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LET57 - Draft #2
August 11, 1987

SUMMARY REPORT OF ACRS WASTE MANAGEMENT FIELD TRIP TO UNIVERSITY OF ARIZONA AND THE NEVADA TEST SITE - July 28-30, 1987

I. Introduction

The field trip consisted of three parts:

1. A visit to the NRC supported HLW Management research program at the University of Arizona in Tucson. This included a visit to their field investigations at the Oracle Ridge Mine near Superior, AZ.

2. A visit to the DOE supported HLW Management research program in Las Vegas, Nevada. This visit included discussions with the NRC Onsite Representative (Paul Prestholt), the leader (Carl Johnson) of the State of Nevada review program organization, and USGS and DOE personnel (including personnel from the Lawrence Livermore Laboratory and the Los Alamos and Sandia National Laboratories).

3. A tour of HLW Management research activities and demonstration projects at the Nevada Test Site. This included a visit to Yucca Mountain and discussions with personnel of the U. S. Geologic Survey who are conducting onsite investigations there.

ACRS Committee members who participated in the tour included Carson Mark, Dade Moeller, Forest Remick, Paul Shewmon and Martin Steindler. Consultants taking part in the field trip included Melvin Carter, Konrad Krauskopf, Frank Parker, George Pinder, and Mihailo Trifunac. Also taking part in the trip were S. J. S. Parry, Senior ACRS Fellow, and Owen Merrill, Senior Staff Engineer, ACRS; Stephen Kale and James Knight of the DOE Staff Headquarters Office of Geologic Repositories; and Keith McConnell, Division of High Level Waste, and Thomas Nicholson, Office of Nuclear Regulatory Research, NRC Headquarters.

II. Visit to the University of Arizona (July 28, 1987)

Presentations to the Subcommittee included coverage of laboratory and field studies on borehole plugging, including the use of cement and bentonite plugs in basalt, granite and welded tuff, as well as the sealing of salt with cement, bentonite and crushed salt.

The visit to the Oracle Ridge Mine included examination of welded tuff in the field and a review of data obtained through the drilling of a series of nine boreholes in a tuff formation.

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The laboratory studies have shown that cement borehole seals, which were initially tight, will with time (7 to 9 months) become loose. A critical factor in the success of the seal appears to be the manner (and care) with which the hole is drilled. If the walls of the borehole are damaged, this can lead to a poor seal. The field studies have shown that the tuff formation "breathes." Sometimes the air flow is into the formation; other times it is out.

One interesting item reported was the development by Lawrence Livermore Laboratory personnel of a technique for electromagnetic geotomography which yields data that closely correlate with those from hydraulic tests (of permeability). Support of further development of this technique at LLL has, however, been terminated.

The major observation noted in the University of Arizona studies is that fractures within a geologic formation will dominate the flow of water through the formation. Therefore the primary need is to understand fracture flow, as well as matrix flow.

Questions raised and comments made by the Subcommittee included the following:

1. All the studies reported appear to be exploratory; there does not seem to be a focus or delineation of clear goals for the work. For example, a number of experiments have been conducted in which a variety of materials have been tested as possible seals for a range of geologic media. If these studies had been arranged on the basis of a factorial experimental design, much more information could have been extracted from the data.

2. The possible influences of chemistry on the behavior of the seals (and their bonding to the geologic medium) do not appear to have been investigated. Although both laboratory and field tests are underway, the integration of the two appears to be absent. There is no clear indication of how either set of tests complements the other. Although they are attempting to obtain a water balance in the flow tests (outlet versus inlet), this does not appear to have been successful. The outlet flow, for example, continues for some time after the inlet flow has been terminated.

3. There were also questions as to how data based on small borehole plugging experiments can be applied to the sealing of large shafts. Plastic (flexible) seals might also be considered. Finally, little attention appears to have been given to the development of methods for testing the adequacy of borehole and shaft seals in the field. This would appear to be crucial to the confirmation of the integrity of a completed repository.

