**STATE OF NEW MEXICO**
**WATER QUALITY CONTROL COMMISSION**

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| IN THE MATTER OF THE TRIENNIAL REVIEW OF STANDARDS FOR INTERSTATE AND INTRASTATE SURFACE WATERS, 20.6.4 NMAC | ) | WQCC No.08-13 (R) |

# WITNESS STATEMENT FOR ARJUN MAKHIJANI

***Submitted on Behalf of Amigos Bravos***
***August 27, 2009***

Estimated Time for Direct Testimony: 20 minutes

The Institute for Energy and Environmental Research (IEER) is a scientific non-profit that advises community groups, policy-makers and others regarding energy and environmental issues, including issues associated with radiation protection standards. This testimony was prepared under contract to Amigos Bravos, a New Mexico statewide river conservation organization. It concerns itself with New Mexico Administrative Code, Section 20.6.4.114, which would be amended to protect certain specified sections of the Rio Grande Basin.[1]

I have a Ph.D. (Engineering), granted by the Department of Electrical Engineering of the University of California, Berkeley, where I specialized in the application of plasma physics to controlled nuclear fusion. I also have a master's degree in electrical engineering from Washington State University, and a bachelor's degree in electrical engineering from the University of Bombay. I am qualified by training and experience as an expert in the fields of plasma physics, electrical engineering, nuclear engineering, and energy-related technology and policy issues. I have extensive professional experience and am qualified as an expert in radioactive waste disposal standards for protection of human health from radiation. I also have extensive professional experience in estimating radiation doses and in calculating source terms for radioactive emissions. I have served as a nuclear engineering expert witness in lawsuits and testified on a variety of issues including the release of radioactivity from nuclear facilities. A copy of my curriculum vita is attached.

Between 1997 and 2002, I was on the expert team monitoring independent audits of the compliance of Los Alamos National Laboratory with the radiation release portion of the Clean Air Act (40 CFR 61 Subpart H), conducted under a Consent Decree, which was the result of a federal court finding that Los Alamos was out of compliance with Subpart H. In that capacity I have reviewed extensive records, models, facilities, procedures, measurements, and other aspects

[1] NMED 2009, pp. 39 to 41.

of the Los Alamos National Laboratory air emissions control and measurement program in order to determine whether the audits were being properly conducted and whether they were thoroughly done. I am the principal author of an assessment of the radioactive waste management and disposal costs of depleted uranium from the National Enrichment Facility (2004 and 2005) and of an analysis of U.S. waste classification regulations. I was the director of a team that analyzed the plans of the Agence nationale pour la gestion des déchets radioactifs (ANDRA) for a geological repository for high level radioactive waste in France on behalf of a French government-sponsored stakeholder committee (2004). I have also served as a member of the Radiation Advisory Committee of the U.S. Environmental Protection Agency's (EPA's) Science Advisory Board from 1992 to 1994 and on the EPA's Advisory Subcommittee on Radiation Standards, which is part of the National Advisory Committee on Environmental Policy and Technology. In addition, I have served as a consultant to numerous organizations, as mentioned in my CV.[2]

I am the principal author of the first ever independent emissions estimate of radioactivity from a nuclear weapons plant, the Feed Materials Production Center near Fernald, Ohio (1988).

As regards water issues, I am the author of *Bad to the Bone: Analysis of the Federal Maximum Contaminant Levels for Plutonium-239 and Other Alpha-Emitting Transuranic Radionuclides in Drinking Water* (2005), which concluded that federal drinking water standards for plutonium-239 and other long-lived alpha-emitting transuranic radionuclides were based on obsolete science and were about 100 times too high. Relevant portions of this report were reviewed by the staff of New Mexico Governor Richardson, who, as a result, stated that he was "in general accord" with the report's recommendation to tighten standards.[3]

Over the past 25 years, I have developed extensive experience with nuclear fuel cycle-related issues, including standards and strategies for radioactive waste storage and disposal, accountability with respect to measurement of radioactive effluent from nuclear facilities, health and environmental effects of nuclear testing, strategies for disposition of fissile materials, energy efficiency, and other energy-related issues. As reflected in my curriculum vita, which is attached, I have authored or co-authored many publications on these subjects. I have testified before Congress on several occasions regarding issues related to nuclear waste, reprocessing, environmental releases of radioactivity, and regulation of nuclear weapons plants.

