

JAN 21 1994

MEMORANDUM FOR: B. J. Youngblood, Director
Division of High-Level Waste Management

THRU: Margaret V. Federline, Chief
Hydrology and Systems Performance Branch
Division of High-Level Waste Management

FROM: Donald L. Chery, Jr.
Hydrologic Transport Section
Hydrology and Systems Performance Branch
Division of High-Level Waste Management

SUBJECT: TRIP REPORT FOR 1993 INTERNATIONAL HIGH-LEVEL
RADIOACTIVE WASTE MANAGEMENT CONFERENCE

Enclosed is the trip report for the Division of High-Level Waste Management staff attendance at the 1993 International High-Level Radioactive Waste Management Conference in Las Vegas, Nevada, April 27-30, 1993.

15

Donald L. Chery, Jr.
Hydrologic Transport Section
Hydrology and Systems Performance Branch
Division of High-Level Waste Management

DISTRIBUTION

Central File	BJYoungblood, HLWM	JJLinehan, HLWM	HLHP r/f
MVFederline, HLHP	RLBallard, HLGE	WReamer, HLPD	NMSS r/f
CNwRA	LSS	LPDR	ACNW
PDR	KChang, HLGE	RCode11, HLHP	NColeman, HLHP
MDelligatti, HLPD	NEisenberg, HLHP	HLefevre, HLGE	KMcConnell, HLGE
SMcDuffie, HLGE	MNataraja, HLGE		

OFC	HLHP	E	HLHP	E	HLHP	E	HLGE		HLPD	E
NAME	DLChery/cj		DJBrooks		MVFederline		RLBallard		RCReamer	
DATE	01/19/94		01/19/94		01/19/94		01/21/94		01/24/94	

C = COVER
G:\93IHLRWM.DLC

E = COVER & ENCLOSURE

N = NO COPY

010114
9402040141 940121
PDR WASTE
WM-1 PDR

109.2
412
WM-1
NH16

TRIP REPORT

DHLWM PARTICIPATION IN THE FOURTH INTERNATIONAL HIGH-LEVEL RADIOACTIVE WASTE MANAGEMENT CONFERENCE, APRIL 26-30, 1993

Contributors

K. Chang, D. Chery, R. Codell, N. Coleman, M. Delligatti,
N. Eisenberg, H. Lefevre, K. McConnell, S. McDuffie,
M. Nataraja

BACKGROUND AND PURPOSE

The Fourth Annual International High-Level Radioactive Waste Management Conference (IHLRWMC) was held in Las Vegas, Nevada, April 26-30, 1993. Staff from the NMSS Division of High-Level Waste Management (DHLWM) attending the conference were J. Linehan, K. Chang, D. Chery, R. Codell, N. Coleman, M. Delligatti, N. Eisenberg, R. Johnson, P. Justus, H. Lefevre, S. McDuffie, M. Nataraja, and J. Park. The conference provided an international forum for sharing information, experience, and expertise related to the disposal of high-level radioactive waste with a particular focus on geologic repositories. The theme of the 1993 conference was "Sharing Technologies for Common Needs."

The DHLWM staff participated in the conference to obtain information on the more recent developments and findings with respect to the issues of interest in the regulatory program including site characterization, aqueous flow and transport in unsaturated and saturated systems, infiltration and climate, tectonics and volcanism, repository performance assessment, expert judgment, rock mechanics, containers and containment barriers, risk perception, and communication. The staff also learned about programs and progress in the management of high-level waste in other countries. Of particular interest to the NRC staff was recent information about the status of the Yucca Mountain project and related technical activities. Further, the staff contributed to the program by participating in the organization of sessions, chairing sessions, and presenting technical and programmatic papers.

SUMMARY OF ACTIVITIES

On Monday preceding the conference (4/26/93) J. Linehan, D. Chery, M. Delligatti, N. Eisenberg, P. Justus, M. Nataraja, and J. Park of the NRC/DHLWM staff made a field trip to the Yucca Mountain site led by DOE staff. The tour had stops at the DOE Yucca Mountain Project Field Operations Office where P. Justus showed the NRC office and gave a short orientation. Following the orientation, there were stops at the Exploratory Studies Facility (ESF), North Portal, the LM-300 drilling rig, Yucca Mountain crest, Trench 14, the Hydrologic Research Facility, and the Sample Management Facility.

