UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

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TO: Charlotte Abrams, HLPD, DHLWM, M/S 4-H-3

FROM: Sr. On-Site Licensing Representatives Office, Las Vegas

DATE: SEPTEMBER 24 1993

SUBJECT: LAWRENCE LIVERMORE NATIONAL LABORATORY, Yucca Mountain Project Status Report - August 1993

Please find enclosed the above-referenced report.

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Lawrence Livermore National Laboratory

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September 14, 1993

WBS 1.2.9
QA: N/A"

Carl Gertz, Project Manager
Department of Energy
Yucca Mountain Project Office
P.O. Box 98518
Las Vegas, Nevada 89193-8518

SUBJECT: Yucca Mountain Project Status Report - August 1993
SCP: N/A

Attached is the August Project Status Report for LLNL's participation in the Yucca Mountain Project.

If further information is required, please contact Elizabeth Campbell of my staff at 510-422-7854 or Jim Blink in Las Vegas at 702-794-7157.

Sincerely,

W. L. Clarke
LLNL Technical Project Officer
for YMP

WC/EC

cc:
Distribution

DISCLAIMER

The LLNL Yucca Mountain Project cautions that any information is preliminary and subject to change as further analyses are performed or as an enlarged and perhaps more representative data base is accumulated. These data and interpretations should be used accordingly.

LAWRENCE LIVERMORE NATIONAL LABORATORY YUCCA MOUNTAIN PROJECT
AUGUST 1993 TECHNICAL HIGHLIGHTS AND STATUS REPORT
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LAWRENCE LIVERMORE NATIONAL LABORATORY
(LLNL)
YUCCA MOUNTAIN PROJECT (YMP) STATUS REPORT

AUGUST 1993

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

1) **WBS 1.2.2.2.4 (Engineered Barrier System (EBS) Field Tests).** [Large Block Test (LBT)] T. Buscheck continued the pre-test modeling and analysis of the Large-Block Test (LBT). The parameter sensitivity study of bulk permeability, k_b, showed that for k_b values of 1, 10, and 280 millidarcy, the vertical extent of the dry-out zone is almost identical, and the effect of buoyant, gas-phase convection is negligible (i.e., does not cause the dry-out zone to deviate from being vertically-symmetrical about the heater horizon). For k_b values of 10 and 100 microdarcy, dry-out due to boiling is effectively throttled, thereby reducing the volume of the dry-out zone relative to the cases where $k_b > 1$ millidarcy.

2) **WBS 1.2.5.4.2 (Waste Package Performance Assessment).** In support of TSPA-2, and at the request of the M&O, the liquid-phase velocity field at various times and the liquid-phase velocity history at various points from the repository horizon down to the water table have been provided based on the repository-UZ-SZ-scale hydrothermal calculations using V-TOUGH. These results can be used to calculate radionuclide transport in the unsaturated zone on the basis of averaged liquid-phase fluxes. Because of the spatial variability of liquid-phase flux, basing transport calculations on average fluxes may not accurately reflect the flow field calculated by V-TOUGH. In order to more accurately reflect the V-TOUGH-calculated flow field, it is preferred to track packets of particles released from waste package locations, as they are driven by the flow field in the underlying natural barrier system. A family of "particle tracking" post-processors for V-TOUGH calculates the x-y location versus time for each of the particles; the pressure, temperature, and saturation history for each of the particles; and a video animation of the moving particles. Colors can be used to "tag" when or where the particles were released, or can be used to indicate the value of either pressure, temperature, or saturation of the moving particles. These post-processors can be the basis for conducting radionuclide transport calculations where retardation may be treated as a function of pressure, temperature, and saturation; and to visualize the spatial and time dependence of transport, as well as the relationship between transport and temperature and saturation.

3) **WBS 1.2.5.4.2 (Waste Package Performance Assessment).** Repository-UZ-SZ-scale calculations have generally assumed homogeneous and isotropic fracture permeability. Even for k_b as large as 84 darcy, these calculations have not shown heat pipes resulting in two-phase boiling conditions persisting at the repository horizon for an APD of 114 kW/acre (154.7 MTU/acre). Recent analytical work of J. Nitao and R. Bradford indicates that two-phase conditions can persist in locations of the repository horizon where sufficient focusing of condensate drainage occurs. For an APD of 114 kW/acre with focusing of condensate drainage two to three orders of magnitude greater than the mean condensate drainage flux, two-phase heat-pipe conditions could persist.

4) **WBS 1.2.2.2.3 (Mechanical Attributes of the Waste Package Environment).** A set of approximately 100 images of the microstructure of Topopah Spring tuff were produced at a variety of magnifications in the range x50 to x1000. The images are of samples taken from holes USW-GU-3 and USW-G-4. The purpose of this imaging of the microstructure is to gain quantitative information on the pore structure of the rock. The images were digitized and stored on computer disks, and two point spatial correlation functions were computed for many of them. This function is a statistical way to measure the geometry of the pore space and provides the basis for estimating several parameters of interest such as local distribution of specific surface area and local estimates of pore size and connectivity. In addition, standard morphological measurements were made on several of the images.

