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Comments of Dr. Arjun Makhijani on Yucca Mountain and the draft EPA standard, submitted for the record of the Senate Environment and Public Works Committee hearing on the "Examination of the Licensing Process for the Yucca Mountain Repository," October 31, 2007

Madam Chairman, I have prepared these comments on the proposed Yucca Mountain repository at the request of the staff of Senate Majority Leader Harry Reid. I appreciate the opportunity to present them for inclusion in the hearing record, should you so decide. My remarks are complemented by comments that Dr. Brice Smith and I prepared on the draft EPA Standard on Yucca Mountain in November 2005 [http://www.ieer.org/comments/waste/yuccaepa.pdf]. I request that these comments also be included in the record.

I am president of the Institute for Energy and Environmental Research and have authored or co-authored articles, reports, and books on issues connected to nuclear waste and its management and on other radiation-related issues. I hold a Ph.D. from the Department of Electrical Engineering and Computer Sciences of the University of California at Berkeley (1972), where I specialized in controlled nuclear fusion.

I wish to note three things at the outset:

1. I support a sound repository program for spent fuel from presently licensed reactors and for Department of Energy high-level radioactive waste.
2. The current Yucca Mountain program is far from sound. Yucca Mountain does not meet the most important criteria for a sound repository program. In my opinion, it is the worst repository site that has been investigated in the United States.
3. Whatever course is chosen for a repository program, decades of storage of spent fuel at reactor sites is a near certainty. On site storage should be hardened to limit the most severe kinds of damage that are possible from terrorist attacks or accidents.

Let me amplify on the second point, since it illustrates the whole problem of Yucca Mountain licensing and standards, and, indeed, why the United States needs to start afresh with a repository program, instead of throwing good money after bad. I will focus on the problems of Yucca Mountain in relation to some important criteria by which a sound repository program can be judged:

1. Future radiation doses

Maximum estimated radiation doses to future generations at the time of peak dose should be within the general limits that we set for protecting our own generation. If they are expected to be much higher, then

the repository will not meet the test of inter-generational equity. Yucca Mountain fails this test miserably. Peak doses to the most exposed people are expected to be much higher than the current norms of 10 to 25 millirem per year incorporated in EPA radiation protection standards relating to nuclear facilities. Table 1, appended to this statement, shows the various risks associated with the proposed EPA standard and with the peak doses (median and 95th percentile) estimated by the DOE in its 2002 Environmental Impact Statement.

The EPA's draft standard would limit radiation dose to 15 millirem per year for the first 10,000 years. Beyond that it would allow half the affected people to get more than 350 millirem per year and half less. This is far in excess of present-day radiation protection norms for the general public. Five out of every hundred people would be allowed to get radiation doses of 2,000 millirem per year or more. At this level, the lifetime fatal cancer risk for females (over a 70-year exposure period) would be about 1 in 10. The corresponding cancer incidence risk would be 1 in 5. These last numbers are not much different than the risk of Russian roulette.

The lifetime fatal cancer risk to females from the 95th percentile peak dose estimated by the DOE in its Final Environmental Impact Statement, about 600 millirem, would be 1 in 35. This means that five percent of women exposed to the effects of Yucca Mountain pollution at that time would be at greater risk, while 95 percent would be at lower risk. The risks for men and for the whole population would be somewhat lower, but still well above prevalent norms. For instance, the average population fatal cancer risk (males and females combined) at 350 millirem per year over a lifetime is about 1 in 71.

2. Characteristics of the Yucca Mountain geologic setting

A minimum requirement of the geologic setting should be that, when the containers fail and begin to leak (and it is a question of when not if), the geology of the repository should be conducive to retarding the movement of the radioactive materials and to preventing most of them from reaching groundwater or surface water resources. Materials produced by the DOE for the Nuclear Waste Technical Review Board (reproduced in the attached IEER comments on the draft EPA standard) show that the Yucca Mountain rock is practically useless in holding back radioactive materials. Almost the entire functioning of the repository depends on the engineered barriers, mainly the metal containers. Unless they function as predicted by the DOE, Yucca Mountain will not meet the draft EPA standard even for the first ten thousand years. And since these containers will eventually rust, all calculations show that the peak dose will greatly exceed EPA's norms for radiation protection today. For instance, the maximum routine exposure to the public from a single nuclear fuel cycle facility from all pathways, including air, water, and food, is limited to 25 millirem per year to any organ (except 75 millirem to the thyroid) or to the whole body (40 CFR 190.10(a)).