Also on April 26, other NRC staff including N. Coleman, J. Gilray, H. Lefevre, K. McConnell, S. McDuffie, and Paul Pomeroy, member of ACNW, and R. Major, ACNW staff, made an informal NRC Yucca Mountain field trip. This trip included stops the C-hole complex (discussion by Neil Coleman), the north portal of the Exploratory Studies Facility, the Fran Ridge fracture mapping test area, Crater Flat in the area of Red and Black Cones (a stop was made near the Lathrop Wells cone where S. McDuffie gave a brief overview of DOE volcanism investigations), and two stops at trenches along the Solitario Canyon fault, where the volcanic ash embedded along the fault plane was observed. The purpose of the trip was to become familiar with recent activities at the site in preparation for the upcoming NRC/DOE (May 25-26, 1993) site visit.

Tuesday through Friday (April 27 - April 30, 1993), the staff attended the 4th Annual International High-Level Radioactive Waste Management Conference which had an opening plenary session and three special plenary sessions addressing issues of "Effects of the '92 Nevada Earthquake," "Yucca Mountain in the News: Information, Content, Signals, and Sources," and "Human Factors and Waste Management." Following the plenary sessions were 69 different technical sessions.

Sessions Chaired:

Kien Chang co-chaired Session "Waste Form Characteristics Affecting Design and Safety" with Hersh K. Manaktala, CNWRA.

Donald Chery, Jr. co-chaired the session "Multiphase Flow in Single Fractures" with Joe Wang, LBL.

Norman Eisenberg co-chaired the session "Selected Topics in Performance Assessment" with Abraham Van Luik, Intera, Inc., Las Vegas.

Papers Presented:

Richard Codell presented a paper, "Model for Release of ¹⁴C from Spent Fuel," in the session "Total System Performance Assessment-I."

Neil Coleman presented a paper, "Groundwater Impacts of Foreseeable Human Activities on a HLW Repository," in the session "Total System Performance Assessment-II."

Norman Eisenberg was a panelist on the panel discussion of "Working Definition of Scenario and a Method of Scenario Construction."

Robert Johnson presented a paper "Nuclear Regulatory

Commission Staff Development of the License Application Review Plan for a High-Level Radioactive Waste Repository" by R. Johnson, J. Holonich, M. Lee, and M. Delligatti.

Harold Lefevre co-authored a paper presented by Michael Miklas of the CNWRA. The paper was titled "Analyses of Natural Resources in 10 CFR Part 60 as Related to Inadvertent Human Intrusion."

Keith McConnell was a panelist on the Plenary Session on the 1992 Little Skull Mountain earthquake.

Keith McConnell made an oral presentation on the Staff Technical Position on the "Investigations to Identify Fault Displacement Hazards and Seismic Hazards at a Geologic Repository."

Organizational Activities:

Donald Chery, Jr. participated in the Technical Program Committee meeting.

John Linehan participated in the Conference Steering Committee meeting.

Other Activities:

Norman Eisenberg met with Johan Andersson, SKI, to discuss the joint NRC/SKI validation strategy activity.

Norman Eisenberg attended the meeting of the ASME, Nuclear Engineering Division, High-Level Radioactive Waste Committee (HLWC) meeting, April 28, 1993, from 6:30 to 9:00 p.m.

Keith McConnell attended the LYNX software demonstration on the afternoon of April 30.

Mysore Nataraja reviewed some Determination of Importance Evaluations (DIEs) for Phil Justus.

IMPRESSIONS AND COMMENTS

PLENARY SESSIONS

Opening Plenary:

Governor Miller of Nevada said that it was two years since he last spoke to the conference, but that Nevada was still opposed to the repository. The argument put forth by DOE that jobs and monetary compensation would accompany the repository reminded him of the movie, "Indecent Proposal." Nevadans are opposed to the

repository because they distrust DOE and they distrust NRC and their licensing process almost as much. DOE earned this distrust by having no viable backup site. Miller felt that DOE has no intention of walking away from its billion dollar ESF. Other DOE activities such as promises of support money to legislators and "contaminated science" produced by scientists trained in public risk techniques induce further distrust. He said DOE is attempting to coopt university scientists through funding and thus applauds withdrawal of funding from Nevada Universities. In conclusion, Governor Miller made it clear that he opposed the "scientifically flawed boondoggle of Yucca Mountain." Governor Miller also believes that NRC is not much more trustworthy than DOE, saying that it is hard to imagine NRC would find Yucca Mountain unsuitable after so much money has been invested there and no alternate site presently exists. Finally, the Governor suggested that dry cask storage be more closely examined as a long-term solution for spent fuel.