5) **WBS 1.2.2.2.5 (Characterization of the Effects of Man-Made Materials on Chemical & Mineralogical Changes in the Post-Emplacement Environment).** One area of mutual interest for the geothermal power companies in New Zealand and the YMP Man-Made Materials Task that will be addressed immediately is cement biodegradation. The rare opportunity to acquire cement samples from a usually inaccessible area that has been exposed to elevated temperatures over a period of five years and is showing extensive signs of biodegradation will present itself in mid-October. A complete plant shut-down at this site, which only occurs once every two years for a period of two days, will take place at that time. During that window of opportunity, if foreign travel arrangements can be made in time, LLNL plans to collect samples for culture and identification, as well as future experimentation. Another site, which contains some of the oldest (up to 40 years) synthesized materials, will be shut down for a similar period of time in February. This shut-down will offer the opportunity to obtain other samples, primarily inorganic materials for analysis.

6) **WBS 1.2.2.3.2 (Metal Barriers).** The interlaboratory agreement (SANL) to ANL for continuation of the slow crack growth rate studies on Alloy 825 and other austenitic alloys was finalized. The studies involve application of a tensile load to pre-cracked compact tension specimens exposed to laboratory-simulated J-13 well water at 95°C. The studies measure crack propagation by the very small changes in electrical resistance manifested as the crack grows, and the technique is sensitive to crack rates less than 10^{-12} meters/second. The crack growth studies have been maintained since 1991. During that period, the crack propagation on Alloy 825 has been imperceptible.

7) **WBS 1.2.5.5.2 (Energy Policy Act Support).** R. Van Konynenburg presented an invited paper at the August 26-27 Las Vegas meeting of the National Academy of Sciences Committee on the Technical Basis for Yucca Mountain Standards. The presentation was entitled "Environmental Transport of Gaseous Releases of Radionuclides" and it focused primarily on carbon-14. The paper emphasized the small impact of repository carbon-14 on individual dose, both local and world-wide.

8) **WBS 1.2.2.3.1.1 (Waste Form Testing - Spent Fuel) Thermogravimetric Apparatus]** A fragment of BWR-105 fuel has run for over 300 hours at 283°C. An oxygen to metal (O/M) ratio of 2.647 has been reached. The sample rapidly gained weight to an O/M of 2.35. A true plateau was never reached since the sample

continuously gained weight, however, d(O/M)/dt decreased significantly after obtaining a 2.35 O/M. After 125 hours, the weight increased at a fairly steady rate. It now appears that the rate of weight gain is slowing down and possibly may be approaching a second "plateau". The test is continuing.

1.2.1 SYSTEMS ENGINEERING

1.2.1.1 Systems Engineering Coordination and Planning

No significant activities.

1.2.1.5 Special Studies

T. Buscheck continued to support the thermal loading systems study with the development of a new suite of repository-unsaturated zone-saturated zone (UZ-SZ)-scale models for repository areas of 570, 744, 1139, 1755, and 2598 acres. For 63,000 MTU of Spent Nuclear Fuel (SNF), these repository areas correspond to Areal Mass Loadings (AMLs) of 110.5, 83.4, 55.3, 35.9, and 24.4 MTU/acre. The models employ a relatively fine gridblock spacing at the outer perimeter of the repository in order to more accurately account for the effect of edge-cooling. A Youngest Fuel First SNF receipt scenario with a 10 year cut-off for the youngest fuel [referred to as YFF(10)] is being assumed. The calculations also account for (in yearly increments) the emplaced inventory of BWR Waste Packages (WPs) containing 40 assemblies and PWR WPs containing 21 assemblies. The waste receipt schedule was supplied by J. King (M&O).

In support of the thermal loading systems study, S. Daveler developed a pre-processor "PBHEAT" that calculates the heat generation tables for the V-TOUGH code. This pre-processor incorporates the GETHT6 subroutine developed by the M&O which calculates kW/MTU for a given fuel type (PWR or BWR), age, burnup, and enrichment. PBHEAT is capable of producing a blended heat generation curve (averaged over the entire repository area), based on the yearly increments of PWR and BWR WPs and the yearly averaged SNF ages, burnups, and enrichments for each of these increments. Rather than assuming that all of the heat generation instantaneously begins at t = 0 yr, the heat generation curve produced by PBHEAT accounts for the "ramping up" of the heat output that occurs over the emplacement period. PBHEAT can also be used to calculate the heat generation curve for specific increments of the emplaced WPs, thereby accounting for the spatial variability of heat generation within the repository. For 30-yr-old PWRs with a burnup of 33,000 GWd/MTU and an enrichment of 3.2%, PBHEAT produced nearly the identical heat generation curve produced by the PWR heat generation pre-processor "HEATCAL", which was developed several years ago by J. Nitao.

1.2.1.6 Configuration Management

Affected document notices (ADN's) were completed for CRs 93/405, 93/418, and 93/422. No LLNL controlled documents were affected.

1.2.2 WASTE PACKAGE

1.2.2.1 Waste Package Coordination and Planning

W. Lin attended the (SOC) Sample Overview Committee meeting at NTS on August 4.

J. Blink participated in the FY94 budget review video conference in Las Vegas on August 23.

B. Viani attended a Geochemistry Integration Task (GIT) meeting on August 24 to discuss the proposal by J. Hunt (UCB) to drill and sample vadose zone "shots" at the NTS as a means for assessing the potential for colloid transport in the unsaturated zone. Work continued on providing for the colloid strategy document.

1.2.2.2 Waste Package Environment

1.2.2.2.1 Chemical and Mineralogical Properties of the Waste Package Environment

Geochemical measurements are also reported in section 1.2.2.2.4 (Large Block Test).