I have done extensive work with respect to the health and environmental effects of nuclear weapons production. I am the principal author of the first independent assessment of radioactivity emissions from a nuclear weapons plant (1989) and a co-author of the first audit of the cost of the U.S. nuclear weapons program (*Atomic Audit,* 1998). I am also a co-author of the first global assessment of the health and environmental effects of nuclear weapons production (*Nuclear Wastelands,* 1995 and 2000), which was nominated for a Pulitzer Prize by MIT Press and the principal editor of this book.

[2] CV attached to this testimony.

[3] See Richardson 2005. Governor Richardson stated that his staff had "reviewed portions of the report" and referred questions to Fernando R. Martinez, Bureau Chief of NMED's Drinking Water Bureau.

I have also written a number of books and other publications analyzing the safety, economics, and efficiency of various energy sources, including nuclear power and sustainable energy sources such as wind and solar energy. I was the principal author of the first evaluation of energy end-uses and energy efficiency potential in the U.S. economy (published by the Electronics Research Laboratory, University of California at Berkeley in 1971). I was also the principal author of the first overview study on *Energy and Agriculture in the Third World* (Ballinger 1975). This study included consideration of both traditional and modern energy sources. I was one of the principal technical staff persons of the Ford Foundation Energy Policy Project, and a co-author if its final report, *A Time to Choose,* which helped shape U.S. energy policy during the mid-to-late 1970s. I am co-author of Investment Planning in the Energy Sector, which is an economic model published by the Lawrence Berkeley Laboratory in 1975. I am also the author of *Nuclear Power Deception* (Apex Books 1999), an analysis of the costs for nuclear power in the United States. On behalf of the SEED Coalition, I have assessed the capital costs of proposed nuclear power reactors in South Texas (2008). In addition, I am the author of *Carbon-Free and Nuclear Free* (RDR Books and IEER Press 2007, reprinted in 2008), the first analysis of a transition to a U.S. economy based completely on renewable energy, without any use of fossil fuels or nuclear power. I have been a consultant on energy issues to several U.N. agencies, the Tennessee Valley Authority (TVA), the Lower Colorado River Authority, the Lawrence Berkeley Laboratory, Edison Electric Institute, and the Congressional Office on Technology Assessment. I was elected a Fellow of the American Physical Society in 2007, an honor granted to at most one-half of one percent of APS members.

**A. Risk level**

The New Mexico Environment Department (NMED) proposes to apply a cancer morbidity lifetime risk level of 1 in 100,000 to estimate the criteria for radionuclide contaminant levels in public water supply systems, with the water intake being 2 liters per day and lifetime being defined as 70 years (25,568 days). NMED used morbidity risk coefficients from U.S. Environmental Protection Agency's (EPA's) Federal Guidance Report 13 (FGR 13), published in 1999.[4] I am in general agreement with the approach of using of FGR 13 morbidity risk factors, since these are the ones published by the EPA.

NMED does not discuss in detail its choice of the risk level of 1 in 100,000 in its proposed amendments other than to note that it "was used in accordance with Commission practice."[5] We presume that the usual Commission practice set forth in NMAC 200.6.4.900B,[6] which relates to Domestic Water Supply is being used to address the issue of radionuclides here since certain sections of the Rio Grande Basin will soon be used for domestic water supply: Specifically, as noted in NMED 2009, it proposes to

> [a]dd public water supply as a designated use on the Rio Grande because the City of Santa Fe plans to divert San Juan-Chama water at the Buckman Direct Diversion on

[4] EPA 1999. A CD with dose conversion and risk factors was published in 2002 as a supplement to the 1999 FGR 13 publication and has also been used here in the calculations. It is cited as EPA 2002.
[5] NMED 2009, p. 41.
[6] NMAC 20.6.4.900B, as of August 2009.

this reach of the Rio Grande. Los Alamos County and Española also have long-term plans to use water from this reach.[7]

In other words, the radionuclide criteria are being set in a context in which large numbers of people in New Mexico will be using the water in question as their public water supply, including for drinking, cooking, and bathing.

