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

October 1993

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

1) WBS 1.2.2.2.1 Chemical and Mineralogical Properties of the Waste Package Environment The preliminary phase of modeling downhole mineralogy at Wairakei, New Zealand, using fluid chemistries obtained from active wells, is complete. The results were presented by LLNL at FOCUS '93, and at the Technical Exchange meeting with the NRC. The results demonstrate that good correspondence can be achieved between downhole mineralogy and simulations, for specific choices of Fe- and Al-controlling phases. Work is now underway to develop guidelines for selecting the controlling phases.

2) WBS 1.2.2.2.2 Hydrologic Properties of the Waste Package Environment LLNL calculations show that refluxing, or the heat-pipe effect, is important to MGDS design because it can affect repository performance in two ways. First, refluxing maintains local temperatures near the boiling point, making it more difficult to dry the rock out. Consequently, the relative humidity may remain high, increasing the likelihood of a liquid film on waste package surfaces. Second, refluxing can bring mobile liquid water in contact with waste packages, affecting container lifetime, waste-form dissolution, and radionuclide transport. Calculations were conducted with a high permeability region above each drift. The resulting heat-pipe zone attracts heat flow (mainly by conduction) from the neighboring rock. In effect, the heat-pipe zone functions as a "cooling fin" that is manifested by an elongated region of liquid saturation buildup. The process of gas-phase focusing into the heat-pipe zone develops more quickly than the process of attracting heat from the neighboring rock. Within 8.5 yr, enough heat is being conducted into the heat-pipe zone for the high AML case to overwhelm the heat pipe, causing the top of the drift to begin to dry out. Preferential heat conduction into the heat-pipe zone continues to dry it out. The effect of focused condensate drainage on the upper dry-out front is no longer evident after 100 yr. For an intermediate AML of 49.2 MTU/acre, which is the reference thermal load in the SCP-CDR, focused vapor flow causes persistent refluxing in the high-k_b zone and marginal boiling conditions. For 20 year old spent nuclear fuel (SNF), the duration of the boiling period (t_{bp}) is only 160 yr, and there is insufficient heat to coalesce the dry-out zones between neighboring drifts. There is also not enough heat to overwhelm the heat pipe and dry out the rock at the top of the drift. Refluxing persists at the top of the drift for several thousand years, long after the end of the boiling period. Diagnosing the potential for these repository-heat-driven effects to impact waste package integrity and radionuclide migration will require in situ heater tests conducted under sub-boiling as well as above-boiling conditions.

3) WBS 1.2.2.2.2 Hydrologic Properties of the Waste Package Environment Based on experience with geothermal systems, some have hypothesized that heat-pipe zones, spaced every 100 m, could dominate the thermal behavior of the entire repository, causing it to remain at the nominal boiling point. The heat-pipe zones function as "cooling fins", attracting heat from other locations in the repository. If this preferential heat flow from the neighboring rock into the heat-pipe zone primarily occurs as heat conduction, the thermal gradients associated with that conduction will necessitate that the temperature at other locations in the repository be elevated above the boiling point. These calculations indicate that it is very unlikely that these heat-pipe zones will cause the temperature of the entire repository to remain at the boiling point.

4) WBS 1.2.2.2.4 Engineered Barrier System (EBS) Field Tests Large Block Test loading frame drawings, prepared by the fabricator, Aircraft Engineering Corp., have been approved by the LLNL design engineer.

5) WBS 1.2.2.2.4 Engineered Barrier System (EBS) Field Tests LLNL initiated discussions with SNL to use some SNL diagnostic equipment for geomechanics data collection in the Large Block Test (LBT). This collaboration would benefit both WBS 1.2.2 and 1.2.4. A proposal was also received from G. Danko, University of Nevada, to install REKA probes in the LBT. This effort would be co-funded, roughly equally, by WBS 1.2.2 and the YMPO-funded University grant program.

6) 1.2.2.2.5 Characterization of the Effects of Man-Made Materials on Chemical & Mineralogical Changes in the Post-Emplacement Environment Preliminary results from the biodegraded cement cores obtained by LLNL from New Zealand last month indicate the presence of both thiobacillus and nitrifying bacteria.

7) WBS 1.2.2.3.1.1 Waste Form Testing - Spent Fuel A milestone report, MOL07, summarizing the experimental data and analysis of the uranium dissolution rates from experiments outlined in the initial test plans for activities D-20-53(a) at LLNL and D-20-53(b) at PNL, has been completed. The forty-two tests examined the effects of temperature and concentrations of carbonate, oxygen and hydrogen ions on aqueous dissolution of UO_2 and spent fuel.

8) WBS 1.2.2.3.1.1 Waste Form Testing - Spent Fuel The draft LLNL/PNL report on the Thermogravimetric Apparatus high temperature oxidation performance of spent fuel is almost complete. X-ray diffraction (XRD) analyses were performed on a 185 mg fragment of BWR (ATM-105) fuel that was oxidized at 283°C for 793 hours to a final oxygen-to-metal ratio of 2.79 and on a 194 mg fragment that was oxidized at 325°C for 120 hours to a final oxygen-to-metal ratio of 2.73. In both cases, the analysis indicates almost complete conversion to U_3O_8 with only a small amount of U_4O_9 remaining.

9) WBS 1.2.2.3 Waste Form and Materials Testing Old and unusable samples of spent fuel prepared by the Materials Characterization Center at PNL under an LLNL sub-contract are going to be packaged and consolidated for storage. These samples are unusable due to contamination in the hot cells and have presented inventory problems. Consolidation will simplify accountability of special nuclear materials.

10) WBS 1.2.2.3.2. Metal Barriers Crack growth test work sub-contracted by LLNL to Argonne National Laboratory (ANL) resumed in August 1993, under YMP sponsorhip, after a two-year hiatus during which one test cell was maintained in operation under internal ANL sponsorship. The work is centered on measuring very slow crack propagation in pre-cracked compact tension specimens. Crack growth is determined by measuring the very small changes in electrical resistance of the specimen as the crack propagates. Thus far, more than 20,000 exposure hours have accumulated. Specimens of 304L and 316L stainless steels and nickel-base Alloy 825 are being tested in 90°C simulated J-13 water under a severe mechanical stress condition. Resolution of any crack extension corresponds to crack growth measurements on the order of 10^{-12} m/s; the significance is that crack would require more than 300 years under continuously wet conditions to penetrate a one-cm thick container wall. Work in FY94 will emphasize corrosion resistant materials that could be used in multiple barrier container designs and to test in more aggressive environmental conditions.