The revised draft Study Plan 8.3.4.2.4.1, "Characterization of the Chemical and Mineralogical Changes in the Post-Emplacement Environment" was returned by the LLNL editor, with several editorial suggestions. The comments are being addressed. The study plan is scheduled to be sent to YMPO by the end of September.

Study of the New Zealand natural analog site continues. The site was visited by C. Bruton, A. Meike (LLNL) and Bob Levich (YMPO) to obtain information from the controlling organizations about data transfer protocols, and to negotiate agreements regarding collaborative research. Formal memoranda will be exchanged in September to establish methods for data transfer. (More information is contained under WBS 1.2.2.2.5.)

Further discussions took place in New Zealand about the first phase modeling activities. Samples collected in the previous month will be analyzed in September and used in initial modeling exercises.

Further EQ3/6 database refinement for the New Zealand simulations proceeded, with tests of the data obtained thus far. Activity diagrams were compared with previous studies to assure that consistency was maintained.

The development of three-dimensional representation techniques has been stalled because of procurement issues. Discussions are proceeding about how best to resolve these problems.

Installation of software for converting graphical displays to video images has been delayed until October due to other programmatic demands of a higher priority.

1.2.2.2.2 Hydrologic Properties of the Waste Package Environment

Model Calculations

Additional model calculations are reported in section 1.2.1.5 (System Studies), 1.2.2.2.4 (Large Block Test), and 1.2.5.4.2 (Waste Package Performance Assessment).

Repository-UZ-SZ-scale hydrothermal calculations have determined the sensitivity to a wide range in bulk permeability, k_b. For $k_b \geq = 280$ darcy (1 darcy ~$10^{-12}m^2$), a zone where the temperature profile is flattened at T_b (~96°C) is redirected. Steam is driven (by higher gas-phase pressures in the boiling zone) away from the repository to locations where cooler temperatures cause it to condense. Above the repository horizon, much of this condensate is driven back to the boiling zone, primarily by three processes:

1) capillary imbibition in the matrix,
2) capillary imbibition in small-aperture fractures, and
3) gravity drainage in fractures.

Gravity drainage in the matrix is not significant in comparison with matrix imbibition, which is driven by large capillary pressure gradients that arise from saturation gradients in the boiling and condensation zones. Below the repository horizon, only the first two mechanisms, capillary-driven flow in the matrix and fractures, contribute to condensate flow back toward the boiling zone, while the third mechanism, gravity drainage in fractures, tends to drain condensate away from the boiling zone. The return flow of condensate back toward the boiling zone establishes a heat transfer mechanism (driven by the convection of latent heat) called the gravity-driven "heat pipe" effect. Given adequately high mass flux rates of the counter-current flow of steam and condensate, heat pipes are capable of sustaining a given heat flux with a much shallower temperature gradient than is associated with heat conduction. Consequently, heat pipes are manifested by a flat temperature profile, with temperatures close to T_b.

Repository-UZ-SZ-scale calculations have generally assumed homogeneous and isotropic fracture permeability. Even for k_b as large as 84 darcy, these calculations have not shown heat pipes resulting in two-phase boiling conditions persisting at the repository horizon for an APD of 114 kW/acre (154.7 MTU/acre). Recent analytical work of J. Nitao and R. Bradford indicates that two-phase conditions can persist in locations of the repository horizon where sufficient focusing of condensate drainage occurs. For an APD of 114 kW/acre with focusing of condensate drainage two to three orders of magnitude greater than the mean condensate drainage flux, two-phase heat-pipe conditions could persist.

In order to investigate the impact of heterogeneity on the focusing of vapor flow and condensate drainage (and how that focusing affects the development of heat pipes), two models are being used; an X-Z cross-sectional drift-scale model and an X-Z cross-sectional model which smears the repository heat load over a 4.6 m thick interval that laterally spans the entire cross-section of the model. Both models are more applicable at the center of the repository prior to the time when edge-cooling affects thermal performance. The drift-scale model represents the actual dimensions and spacings of drift-emplaced WPs and the emplacement drifts (in the

plane orthogonal to the axis of the drifts). Because the drift-scale model smears the thermal load along the drift axis, end-to-end WP spacing is effectively neglected. A 1.6 m wide "fracture zone" is assumed to exist along the WP axis. The k_b of this zone is assumed to be several orders of magnitude larger than k_b throughout the rest of the model. The center-to-center spacing between the high-k_b fracture zones is 38.4 m (the same as the center-to-center drift spacing). The X-Z, smeared heat source model represents a series of uniformly-spaced 1.0 m wide "fracture zones" of high k_b. By the end of the month, parameter sensitivity studies where k_b in the fracture zone ranges from 10 to 84 darcy and k_b in the "nominally fractured" rock ranges from 10 microdarcy to 280 millidarcy had been initiated. Results of this heat pipe study will be reported in the September monthly report and at the FOCUS '93 conference in Las Vegas.

Laboratory Experiments

Work continued to measure electrical resistivity as a function of moisture content of Topopah Spring Tuff samples from the G-4 and GU-3 holes using J-13 water and distilled water as pore fluids. For the GU-3 samples, the wetting phase measurements at 40°C have been completed, and the drying phase measurements at 40°C were started. The preparation of samples machined parallel to the core axis were also started. For the G-4 samples, all measurements at room temperature were completed, and the measurement at 40°C was started. These measurements included wetting and drying cycles, using J-13 water and distilled water, on samples machined parallel and perpendicular to the axis of the original core section. Very little anisotropy in the measured electrical conductivity with respect to the core axis was found. The measurement of electrical conductivity as a function of frequency within the range of water saturation from 0 to 50% was completed for the G-4 sample. The data are being analyzed.