In this context, Colorado, in an agreement with the federal government, and Ontario have used a lifetime risk level of $10^{-6}$ to set or propose water quality goals. Let us consider the latter first.

In May 2009, the Ontario Drinking Water Advisory Council recommended, after an extensive review, that the drinking water standard for tritium should be tightened to 20 Bq/L (becquerels per liter, equal to 540 pCi/L) from the current 7,000 Bq/L (about 189,000 pCi/L).[8] The risk level chosen was $10^{-6}$, in large measure because, in Canada, tritium is the most common radioactive pollutant being emitted from its commercial nuclear power plants. The water discharged from the power plants would be allowed to have higher tritium levels, but remedial action would be taken if drinking water levels exceeded a 52-week running average of 20 Bq/L.[9]

The same point is illustrated in a context more directly relevant to the present situation in New Mexico: clean up at the Rocky Flats nuclear weapons site, where plutonium triggers for U.S. nuclear weapons were fabricated for decades. As part of the cleanup agreement with the State of Colorado, a **segment-specific standard** in waters flowing out of the Rocky Flats was set for plutonium and americium-241 at 0.15 pCi/L and for tritium at 500 pCi/L.[10] For plutonium and americium, these values were selected as "action levels" based on a $10^{-6}$ lifetime risk level agreed upon by the U.S. Department of Energy and the State of Colorado.[11] The Colorado value for tritium appears to have been derived using an older EPA Federal Guidance Report, FGR 11. When the present guidance in FGR 13 is used, a $10^{-6}$ lifetime risk level yields a figure of 400 pCi/L for tritium.

The Colorado standards were also set in the context of potential added runoff during accelerated decommissioning of Rocky Flats. They are shown in a table in Colorado Regulation 38; the table is reproduced below.

[7] NMED 2009, p. 40, re: NMAC 20.6.114 Basis for change.
[8] ODWAC 2009, p. 6 and p. 20. Note, a variety of methods was used to derive a tritium level corresponding to a $10^{-6}$ risk level, yielding a range of values of 7 to 109 Bq/L. The value of 20 Bq/L was chosen from this range as representing both the target risk level and a level reasonably achievable, given the emissions from Canadian power plants. In the United States, the method is more standardized in the context of drinking water, as is the use of FGR 13, which is the basic guidance for calculating both internal doses and cancer risks. This results in a value of 400 pCi/L. which is somewhat lower than 20 Bq/L but higher than the lower value in the Ontarian range of 7 Bq/L.
[9] ODWAC 2009, p. 5 and p. 45.
[10] Colorado Reg. 38 2009 Table 2 (p. 35). See values for Woman Creek and Walnut Creek. It should be noted that the main contaminants of concern at Rocky Flats would be plutonium and americium-241 (which is a decay product of plutonium-241 and builds up as plutonium-241 decays.)
[11] Rocky Flats 2003, p. 5-7, Table 1 (p. 5-25), and Colorado Reg. 38 2009, p. 136.

Table 2
SITE SPECIFIC RADIONUCLIDE STANDARDS*
(in Picocuries/Liter, except as noted)

The radionuclides listed below shall be maintained at the lowest practical level and in no case shall they be increased by any cause attributable to municipal, industrial, or agricultural practices to exceed the site specific numeric standards.

| A. Ambient based site-specific standards: | | | | |
|---|---|---|---|---|
| | Segment 2<br><br>Standley Lake | Segment 3 Great Western Reservoir | Segment 4a Segment 5 Woman Creek | Segment 4a Segment 4b Segment 5 Walnut Creek |
| Gross Alpha | 6 | 5 | | |
| Gross Beta | 9 | 12 | | |
| Plutonium | .03 | .03 | 0.15** *** | 0.15** *** |
| Americium | .03 | .03 | 0.15** *** | 0.15** *** |
| Tritium | 500 | 500 | 500 | 500 |
| Uranium | 3 | 4 | 16.8 µg/l | 16.8 µg/l |
| | | | | |
| B. Other site-specific standard applicable to segments 2,3,4a, 4b, and 5. | | | | |
| Curium | 60 | 60 | 60 | 60 |
| Neptunium | 30 | 30 | 30 | 30 |

*Statewide standards also apply for radionuclides not listed above.
**0.15pCi/l Statewide Basic Standards.