11) WBS 1.2.2.3.5 Nonmetallic Barrier Concepts This LLNL task has recently been funded, following a three year hiatus. We are in the process of identifying a principal investigator/task leader for the work. The work planned for FY94 includes preparation of a survey on possible ceramic materials that could be used in a multiple barrier design, the state of technology in fabricating ceramics of dimensions suitable for a waste package barrier, and possible degradation modes affecting ceramics used for long-term disposal. As needed, the various planning documents for this task will be updated and modified.

12) WBS 1.2.5.3.4 Geologic and Engineering Materials Bibliography of Chemical Species (GEMBOCHS) A revised and improved set of auxiliary-basis aqueous species for writing dissociation reactions involving organics was generated at LLNL. Such reactions were revised accordingly for a large number of aqueous organic species. This update will significantly improve the accuracy of EQ3/6 speciation and mass transfer models for organic and inorganic/organic systems.

13) WBS 1.2.5.4.2 Waste Package Performance Assessment LLNL participation in the Total System Performance Assessment 1993 (TSPA-2) continued. Final borehole-emplacement hottest-fuel temperature histories were provided to SNL with compromise boundary conditions imposed on the rock wall. This compromise applied the SNL-calculated temperatures for waste package surface onto the rock wall and should represent the early time thermal transient fairly well with moderate errors at long times (perhaps 20 degrees high at 1000 years).

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 continues to support the thermal loading systems study with the development of a new suite of repository unsaturated zone-saturated zone scale models for repository areas of 570, 744, 1139, 1755, and 2598 acres. For 63,000 MTU of Spent Nuclear Fuel (SNF), the repository areas correspond to Areal Mass Loadings (AMLs) of 110.5, 83.4, 55.3, 35.9, and 24.4 MTU/acre. The models assume radial symmetry and represent the repository area as a disk. They are appropriate for representing mountain-scale thermo-hydrological behavior, such as mountain-scale, buoyant, gas-phase convection. Sub-repository-scale behavior will be investigated with the drift-scale model. This suite of calculations assumed a uniform fracture permeability which yields an approximately uniform bulk permeability, k_b, throughout the unsaturated zone. The following values of k_b were considered: 280 millidarcy, 10, 40, and 84 darcy (1 darcy~$10^{-12}m^2$). 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 is used with a 10 yr cut-off for the youngest fuel, referred to as YFF(10). We are also accounting 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 John King of the M&O.

The 280-millidarcy cases showed negligible mountain-scale, buoyant, gas-phase (MSBGP) convective effects. Average repository temperature for the lowest two AML cases (24.4 and 35.9 MTU/acre), never exceeds the boiling point, with peak temperatures of 66 and 86°C, respectively. The peak temperatures for AMLs of 55.3, 83.4, and 110.5 MTU/acre are 109, 146, and 187°C, respectively. The impact of MSBGP convection on thermo-hydrological performance during the boiling period is very dependent on AML. Relative to the 280-millidarcy case, the cooling effect of MSBGP convection, reduces the duration of boiling by 32, 17, and 0.7% for AMLs of 55.3, 83.4, and 100.5 MTU/acre and k_b = 10 darcy. The development of a large zone of above-boiling temperatures suppresses the effect of convection; consequently, these effects decrease with increasing AML. The k_b = 40 darcy cases have an even larger cooling effect relative to the 280-millidarcy case, with t_{bp} being reduced by 65, 26, and 8% for the same three AMLs, respectively for k_b = 84 darcy, t_{bp} is reduced by 82, 42, and 16%.

The impact of buoyant, gas-phase convection on bulk moisture movement and on cooling effects at the edge of the repository will be reported in November.

1.2.1.6 Configuration Management

Affected document notices (ADN's) were completed for CRs 93/379, 93/380, 93/381, 93/385, 93/452, 93/461, 93/505, 93/513, and 94/002. No LLNL controlled documents were affected.

1.2.2. WASTE PACKAGE

1.2.2.1 Waste Package Coordination and Planning

W. Clarke, J. Blink, R. Stout, D. Wilder, W. Halsey, R. Van Konynenburg, and D. McCright attended a meeting held October 26 in Las Vegas, Nevada on design interfaces. The meeting was convened by D. Stucker of YMPO. An important goal of the meeting was to establish an ongoing dialogue between the YMP participants involved with various aspects of repository and engineered barrier design activities.

W. Lin attended the (SOC) Sample Overview Committee meeting at NTS on October 6.

D. Chesnut and T. Buscheck attended the Hydrology Integration Task Force meeting at NTS.

1.2.2.2 Waste Package Environment

1.2.2.2.1 Chemical and Mineralogical Properties of the Waste Package Environment

The New Zealand natural process analog site work continued. The formal understandings for data transfer between the production companies and LLNL were drafted and are being reviewed. Data on well waters, and mineralogy and petrology from Kawerau, Wairakei, and Champagne Pool are being collected and summarized by the New Zealand researchers. Preliminary reports summarizing the Wairakei properties were submitted. Samples from Champagne Pool have been submitted for analysis. These data will be used to model precipitation and fluid mixing. Samples that were collected from the drains at Wairakei were analyzed by x-ray diffraction (XRD). These samples are of interest because they represent a system in which silica precipitation from solutions of known composition is occurring. The intent is to conduct experiments in this system to evaluate current models of precipitation kinetics. XRD of these samples has been completed, revealing that the precipitate consists of amorphous silica, albite and halite. Scanning electron microscope (SEM) work is underway to further characterize these materials.

The preliminary phase of modeling downhole mineralogy at Wairakei, using fluid chemistries obtained from active wells, is complete. The results were presented at

FOCUS '93, and at the Technical Exchange meeting with the NRC. The results demonstrate that good correspondence can be achieved between downhole mineralogy and simulations, for specific choices of Fe- and Al-controlling phases. Work is now underway to develop guidelines for selecting the controlling phases.