Frank Peters, Deputy Director of the Office of Civilian Radioactive Waste Management (OCRWM), brought greetings from Secretary O'Leary and Lake Barrett. He stated that the program is being refocussed to emphasis the highest quality science and the inclusion of outside views. Further, a position of Chief Scientist had been added, stakeholder involvement would be pursued, and the program would not be unduly driven by schedule. The Chief Scientist would oversee the scientific investigations at Yucca Mountain with a primary responsibility of assuring that all work conducted at Yucca Mountain is of the highest scientific quality, assuring that the work is focused on resolving issues that critical to determining the suitability of the site, and establishing a systematic peer evaluation process that would include nationally recognized experts in appropriate scientific disciplines. Mr. Peters said that recent accomplishments were starting the ESF, scheduled letting of a contract for the TBM in May 1993, planning for drilling additional boreholes, and initiating a public relations activity of sending program information by satellite to science teachers.

The opening plenary continued with Chris Whipple, Chairman of the Board on Radioactive Waste Management of the National Research Council of the National Academies of Science and Engineering, discussing health standards for the repository. His opinion is that the final EPA standard should: 1) be a measurable limit; 2) have a standard of proof that is achievable; 3) have criteria that agree with what we perceive as the risks of the repository. The final standard should not be written such that it allows waste disposal anywhere or prohibits it everywhere. He contended that early standard development focused on site selection and that now the current standard focuses on protecting populations, not individuals which is an unusual approach. He also thought that a generic standard may not be supportable.

John Cantlon, Chairman of the Nuclear Waste Technical Review Board (NWTBR), articulated the need for an overall system plan for high-level waste management. In March the NWTBR issued a report to Congress with three main recommendations: (1) establish a more flexible, realistic schedule, (2) consider all the different types of waste that must be accommodated by the repository, (3) provide for independent evaluation of the management and organization of OCRWM. In commenting on the high-level waste program, he indicated that it has a non-realistic (not long enough) schedule that is program-driven and recommended that a flexible, long term program be developed in order to assure high quality of the scientific investigations. He further concluded that, based on currently available information, the NWTBR has identified no basis for rejection of the Yucca Mountain site.

In summary, it was interesting to note the opposite perspectives that have been taken by two parties to the high-level waste program (State of Nevada and the DOE) relative to the site characterization process. Nevada's Governor Bob Miller, on one hand, contends that the proposed site is being constructed, not characterized while, on the other hand, Frank Peters of the DOE's Office of Civilian Radioactive Waste Management (OCRWM) program contended that the site is being characterized, not constructed.

The opening plenary was concluded with a keynote speech - "Safety of Nuclear Energy in Russia and Eastern Europe," delivered by The Lord Marshall of Goring, England. Some of the interesting insights provided by the speaker included: (1) collapse of the Soviet system has not affected the power generation in the Former Soviet Union (FSU), because the power station operators are largely isolated from the larger society and control the communities near the power stations; (2) some of the problems with the failed Chernobyl reactor included a large positive void coefficient, a positive power coefficient, and bad design for the control rods; (3) some of the operators at Chernobyl who abandoned their posts are still employed; (4) the Chernobyl sarcophagus is holding up, but the internals are collapsing; (5) the Armenian reactor at Yerevan is critical, because other energy pipelines, going through Azerbaijan, have been shut off. In summary the speaker said that Western organizations have criticized the Eastern societies, sought governmental funds to intensify the criticism, while the Eastern operators of the nuclear power plants are the true customers for help from the West. Practical assistance would be the most useful thing provided by the West, e.g., fire-retardant paint and ultrasound equipment. Western scale assistance, e.g., integrating technologies, are not as useful. Assistance to a user's group is probably unworkable because of the political differences among the states of the FSU. Although this talk was quite interesting, a direct relevance to high-level waste management was not apparent.

Plenary on Effects of the '92 Nevada Earthquake

James Brune, U. of Nevada, Reno, Winn Wilson, DOE, and Larry Engwall of Office of Civilian Waste Management (OCRWM) M&O spoke at this plenary session. Jim Brune gave an overview of the seismic information derived from the Little Skull Mountain earthquake, approximately 14 miles from Yucca Mountain. The fault plane responsible for the tremor is believed to be a normal fault 10 km below the surface, with a dip of approximately 50 degrees. The offset near the focus was probably about 1.5 feet. Brune also discussed his study of precariously positioned rocks in the Yucca Mountain area. Many such rocks he found would be jarred loose by ground acceleration less than .1g, leading him to believe that no major earthquakes have occurred near Yucca Mountain in the recent past. In his view the Little Skull Mountain earthquake was triggered and related in time to the magnitude 7 Landers, CA, earthquake.