Work continued on the experiment to determine the moisture retention curve and one-dimensional imbibition using G-4 core The data from this experiment will be used for calculating relative permeability as a function of water saturation. The wetting phase of the moisture retention curve at 25°C was completed. The samples are in the drying phase. Data analysis of the one-dimensional imbibition experiment continues. Use of the four-electrode method on a rectangular sample is being evaluated.

The pore-water pressures are still in the process of reaching equilibrium in the intact Topopah Spring tuff sample from the G-4 hole which is being used to determine saturated water permeability.

Meetings and Publications

Responses were completed on the review comments for the paper by W. Lin entitled "Technical Basis and Programmatic Requirements for Laboratory Study of Hydrological Properties of the Near Field Environment" and were submitted to YMPO for final approval. This LLNL report documents the draft Study Plan 8.3.4.2.4.2 which has been submitted to YMPO for technical review.

1.2.2.2.3 Mechanical Attributes of the Waste Package Environment

A response to NRC comments on Study Plan 8.3.4.2.4.3 was prepared and forwarded to YMPO. This response included a description of proposed revisions to the Study Plan scheduled for FY95.

A set of approximately 100 images of the microstructure of Topopah Spring tuff were produced at a variety of magnifications in the range x50 to x1000. The images are of samples taken from holes USW-GU-3 and USW-G-4. The purpose of this imaging of the microstructure is to gain quantitative information on the pore structure of the rock. The images were digitized and stored on computer disks, and two point spatial correlation functions were computed for many of them. This function is a statistical way to measure the geometry of the pore space and provides the basis for estimating several parameters of interest such as local distribution of specific surface area and local estimates of pore size and connectivity. In addition, standard morphological measurements were made on several of the images.

Work continued on Activity Plans for both laboratory and numerical studies of the geomechanics of the near field environment.

1.2.2.2.4 Engineered Barrier System (EBS) Field Tests

Large Block Test (LBT)

Comment resolution for the Scientific Investigation Plan for the LBT has been completed and the plan is awaiting approval signatures by YMPO. The drafting of the Activity Plan was started. The preparation for laboratory tests on smaller blocks and quarrying the large block are continuing. SNL completed prototype cuttings using a 2 m belt saw. W. Lin inspected the prototype sawing and reviewed the performance of the 2 m saw with C. Brechtel (SNL) on August 30. It is confirmed that the saw performs well in making vertical cuts in the fractured Topopah Spring tuff outcrop. REECo has received funding to level the outcrop area and drill the vertical holes. They will start the job in September.

The samples obtained of the fracture system at the LBT facility in late June were examined by petrographic microscopy and x-ray diffraction (XRD). Preliminary examination of the thin sections indicates that dark alteration zones along the fracture margins are the result of fluid-rock interaction during vein formation in which oxidized iron phases are reduced possibly hematite to magnetite. Carbonate has invaded the rock along the vein margins, partially replacing the feldspar/cristobalite phases. The veins themselves consist of quartz margins, bladed calcite vein filling, and calcite-quartz polygonal mosaics in the vein center. Further work to more thoroughly characterize these materials will be undertaken in October.

T. Buscheck continued the pre-test modeling and analysis of the Large-Block Test (LBT). The block is represented with an R-Z axisymmetric model which averages the heating from five 300-W heaters with a disk-shaped, 2.985 m diameter heat source. The 3 m x 3 m cross-sectional area of the block is represented by a circular

cross section with a 3.385 m diameter (giving it the same cross-sectional area). The heater horizon is located 3 m below the top of the block. The R-Z axisymmetric model can represent the heat loss out of the sides of the block. The sides are modeled as having a layer of insulation with a specified thickness and thermal conductivity, K_{th}. A suite of calculations assuming the block to have adiabatic sides (which could be achieved through the use of guard heaters) was also run. The parameter sensitivity study of bulk permeability, k_b was continued. Last month, k_b values of 1, 10, and 280 millidarcy, and 5 and 40 darcy were considered (1 darcy is $10^{-12}m^2$). This month values of k_b of 10 and 100 microdarcy were considered. For k_b values of 1, 10, and 280 millidarcy, the vertical extent of the dry-out zone is almost identical, and the effect of buoyant, gas-phase convection is negligible (i.e., does not cause the dry-out zone to deviate from being vertically-symmetrical about the heater horizon). For k_b values of 10 and 100 microdarcy, dry-out due to boiling is effectively throttled, thereby reducing the volume of the dry-out zone relative to the cases where $k_b > 1$ millidarcy.

The paper by W. Lin entitled "Technical Basis and Programmatic Requirements for Large Block Testing of Coupled Thermal-Mechanical-Hydrological-Chemical Processes" has been approved by YMPO and has been sent for printing at LLNL. It will be available in September. This LLNL report documents the draft Scientific Investigation Plan for the Large Block Test, which is awaiting YMPO approval.

W. Lin, Y. Chang, D. Peterson and J. Blink visited Aircraft Engineering in Paramount, CA on August 17 to discuss procurement bids for the loading frame for the LBT.

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

The draft Man-Made Materials Study Plan (8.3.4.2.4.5) is almost complete and should be submitted to YMPO by the September 30 deadline.