Further discussions are underway to refine the work plan for the New Zealand collaborators, in light of the results to date.

The development of three-dimensional representation techniques progressed. Installation of EARTH VISION software has been completed, and test cases were run. Data sets specific to Yucca Mountain are being collected. These sets will be used as the basis for representing mineralogical and chemical changes associated with various waste loading scenarios and repository geometrics.

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

The revised study plan for Waste Package Geochemistry and Mineralogy is now being edited. The internal review process should be complete and the study plan submitted to YMPO by the end of November.

1.2.2.2.2 Hydrologic Properties of the Waste Package Environment

The draft of Study Plan 8.3.4.2.4.2, "Hydrological Properties of the Near-Field Environment", was revised in response to internal comments and reformatting to meet the new DOE NRC agreement. The Study Plan will be submitted to YMPO in November.

Model Calculations

Refluxing, or the heat-pipe effect, is important to MGDS design because it can affect repository performance in two ways. First, refluxing maintains local temperatures near the boiling point, making it more difficult to dry the rock out. Consequently, the relative humidity may remain high, increasing the likelihood of a liquid film on waste package surfaces. Second, refluxing can bring mobile liquid water in contact with waste packages, affecting container lifetime, waste-form dissolution, and radionuclide transport.

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), we considered the situation in which a vertically contiguous zone, with bulk permeability k_b much greater than the nominally fractured rock, intersects the waste package. We found that the degree of vapor flow focusing into the high-k_b zone, and the resulting duration of refluxing in the repository, depends on three factors. First, k_b of the nominally fractured rock must be large enough to not significantly throttle the rate of vaporization. Second, the k_b contrast between the zones must be large enough to result in a gas-phase pressure differential that

preferentially drives vapor flow into the high-k_b zone. If enough water vapor enters and condenses in this zone, the condensate drainage flux will be large enough to maintain refluxing in the repository. Third, there must be sufficient spacing between the high-k_b zones to focus enough water vapor into these zones to make the local condensate drainage flux much greater than the mean flux. Effectively, the high-k_b zones are competing for the finite quantity of vapor flow and condensate generation. Consequently, there is a trade-off between the duration of refluxing and the number of locations where it can occur in the repository. If there are too many such zones, focusing will not be sufficient to cause persistent refluxing in the repository. The degree of focusing necessary to cause persistent refluxing limits the number of locations where it can occur. Therefore, it is unlikely that refluxing can dominate overall thermal behavior in the entire repository.

The effect of focused vapor flow and condensate drainage was calculated for a high and an intermediate Areal Mass Loading (AML), 154.7 and 49.2 MTU/acre, respectively. For both cases, high-k_b zones were aligned along the axis of the drifts and separated by nominal-k_b zones. The gas-phase pressure differential between these zones drives water vapor back toward the drift and into the high-k_b zone. Water vapor flows up the high-k_b zone until it condenses and drains back down. Refluxing (and the resulting heat-pipe effect) enables the temperature at the drift ceiling to remain at the nominal boiling point, causing a depression in the dry-out zone. In spite of persistent refluxing at the top of the drift, the temperatures along most of the remainder of the drift wall, the air in the drift, and the waste package itself are well above the boiling point. Therefore, although liquid water may be dripping in the drift, the relative humidity around the waste package can still be low.

The heat-pipe zone attracts heat flow (mainly by conduction) from the neighboring rock. In effect, the heat-pipe zone functions as a "cooling fin" that is manifested by an elongated region of liquid saturation buildup. The process of gas-phase focusing into the heat-pipe zone develops more quickly than the process of attracting heat from the neighboring rock. Within 8.5 yr, enough heat is being conducted into the heat-pipe zone for the high AML case to overwhelm the heat pipe, causing the top of the drift to begin to dry out. Preferential heat conduction into the heat-pipe zone continues to dry it out. The effect of focused condensate drainage on the upper dry-out front is no longer evident after 100 yr.

For an intermediate AML of 49.2 MTU/acre, which is the reference thermal load in the SCP-CDR, focused vapor flow causes persistent refluxing in the high-k_b zone and marginal boiling conditions. For 20 year old spent nuclear fuel (SNF), the duration of the boiling period (t_{bp}) is only 160 yr, and there is insufficient heat to coalesce the dry-out zones between neighboring drifts. There is also not enough heat to overwhelm the heat pipe and dry out the rock at the top of the drift. Refluxing persists at the top of the drift for several thousand years, long after the end of the boiling period. Diagnosing the potential for these repository-heat-driven

effects to impact waste package integrity and radionuclide migration will require in situ heater tests conducted under sub-boiling as well as above-boiling conditions.

We also considered the situation in which a vertically contiguous zone, with k_b much greater than the nominally fractured rock, occurs in the middle of the pillar between emplacement drifts. With a 38.4 m center-to-center drift spacing, the high-k_b zone is 19.2 m away from the waste package. For this situation, the duration of refluxing at the repository horizon is five times longer than when the high-k_b zone intersects the waste package. Therefore, the details of the heat and permeability distributions within the repository are very important when analyzing the effects of focused vapor and condensate flow. Calculations that smear the waste package heat output over the repository area will significantly overestimate the duration of refluxing in the vicinity of waste packages.

Another important observation concerns the persistent thermal disequilibrium that can exist over a distance of a few meters in the emplacement drift. For the intermediate AML of 49.2 MTU/acre and 10 yr old SNF (the SCP-CDR case), t_{bp} is 660 yr, which is much greater than the same AML with 20 yr old fuel (t_{bp} = 160 yr). It is important to note that a subtle change in the heat output causes an extreme change in thermo-hydrological performance for the SCP-CDR thermal load; an extremely large k_b contrast causes refluxing (heat-pipe) conditions to persist during (and after) the boiling period. During the boiling period, the temperature in the high-k_b zone at the center of the drift ceiling remains at the nominal boiling point (~96°C), while only 3 meters away, in the upper corner of the drift, temperatures are always above the boiling point. The existence of a heat-pipe zone at the center of the drift ceiling is not able to dominate the overall thermal behavior of the drift and cause temperatures at other locations in the drift to remain at the boiling point. Heat flow in the heat-pipe zone primarily occurs as the convection of latent heat, while heat flow from the nominal-k_b rock to the high-k_b rock occurs as heat conduction.