Winn Wilson indicated that confirmation was obtained that the underground forces were less than the surface forces, a well-known effect. Most of the damage at the site was minor. Prefabricated buildings (e.g., Sample Maintenance Facility) did very well; the Field Operations Center suffered \$400 in damage. Kevin Coopersmith classified earthquake hazards as (1) surface fault displacement, (2) strong shaking, and (3) ground failure. He then discussed the derivation and meaning of the seismic hazard curve. He has taken displacements greater than 10 cm as causing damage to the waste package. He made it clear that, in his view, seismic hazard was just one element in a total system performance assessment.

Larry Engwall, OCRWM M&O, presented more information about the Little Skull Mountain earthquake. The ground acceleration from this event at the surface above the X tunnel in Little Skull Mountain is estimated to have been about .1g, but only .02g inside X tunnel. No new cracks in X tunnel were observed after the seismic event. Engwall also stated that there was no detectable movement in the Midway Valley trench.

This plenary discussion ended with a panel discussion. Keith McConnell of the NRC participated in the panel. Carl Johnson of the State of Nevada began the discussion with his statement that geologists do not have the tools to fully understand the complex geologic system at Yucca Mountain. He later stated his opinion that it will be necessary for the applicant to demonstrate during licensing how faulting will affect the fracture system and other physical characteristics of the site, but he believes that these links will be impossible to determine. Other information coming out of the discussion was that the Little Skull Mountain earthquake caused local deviations in the water table as large as three feet and to date there is no evidence of Quaternary

movement on the Ghost Dance Fault.

Plenary on Yucca Mountain in the News Information Content, Signals, and Sources

This session provided some useful insight into the rationale and motivation for news reports on the Yucca Mountain site.

Plenary on Human Factors and Waste Management

According to some staff little useful information was provided in this Plenary.

TECHNICAL SESSIONS:

Hydrologic-Thermo Flow and Transport System Representation:

The following review is of various papers that deal with estimation of infiltration in the unsaturated zone for present and future climates, and the effects of repository heat on the hydrology of the unsaturated zone. Both areas are important to estimating the extent of contact between liquid water and the waste form, and the transport of water-borne radionuclides to the accessible environment.

Austin Long from the University of Arizona and Stuart Childs, a consultant, presented "Rainfall and Net Infiltration Probabilities for Future Climate Conditions at Yucca Mountain." The authors used synthetic time series of precipitation events based on both current rainfall and climate records, and those projected for pluvial conditions. The time series of precipitation events were then fed into a mechanistic model for runoff, infiltration and evapotranspiration in order to predict the net infiltration. Factors for the mechanistic model were estimated from indicators of past climates including chemical tracers and paleobotanical remains. The projections of future climates also try to take "greenhouse" effects into account. The estimate, using the model, indicated a net infiltration of about 1 mm/yr presently, and up to 2.4 mm/yr as far as 100,000 years into the future.

Joseph Hevesi and Alan Flint of the U.S. Geological Survey presented "The Influence of Seasonal Climatic Variability on Shallow Infiltration at Yucca Mountain." This study was similar to that presented by Long in the previous paper, but for smaller length and shorter time scales. The model simulated infiltration into alluvium and flow to bedrock, a depth of about 12 meters. This study used a 15 year synthetic record based on data from a nearby meteorological station. The model assumed the basic evapotranspiration formula with zero runoff. Percolation from the surface down

was calculated by solving the transient Richards equation for unsaturated flow. The model was used to predict the net infiltration at depth from the synthetic weather record. This simulation indicated that there would be no significant increase in water content below 2 meters deep, even after an extended period of wet weather which included a measured daily precipitation of 89 mm. Areas of Yucca Mountain where there are layers of alluvium more than a few meters thick should therefore act as buffers to infiltration from large precipitation events. The model did not take into account several mechanisms which might divert or concentrate the infiltration. These effects could not have been simulated with the one-dimensional models used in these two papers.