A. Meike (Man-Made Materials Task Leader, LLNL), C. Bruton (New Zealand Analog Study Coordinator, LLNL) and R. Levich (International Projects, YMPO) visited with geothermal power companies in Taupo, New Zealand. The purpose of these meetings was to discuss the development of a collaborative relationship that will provide long term chemical information of interest to YMPO and to obtain access to chemical data, samples of degraded materials, boreholes for experimentation and sampling, and geothermal areas not accessible to the public.

Details of the meetings with the New Zealand Geothermal Power Companies are furnished in the Foreign Trip Report (by A. Meike and C. Bruton) that has been filed with Lawrence Livermore National Laboratory for this travel. This study will benefit both the Geochemistry and the Man-Made Materials tasks and will be conducted by both tasks. (The Geochemistry Task supports work in WBS elements 1.2.2.2.1, Near Field; 1.2.3.2.1.2.1, Natural Analogs; and 1.2.3.10, Altered Zone). A contract is presently in place between the Institute of Geological and Nuclear Sciences, a Crown Research Institute of New Zealand and the Geochemistry Task at LLNL for the initiation of geochemical studies. Of particular interest to the power

companies are many of the long term materials degradation issues of the Man-Made Materials task.

One area of mutual interest for the geothermal power companies and the Man-Made Materials Task that will be addressed immediately is cement biodegradation. The rare opportunity to acquire cement samples from an usually inaccessible area that has been exposed to elevated temperatures over a period of five years and is showing extensive signs of biodegradation will present itself in mid-October. A complete plant shut-down at this site, which only occurs once every two years for a period of two days, will take place at that time. During that window of opportunity, if foreign travel arrangements can be made in time, LLNL plans to collect samples for culture and identification, as well as future experimentation. Another site, which contains some of the oldest (up to 40 years) synthesized materials, will be shut down for a similar period of time in February. This shut down will offer the opportunity to obtain other samples, primarily inorganic materials for analysis.

Diesel Fuel Stability Experiments

K. Jackson and S. Carroll continue diesel fuel stability experiments. There is good evidence of chemical reactions taking place at 200°C. Some of the products are carboxylic acids which may prove to be aggressive to waste canister materials.

The paper by A. Meike entitled "Chemical and Mineralogical Concerns for the Use of Man-Made Materials in the Post-Emplacement Environment" was submitted to YMPO for approval on August 9. This paper was originally written last winter and has been stalled in the review process.

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

Two experiments with schoepite (UO_3) have begun at room temperature and 20% oxygen at LLNL. One experiment includes hydrated schoepite ($UO_3 \cdot 2H_2O$) as a sample; the other experimental sample is dehydrated schoepite ($UO_3 \cdot H_2O$). These are prototypes of a new sequence of experiments to examine the effects of oxidation state on uranium oxide dissolution. The results of these two experiments will be compared with similar experiments previously conducted at very low oxygen concentrations. These archetypes will help guide the planning and execution of the oxidation state studies in FY94 . These experiments are similar to those experiments beginning at PNL on spent fuel.

Two other experiments at LLNL are also underway which are repeats of individual runs in the original test matrix. The two earlier runs had dissolution rates that varied considerably during the course of the experiments and were not consistent with other runs in the matrix. These repeats will be integrated with the ongoing data analysis of the original test matrix.

Some of the flow through dissolution tests at PNL with oxidized spent fuels have been completed according to the newly approved addendum to the test plan. A paper describing the results of these tests is being prepared for presentation at the MRS meeting which will be held in Boston, MA, November 29-December 3. Preparation of spent fuel test specimens that will be used in the remaining tests has been delayed by some clean-out and waste disposal work, which took precedence in the hot cells. Sample preparation and start-up of the additional dissolution tests are now expected to be completed in September.

Spent Fuel Oxidation

The paper by R. Stout, E. Kansa and A. Wijesinghe entitled "Kinematics and Thermodynamics Across a Propagating Non-Stoichiometric Oxidation Phase Front in Spent Fuel Grains" was submitted to YMPO for approval on August 9. This completes Milestone M0L09.

Dry Bath Testing

An interim dry bath weight examination at PNL was conducted on the 255°C test at 1667 hours. The samples continue to gain weight at a reduced rate. No samples were removed for analysis. Another interim measurement is planned in three weeks.

Thermogravimetric Apparatus (TGA)

Preliminary tests are being performed in support of a TGA oxidation test plan. The tests are being run to calibrate the equipment and to obtain baseline information to be used to determine a suitable test matrix.

A piece of unirradiated UO_2 doped with 8% Gd_2O_3 was held at 283°C for 454 hours. This sample exhibited behavior similar to that of spent fuel (an oxygen-to-metal ratio of 2.35 plateau was reached). This sample broke into powder while being removed. Subsamples for x-ray diffraction (XRD) and scanning electron microscopy (SEM) analysis were taken. An adequate subsample for transmission electron microscopy (TEM) analysis was not obtained due to sample friability. Both XRD and SEM confirmed the presence of U_4O_9 and approximately 3% U_3O_8. The initial results from SEM analysis indicate the U_3O_8 is dispersed throughout and not located on the grain boundaries.

A fragment of BWR-105 fuel has run for over 300 hours at 283°C. An O/M ratio of 2.647 has been reached. The sample rapidly gained weight to an O/M of 2.35. A true plateau was never reached since the sample continuously gained weight, however, d(O/M)/dt decreased significantly after obtaining a 2.35 O/M. After 125 hours, the weight increased at a fairly steady rate. It now appears that the rate of weight gain is slowing down and possibly may be approaching a second "plateau". The test is continuing.

