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Lois Chalmers/IEER <lois@ieer.org> on 01/10/2008 09:52:46 AM

To: EIS_Office@ymp.gov
cc: Arjun Makhijani <arjun@ieer.org>, Lisa Ledwidge/IEER <ieer@ieer.org>
Subject: DOE/EIS-025F-S1D - Comments of Arjun Makhijani of IEER

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Dr. Jane Summerson and Mr. Lee Bishop
EIS Office, Office of Civilian Radioactive Waste Management
U.S. Department of Energy
1551 Hillshire Drive
Las Vegas, NV 89134
1–800–967–3477; Fax: 1–800–967–0739
email: EIS_Office@ymp.gov
via http://www.ocrwm.doe.gov

Dear Dr. Summerson and Mr. Bishop:

Please find attached:

Comments of the Institute for Energy and Environmental Research on the Department of Energy's *Draft Supplemental Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada.* (DOE/EIS0250FS1D) (Draft Repository SEIS).
Arjun Makhijani, Ph.D., President, Institute for Energy and Environmental Research
January 10, 2008.

Sincerely yours,

Lois Chalmers IEER comments on DOE-EIS-0250F-S1D - 2008-01-10.pdf

ieer

INSTITUTE FOR ENERGY AND ENVIRONMENTAL RESEARCH

6935 Laurel Avenue, Suite 201
Takoma Park, MD 20912

Phone: (301) 270-5500
FAX: (301) 270-3029
e-mail: ieer@ieer.org
http://www.ieer.org

Comments of the Institute for Energy and Environmental Research on the Department of Energy's *Draft Supplemental Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada* (DOE/EIS0250FS1D) (Draft Repository SEIS)

Arjun Makhijani, Ph.D., President, Institute for Energy and Environmental Research
January 10, 2008

1 These are comments of the Institute for Energy and Environmental Research on the Department of Energy's *Draft Supplemental Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada* (DOE/EIS0250FS1D) (Draft Repository SEIS), published in October 2007.

Yucca Mountain, Nevada: A Bad Repository Choice

By Arjun Makhijani[1]

The nuclear industry has been quick to proclaim that a "nuclear renaissance" is occurring, or is at least in the offing, though not a single new reactor has been ordered at the time of this writing (mid-November 2007).

The industry has been correspondingly slow to say what will happen to all the spent fuel that will be generated by these new power plants, though the general assumption is that the government will take it away from reactor sites and do something with it – store it at its own sites (such as Savannah River Site in South Carolina), reprocess it (a variety of sites have been proposed), or put it in the proposed deep geologic repository at Yucca Mountain, Nevada.

Storage and reprocessing do not obviate the need for a repository; therefore the availability of Yucca Mountain (and/or some other yet-to-be-named repository) remains a consistent underlying theme of the much-vaunted "nuclear renaissance."

Yet, Yucca Mountain is in deep trouble (so to speak) for very good reasons. Though I have written a rather large volume of words on the topic,[2] it may serve as a useful reminder in the current context to summarize why Yucca Mountain is an unsound repository location. Indeed, in my opinion, it is the worst

[1] This is the text of an article that has been published in *Science for Democratic Action*, v.15, no.2, January 2008. It is based on "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, and on IEER comments on the EPA draft standard for Yucca Mountain, November 2005, on the Web respectively at www.ieer.org/comments/waste/yucca071031.html and www.ieer.org/comments/waste/yuccaepa.pdf.

[2] See IEER's web site, specifically www.ieer.org/webindex.html#waste.

repository site that has been investigated in the United States. I will focus on the problems of Yucca Mountain in relation to some important criteria by which a sound repository program can be judged.

Repository standards and 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 U.S. Environmental Protection Agency (EPA) radiation protection standards relating to nuclear facilities. Table 1 shows the various risks associated with the proposed EPA standard and with the peak doses (median and 95^{th} percentile) estimated by the U.S. Department of Energy (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. The average population fatal cancer risk (males and females combined) at 350 millirem per year over a lifetime is about 1 in 71, which is over 20 times the risk of a 15 millirem per year limit and over a hundred times greater than EPA's general goal of limiting lifetime fatal cancer risk to 1 in 10,000.