Thomas Robey, a Sandia contractor, presented "Numerical Methods for Fluid Flow in Unsaturated Heterogeneous Tuff," in which he used a two-dimensional model of infiltration in the unsaturated zone. The properties of the medium were generated from a geostatistical simulation conditioned on actual properties of porosity and permeability observed in the boreholes. A number of simulations with these spatially varying random fields were then performed with the unsaturated flow model using saturations observed in boreholes as boundary conditions rather than specifying an infiltration. As expected, the model showed channeling effects from concentration of the flow in selected areas caused by the spatially varying hydraulic properties. While this paper was thought provoking, it may be that the spatially varying fields were generated incorrectly, since regular geostatistical methods fail to preserve features such as layers. A paper in another session by J.D. Porter "Application of Indicator Geostatistics to the Gorelben Data Set," pointed out that only indicator geostatistics should be used when trying to generate random realizations for layered systems.

Another estimate infiltration at the Yucca Mountain site was presented by John Gauthier, Sandia, in "The Most Likely Groundwater Flux Through the Unsaturated Tuff Matrix at USW H-1." His model was a one-dimensional Darcy's equation for steady-state infiltration, which assumes that infiltration is equal to hydraulic conductivity with a gradient of unity. He performed 100 runs, in which the hydraulic conductivity for each layer was assigned randomly from a range of observed properties in the layers. The results of these model runs indicated that infiltration must have been between zero and 0.01 mm/yr to match present day conditions. These very low estimates of infiltration may be correct, but the model is incapable of simulating two-dimensional effects, transient effects, or saturated fracture flow. It may be that if these phenomena are included in the model, higher infiltration rates would be predicted for the

observed saturations.

While infiltration is certainly an important variable for transport of radionuclides, there is developing evidence that suggest that the effects of repository heat may so alter the environment of the waste packages that infiltration water will have little to do with the saturation in the near field. Several studies used sophisticated two-dimensional models with two-phase heat and mass transfer to demonstrate the zone of dry-out and saturation caused by the heat. Several critical assumptions used in these models must be field tested, and there were several papers detailing aspects of heater tests DOE is planning as part of the Yucca Mountain site characterization.

Tom Buscheck, Dale Wilder, and John Nitao presented "Large-Scale In Situ Heater Tests for Hydrothermal Characterization at Yucca Mountain." These authors have been at the forefront of model development for the effects of repository heat on near-field hydrology and gas transfer. They have been proponents of the "Extended Dry Repository" concept, in which repository heat would be used constructively to keep the waste packages dry, but have been criticized for failing to recognize the potential pitfalls in making predictions with models not properly field tested. In this paper, they appear to acquiesce to their critics, and point out that some of the phenomena included in their mathematical models are poorly understood, and that in situ heater tests will be required to provide an understanding of the coupled effects. Any such test will have to be performed quickly in order to obtain the needed information in time for licensing. It will be difficult to accelerate the test with higher heat loads and not affect coupled effects. The validation of their mathematical models with the field heater results will address the following hypotheses: (1) whether heat conduction dominates heat flow, (2) whether fracture density and connectivity are sufficient to promote rock dry-out, and (3) whether re-wetting of the dry-out zone back to ambient saturation significantly lags behind the end of the boiling period. Furthermore, they will attempt to determine whether complex coupled effects can be conservatively accounted by bounding analyses.

Karsten Preuss and Yvonne Tsang of Lawrence Berkeley Laboratory, presented "Modeling of Strongly Heat-Driven Flow Processes at a Potential High-Level Nuclear Waste Repository at Yucca Mountain Nevada." They developed two numerical models using the TOUGH code to look at the effect of repository heat at the waste package scale and repository scale. They found that thermal effects altered the magnitude and direction of liquid and gas flow, and that modeling with two-phase flow codes was essential for assessing repository performance. They modeled the

formation of a partial dry-out around the repository and a condensation halo outside the dry zone. The region of dry-out was not greatly affected by large infiltration rates. These authors were not convinced however that the model considered enough real-world phenomena to confidently predict that the region of drying could be relied on to protect the waste from infiltration of liquid water, and that more field tests of the model assumptions are necessary. They appeared to be critical of some of the suggestions by Tom Buscheck in previous papers that waste containment benefits associated with the formation of a dried out zone could be enhanced by repository heat in the "Extended Dry Repository" concept. They pointed out that increased heat loads might promote non-equilibrium flow of condensate along fractures, which was not included in any of the models, and that this could have an adverse impact on the waste. They recommended further experimental and theoretical study to develop a better understanding of liquid flow in partially saturated fractures.

