ACNWC-0028

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Advisory Committee on Nuclear Waste
Washington, D.C. 20555

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Dear Ms. Deering,

Thank for the opportunity to participate in the ACNW's meeting on isotopic methods and their use in the Yucca Mountain site characterization program held on November 21, 1994 in Las Vegas, Nevada. We apologize for this letter report being late and due to changes in Paul Davis' WIPP program responsibilities future reports should be much more timely. We have chosen to organize this report in the following manner. A summary of our overall impressions and conclusions from the meeting is provided below and then attached you will find a table showing the objectives and conclusions of each of the presentations.

First of all DOE should be commended for presenting this valuable information to the ACNW in a timely and accommodating manner. All of the presentations were of high quality and the presenters were very responsive to all questions. We believe this topic to be of critical value to the program because isotopic dating of ground waters provides one of the only relatively direct indications of the system performance. That is, the vast majority of the characterization efforts are designed to measure input or independent model parameters. On the other hand, measurements the most relevant model output (i.e., integrated release over 10,000 years) can't be taken and isotopic measurements provide perhaps the closest analogues to those model outputs that we will ever have. In addition to providing some indication of system performance, these isotopic measurements provide an invaluable source of information that can and should be used to assess the conceptual models and parameter input for models of total system performance.

While the intent and potential use of these methods is in line with the programmatic needs, the information presented at the meeting was at first difficult to sort through with respect to the ultimate use of the data. In fact, one could have been left with a feeling that these methods have a great potential for misuse, especially in a public forum. By that we mean the results and the analyses of the results could either imply a false overconfidence of ground-water velocities by a simple presentation of ground-water ages or could lead to a total lack of confidence by a detailed presentation of all of the uncertainties associated with the interpretation of the measurements. In this day of meetings we got presentations of both flavors but at the end of the day we were left with the following impressions.

Quantitative Uses of Isotopic Measurements

Isotopic measurements can not yield a unique estimate of either the ground-water age or the ground-water travel time because of the large number of uncertainties associated with each method and the requirement that one know the ground-water flow path by other means first before you can use the age dates to infer ground-water travel time. It appears that the best one can hope for is some bracketing of ground-water ages via the analysis of multiple isotopes (and all other hydrogeologic information).

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Qualitative Uses of Isotopic Measurements

Although the problems listed above are very real they do not preclude the use of the isotopic data for purposes of bounding the potential minimum travel times and, or equal importance, they do not limit their usefulness in shedding light on the potential mechanisms for ground-water flow in terms of potential conceptual ground-water flow models. Perhaps the most important example comes from the fact that anthropogenic tracers (i.e., bomb- pulse tritium and chlorine-36) are found at great depths. The importance of this fact (and given presentations by Al Yang this year and last on sample gathering and analysis procedures, we do believe it is a "fact") is that none of the existing conceptual models implemented in current DOE numerical models are consistent with these results. Furthermore these results demonstrate that all of the existing models seriously overestimate the ground-water travel times because they are based on porous media or equivalent porous media concepts and homogeneous representations of each layer. The existence of bomb-pulse tritium at great depths is extremely difficult to explain using these concepts. Couple this with the fact that the existing site models are used to guide characterization and you have the potential for misguided and misleading data collection activities.

Use of Future Isotopic Measurements

It is very difficult to determine how useful isotopic measurements will be in the future because we were not provided with any evidence on how the DOE intends to use the information in either site characterization, performance assessment, or regulatory compliance. Without such an overview we can only speculate on the use and usefulness of future isotopic measurements. Perhaps a way to shed light on the usefulness of future isotopic measurements is to look at some of the remaining issues for the YMP. Major issues include: 1) what distribution of flux between fracture and matrix flow should be used in estimating total system performance; 2) what are possible ground-water travel times from the repository to the accessible environment; 3) what are the implications of climate change on understanding future states of the repository system and on understanding the existing state of the system and; 4)what conceptual models should be used for estimating total system performance and ground-water travel time, specifically, what are the scales and distributions of hydrologic heterogeneities within the system.

With respect to the assessing the relative flux between matrix and fracture flow it is not clear that the isotopic measurements could ever provide such information since they do not provide any direct evidence of the quantity of water that has reached a given location. DOE gave some indication of future work on a mixing cell model and since the meeting we have received some information on that approach. Although, we have not evaluated the new information in detail, it appears that the approach will yield only crude bounds on the distribution of flux between the fractures and the matrix.

Regarding the issue of ground-water travel time, the ball seems to be in DOE's court to prove that the short travel times from the land surface to depths of approximately 1200ft. do not occur from the repository downward to the water table. In this case, isotopic measurements will be useful only in the sense of a demonstrating unacceptably low ground-water travel times. That is if anthropogenic tracers are found below the repository then it would be difficult for DOE to prove that the Yucca Mountain site complies with the NRC's ground-water travel time rule. On the other hand, if anthropogenic tracers are not found below the repository it could either mean that: 1) it is not feasible to find fast travel pathways with a few small bore holes due to the heterogeneities of the site or; 2) the travel times from the land surface where recharge occurs to the zones below the repository is long relative to the half-life of the man-made tracers but short relative to ground-water travel times that are of regulatory interest (say less than 10,000 years).