4. Other questions raised included: The adequacy of their QA program; uncertainties and limitations in the data they are obtaining; and who it is that performs independent reviews of the work they are doing. In this regard, it might be noted that the headquarters NRC Project manager appears to have had a major impact on the nature of the research they are conducting.

5. Lastly, there were questions as to how successful the University of Arizona staff has been in keeping up with related research being conducted elsewhere, and the transfer of the results of their work to others. The NRC Onsite Representative (in Las Vegas), for example, had essentially no familiarity with the work being done at the University of Arizona, even though the work was supposedly being conducted primarily in support of the proposed HLW repository being considered for location in Yucca Mountain.

III. DOE Presentations in Las Vegas (July 29, 1987)

A. Presentation by NRC Onsite Representative

The opening technical presentation was made by Paul Prestholt, the NRC Onsite Representative for the proposed Yucca Mountain repository. Mr. Prestholt has a background in geology and quality assurance and appeared to have a solid grasp of the project. He accompanied the Subcommittee throughout the meetings in Las Vegas and the tours at the Nevada Test Site. Mr. Prestholt appeared to have good working relationships with the headquarters NRC Staff, the DOE Staff and the State of Nevada personnel.

Comments and observations made as a result of contacts with Mr. Prestholt included the following:

1. Both the DOE Staff and Mr. Prestholt indicated that the NRC needs to give more attention to the guidance being provided to the DOE Staff. At present, such guidance appears to be less than effective -- certain terms are not clear or need to be better defined; in some cases the DOE Staff simply does not understand what the NRC desires be done. A clear example was the fact that the NRC regulations (which are based on EPA standards) specify limitations on groundwater travel time. What is important is the travel times of the radionuclides being transported by the water. This should be indicated and/or clarified.

2. Mr. Prestholt is hampered by a lack of funds for support of travel by NRC headquarters personnel. For example, during a recent QA review of the DOE HLW research work, he requested the assistance of a QA expert from NRC headquarters. Such help was not provided due to limitations on travel funds. Mr. Prestholt also believes the project is frequently hampered by the high turnover rate of NRC personnel. New people must receive orientation both from Mr. Prestholt and the DOE Staff, with resultant delays. There also appears to be little Commissioner interaction with NRC HLW operations in the field. Except for a trip by Chairman Zech to the BWIP site, the interaction of the Commissioners with NRC and DOE personnel at the several proposed repository sites appears to have been minimal.

3. There are also questions about the availability of written reports pertaining to the HLW repository investigations and related

work. Neither Mr. Prestholt nor any of the DOE personnel had seen any of the recent ACRS reports on the HLW repository program. This includes the recent report (letter) expressing our concerns about the associated QA program. In a similar manner, none of the ACRS Subcommittee members or consultants have seen any of the quarterly reports being submitted to NRC headquarters by Mr. Prestholt. Efforts may need to be taken to make such reports more widely available.

4. Finally, the question was raised as to whether the three sites currently proposed as possible locations for a HLW repository are receiving comparable attention in terms of laboratory and field investigations, evaluations and reviews. According the the NWPA, all three should be evaluated on a comparable basis.

B. Presentation by State of Nevada Representative

The next presentation was made by Mr. Carl Johnson, Director of the Nevada Office of Technical Programs, who is responsible for reviewing the proposed repository in Yucca Mountain. Mr. Johnson's office includes 4 to 5 technical staff members, and is supported by a seven member Citizens Advisory Committee. Also interacting with his group is a seven member committee from the State legislature. Mr. Johnson indicated that, on the basis of his work, there were six critical issues related to the proposed repository in Yucca Mountain.

1. Characterization of moisture movement through the unsaturated zone.

2. Relation of the groundwater beneath Yucca Mountain to the regional aquifer system in that area. This was considered significant because such a system may be a potential future source of drinking water for the city of Las Vegas.

3. Effects of long term climatic changes. Here Mr. Johnson stated that predictions (based on historical records) are that the climate will become wetter and cooler.