George Danko and Tom Buscheck discussed instrumentation for the block-scale thermal heater experiments in "Single Hole In Situ Thermal Probe for Hydrothermal Characterization at Yucca Mountain." They discuss using REKA (Rapid Evaluation of K and Alpha), which employs a single-hole heater and probe to determine the hydrological and thermal properties of the rock necessary for proper simulation of two-phase flow, drying, and rewetting. Results from the measurements of the thermal probe must be interpreted with computer simulations of two-phase flow, and are therefore highly computer-intensive. The single hole tests on small blocks or repository rock will compliment the larger multiple heater tests conducted in the field.

Concerns about prior higher groundwater levels were discussed in a paper by Marshall, B. D., Z. E. Peterman, and J. S. Stuckless titled "Strontium Isotopic Evidence for a Higher Water Table at Yucca Mountain." A brief review of their presentation follows:

Marshall and his co-authors presented evidence of a former, higher stand of the water table at Yucca Mountain. The evidence consists of strontium isotopic data from calcite samples collected from borehole USW G-2. They state "Comparison of the [strontium isotopic data from] the four samples nearest the water table from hole USW G-2 with other secondary calcites as well as ground-water samples show that groundwater from the Tertiary aquifer is the probable source for the strontium. The strontium data clearly indicate distinct origins for unsaturated zone and saturated zone calcites, and suggest that the present water-table position may have been approximately 85 m higher in the recent past in order to explain the [strontium isotopic] values of the

four G-2 samples."

Other evidence supports the hypothesis of a higher stand of the water table. Paleo-spring deposits occur at the southern end of Crater Flat, about 20 km southwest of Yucca Mountain. Uranium series dating of those deposits shows that they were episodically active discharge sites during the Quaternary. When the springs were active, the water table (or perhaps a perched water system) must have occurred at land surface. However, today the water table is 75-120 m below land surface at the paleo-spring sites. The water table system is believed to be continuous between Yucca Mountain and the southern end of Crater Flat (no hydrogeologic flow barriers are known in this area). Therefore, a former higher stand of the water table at the paleo-spring sites would suggest a higher water table at Yucca Mountain. Two factors must be considered: (1) the apparent water table change might have been caused by vertical tectonic displacements; and (2) the isotopic data may have been influenced by a perched water system.

The first technical session on radionuclide transport was quite contentious. There was strong disagreement between Ines Triay of LANL and Gopala Rao of Howard University as to the best method of modeling radionuclide adsorption in the zeolitized tuff at Yucca Mountain.

Geologic Issues:

In the session on "Local Geologic Structure, Faulting, and Earthquakes," D. Ponce (USGS) spoke on the geophysical evidence for faulting in the vicinity of Midway Valley at Yucca Mountain. Most of the information had been presented to NRC staff at a prior site visit in September 1992. Coppersmith and others presented the results of EPRI's "Preliminary Assessment of Fault Rupture Hazard at the Yucca Mountain Site Based on Expert Judgement." This presentation revolved around EPRI's expert elicitation on fault displacement hazard and seismic hazard and the results of their analysis. All of this information was subsequently published in 1993 in EPRI report TR102000.

"Assessment of Volcanic and Tectonic Hazards to High Level Radioactive Waste" was of interest. Wallmann is a relatively new arrival to the issue of volcanism at Yucca Mountain. He developed a performance assessment model to describe the volcano-tectonic system. Wallmann considered the scenarios of faulting and seismic motion affecting repository performance, as well as two possible effects of volcanism on performance: direct disruption, and a dike acting as a dam to raise the water table. His finding is that neither faulting nor volcanism will have a significant effect on performance.

In the Regional Geologic Structure session, Howard Oliver of the USGS provided his gravity-based interpretation of Crater Flat and Yucca Mountain structure. Oliver suggested the data could represent a detachment fault dipping west beneath Yucca Mountain rather than a caldera, as has been previously proposed. Steve Young of CNWRA presented his faulting model for Yucca Mountain. Michael Cline, of Woodward/Clyde, discussed the regulatory implications of detachment faults at Yucca Mountain. He finds no evidence of Quaternary activity on such faults, and believes their only regulatory implication is in terms of pathways for radionuclide migration. The session concluded with Elizabeth Langenheim of the USGS giving a description of the buried magnetic anomalies in the Amargosa Valley. She stated that the largest of the five anomalies could possibly be a dike complex. She and her co-authors noted that three of the anomalies "...are located roughly along the continuation of a large gradient in both magnetic and gravity fields, indicating that these buried volcanic rocks may have erupted along a fault...." A drill core sample from one of the anomalies was dated at 4.3 million years.