On the issue of climate change, future isotopic measurements may be of value. First, additional measurements could be used to assess the whether the hydrologic system is currently under steady-state conditions or whether this system is still responding to past climatic variations. This knowledge could be used in evaluating and using the current measurements of hydraulic pressures and moisture contents. In addition, future isotopic measurements, especially below the repository and above the water table, could be used to assess past climatic variations and by implication, potential future climates.

With respect to the issue of conceptual model uncertainty, the results of the measurements to date have demonstrated that the hydrology of the mountain is very heterogeneous and complex and that fast ground-water flow probably occurs along fractures. It is possible that DOE could undertake a very detailed assessment of the heterogeneities by collecting isotopic information at many locations and many depths. At this time, however, it is not possible to determine how many measurements would be required because the general relationship between site characterization and regulatory compliance is undefined. In other words, the degree to which you have to understand the heterogeneities depends on how much credit is being taken for the geologic barrier in a general sense and how much credit is taken for matrix versus fracture flow and a variety of other related issues. For example, the project may wish to only take credit for long travel times and high radionuclide sorption associated with unfractured non-welded tuff and assume that radionuclides move instantaneously through the fractured tuffs. Given that results of such analyses complied with the regulatory criteria and that the properties of the non-welded tuffs could be proven, this would be an acceptable approach. However, DOE did not present an integrated view of site characterization and compliance, therefore, definitive statements about the usefulness of additional isotopic measurements can not be made.

In summary, we believe the isotopic measurements will never provide an unambiguous estimate of ground-water travel times or velocities but the results from isotopic measurements to date have provided invaluable data to the project by invalidating existing models of ground-water flow and radionuclide transport by demonstrating that rapid flow along fractures in a very heterogeneous media is occurring. These methods also appear to hold promise for understand the effects of climatic change and for continuing to serve as an independent line of evidence about conceptual models of the site. The usefulness of future isotopic measurements for ground-water travel time estimation and evaluation of total system performance is unclear at this time because DOE has not presented an integrated approach to site characterization and regulatory compliance. And finally, perhaps the most important information coming from these measurements is the realization that the Yucca Mountain site will be extremely difficult to characterize.

Again, thank-you for the opportunity to be involved in the discussion of these topics and if you have any questions or concerns about this report please contact Paul Davis at 505-848-0754 or Steve Conrad at 505-848-0759.

If you have any further questions or would like me to clarify any of the points made herein please call at 505-848-0754.

Sincerely,

Paul A Davis

Paul A. Davis

Stephen Conrad

Stephen Conrad

The following table is a simple re-statement of objectives and conclusions as stated by the presenters at the ACNW meeting on the uses and limitations of groundwater dating methods. It is meant to provide a brief overview of the status of each of the efforts. We provide this table also in an attempt to gain overall insight into what general conclusions can be drawn from the meeting.

OBJECTIVE	CONCLUSIONS*
• Determine the source of perched water	• The source of perched water is natural. • Downward flow of ground water through fractures is thought to provide the mechanism for creating the perched zone
• Characterize water movement through the unsaturated zone	• .01-.8mm/yr. of infiltration is occurring below the root zone • Evidence for fast paths exists • Upper estimates of residence times were made • Approach has inherent limitations that can't be fixed - especially the requirement that the ground-water flow paths must be known ahead of time • Average infiltration rate is of limited usefulness • Average residence time is of limited usefulness • Yucca Mountain is a highly heterogeneous system

• Understand gas transport
• Design methods of data collection and analysis
• Provide independent evidence of flow directions
• Determine rock/water interactions
	• Preferential flow paths exist
	• Diffusion likely for gas transport
	• Fracture and lateral flow exists
	• Observations:
	  • Large fluxes and water and water level rises and falls
	  • Water dripping from fractures
	  • Perched water

• Estimate ground-water travel time in the saturated system • Evaluate responses of the hydrology to past and future climates	• Current climate ground-water greater than 1,000 years in saturated zone • Apparent C-14 ages too high • Ground-water moved through the unsaturated zone as recently as 20,000 years or LESS • Ground has been flowing through the unsaturated zone for at least 400,000 years • The elevation of the water table has been as much as 100m higher in the past and therefore shorter pathways for performance assessment must be considered

• Characterize the transport of C-14 and water vapor by gas transport in the unsaturated zone	• Ground-water travel time through the Tiva Canyon is less than 40 years • The Paintbrush non-welded tuff is a barrier to C-14 gas transport • The deeper system has a slower time scale of response with respect to gas transport • There is little or no gas/pore water interaction • Very rapid percolation through fractures will produce results that are very difficult to predict • CFC data provide an upper limit on C-14 ages
• Answer ground-water travel time questions relative to recent model results especially the issue of model consistency with isotopic data	• Simulations of hypothetical conditions have been made but no conclusions have been drawn

* Note: this table was reproduced from handwritten notes taken at the meeting and you should check the accuracy against the actual viewgraphs prior to quoting.