3. The waste package

The DOE is proposing to use metal containers as the central element of the waste package for spent fuel disposal. The Yucca Mountain geologic environment is oxidizing; it also has some humidity. The waste will be hot for an extended period and it will heat the surrounding materials and rock. This combination of heat, humidity, and oxygen is a recipe for rust. How fast the containers will corrode is a matter of some debate. The containers could, under some circumstances, corrode much faster than 10,000 years (the time the EPA proposes for a reasonably protective dose limit of 15 millirem per year). The metal alloy proposed for the containers is new – there is no long-term experience with its performance. As a result, there is a real possibility that DOE's silver bullet may turn out to be a dud. Since the repository

location itself is not protective, a failure of the containers would lead to serious pollution of the groundwater and render it useless in an area where water is very scarce.

4. Water resources

There are no surface water resources in the general region of Yucca Mountain. The only aquifer in the area is currently being used in Amargosa Valley, just 20 miles downstream from Yucca Mountain. The scarcity of water ensures two things. First, if the containers don't hold up, there will be little dilution and the water will become very polluted. Second, the lack of alternative water resources makes it likely that future residents may unknowingly use the polluted groundwater. This is not a new finding. About a quarter of a century ago, the DOE had commissioned the National Research Council of the National Academy of Sciences to prepare a report that was supposed to guide it in its search for a sound repository. That report, published in 1983, four years before the 1987 legislation that restricted site characterization to Yucca Mountain, showed that radiation doses due to high-level radioactive waste disposal at Yucca Mountain could be very high, in large measure due to the scarcity of water.[1] To the best of my knowledge, the DOE does not appear to have used this report to guide its repository program, though it paid for it.

5. Conclusions

The evidence shows that Yucca Mountain is an unsound repository program that should not be pursued further. If there were a reasonably protective radiation standard – one that protected future generations to the time of peak dose according to present-day EPA norms – Yucca Mountain could not be licensed. Security, health, safety, and environmental considerations indicate that the Yucca Mountain program should be scrapped and replaced by a repository program based on sound science and public health protection criteria. It should be managed not by the DOE but by an institution that does not itself generate high-level waste or spent nuclear fuel. The same considerations also point to the need for Hardened On-Site Storage (HOSS) of spent fuel as an interim step.

Thank you for the opportunity to present this statement for possible inclusion into the record of the hearing. I would be happy to answer in writing any questions you may have for the record.

[1] Waste Isolation Systems Panel, Board on Radioactive Waste Management, National Research Council. *A Study of the Isolation System for Geologic Disposal of Radioactive Waste*. Washington, DC: National Academy Press, 1983.

Table 1: Cancer risks associated with the draft EPA standard for Yucca Mountain and with DOE estimated median and 95th percentile peak doses

	EPA draft std. 1st 10,000 yrs	EPA draft std. **median** after 10,000 yrs	EPA draft std. **95th percentil**e value	DOE estimate **median** peak dose	DOE estimate **95th percentile** peak dose
Annual exposure, Effective dose equivalent, millirem/year	15	350	2,000	140	600
Lifetime dose over 70 years, millirem	1,050	24,500	140,000	9,800	42,000
Average Risk factor from EPA FGR 13, fatal cancers per mrem (males and females)	5.75E-07	5.75E-07	5.75E-07	5.75E-07	5.75E-07
Average lifetime fatal cancer risk	6.04E-04	1.41E-02	8.05E-02	5.64E-03	2.42E-02
Average (males and females) lifetime fatal cancer risk, expressed as 1 in	**1,656**	**71**	**12**	**177**	**41**
Average Risk factor from EPA FGR 13 for females, fatal cancers per millirem	6.83E-07	6.83E-07	6.83E-07	6.83E-07	6.83E-07
Lifetime fatal cancer risk for females	7.17E-04	1.67E-02	9.56E-02	6.69E-03	2.87E-02
Lifetime fatal cancer risk for females, expressed as 1 in	**1,394**	**60**	**10**	**149**	**35**

Notes: 1. FGR 13 stands for EPA's Federal Guidance Report 13. It is an official EPA guidance report.
The DOE estimates that there will be many peaks of doses due to future climatic variations. The figures above represent the largest estimated values of the peak dose. They are estimated to occur hundreds of thousands of years from the present.