R. Spengler (USGS) presented information on the mapping of the Ghost Dance fault at Yucca Mountain. Again, much of this information had been presented to the staff at the September 1992 site visit. Spengler reiterated that the Ghost Dance fault was now viewed as a 700 ft. wide zone of anastomosing faults that commonly offset strata 3m to 6m. Later, several presentations discussed the modelling of hydrologic flow through faults. Wang and others noted that in tunnel U12n in Rainier Mesa, that fractures and faults occasionally yield significant amounts of water, 50% to 60% of the 110 faults mapped in the drifts yielded most of the $34,800 \pm 5,300$ m³/yr of water discharged from the tunnel. The moderator ended the session by suggesting that the characterization of flow through faults was a very significant factor for site suitability determinations.

Performance Assessment:

Robert Shaw, EPRI, and Robin McGuire, Risk Engineering, Inc., presented, "Demonstration of a Risk-based Approach to High-Level Repository Evaluation 'Phase II'." They focused on the effects of heat loading and container design on repository performance. The method of analysis, favored by EPRI, generates a "tree" structure whose sequential nodes consisted of: (1) heat loading, (2) container metals, and (3) heat transfer mechanisms. Four thermal profiles in time, corresponding to four different repository designs, were considered: (1) alpha - greater than 100°C; (2) beta - always less than 100°C; (3) gamma - 100°C then drop; (4) delta - initially a decaying temperature, then greater than 100°C for a long time. The analyses provide joint distributions of package temperatures at various times and wetting conditions with heat load histories (essentially different designs) as a parameter. Performance evaluations were

made using three concepts of performance: (1) the distribution of temperature method of representing performance, (2) small effect of temperature loading on performance, given the uncertainties in the various mechanisms, methods, and (3) multiple component packages have a significant effect, while single metal containers are not as effective method.

Mike Wilson, SNL, presented, "Sensitivity Analyses for Total-System Performance Assessments." In his talk, Wilson stated that the EPA regulations do not apply to Yucca Mountain, because of the 1992 Energy Policy Act. This statement needs further explanation. Wilson also claimed that sensitivity analyses on the logarithms of the variables gave better results than raw regressions. Again, the measures of statistical significance and convergence may be better, but transforms such as these (including rank transformations) may mask important system behavior. This could cause significant sensitivity in certain parameter ranges to be missed.

Johan Andersson, SKI, and Annette McIntyre, LLNL, organized and chaired a session on Scenarios Development. The session began with two papers. T. J. Summerling gave "Scenario Development for Safety Demonstration for Deep Geological Disposal in Switzerland." George Barr gave, "A Working Definition of Scenario and a Method of Scenario Construction." The Swiss used an adaptation of the methodology developed by Sandia National Laboratory (SNL). Barr presented the OCRWM/SNL approach using FEP trees, as in the SNL TSPA.

Norm Eisenberg began the panel discussion of "Working Definition of Scenario and Method of Scenario Construction" by making the main point that there are a lot of ways to define scenarios, the definition depends on the needs of the analysis and the desires of the analyst. He explained the approach used by NRC in Phases 1 and 2 of IPA and the rationale for the NRC choice. The panel discussion that followed surfaced considerable controversy on the subject. It is apparent that the topic needs continuing discussion with DOE; NRC needs further evaluation in their analyses, and that notes need to be compared with what the international community is doing, and develop some guidance on the subject as soon as budgetary constraints permit.

Model Validation

Malcolm Siegel, SNL, presented, "Testing Models of Flow and Transport in Unsaturated Porous Media." This paper discussed plans for tests to be used in validating geochemical models used to predict radionuclide migration. Unfortunately, this effort never seems to go beyond the planning stage, similar plans were advanced when SNL was doing work for NRC. Perhaps we could encourage DOE to get on with the testing and move beyond the planning stage, even if the experimental program is not perfect.

The next paper, "Simulating the Behavior of Natural Geological Systems: Sources of Uncertainty and Bias," by D. Read et al., WS Atkins Science & Technology, was a very good paper and compared well to the NRC views on uncertainty as articulated in a Commission Paper. We could probably use some of their ideas to support our position.

Regulatory and Socio-Economic Issues

With regard to the papers given on socio-economic issues and issues related to public perception (e.g., risk/benefit of repository siting), it continues to be clear that the majority of the work is being undertaken by parties other than DOE. Hemphill (Argonne National Laboratory) and Bassett (University of Chicago) in particular, discuss this issue in their paper. They discuss the question of perception-based economic impacts. They discussed the issue of perceptions being "controlled" by one side in the debate, not allowing a full and clear picture of the economic impacts to be developed.