Based on experience with geothermal systems, some have hypothesized that heat-pipe zones, spaced every 100 m, could dominate the thermal behavior of the entire repository, causing it to remain at the nominal boiling point. The heat-pipe zones function as "cooling fins", attracting heat from other locations in the repository. If this preferential heat flow from the neighboring rock into the heat-pipe zone primarily occurs as heat conduction, the thermal gradients associated with that conduction will necessitate that the temperature at other locations in the repository be elevated above the boiling point. These calculations indicate that it is very unlikely that these heat-pipe zones will cause the temperature of the entire repository to remain at the boiling point.

See WBS 1.2.1.5 for further hydrological calculations.

Laboratory Experiments

Measurement of electrical resistivity as a function of moisture content of Topopah Spring tuff samples from the G-4 and GU-3 holes continued. Distilled and J-13 water are being used as pore fluid. Measurements of the G-4 samples at 40°C are complete; measurements included the wetting and drying cycle and the use of both J-13 and distilled waters. The samples were 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. Measurements at 65° will begin in November.

The experiment to determine the moisture retention curve and one-dimensional imbibition using G-4 core continues. The data from this experiment will be used to calculate relative permeability as a function of water saturation. Measurements have been completed of a complete imbibition-drying cycle at 25°C. Measurements at high temperatures will begin in November. Data analysis of the one-dimensional imbibition experiment is proceeding. Evaluation of the use of the four-electrode method on a rectangular sample continues.

The saturated water permeability measurement on an intact sample from G-4 is ongoing. The sample is under a confining pressure of about 5 MPa and a pore-water pressure of about 2.4 MPa. Analysis of the water flowed through the sample detected no leak of the confining pressure medium. The pore pressure in the sample was brought to an equilibrium. Permeability measurements at a pore pressure less than 2.4 MPa will be conducted next month.

1.2.2.2.3 Mechanical Attributes of the Waste Package Environment

Effort was directed to the planning and administration of geomechanics investigations to be conducted during FY94. Input was prepared for the project planning system (PACS) and work continued on the Activity Plan for geomechanical studies of the near-field environment including the addition of discussion of laboratory experiments on 0.5 m scale blocks.

See WBS 1.2.2.2.4 (Large Block Test) for more information on this month's activities.

1.2.2.2.4 Engineered Barrier System (EBS) Field Tests

Study Plan 8.3.4.2.4.4, entitled "Engineered Barrier System Field Tests," has been reviewed by the Project Office. Comments are being resolved by the PI.

Large Block Test (LBT)

The first draft of the Activity Plan for the LBT has been completed. The LLNL internal review will begin in November. The activity plan, according to LLNL QA

procedures, will not require external review. However, J. Blink will circulate his copy externally and provide any submited comments to the PI; these comments need not be resolved but will be considered.

Loading frame drawings, prepared by the fabricator, Aircraft Engineering Corp., have been approved by the LLNL-YMP design engineer.

Leveling of the site for the LBT continued. The last series of blasts was conducted on October 28. The site will be cleaned for fracture mapping in November.

Technical progress was also made in the identification and evaluation of techniques and instrumentation to be used in both laboratory tests on small blocks and the LBT. Discussions with investigators at SAIC indicate there is an acoustic source that may be suitable for use on the LBT. Arrangements have been initiated with SAIC for use of this source.

Discussions were initiated with SNL to use some SNL diagnostic equipment for geomechanics data collection in the LBT. This collaboration would benefit both WBS 1.2.2 and 1.2.4. A proposal was also received from G. Danko, University of Nevada, to install REKA probes in the LBT. His effort would be co-funded, roughly equally, by WBS 1.2.2 and the YMPO-funded University grant program.

Authorization has been received from YMPO to use a radioactive sealed source as part of the moisture density measurement tests on the LBT.

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

New Zealand

Preliminary results from the biodegraded cement cores obtained last month indicate the presence of both thiobacillus and nitrifying bacteria. Steps are being initiated to set up a contract with Biodegradation Systems, Inc. to continue the work during FY94.

Diesel Exhaust

A dialogue has been initiated with J. Younker, M&O Performance Assessment, to discuss the potential chemical ramifications of the presence of diesel exhaust in the ESF and ultimately the potential repository at Yucca Mountain.

A. Meike has provided a draft response to reviewer's comments on the white paper "Chemical and Mineralogical Concerns for the Use of Man-Made Materials in the Post-Emplacement Environment". A formal reply will be provided during the month of November.

The draft Man-Made Materials Study Plan (SP 8.3.4.2.4.5) has been submitted to LLNL QA for review.

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

A milestone report (MOL07) summarizing the experimental data and analysis of the uranium dissolution rates from experiments outlined in the initial test plans for activities D-20-53(a) at LLNL and D-20-53(b) at PNL, has been completed. The forty-two tests examined the effects of temperature and concentrations of carbonate, oxygen and hydrogen ions on aqueous dissolution of UO_2 and spent fuel.

Both sets of data show the expected linear Arrhenius type dependence of the logarithmic dissolution rate on inverse temperature, although the slopes (activation energies) are different for UO_2 and spent fuel. Increased levels of dissolved oxygen increase the dissolution rate in both, but the effects vary in magnitude. Whether the differences are significant is yet to be determined. The dissolution response to carbonate concentration seems nonlinear in both studies, even in log-log plots. The cause or importance of this is not yet clear. The effect of pH on the uranium dissolution rate seems random. In the case of spent fuel, the pH response is almost flat. However, the pH effect on UO_2 is more spread out. The data give some indication that increasing pH results in increased UO_2 dissolution. However, such an apparent effect is strongly influenced by two or three data points. Without the effect of these few points, the effect of pH on UO_2 dissolution would also look random.