The draft EPA standard would allow five out of every hundred people 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 shooting oneself while playing Russian roulette – except here the present generation would be forcing it on those far in the future who had no part in our decisions.*

The Department of Energy (DOE) made its own estimates in its Final Environmental Impact Statement on Yucca Mountain. The DOE estimated that the 95^{th} percentile of the peak dose would be about 600 millirem (see Figure 1). The lifetime fatal cancer risk to females from this dose would be about 1 in 35 (rounded). The "95^{th} percentile" part of this means that five percent of women exposed to Yucca Mountain pollution at that time would be at greater risk than 1 in 35, while 95 percent would be at lower risk. Cancer incidence risk would be about double this value or about 1 in 17 (rounded).

EPA draft standard vs. DOE peak dose estimate

The U.S. Environmental Protection Agency is responsible for setting a limit for how much radiation the public can be exposed to by the proposed nuclear waste repository at Yucca Mountain. 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. A final standard has not been issued as of this writing (late November 2007).

In a federally-mandated environmental impact statement, the U.S. Department of Energy made projections for future radiation doses from the Yucca Mountain repository. The DOE estimated that median peak dose would be approximately 140 millirem per year and would occur roughly 400,000 to 500,000 years after repository closure.

Figure 1. Mean and 95th-percentile doses from Yucca Mountain spent fuel disposal estimated by the DOE

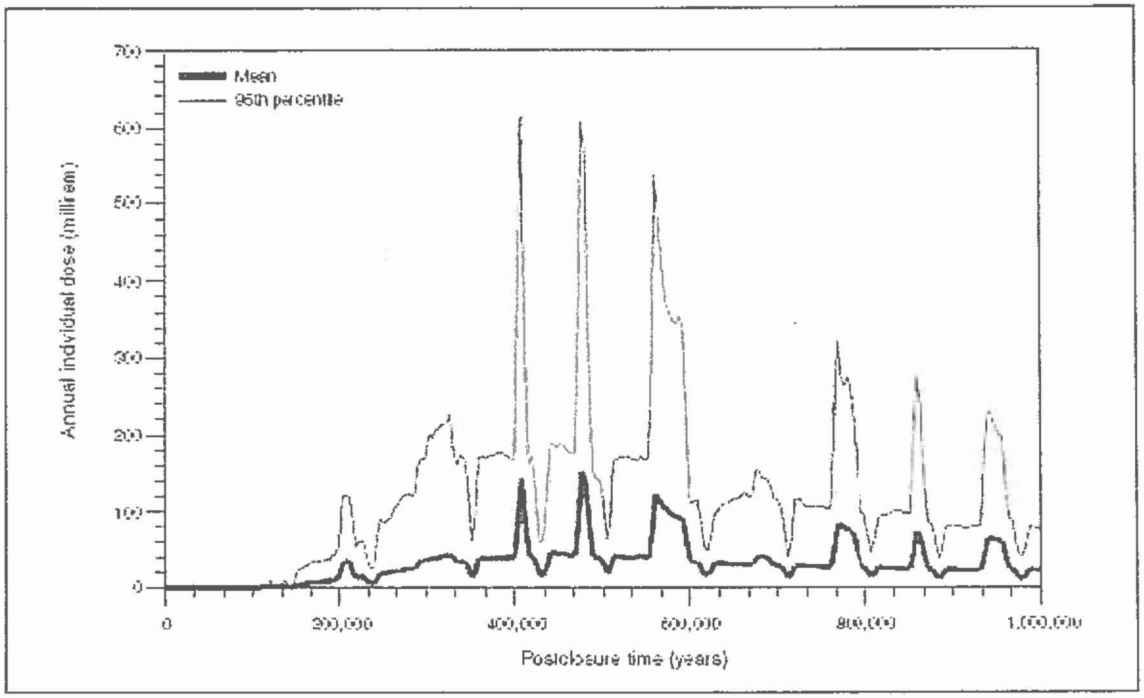


Figure 1 taken from page 5-26 of Volume 1 of the *Final Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada*, February 2002. On the Web at http://www.eh.doe.gov/nepa/eis/eis0250/eis0250index.html.