Allison, Argonne National Laboratory, discussed determination of risk perceptions associated with 11 nuclear facilities and their impact on local economic development. This paper complimented Hemphill and Bassett's work in that it discussed ways in which negative perceptions can be met and, to some extent, overcome to enable sites for nuclear facilities to be found.

A panel on Safeguards, Security, and Safety discussed issues of concern to both the repository and Monitored Retrievable Storage programs. Particularly, the presentations demonstrated the need for more and better communications between NRC and DOE on regulatory requirements for safeguards and security at various waste storage and disposal facilities.

In the session on Science Education and University Programs, the presentation titled "Is an Institute for the Study of High-Level Radioactive Waste Disposal Needed in Southern Nevada?" was fairly provocative. Donald Baepler of UNLV believes such an institute is needed, and suggests using the University Corporation for Atmospheric Research or the University Space Research Association as a model.

In the session on Topics Pertinent to the Development and Application of Waste Standards, Mike Miklas, CNWRA, gave a presentation on natural resources and human intrusion as they relate to 10 CFR Part 60. Floyd Galpin of EPA presented an overview of the evolution of the EPA standards for high-level waste repositories.

In the session on Regulatory Evolution in Waste Management, April Gil of DOE gave an excellent presentation on DOE's issue

resolution process. She described the means by which any issue, regulatory or technical can be addressed and clarified and then presented - through the issuance and preparation of a topical report. Topical reports can document DOE compliance with a specific portion of the applicable regulations and/or document the methodology that the DOE plans to use in demonstrating regulatory compliance. Eight issues are currently active in this process. DOE has working groups to address these several issues, and these groups are overseen by an Issue Resolution Steering Committee. Examples of issues which have working groups are volcanism, erosion, calcite-silica deposits, and seismic hazards. A topical report on extreme erosion has been completed and was submitted to the NRC on March 8, 1993.

T. W. Bjerstedt's paper "Qualification of Existing Data for the Yucca Mountain Site Characterization Project" described DOE's process for qualifying existing data using the NRC's NUREG-1298 "Qualification of Existing Data for High-Level Nuclear Waste Repositories." DOE's data qualification process was first implemented through preparation of a topical report on erosion. Most of the data used in support of this topical report was collected prior to NRC's acceptance of the DOE Quality Assurance Requirements Document. DOE has concluded, in the case of data supporting the erosion topical report, that the data collection process and the evaluation of these existing data are fully qualified and would not differ under current QA and technical procedures for Los Alamos and the U.S. Geological Survey.

Tom Williamson of Duke Engineering gave a description of the Annotated Outline process. The outline is a tool which aids in the preparation of a license application; it helps identify important technical and regulatory issues. NRC can expect to receive Revision 3 of the Annotated Outline (AO) around November 1993. Robert Johnson gave a fine presentation explaining the steps taken by NRC in creating the License Application Review Plan (LARP).

This paper complimented the staff's paper on the development of the LARP. These two papers demonstrated that NRC and DOE are working toward a mutual understanding of the requirements for repository licensing and that the prelicensing consultation process, which involves interactions with the state of Nevada and affected units of local government, has been successfully implemented. Discussions during the session at which these papers were presented also demonstrated the importance of open communications among all of the program participants.

GENERAL COMMENTS - CONCLUSION

Compared to the first conference (1990), the 1993 conference has attracted more international visibility, as indicated by the

large number of papers (70 out of 350) and sponsoring organizations from outside the U.S. The range of topics has also broadened and are more site and issue specific.

One individual had the impressions that roughly half of the papers at the conference dealt directly with Yucca Mountain and would have liked to have heard even more. However there is the problem that it was frequently the case that two or three papers that one wanted to hear were given at the same time. In its fourth year, the conference has grown to overwhelming proportions, and it is not clear that this is necessarily a good thing. Perhaps the criteria for screening abstracts could be tightened, and the content restricted to truly new information only. Nevertheless, the conference was stimulating, and brought together a large fraction of the scientists, engineers, and administrators working on high level waste in the U.S. and abroad.

For some, the meeting was helpful in becoming familiar with the many technical issues facing Yucca Mountain. For new employees most of the information presented was new.

For one, the impression was that the 1993 meeting had fewer presentations on geology-related topics than some past meetings, but that gave an opportunity to attend a more diverse mix of sessions.

For some who had not previously visited certain locations at the site, it was quite useful to go on the field trip and see the ESF construction, the Sample Management Facility, and the trench-14 for the first time.