There are several noteworthy features of the UO_2 and spent fuel data sets. The most significant feature is that the mean dissolution rates(DR) of the two similar studies are not much different. The mean dissolution rate for the spent fuel is 2.5 $mg/m^2/day$ (log DR=0.4). The UO_2 mean dissolution rate is 4.3 $mg/m^2/day$ (log DR=0.63), less than a two-fold difference. There is a larger spread in the UO_2 data than that of spent fuel, about 50% as measured by the inter-quartile range (IQR). The IQR is the difference in dissolution rate between the 75th and 25th percentile and is a measure of data spread. The median and mean dissolution for the spent fuel data are similar, indicating a somewhat normal distribution. The median of the UO_2 dissolution rates is lower than the mean because the mode (or most frequently occurring rate) is higher than the mean.

Specimens of ATM-104 (PWR) and ATM-105 (BWR) spent fuel are being prepared for use in dissolution tests with oxidized fuel. Part of the preparation involves exposing short sections (about 20 mm long) of the fuel and its associated cladding

to deionized water for one week. These waters will be analyzed to determine the so-called gap inventories of Cs-137, I-129, and other radionuclides. Following the water exposure, portions of each fuel will be oxidized to U_3O_8 for use in flow-through dissolution tests. Other portions are ground and screened to produce specimens consisting of individual grains. These will be subjected to short-term dissolution tests designed to measure the grain-boundary inventories of Cs-137, I-129, and other radionuclides. The specimens will then be used in flow-through dissolution tests where the results will be compared with test results from other specimens of ATM-104 and ATM-105 fuels that were oxidized to U_4O_{9+x}.

A draft paper written by S. Steward and H. Weed describing the LLNL UO_2 dissolution work has been submitted to the Fall 1993 Materials Research Society Meeting in Boston for review. It will be submitted to YMPO for approval when the MRS comments are resolved. It will eventually be published in the proceedings of the symposium entitled "Scientific Basis for Nuclear Waste Management XVII".

Spent Fuel Oxidation

A rough draft of the TGA Test Plan Addendum has been completed. Corrections and revisions are underway and will be completed in October.

Dry Bath Testing

Drybath testing continued without incident. The next interim examination is scheduled in December.

Thermogravimetric Apparatus (TGA)

The draft report on the Thermogravimetric Apparatus high temperature oxidation performance of spent fuel is almost complete. X-ray diffraction (XRD) analyses were performed on a 185 mg fragment of BWR (ATM-105) fuel that was oxidized at 283°C for 793 hours to a final oxygen-to-metal ratio of 2.79 and on a 194 mg fragment of ATM-105 fuel that was oxidized at 325°C for 120 hours to a final oxygen-to-metal ratio of 2.73. In both cases, the analysis indicates almost complete conversion to U_3O_8 with only a small amount of U_4O_9 remaining. Subsamples are awaiting scanning electron microscope (SEM) analysis.

A 207 mg fragment of ATM-105 fuel was oxidized in TGA#1 at 304.5°C for 210 hours. Again, no sustained plateau was observed; however, the rate of oxidation for the first 16 hours was ~5 times the rate for the remainder of the test. Using this change in rate to define the first plateau, a plateau at an oxygen-to-metal ratio of 2.39 was reached after 16 hours. The second plateau was reached after ~150 hours and reached an oxygen-to-metal ratio of 2.75. The sample has been unloaded and is awaiting subsampling for XRD and SEM analyses. The fragment had broken into powder.

TGA#1 has been reloaded with a 203 mg fragment of ATM-105 fuel, and a test at 270°C has been initiated.

Materials Characterization Center (MCC) Hot Cell Activities

Old and unusable samples of spent fuel prepared by the MCC are going to be packaged and consolidated for storage. These samples are unusable due to contamination in the hot cells and have presented inventory problems. Consolidation will simplify accountability of special nuclear materials.

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 90 months. Enough liquid should have collected since the last sampling period to allow for some useful additional testing in support of EBS design to be done.

The N3 tests (ATM-10, a West Valley actinide-doped glass) continue and have been in progress for 71 months.

The next QAC surveillance has been scheduled for December.

Due to continued low funding, no work was done in the following areas:

1) Static Leach Testing of WVDP and DWPF Glass
2) Parametric Studies of WVDP and DWPF Glasses Based on the Unsaturated Test
3) Parametric Studies of WVDP and DWPF Glass
4) Studies of Glass Surface Layers and Precipitation
5) Development of Licensing Database for Glass Waste Form Materials Interactions

1.2.2.3.2 Metal Barriers

The need to modify and update the present Metal Barrier Scientific Investigation Plan (SIP) is obvious in light of project emphasis on advanced conceptual designs, particularly those involving multiple barrier waste packages. The present SIP, dating from 1987 with some format revisions made in 1989, is limited to the conceptual design (single metal barrier used in thin section). The revised SIP is a high priority for this WBS element.

During review of the draft degradation mode survey prepared on carbon steels, alloy steels, and cast irons as possible corrosion allowance materials in multiple barrier waste package designs, it was apparent that the current draft did not adequately address a wide enough range of environment conditions and did not

cite a large enough base of references. Therefore, the document needs more work before publication. A possible principal investigator (outside the Laboratory, but formerly a YMP participant) to modify and extend the current draft has been identified, and a sub-contract arrangement is being pursued.

Crack growth test work is sub-contracted to Argonne National Laboratory (ANL), with D. Diercks serving as the Principal Investigator and J. Park as Co-Investigator. J. Bates manages the QA aspects of the work. YMP sponsorship of the ANL work was resumed in August 1993 after a two-year hiatus during which one test cell was maintained in operation under internal ANL sponsorship. The work is centered on measuring very slow crack propagation in pre-cracked compact tension specimens. Crack growth is determined by measuring the very small changes in electrical resistance of the specimen as the crack propagates. Thus far, more than 20,000 exposure hours have accumulated. Specimens of 304L and 316L stainless steels and nickel-base Alloy 825 are being tested in 90°C simulated J-13 water under a load ratio of 0.9. This load ratio corresponds to a stress intensity of 25 MPa-$m^{1/2}$, which is a severe mechanical stress condition for these materials. Resolution of any crack extension corresponds to crack growth measurements on the order of 10^{-12} m/s; the significance is that crack would require more than 300 years under continuously wet conditions to penetrate a one-cm thick container wall. The work is planned to continue through FY94. D. McCright is planning to visit ANL in November to discuss the work and to make plans for additional test cells and specimens. The work in FY94 will emphasize corrosion resistant materials that could be used in multiple barrier container designs and to test in more aggressive environmental conditions. A report summarizing the work completed through FY94 is in preparation by the ANL principal investigators.