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. Materials produced by the DOE for the Nuclear Waste Technical Review Board 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.[3]

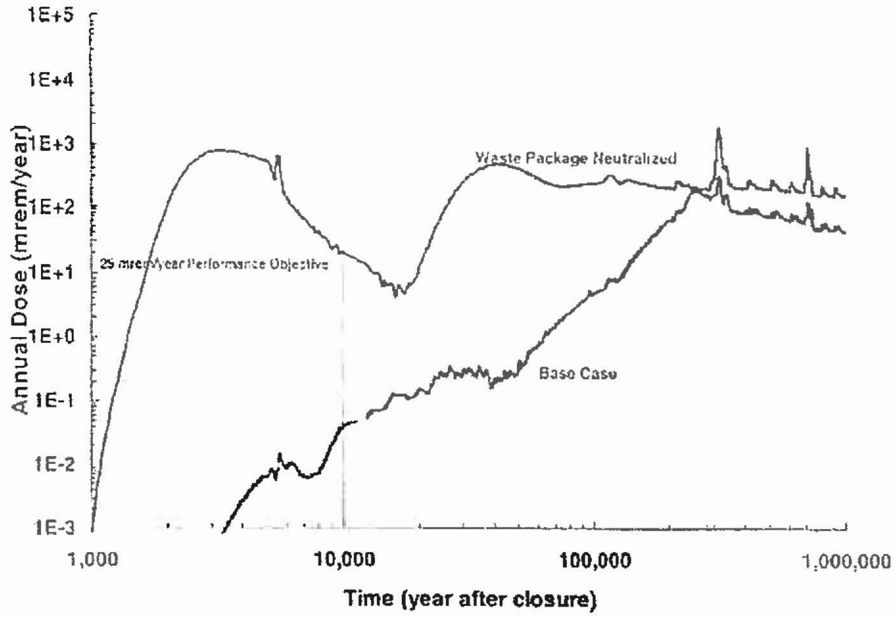
The graph in Figure 2 was prepared in 1999 by the DOE for the Nuclear Waste Technical Review Board (NWTRB), an advisory board created by Congress to oversee the Yucca Mountain Project. The Board had requested that the DOE evaluate each element in the geologic isolation system for its contribution to

[3] 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))

overall performance in meeting the then-assumed limit of 25 millirem per year for the first 10,000 years of repository operation. (No dose limit was proposed beyond that time. Later, a federal court invalidated the standard first proposed by EPA mainly because it too did not look beyond 10,000 years.

The DOE graph, supplied to the NWTRB as part of its request, shows that if the entire system were in place and performed as modeled, the dose limit of 25 millirem would be met rather easily for the first 10,000 years, though it would eventually be exceeded by a considerable margin at 100,000-plus years after repository closure. However, it shows that if the "waste package," which consists primarily of a huge metal container made of a special nickel-based alloy called C-22, degrades quickly (in hundreds of years or a few thousand years), the peak dose would rapidly increase to nearly 1,000 millirem well within 10,000 years, which is greatly in excess of any standard that has been proposed for that time period.

Figure 2: DOE Estimates of Yucca Mountain Total System Performance ("Base Case") and Performance without the Waste Package ("Waste Package Neutralized")



Note on y-axis figures: "1E-3" signifies 10^{-3} which also can be written 0.001. Similarly, 1E+5 = 10^{+5} = 100,000 and 1E+0 = 10^0 = 1.

The waste package

As a result of the above, the reliability of the DOE estimate of the performance of the metal containers becomes critical to the performance of the repository. If the containers do not perform as estimated in the DOE's "base case" or close to it, the repository will be a terrible failure. As a result, a high confidence in the performance of these containers is essential. However, current knowledge does not admit such confidence. On contrary, basic as well as Yucca Mountain-specific considerations indicate that the waste package may degrade rather rapidly.

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. The rate of rusting in such an environment is a matter of some debate. The containers could, under some circumstances, corrode much faster than 10,000 years. Indeed, in some circumstances the containers may corrode in decades. Further, 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 container 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.