4. Future faulting and other tectonic events.

5. Future volcanism.

6. Possible human interference -- natural resource exploration.

Of these issues, Mr. Johnson stated that the last three were most critical and that any one of them could (in his opinion) represent grounds for disqualification of the Yucca Mountain site from further consideration for a HLW repository.

Mr. Johnson also indicated that he was concerned about potential impacts on the site of future underground nuclear weapons

testing at the Nevada Test Site. In response, the DOE staff indicated that limitations on the ground shaking in the city of Las Vegas should assure protection of the Yucca Mountain region. Mr. Johnson also indicated that there was some potential for hydrothermal activity within the region and this was a concern to him. Overall, he stated that he is not satisfied with the DOE research program or the directions in which it is heading.

With respect to the review activities being conducted by the State of Nevada, the Subcommittee made the following observations:

1. The Staff program is funded by the DOE. Over the past six years, it was indicated that the funds provided had totalled about $100 million, a portion of which is used to provide contracts to State organizations (for example, the University of Nevada in Las Vegas and related units in Reno).* Such contracts range on an annual basis from $150 thousand to well over $1 million. In spite of this, Mr. Johnson indicated that the funding level needed to be increased.

2. The Governor of Nevada has indicated that he is opposed to the siting of a HLW repository in his State. It is his opinion that the State of Nevada has, through the nuclear weapons testing program, contributed more than its share to the Nation's nuclear programs. Since Mr. Johnson is a political appointee and must be responsive to the Governor, the objectivity of his review may be in question.

3. Although the State of Nevada and the NRC would appear to share identical objectives -- to assure that any repository located within Nevada can be constructed and operated with full protection of the health and safety of the public and the environment, and also comply with all applicable regulations -- these two organizations do not conduct any research activities on a cooperative basis, nor do they appear to share thoughts and concerns in terms of their reviews and evaluations of the Yucca Mountain project. Since their interests and roles would appear to be identical, such cooperation might be explored.

C. Presentations by DOE Staff and Contractors

Opening remarks in this portion of the program were made by Donald Vieth, former director of DOE HLW operations in Nevada. He indicated that DOE's major goals were to determine whether the geology would support a repository and to gather sufficient scientific data either to support or deny that indication, while also striving for intellectual honesty in the pursuit of these goals. To assist in these activities, they have established an "issues hierarchy" and a system for resolving each of the issues identified.

Although in a "typical" respository, access would be through a vertical shaft drilled from the surface, the Yucca Mountain site would permit access by drilling through the side of the Mountain, as

* According to DOE's "Annual Report to Congress" (DOE/RW-0144, dated April, 1987) the funds granted to the State of Nevada for FY 1983-86 totalled $7.3 M.

well as from the top. Current thoughts are that the primary entrance will be through the side.

Individual presentations were then made by DOE representatives on each of the following subject areas:

1. Site Characterization -- the objective was to provide information on what the program was designed to accomplish. Subcommittee questions pertained primarily to the performance allocations for the various site parameters -- how the individual goals or limitations were set and the basis for the specific numbers chosen.

2. Groundwater Travel Time -- the studies are designed to determine flow through the matrix and the fractures. Dr. Steindler noted that they had observed a 300 foot hydraulic discontinuity in the water table; this is similar to observations made at the BWIP site.

3. Geologic Faults -- several have been observed in the region of Yucca Mountain. Trenches have been dug to examine them in more detail.

4. Volcanism -- recent studies indicate that a nearby calandra may have been located that has an age less than 20,000 years. However, the releases appear to have declined substantially in recent history, and calculations indicate that the population doses accompanying a volanic release of material within the repository would be minimal (millirems, at most). Nonetheless, because of the interest of the State of Nevada in these matters, the DOE Staff is continuing these studies.

5. Hydrothermal Activity -- this is being investigated. Recent data indicate some potential for such activity in the area. Accompanying releases could affect the waste containers.

Following these presentations, the Subcommittee members formulated a list of questions they thought should be addressed. These were provided to the DOE Staff who offered to provide written responses, including a list of appropriate references, on each topic. The questions included the following:

1. How will the integrity of the completed repository be determined? That is, how will the integrity of the sealed shafts be assured?