Work is continuing on setting up a slow crack growth rate measuring system, similar to that being used for YMP-sponsored work at Argonne National Laboratory, in our own laboratory. This apparatus will be used for determining stress corrosion resistance of corrosion allowance materials, and would complement the Argonne work. J. Estill and S. Gordon are working with personnel from General Electric (manufacturer of the unit) to update and modify the software, which was purchased with the unit.

The Cahn Thermogravimetric Apparatus (TGA) unit was received in early October and is being installed in the laboratory. The TGA unit will be used to determine the temperature-humidity relationship for formation of water layers that cause corrosion cells to initiate on a metal surface. It is expected that formation of the critical amount of water on the surface will lead to a discernible difference in weight gain due to the initial rapid kinetics of aqueous corrosion. Various specimen geometrics are being considered, and a number of different corrosion-active metals are proposed for the first round of studies.

G. Henshall has rejoined the YMP and is working to update the pitting corrosion model that he had worked on previously. The model focuses on the development and growth of critical-sized pit embryos. He is planning to perform some experimental confirmation of the model under controlled electrochemical potential and environmental conditions to determine some of the values of parameters used in the pitting model. The model will initially emphasize predictions of pitting attack on high nickel alloys.

J. Mitchell retired from the University of California on October 29. We are in the process of finding a principal investigator to replace him.

J. Farmer attended the National Association of Corrosion Engineers Conference in Houston, Texas on September 20 - 24. He replaced D. McCright as a session chairman for a waste containment session. There were several interesting papers presented during the conference on the role of water films in initiating corrosion, as well as papers on microbiologically induced corrosion of materials. Selected papers were compiled for future reference.

D. McCright presented a paper at the ASM-International and TMS Materials Week Congress held October 18 - 21 in Pittsburgh, Pennsylvania. This paper covered container materials selection for high level nuclear waste disposal. He outlined the process used in the conceptual design phase of the waste package and how the process will be modified for use during the advanced conceptual design phase.

H. Benton, D. Stahl, R. Fish, and T. Doering from the M&O attended a meeting at LLNL on October 27 to plan technical activities involving the waste package and other engineered barriers. D. McCright and R. Van Konynenburg represented the Metal Barrier task. There was a great deal of discussion on metal barrier testing and meaningful environments for testing. One important conclusion reached was that "long-term" testing should receive a high priority and begin as soon as possible. This is being taken into account in planning the laboratory work and in the planning documents Milestones and deliverables were discussed and dates reviewed for their completion.

1.2.2.3.3 Other Materials

This WBS element has not been funded in FY94.

1.2.2.3.4 Integrated Testing

1.2.2.3.4.1 Integrated Radionuclide Release: Tests and Models

<u>Determination of Elemental Profiles in Rocks, Minerals, and Glasses using the Ion Microscope</u>

Preparation of the status report on diffusion in clinoptilolite continues.

Interactions of Actinide-Bearing Solutions with Rock Core Samples

The status report on the test phase of the flow-through apparatus is in the preparation stage.

The flow-through apparatus was damaged due to overheating caused by a faulty temperature controller. The apparatus is currently in repair, and a new saw-cut core piece is being prepared.

B. Viani met with I. Triay (LANL) and A. Simmons (YMPO) on October 5 to discuss and plan experiments related to radionuclide transport. B. Viani and S. Martin toured LANL's radionuclide transport laboratory on October 15.

Due to continued low funding, no work was performed in the following areas:

1) Modeling Actinide Distribution in Tuff
2) Interaction of Materials under Repository Conditions
3) Source Term Model Development
4) Source Term Model Validation

1.2.2.3.4.2 Thermodynamic Data Determination

A total of $400k has been allocated to this task in FY94. $ 200k of YMPO funds will support experimental work. A total of $200k (half from the International Program) will support NEA data reviews. PACS accounts were established for these activities.

1.2.2.3.5 Nonmetallic Barrier Concepts

This task has recently been funded, following a three year hiatus. We are in the process of identifying a principal investigator/task leader for the work. The work planned for FY94 includes preparation of a survey on possible ceramic materials that could be used in a multiple barrier design, the state of technology in fabricating ceramics of dimensions suitable for a waste package barrier, and possible degradation modes affecting ceramics used for long-term disposal. As needed, the various planning documents for this task will be updated and modified.

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 FY94.

1.2.3 SITE INVESTIGATIONS

1.2.3.1 Site Investigations Coordination and Planning

No significant activities.

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 FY94. Funding has been requested from the YMPO WBS manager (A. Simmons) in order to write the Study Plan required by the RSED Director in FY94.

1.2.3.4 Geochemistry

1.2.3.4.2 Geochemical Modeling

Work to prepare a Version 7.2a update package for EQ3/6 continued. The package was tested on a PC platform under both DOS and Windows. Although the Windows version ran, the principal codes (EQPT, EQ3NR, EQ6, XCON3, XCON6) could not be run using interface software under DOS. We found that the executable file for an interface code must be configured after linking to limit the amount of extended memory allocated via the XMS and VCPI interfaces. In the absence of such a limit, all the extended memory is allocated to the interface code, leaving none for the principal code which the interface code is to run. Under Windows 3.1, the DPMI interface is engaged, which automatically imposes limits. This is why the software worked correctly under Windows 3.1

In addition, some effort was spent working with the Principal Investigator for the Data Base to revise the reactions for the species in the organic subset. The purpose is to allow greater flexibility to the EQ3/6 user. A new set of data files will be available in early November and included in the Version 7.2a release.

