy examination of a natural surface (not freshly cleaved) revealed a number of pits in the surface, atomic-force microscopy of the same sample (conducted in air) showed a uniformly smooth surface. We believe that the explanation for this is that the natural surface was covered by a thin layer of another mineral that filled the pits and led to the detection of a smooth surface, and the mineral, which we think may be calcite, then dissolved in water to expose the pitted surface. Our results emphasize that natural surfaces of the minerals in Yucca Mountain tuffs may be coated with other materials, which may have very different sorptive properties. We believe it is important to develop ways to identify these surface coatings.

WBS 1.2.3.4.1.3 (Speciation)

We have been able to determine the oxidation state of 250 nM Pu solutions at pH 8.5–9, as a function of bicarbonate concentration. As reported previously, three regions of Pu speciation have been characterized by their optical signatures. A Pu(IV) species has been associated with high [$NaHCO_3$]; however, the Pu oxidation state of the other two species has not yet been directly established. We

used the PAS method to test the presence of the two other species, and this control experiment showed that we can indeed observe the oxidation state for an unknown solution.

WBS 1.2.3.4.1.4.1 (Dynamic Transport)

Staff continued investigating Np transport through Yucca Mountain tuffs and compared the results of batch sorption experiments with those obtained using crushed-tuff columns. Using a one-dimensional transport model within the code SORBEQ, the Np elutions through three crushed-tuff columns were fitted. The transport model incorporated advection, dispersion, and equilibrium sorption in a porous medium.

Last month, we reported that the batch sorption coefficient (K_d) for Np in tuff G4-1530 using J-13 water was 2.4 ml/g. There is a good agreement between this result and the K_d we obtained this month by modeling (fitting the Np elution data). Consequently, we found no differences between Np retardation determined under flowing conditions and Np sorption determined via batch techniques.

WBS 1.2.5 (Site Characterization Program)

Worked continued on the topical report on volcanism. The section on tectonic setting of basaltic volcanism in the Yucca Mountain region was completed, and final editing of the section on geochemistry and models for the derivation of the basalt units of the Yucca Mountain region was begun. Work also continued on the erosion and calcite/silica topical reports.

WBS 1.2.6 (ESF and IDS)

Staff continued to gather information on the use of tracers, fluids, and materials (TFM) used at the Yucca Mountain with emphasis on FY 1993 ESF-related activities. Waste isolation impact and test interference analysis for the TFMs were requested from CRWMS M&O. We transmitted a paper on the Integrated Data System for ESF to the Second International Symposium on Mine Mechanization and Automation in Sweden. We also prepared papers on TFM and on ESF test prioritization and coordination, which will be presented at the 1993 High-Level Radioactive Waste Management Conference.

WBS 1.2.11.2/.3/.5 (Quality Assurance)

Procedures QP-03.5, R1 (Documenting Scientific Investigations) and QP-06.1, R5 (Document Control) were issued. Detailed technical procedures LANL-INC-DP-94, R0 (Using Ion Chromatography to Determine Chloride and Bromide Concentrations) and LANL-EES-DP-119, R2 (Moisture Evolution Analyzer Procedure) were also issued. Audit plans LANL-AR-92-13 (EES-4 and EES-15), LANL-AR-92-08 (INC Division), and LANL-AR-92-17 (EES-13 software) were approved, and the audits were conducted. Internal stop work order SWO-LA-06 was lifted.