2. Which is important -- the travel time of the groundwater or the radionuclides that it contains? The DOE staff is to clarify its questions regarding this issue and the Subcommittee will seek a response from the NRC Staff.

3. How were the retardation coefficients determined? In fact, could more information be provided on all the geochemistry work from the standpoint of how it was assured that collected

samples were representative, that their analyses were accurate, and that the interpretation of the resulting data were properly conducted.

4. The same information is needed regarding measurements of stress fields in the area. Where did the numbers come from? Details of the calculations should be provided.

5. Indications are that the underground nuclear weapons tests have altered (temporarily and/or long range) the water tables in the area. Data on these changes should be provided.

6. As previously indicated, the procedures for determining the performance allocations for various parameters within the HLW repository should be carefully documented and provided to the Subcommittee.

7. Finally, the Subcommittee encouraged the DOE Staff not only to seek to meet the NRC regulations in the design, construction and operation of a HLW repository, but also to assure protection of the health and safety of the public, as well as the environment.

D. Site Tours (July 30, 1987)

The third day of the field trip was devoted to a tour of relevant work and research activities within the Nevada Test Site and at Yucca Mountain. Specific items covered included the following:

1. Drilling Rigs -- included a description and tour of rigs for constructing holes up to 12 feet or more in diameter (in a single cut). Current plans call for increasing the size up to perhaps 20 feet. Newer techniques permit more rapid drilling at far reduced cost.

2. G-Tunnel -- this includes tunnels one mile or more into the side of a mountain, including excavations within welded tuff some 1400 feet beneath the surface. The tuff (which was in a thin layer that cooled rapidly) was highly fractured and cracked. Within Yucca Mountain where the welded tuff layer is thicker and cooled more slowly, it is anticipated that far less fracturing will be present.

3. Spent Fuel Test -- Climax -- this consisted of a vertical shaft down some thousand feet or more into a granite formation. Spent fuel elements from the Turkey Point (PWR) Plant were encapsulated and remotely transported and stored here for some three years, during which extensive analyses and testing were conducted. Later the fuel elements were retrieved and the tests were subsequently terminated. This was a positive demonstration of the capability to emplace spent fuel in a granite repository at depth and later to retrieve it.

4. Sedan Crater -- the Subcommittee observed the Sedan Crater that was formed by an underground 100 KT explosion in 1962 as part of the Plowshare Program. The crater is in excess of 1200 feet in diameter and 300 feet deep.

5. Yucca Mountain -- here the Subcommittee observed the site, the local geology, and interacted with the USGS Staff who are conducting field studies in the area. The studies include measurements of the porosity of the overlying soil and welded tuff, and downward migration of surface rainfall. Nearby activities include the digging of exploratory trenches to explore faults in the area. The site is in a very remote and desolate area.

Summary Comment: The Subcommittee members and consultants were unanimous in their conclusion that the field trip had been a major success. Being provided the opportunity to observe the DOE laboratory and field facilities engaged in HLW research enhanced our understanding of the work and the associated problems.

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August 10, 1987

ACRS CONSULTANT'S REPORT

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Dear Dade:

Though I was unable to attend the morning meeting at the University of Arizona due to the delay of the plane because of an intense electrical storm in Nashville, I have read all of the material sent to me and did participate in the visit to the geohydrology test site. In addition, I did participate in the discussions in Las Vegas, though I did not make the field visit. I have, however, previously toured most, if not all, of the sites.

Because of the lack of time on both occasions for full detailed discussions with the researchers involved, and without access to the voluminous documentation already available on the site, I shall restrict my comments to general impressions based upon the information that I have, recognizing that we did not have complete briefings, particularly on performance assessment that would indicate how they intend to meet the requirements of both 40 CFR 191 and 10 CFR 60.

Perhaps it would also be best to recall that the Environmental Assessments specifically do not address the system guidelines except in a preliminary and conservative way. It would be useful then to compare the technical guidelines for selection of sites for characterization and note that they must be met. They will be discussed in a manner corresponding to that outlined in the Guidelines and the EA Overview Document whose pages will be cited.