Work is continuing on EQ3/6 Version 8.0. In FY93, we completed a major re-write of the software, incorporating major changes in the data structure in order to accommodate improvements in numerical methods and the addition of new functional capabilities. This included modifying the EQ6 code to utilize the auxiliary basis concept, thus allowing it to make reaction path calculations incorporating specified redox disequilibria. This capability is important in treating the metastable persistence of dissolved components such as sulfate, nitrate, and organics in laboratory and field settings. In FY94, we are adding two additional capabilities to EQ3/6: (1) a generic ion-exchange model, and (2) correction of supporting data, mostly thermodynamic, to pressures off the 1.013 bar-steam saturation curve. Release of EQ3/6 Version 8.0 for non-quality affecting work is planned for late in FY94.

1.2.3.5 Drilling

1.2.3.5.2.2 Engineering, Design, and Drilling Support

Five logging sessions were conducted at UZ14. A total of eight runs were made with the borehole camera to accomplish a cement job inspection, monitor water movement and perform inspection of the hole. They were conducted on October 7, 12, 18, and 26. Runs were performed on October 26 and 27 using the fluid locator tool.

One logging session was conducted at UZ16. Field testing of a new color camera system, to perform a hole inspection, was completed on October 25. The system passed the field test and is now in use by the LLNL/LANL Geotechnical Engineering Group.

1.2.3.10 Altered Zone Characterization

Preliminary activites were initiated to begin experiments to evaluate the effect of relative humidity on reaction products and rates in vitric material. The sample material was prepared for initial characterization prior to loading into reaction vessels. Completion of characterization is projected for November and experimental runs will begin in December. The reaction products will be provided to Los Alamos National Laboratory (LANL) for use in studies of dehydration/ rehydration effects in single phases.

Plans for reaction precipitation studies are being developed. Existing equipment is under evaluation for suitability.

Discussions with LANL were initiated concerning the use of HFEM for coupled code efforts. The types of modifications that would be required, data inputs that could be developed using EQ3/6 output files, and methods for evaluating the effects of mineralogical changes on hydrological properties were discussed.

Additional existing codes that couple hydrological and geochemical processes were obtained. Installation of the codes is now in progresss. Test cases are in the planning stage. Code comparisons will be performed when the codes are running and the test cases are adequately refined.

The study plan for this WBS is now being written. Projected completion is May 1994.

1.2.3.11 Integrated Geophysical Testing for Site Characterization

1.2.3.11.3 Geophysics - ESF Support, Subsurface Geophysical Testing

PACS planning was completed for this new WBS element.

1.2.5 REGULATORY

1.2.5.1 Regulatory Coordination and Planning

W. Halsey participated in PACS planning for PA activities.

1.2.5.2 Licensing

1.2.5.2.2 Site Characterization Program

LLNL participated in the NRC-DOE Technical Exchange held on October 13 and 14 in Los Alamos, New Mexico. The technical exchange was concerned with both the far-field and near-field phenomena related to radionuclide releases from the EBS. T. Buscheck presented "Modeling Effects of Heat on the Saturation of Rock and on the Circulation of Air and Water Vapor" and "Modeling of Dripping in Fractures in the Heated Zone". B. Viani presented "Integrated Testing" on October 14. W. Halsey presented "Conceptual Models for Releases of Radionuclides from the EBS in Realistic Near-Field Environments" to illustrate how near-field processes are incorporated into subsystem models and the performance assessment source term. D. McCright presented "Experiments on the Interaction of Steam and Water with Components of the EBS"; this talk also included some recent results obtained in the Man-Made Materials Task (WBS 1.2.2.2.5) on the pyrolysis of diesel fuels with steam to form carboxylic acids that would create a more aggressive environment toward iron-base materials (carbon steels, low-alloy steels, and cast irons) used as an outer corrosion-allowance barrier. R. Van Konynenburg presented "Radiation Effects on Environmental Conditions"; This talk included detailed discussion of the chemical species that could form due to gamma radiation in Yucca Mountain repository environments and what the consequences of these species would be on the metal container and other parts of the engineered barrier system. He also discussed the effect of additional shielding (increased thickness, additional barriers) on reducing radiolysis effects and on radiation effects related to worker safety.

D. Wilder presented "Thermal Testing Update" at the NWTRB meeting in Las Vegas on October 20, 1993.

1.2.5.3 Technical Data Management

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

Development of a Windows/4GL (mouse-driven) version of JEWEL is continuing. This program facilitates interactive point-and-click generation of customized thermodynamic data files for EQ3/6, GT, and other geochemical modeling packages.

A revised and improved set of auxiliary-basis aqueous species for writing dissociation reactions involving organics was generated. Such reactions were revised accordingly for a large number of aqueous organic species. This update will significantly improve the accuracy of EQ3/6 speciation and mass transfer models for organic and inorganic/organic systems.

1.2.5.3.5 Technical Data Base Input

Technical data submissions were included in PACS milestones for data generating activities.

1.2.5.4 Performance Assessment

1.2.5.4.2 Waste Package Performance Assessment

Participation in the Total System Performance Assessment 1993 (TSPA-2) continued. Final borehole-emplacement hottest-fuel temperature histories were provided to SNL with compromise boundary conditions imposed on the rock wall. This compromise applied the SNL-calculated temperatures for waste package surface onto the rock wall, and should represent the early time thermal transient fairly well with moderate errors at long times (perhaps 20 degrees high at 1000 years). Initial text has been provided to SNL for Sections 5.1 and 5.2 of the report. Several LLNL staff participated in a TSPA-2 preliminary briefing to YMPO in Las Vegas on October 21 and 22.

W. Halsey presented a paper entitled "Engineered System Performance Assessment" at the special session on "Materials Selection and Corrosion for High Level Nuclear Waste Storage Containers" at the ASM/AIME Materials Week in Pittsburgh, Pennsylvania on October 20.

The paper entitled "The Role of Multiple Barriers in Assuring Waste Package Reliability" by R. Bradford was approved by YMPO.

1.2.5.5. Special Projects

1.2.5.5.1 Integrated Test Evaluation (ITE)

This activity has not been funded in FY94.

1.2.5.5.2 Energy Policy Act Support

No significant activities.