Since there is a large and growing amount of spent fuel to be disposed of, jamming a large amount of it into Yucca Mountain is a temptation. However, this would result in high temperatures in the repository conducive to rapid corrosion.[4] The DOE has so far refused to specify a repository design, though such a specification is an essential part of a minimally complete license application. The license application was due in 2002 and has not yet been filed. The DOE has stated that it will be filed in mid-2008.

Reliance on a single element of a complex system as the only guarantee of performance is risky under the best of circumstances. For instance, commercial passenger aircraft that have two engines are required to be able to operate in emergencies on only one, even though there is vast experience with jet engine reliability and performance. Redundancy is even more essential in a system of an unprecedented nature whose performance is very difficult to estimate under the best of circumstances due to the long times involved.

Redundancy in repository design means that if the containers fail, the rock should adsorb the radionuclides and prevent or greatly retard their migration into groundwater. By this criterion, Yucca Mountain is a near-total failure, since the performance of all waste isolation components taken together but without the waste package does not amount even to the proverbial hill of beans. That is the central message of Figure 2. The waste could be put in almost any geologic location with equal or better performance, since the performance of the Yucca Mountain host rock is next to nil. This is shown in Figures 3 and 4, also taken from the set produced by the DOE for the NWTRB.

Figure 3 shows that if the rocks surrounding the waste disposal zone ("unsaturated transport barrier") were removed, but the waste package performed as estimated in the "base case," there would be essentially no change in the performance of the system. In other words, the volcanic tuff at Yucca Mountain is practically useless in holding back the radionuclides once the waste package fails. Figure 4 shows that the same is true of the saturated zone. That is, once the waste reaches the groundwater, there will be no mechanism that would significantly reduce dose.

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[4] Paul P. Craig, "Rush to Judgment at Yucca Mountain," *Science for Democratic Action*, Vol. 12, No. 3, June 2004, on the Web at www.ieer.org/sdafiles/12-3.pdf.

Figure 3: Unsaturated Yucca Mountain Transport Barrier Removed

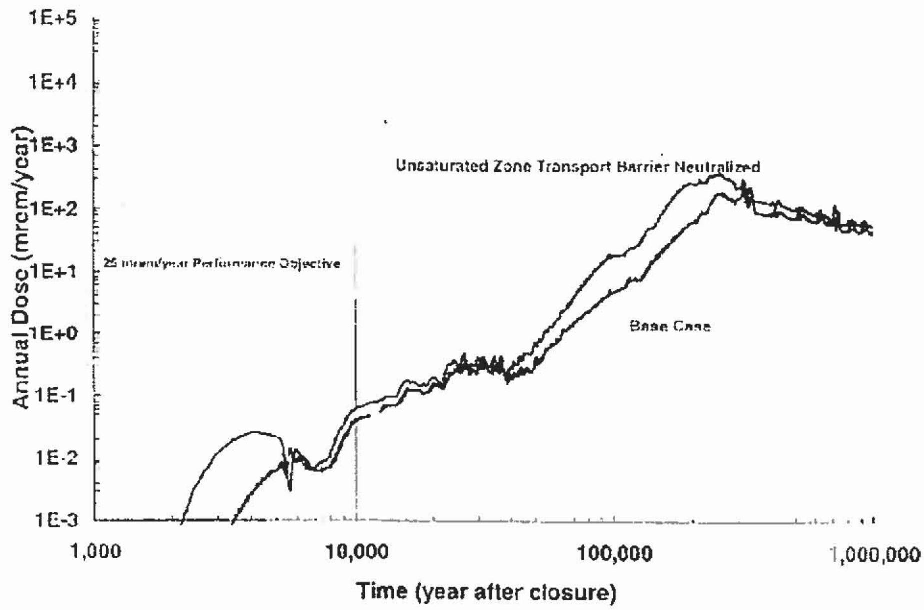
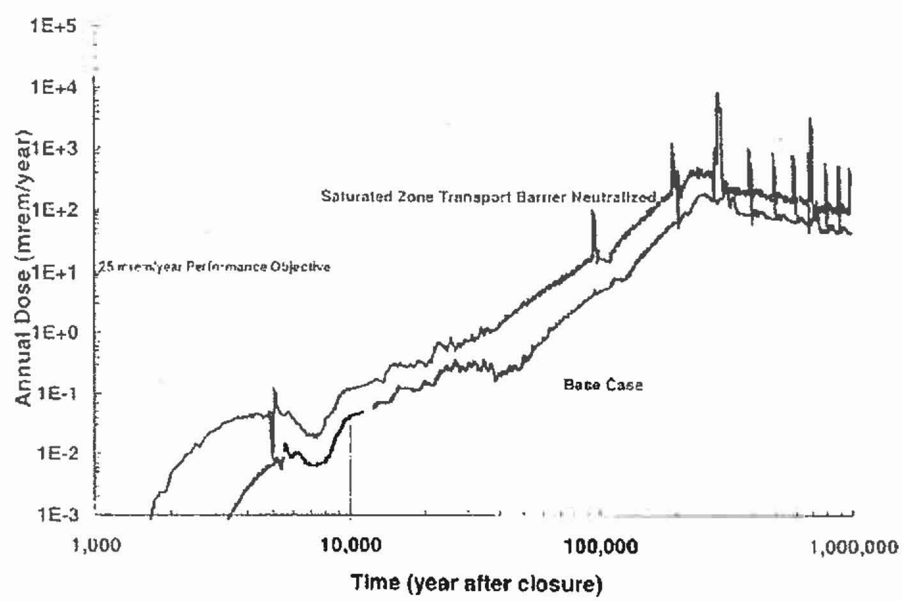