In the section on Geohydrology on page 22, it states that there are four major considerations:

1. ground water travel time and flux
2. effect of climatic changes
3. ease of characterizing and modeling the geo-hydrological system
4. local ground water used for consumption and irrigation

Since ease of characterization impacts all the others, I shall address this first, despite the fact that DOE says that "Since it is not an intrinsic physical characteristic of the geohydrological setting, this consideration is not as important as the first two considerations." This statement is true if one had infinite time and dollars and were willing to destroy the site in order to understand it. However, under the circumstances of tight money and time schedules, the logic of this escapes me because if the site cannot be

characterized and modelled in real time without endless scientific dispute, then one cannot get reasonable scientists to agree on the first two topics. Looking at all of the literature and even more importantly at what we learned on our field trip, such as that when rain water flows into the unsaturated zone, the impact is felt 5000 feet in the limestone aquifer below the tuff within one month. Visual observation of the tuff outcrops indicates it is highly fractured. Two of the topics in geohydrology about which there is not agreement even on the fundamentals is fracture flow and vadose zone flow. Yet this is precisely what one has at the Yucca Mountain site. Both are extraordinarily difficult problems. One cannot tell from the surface nor by geophysical means what are the number, orientation, size, connectiveness and chemical characteristics of the fractures. In the vadose zone, the hydraulic conductivity is a function of the head and the moisture content. Determining the moisture content in detail is difficult, and in addition, the conductivity varies depending upon whether the matrix is wetting or drying. Taking meaningful samples is also very difficult. Finally, the recharge is obtained by indirect means based upon the precipitation and the calculation of evapotranspiration. Evapotranspiration remains a black box with the empirical calculation of Thornthwaite in the 30's still the standard methodology, if any. The recharge is determined by the difference between precipitation and losses by runoff and evapotranspiration. Therefore, a small error in any of the input data can make a major difference in the output. The accuracy of the Thornthwaite formulation is low. Consequently, one can expect large differences in the source term. Taking all of these considerations into account, it is difficult to understand how one can fashion a credible model in the time available to do so.

Since the region around Yucca Mountain is a closed basin and the water in the vadose zone appears to move primarily in the fractures and joints, which one is not sure to intersect, it is difficult to measure flow times and be sure that the total flux is accounted for and that the fastest flow times have been included. As discussed above, a credible model is difficult to obtain, therefore determination of flow times and water flux with acceptable accuracy will be difficult to obtain. The effects of climatic changes can be calculated only if there is a credible model. As discussed above, that is difficult. Consequently, the effects of climatic change can be calculated only with a high degree of uncertainty.

This is not to imply that the work is not of high scientific caliber. Though we did not have time to make such determinations, the researchers are scientists with fine reputations. Rather the problem is one of approach. The problem cannot be solved scientifically with the time, manpower and funds available. Consequently, much higher reliance must be placed on the engineered barriers and an optimized combination of the engineered barriers with the natural barriers. The proper approach would be to determine precisely what can be said now with existing theory plus the advances that can reasonably be expected in the time available and the data already in hand and that which can reasonably be expected for use in license application, and design the engineering system to fulfill the system requirements with some degree of

safety. I am quite confident that this would indicate that the system's requirements could easily be met. It is less clear to me that all of the individual technical requirements can so easily be met. These determinations require a symbiotic relationship with the performance assessment group so that the most important parameters can be determined so that the investigations will focus on reducing the degree of uncertainty in the most critical items. While all of this may be happening, it was not clear to me that this was in fact the case.

In summary, to reach the goals of acceptance of waste at the repository in a timely fashion, an engineering approach to the problem is mandatory. We need as much as possible of the underlying theory, but will have to accept increased factors of safety to offset our uncertainty in theory and data.

Detailed comments on the individual presentations would require far more detailed information than we have available to us at this time.

Sincerely yours,

Frank L. Parker

FLP:bl

cc: Owen Merrill