1.2.9 PROJECT MANAGEMENT

1.2.9.1 Management and Coordination

1.2.9.1.2 Technical Project Office Management

J. Blink escorted several groups at the Large Block Test on October 6 and 21: the Dan Dreyfus tour, the Hydrology Integration Task Force tour, Nye County representatives, and three NRC representatives. The NRC contact was reported to YMPO. A sample provided to the Nye County representatives was reported to the SMF. J. Blink also briefed Sean Kennedy of OCRWM on October 6 and 7.

W. Clarke attended the TPO meeting in Las Vegas on October 25. J. Blink attended the TAG meeting on October 8 in Las Vegas. J. Blink attended IRAT meetings on October 7 (Las Vegas) and on October 28 (Denver). J. Blink attended a Cost Reduction Steering Committee meeting on October 13 and 18 and the Monthly Management meeting on October 29.

J. Blink attended a LESSON-NV subcommittee meeting on October 29. He presented hands-on science programs at Ruby Thomas School on October 8 and Fitzgerald School on October 18. He also presented a laser workshop as part of DOE-NV's Science Now day on October 14 and an energy workshop for the University of Nevada Environmental Outreach Program at Bridger Junior High School on October 19.

1.2.9.2 Project Control

1.2.9.2.2 Participant Project Control

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

1) EBS Field Tests, 1.2.2.2.4
2) Spent Fuel, 1.2.2.3.1.1
3) Project Control, 1.2.9.2.2
4) QA Quality Implementation, 1.2.11

LLNL-YMP completed the FY93 Year-End Financial Closing. The total of costs, obligations and commitments show that LLNL expended 98% of our total FY93 budget. Efforts to complete the Basis of Estimates package were tabled to allow for year-end closing.

FY94 PACS cost, schedule, workscope, and milestones were submitted to YMPO via the PACS workstation. Data are being adjusted as input is received from DOE WBS managers, the M&O, and other participants. A list of anticipated obligations for each two week period from October 22 through December 2 was submitted to

YMPO for FY94 continuing resolution. A series of FY94 internal financial planning documents were prepared in support of DOE/LLNL exercises. An initial LLNL-YMP allocation of $20k was included in the REECo budget; these funds will be used to cover Nevada expenses for vehicles, phones, radios, etc. Work orders are being established.

Findings are scheduled to be released during the month of November from the IG audit of the LLNL-YMP program which was conducted by five auditors for two days during the month of September. The primary focus was on a detailed examination of costs and technical achievements during FY92 and FY93.

The Socioeconomic Procurement Monitoring Data Report for the period of April 1 through September 30, 1993 was submitted to YMPO.

1.2.11 QUALITY ASSURANCE

1.2.11.1 Quality Assurance Coordination and Planning

R. Monks attended meetings regarding quality assurance in Las Vegas on October 18 and 21 and participated in Requirements Traceability Network (RTN) training in Las Vegas on October 29.

1.2.11.2 Quality Assurance Program Development

LLNL-YMP procedure revisions, to assure compliance with new QARD and matricing requirements, have been completed. Data entry into the RTN is now in progress.

1.2.11.3 Quality Assurance Verification

1.2.11.3.1 Quality Assurance Verification - Audits

A schedule for internal and external audits to be performed during FY94 was submitted to YMPO on October 22.

A package representing corrective actions taken to resolve Corrective Action Report (CAR) YM-93-085 (Annual Evaluation of Sub-Contractor QA Programs) resulting from audit YMP-93-14, was submitted to YMPO on October 25 for review and verification.

LLNL requested an extension to December 31 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

No significant activities.

1.2.11.5 Quality Assurance - Quality Engineering

No significant activities.

1.2.12 INFORMATION MANAGEMENT

1.2.12.2 Records Management

1.2.12.2.2 Local Records Center Operations (LRC)

In October, Document Control issued no new revisions and one change notice. Michelle Stewart has assumed the responsibility of Document Control Coordinator and Publications Manager.

1.2.12.2.3 Participant Records Management

A total of 175 items were logged into the LLNL-YMP tracking system. This includes 29 records/records packages that were processed through to the CRF. Twelve action items were closed.

B. Bryan and J. Sippel attended a Records Management meeting held in Las Vegas on October 25 and 26.

1.2.12.2.5 Document Control

LLNL received no funding under this WBS for FY94. Work performed to complete LLNL's obligation in this WBS is funded under WBS 1.2.12.2.2.

1.2.13.2 SAFETY AND OCCUPATIONAL HEALTH

1.2.13.2.5 Occupational Safety and Health

J. Blink reviewed minutes of safety meeting.

1.2.15 SUPPORT SERVICES

1.2.15.2 Administrative Support

LLNL's input to the Site Characterization Progress Report (PR 9) was submitted to YMPO on October 7.

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

Currently there are 87 participants on the project who are to be trained and/or tracked.

During October, nine LLNL-YMP participants left the project and six new participants were added. 138 self-study assignments were processed.

Newly revised training matrices are now in effect and were used to complete the Management Re-Certification process. The revised matrices have significantly reduced the amount of "just-in-case" training by allowing management to specify "before use" training.

PACS training for LLNL-YMP Account Managers will be held in November.

J. Blink attended Underground Worker Training at Area 25, Nevada Test Site, on October 19.

LLNL PROJECT STATUS REPORT DISTRIBUTION

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Lawrence Livermore National Laboratory

LLYMP9312
December 15, 1993

WBS 1.2.9
QA: N/A

I-351109

Robert M. Nelson, Jr., Acting Project Manager
Department of Energy
Yucca Mountain Project Office
P.O. Box 98518
Las Vegas, Nevada 89193-8518

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

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

If further information is required, please contact Carol Passos at 702-794-7511 or Jim Blink at 702-794-7157.

Sincerely,

for W.L. Clarke
LLNL Technical Project Officer
for YMP

WC/CP

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.

ENCLOSURE 3

Lawrence Livermore National Laboratory

LLYMP9312093
December 15, 1993

WBS 1.2.9
QA: N/A

J. Russell Dyer, Acting Project Manager
Department of Energy
Yucca Mountain Project Office
P.O. Box 98518
Las Vegas, Nevada 89193-8518

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

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