Figure 4: Saturated Yucca Mountain Transport Barrier Removed



Source for figures 2-4: U.S. DOE Office of Civilian Radioactive Waste Management, "NWTRB Repository Panel meeting: Postclosure Defense in Depth in the Design Selection Process," presentation for the Nuclear Waste Technical Review Board Panel for the Repository, January 25, 1999.

Water resources

The performance of the repository in relation to groundwater matters more for Yucca Mountain because there are no surface water resources in that general region of Nevada. The only water source in the area is an aquifer that 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.[5] To the best of my knowledge, the DOE does not appear to have used this report to substantially guide its repository program, though it paid for it.

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.[6]

A "nuclear renaissance" based even implicitly on the availability of Yucca Mountain for spent fuel from new reactors is founded on wrong-headed thinking similar to that of the 1950s that assumed waste disposal would be a problem that could be managed relatively easily. Based on that kind of thinking, the DOE, in the early 1980s, entered into contracts with nuclear utilities to begin take possession of spent fuel from them and start disposing it of in a deep geologic repository by January 31, 1998. That deadline has long since passed and the DOE has not even applied for a license.

The opening of Yucca Mountain, if it ever happens, appears more remote than ever for a host of reasons. Because the first repository characterization has been a costly failure so far by every reasonable measure of contract performance, assuming that the government would take responsibility for nuclear waste from new reactors decades from now may well add folly to the error of having created so much waste in the first place. Why then are so many so eager to pursue nuclear power, with its concomitant embrace of nuclear waste, when we don't need the headaches of nuclear to completely eliminate fossil fuel use from the U.S. economy?[7]

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[5] 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.
[6] See www.ieer.org/comments/waste/yuccaalt.html for a discussion of HOSS.
[7] For a roadmap to a nuclear-free renewable energy economy, see Arjun Makhijani, *Carbon-Free and Nuclear-Free: A Roadmap for U.S. Energy Policy*, IEER Press and RDR Books, 2007. On the Web at www.ieer.org/carbonfree/.

Table 1: Projected radiation doses and cancer risks -- Yucca Mountain
Using draft EPA standard and DOE estimated peak dose estimates

	Draft EPA standard			DOE peak dose estimates (see note)	
	First 10,000 years	Median after 10,000 years	95th percentile value after 10,000 years	Median value	95th percentile value
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 lifetime fatal cancer risk (males and females), expressed as 1 fatality among XXX exposed	1,656	71	12	177	41
Lifetime fatal cancer risk for females, expressed as 1 fatality among XXX exposed	1,394	60	10	149	35

Note: The DOE estimates that there will be many peaks of doses due to future climatic variations. These figures represent the largest estimated values of the peak dose. They are estimated to occur hundreds of thousands of years from the present.