A second TGA has been reassembled and evacuated. A 20% ^{18}O atmosphere test has been started to check for leaks and to determine how well the TGA furnace and controller will control the temperature (at 300°C.)

Materials Characterization Center (MCC) Hot Cell Activities

The paper by S. Marschman, R. Stout and R. Einziger entitled "Rationale for Determining MCC Spent Fuel Acquisitions" was approved by YMPO on August 26. It will soon be published by PNL.

1.2.2.3.1.2 Waste Form Testing - Glass

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 88 months. The N3 tests (ATM-10, a West Valley actinide-doped glass) continue and have been in progress for 69 months.

A QAC surveillance on the N2/N3 activities was performed on June 30 by ANL. All Scientific Notebooks and logs were reviewed by the QACs. M&TE was checked for proper labels identifying calibration due dates. The next QAC surveillance will be scheduled for December.

1.2.2.3.2 Metal Barriers

Characterization of the well string from the USW H-5 well is continuing. The steel used for the string is API grade J-55, a common carbon-manganese steel used in petroleum wells. Samples of a string recently pulled from the WT-2 well were received at LLNL for evaluation. Samples exposed in the saturated zone from this well appear to be much less corroded than those obtained from the H-5 well even though the time of exposure was the same (10 years). Information received from USGS PIs involved in these wells and others suggests that the depth of the well, the particular tuff layer, the fracture pattern in the rock, and the flow rate are important in determining the corrosion rate, since these factors govern the transport of oxygen that can reach the corroding steel surface. J. Mitchell is preparing a report on the observations of steel exposed in these wells.

The interlaboratory agreement (SANL) to ANL for continuation of the slow crack growth rate studies on Alloy 825 and other austenitic alloys was finalized. The studies involve application of a tensile load to pre-cracked compact tension specimens exposed to laboratory-simulated J-13 well water at 95°C. The studies measure crack propagation by the very small changes in electrical resistance manifested as the crack grows, and the technique is sensitive to crack rates less than 10^{-12} meters/second. The crack growth studies have been maintained since 1991. During that period, the crack propagation on Alloy 825 has been imperceptible. The PI for this work at ANL is D. Diercks. A progress report will be drafted at the end of FY93 on results to date.

J. Estill has been in contact with Cahn Microbalances, Inc. on the status of the thermogravimetric analysis (TGA) unit. The expected delivery date is October 15.

D. McCright gave a seminar on August 10 to senior LLNL Chemistry and Materials Science Division management on the status of the waste package container work. In particular, the personnel needs for the coming fiscal year were discussed. PIs were identified who might lead the corrosion performance modeling effort and the non-metallic barrier materials effort.

R. Sandifer, H. Benton and R. Fish (M&O) met with W. Clarke and D. McCright on August 17 to discuss interfaces between the work scopes for the two organizations. The discussions principally involved evaluations and selections of waste package materials for the different configurations being considered in the advanced conceptual design (ACD) phase. A follow-up meeting on this subject is scheduled for September 2.

Several meetings were held regarding the planned FY94 budget, accounting structure and the schedule of milestones and deliverables in the PACS system.

R. Van Konynenburg is organizing the MRS symposium on Nuclear Waste Management to be held in Boston, MA, November 29-December 3. Both DOE and NRC have made financial commitments to support the symposium.

Degradation Mode Surveys

J. Mitchell has completed a draft of the degradation mode survey on carbon steels, cast irons, and low-alloy steels. These materials are corrosion allowance materials that could be used in multiple barrier waste package designs. The survey is undergoing internal technical review.

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

The preparation of a status report on diffusion in clinoptilolite was initiated.

Interactions of Actinide-bearing Solutions with Rock Core Samples

A sample of well J-13 water (collected by W. Steinkampf, USGS) was analyzed for colloids using light scattering. Samples of this water were prepared for TEM analysis.

Analysis of preliminary flow testing continued and preparation of the report on the test phase for the flow through apparatus was initiated.

1.2.2.3.4.2 Thermodynamic Data Determination

The review and initiation of the publication of a thermochemical data task will be completed this fiscal year. The draft copy of the Am review is complete and will soon be sent to YMPO. R. Silva has contacted Dr. I. Puigdomenech, head of the NEA database effort, and asked him to recommend three outside reviewers for this review. For the U.S. reviewers, R. Silva will initiate contracts to cover the cost for their reviews.

The reviews of Np and Pu thermochemical data were not completed. This work is expected to continue in FY94 provided that Dr. I. Puigdomenech gives technical direction.

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. LLNL has been added to the list of participants for this WBS element in the WBS Dictionary.

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

Updated packages of EQ3/6 Version 7.2 were prepared for transmittal to all YMP-related users. Distribution was held up by the need for a software release re-review by the LLNL ADPR&I office. This review is expected to be completed by September 3.

Work is continuing on Version 8.0. As specified in the Software Design Description (SDD), this version is a major re-write, incorporating major changes in the data structure in order to accommodate improvements in numerical methods and the addition of new functional capabilities. The new capabilities planned for Version 8.0 include:

1) allowing for redox disequilibrium in reaction-path calculations (important to treating the metastable persistence of dissolved components such as sulfate, nitrate, and organics),

2) a generic ion-exchange model, and

3) correction of supporting data, mostly thermodynamic, to pressures off the 1.013 bar-steam saturation curve.

Effort is being addressed to bring Version 8.0 up-to-date with the recent changes in Version 7.2 (including PC compatibility). The data restructuring critical to the redox disequilibrium capability in EQ6 was subsequently completed. However, some parts of EQ6 are still being revised. In particular, a new simplified methodology of finding phase boundaries is being implemented. An obsolete numerical technique (f02 scanning) is being deleted. The code will then be ready for large-scale testing. The EQ3NR code is now ready for such testing. The XCON3 and XCON6 input file reformatters are being extended to convert files to Version 8 format. This extension should be completed in early September and will allow the entire Version 7 test case library to be converted for use in testing.

1.2.3.5 Drilling

1.2.3.5.2.2 Engineering, Design, and Drilling Support

D. Felske began the process of converting LLNL-Nuclear Test Program technical procedures to the LLNL-YMP Technical Implementing Procedures (TIPS).

1.2.3.10 Altered Zone Characterization

Work completed in August will be included in the September status report.

1.2.5 REGULATORY

1.2.5.1 Regulatory Coordination and Planning

This WBS element has not been funded in FY93. LLNL has been added to the list of participants for this WBS element in the WBS Dictionary.

1.2.5.2 Licensing

1.2.5.2.2 Site Characterization Program

D. McCright and W. Halsey attended the DOE-NRC Technical Exchange on Substantially Complete Containment and Waste Package/Engineered Barrier System Design Concepts held August 24 in Bethesda, MD. He presented a talk on

the status of materials testing efforts. In preparation for the exchange, a dry run was held for the presenters on August 12 in Las Vegas.

S. Blair attended the comment resolution meeting for Study Plan 8.3.1.15.1.4 in Las Vegas on August 19.

1.2.5.3 Technical Data Management

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

FACET was used to enter equilibrium-constant and reaction-enthalpy data for the CHEMVAL-II database. This database was to be used for a set of EQ3/6 calculations performed by W. Glassley in support of the CHEMVAL-II verification tests, aimed at establishing the mutual agreement of several different speciation/mass transfer codes when applied to a set of relevant geochemical problems.

A modified version of JEWEL which facilitates generation of a CHEMVAL-II thermodynamic datafile for use with EQ3/6 was created. This modified code was applied to generate the datafile used by W. Glassley in his verification tests, the results of which he reported at the recent CHEMVAL conference in Germany.

The development of a WINDOWS/4GL (mouse-driven) version of JEWEL is continuing. This program facilitates interactive point-and-click generation of thermodynamic datafiles for EQ3/6, GT, and other geochemical modeling packages.

J. Johnson generated a glossary of species for the various GEMBOCHS datasets as well as a revised and updated GEMBOCHS data dictionary.

1.2.5.3.5 Technical Data Base Input

N. Rector completed a review of the Integrated Data System (IDS) Design Requirements Document, Revision 0A and DRs were sent to Las Vegas on August 23.

J. Blink and W. Glassley reviewed the technical data parameter dictionary.

1.2.5.4 Performance Assessment

1.2.5.4.2 Waste Package Performance Assessment

In support of TSPA-2, and at the request of the M&O, the liquid-phase velocity field at various times and the liquid-phase velocity history at various points from the repository horizon down to the water table have been provided based on the repository-UZ-SZ-scale hydrothermal calculations using V-TOUGH. These results can be used to calculate radionuclide transport in the unsaturated zone on the basis of averaged liquid-phase fluxes. Because of the spatial variability of liquid-phase flux, basing transport calculations on average fluxes may not accurately reflect the flow field calculated by V-TOUGH. In order to more accurately reflect the V-

TOUGH-calculated flow field, it is preferred to track packets of particles released from waste package locations, as they are driven by the flow field in the underlying natural barrier system. With the guidance of J. Nitao and T. Buscheck, S. Daveler developed a family of "particle tracking" post-processors for V-TOUGH, called P-TRACK, PT-PLOT, and PT-MOVIE. P-TRACK calculates the x-y location versus time for each of the particles. PT-PLOT calculates the pressure, temperature, and saturation history for each of the particles. PT-MOVIE is a graphics program that produces a video animation of the moving particles. Colors can be used in PT-MOVIE to "tag" when or where the particles were released, or can be used to indicate the value of either pressure, temperature, or saturation of the moving particles. P-TRACK and PT-PLOT can be the basis for conducting radionuclide transport calculations where retardation may be treated as a function of pressure, temperature, and saturation. PT-MOVIE is an extremely valuable aid to visualize the spatial and time dependence of transport, as well as the relationship between transport and temperature and saturation.

The resolved comments on the paper by W. O'Connell, T. Ueng and L. Lewis entitled "Post-Closure Performance Assessment of Waste Packages for the Yucca Mountain Project" were submitted to YMPO on August 4.

J. Blink and W. Halsey attended the PA Management meeting in Las Vegas on August 18.

1.2.5.5.2 Energy Policy Act Support

R. Van Konynenburg presented an invited paper at the August 26-27 Las Vegas meeting of the National Academy of Sciences Committee on the Technical Basis for Yucca Mountain Standards. The presentation was entitled "Environmental Transport of Gaseous Releases of Radionuclides" and it focused primarily on carbon-14. The paper emphasized the small impact of repository carbon-14 in individual dose, both local and world-wide. A coordinating meeting was held August 19 prior to the NAS meeting at the M&O headquarters in Vienna, VA.

1.2.9 PROJECT MANAGEMENT

1.2.9.1 Management and Coordination

1.2.9.1.2 Technical Project Office Management

In response to a GAO request for manpower information, LLNL provided a current staff listing, the LLNL-YMP Organizational Chart. and a percentage breakdown of technical effort expended.

J. Blink attended the Tracer/Fluid/Materials meeting in Las Vegas on August 9, the Quality Integration Group meeting in Las Vegas on August 10, the IRAT meeting in Las Vegas on August 27, and the monthly management meeting in Las Vegas on August 31. C. Passos attended the ALARA committee meeting on August 27 in Las Vegas.

J. Blink attended an awards ceremony at the Nevada Operations Office on August 27 where he was recognized for his contributions to the Educational Outreach Program. He also presented a hands-on science activity to the YMCA Day Camp on August 6 at the Yucca Mountain Information Office in Las Vegas. He presented a science workshop to 20 fifth and sixth grade teachers at the Pahrump fifth-sixth grade center on August 20.

1.2.9.2 Project Control

1.2.9.2.2 Participant Project Control

The July Cost/FTE report was submitted to YMPO. The July actual schedule progress and costs were submitted via the PACS workstation. The Cost Plan was updated to include July actuals. Variance analysis explanations were developed for four P&S accounts:

1) EBS Field Tests, 1.2.2.2.4,
2) Man-Made Materials, 1.2.2.2.5,
3) Project Control, 1.2.9.2.2
4) QA Quality Implementation, 1.2.11.

Work continues to refine the cost-to-close-FY93 as more cost information becomes available. A series of meetings are being conducted with Technical Area Leaders and Cost Account Managers to discuss current state of budget, forecast of internal manpower and non-labor, subcontractor invoicing and capital equipment requests.

An estimate for FY93 carryover to YMPO is being submitted. It is anticipated that the LBT frame fabrication and quarry activities will continue into FY94. These (FY93) activities were not included in the FY94 budget estimate; therefore, FY93 funds will be required.

The FY94 PACS cost, schedule, workscope and milestones were developed and submitted to YMPO via the PACS workstation. Data are being adjusted as input is received from DOE WBS managers.

Preparations began for an IG audit scheduled for September 8-9.

The following Cost and Schedule Change Request (C/SCR) was submitted to the CCB and approved:

1) Move $15K from LLNL WBS element 1.2.3.10.2 (Altered Zone Characterization) to LLNL WBS element 1.2.3.5.2.2 (Drilling).

J. Blink worked with J. McGrath of the M&O to improve the integration of the C/SCR and AFP processes.

J. Blink and P. Burklund worked with P. Gottlieb and S. Simms of the M&O to update FY93 and FY94 milestones.

M. Owens, an LLNL employee who is based at NTS, has been designated as the LLNL property control custodian for NTS property used by LLNL-YMP.

1.2.11 QUALITY ASSURANCE

1.2.11.1 Quality Assurance Coordination and Planning

R. Monks attended Quality Assurance meetings in Las Vegas on August 11-12.

1.2.11.2 Quality Assurance Program Development

Scientific Investigative Plan NF-02, Revision 0, was submitted to YMPO on August 2 for review and approval.

Internal grading Reports LLNL-QAG-L-068, Revision 0, "Pre-test Model Calculations" and LLNL-QAG-L-062. -063, -064, -069, "Large Block Testing", were completed and distributed effective August 20.

LLNL is continuing to work on the revision of procedures to comply with the new QARD and matricing requirements against LLNL-YMP procedures.

1.2.11.3 Quality Assurance Verification

1.2.11.3.1 Quality Assurance Verification - Audits

LLNL Audit Report 93-02, "LLNL-YMP QA Program" was completed and distributed August 9.

Corrective Action Report LLNL-027 was completed, verified, and distributed to YMPO on August 16.

The response to Corrective Action Report (CAR) YM-93-085, resulting from audit YMP-93-14, was submitted to YMPO on August 24.

LLNL requested an extension to November 1 for CAR-YM-91-056. Corrective action for this CAR requires the generation of a matrix wherein compliance with the QARD will be delineated.

1.2.11.3.2 Quality Assurance Verification - Surveillance

No significant activities.

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 continued for the Waste Form Characterization technical area.

1.2.12 INFORMATION MANAGEMENT

1.2.12.2 Records Management

1.2.12.2.2 Local Records Center Operation (LRC)

Five new revisions were issued by Document Control.

1.2.12.2.3 Participant Records Management

A total of 244 items were logged into the LLNL-YMP tracking system. This includes 34 records/records packages that were processed through to the CRF. Twenty action items were closed.

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

J. Blink will continue as the LLNL delegate to the Safety and Health Advisory Committee. There are also two alternates, T. Roy and C. Passos, who will attend meetings in his place when necessary.

T. Roy gathered the necessary documents to request ALRA committee approval for neutron logging of the LBT. He also inspected the LBT job site.

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

Eighty five people were trained to forty eight different self-study assignments. Currently, there are ninety eight participants on the project who are to be trained and/or tracked.

C. Rehkop (DOE) and R. McCarthy (SAIC) visited LLNL-YMP for their annual training management review.

The Training Organization, QA Manager and Technical Staff have begun a re-evaluation of the training matrices in an effort to ensure real-time training as opposed to just-in-case training. This effort should realize a cost-savings for LLNL-YMP training. J. Blink completed GET refresher training on August 30 in Las Vegas.