***For plutonium and americium measurements in Segment 5 in Woman Creek and Segment 5 in Walnut Creek, attainment will be assessed based on the results of a 12-month flow-weighted rolling average concentration (computed monthly).

Source: Colorado Reg. 38 2009, Table 2 (p. 35 of the Tables section).

The above Colorado segment specific standards were directed at segments of the two creeks (Segments 4a and 5 of Woman Creek and Segments 4a, 4b, and 5 of Walnut Creek) that runoff from Rocky Flats, a far broader approach than standards directed only at drinking water protection. This was done in order to protect public water supplies downstream (Great Western reservoir and Standley Lake).[12] In this context, it should also be noted that standards suggested for man-made radionuclides, neptunium and curium in the above-named segments were far more lax. However, these radionuclides were present in only trace quantities at LANL and would not be expected to be principal radioactive contaminants of run-off from the site. For instance, a 1999 report to the Colorado Department of Health on Rocky Flats source terms does not discuss

[12] Colorado Reg. 38 2009, p. 94.

neptunium or curium as source terms but discusses plutonium, americium, and tritium at length as Rocky Flats-related man-made radionuclides.[13]

At the same time, it should also be noted that the standards for plutonium, americium, and tritium for the two drinking water reservoirs downstream from Rocky Flats, Great Western Reservoir and Standley Lake, were set at "ambient levels" – which were five times lower than the $10^{-6}$ levels set for the surface water in the segments of the two creeks in question. While these standards in these two reservoirs also contain lax limits for neptunium and curium, these limits are effectively not operational. This is because these radionuclides are indirectly limited by the much lower overall gross alpha limit of 6 pCi/L, which includes them as well as plutonium, americium, and a whole list of natural alpha-emitting radionuclides, including radium-226, thorium-230, thorium-232, and other alpha-emitting radionuclides in the thorium-232 decay chain (thorium-228, for instance). Since up to 5 pCi/L per liter of radium-226 contamination is allowed in the federal and Colorado standards, the effective standard for the drinking water reservoir downstream from Rocky Flats for all other alpha emitters, except uranium and radon is quite strict – far more strict than the federal gross alpha drinking water standard of 15pCi/L, which also includes natural and man-made alpha-emitting radionuclides, except uranium and radon. The plutonium and americium standard of 0.15 pCi/L, corresponding to a $10^{-6}$ risk level was also made part of state wide radionuclide standards for surface waters.[14]

When we survey these different examples, some critical points emerge:

- A $10^{-6}$ lifetime risk level is the level of choice for protection of public health when man-made radionuclide contaminants that are known to be emitted or discharged by nuclear facilities may threaten public water supplies.
- The federal government has agreed to site-specific criteria involving a nuclear weapons site that correspond to $10^{-6}$ risk levels for criteria pollutants from Rocky Flats (tritium, americium, and plutonium) for the surface water creek segments associated with the site.
- Colorado has also set strict statewide standards for surface waters for the main transuranic alpha emitters associated with Rocky Flats – plutonium and americium corresponding to a $10^{-6}$ risk level.[15]
- Colorado has set ambient quality standards for drinking water in the two reservoirs downstream of Rocky Flats that supply drinking water that are generally far stricter than federal standards[16] and in practice also generally stricter than the surface water limits for Rocky Flats-associated stream segments (as discussed above).

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[13] RAC 1999.

[14] Colorado Reg. 31 2008, pp. 25-26. The statewide regulation for tritium for surface water is the same as the federal drinking water standard. Note that a regulation for surface water set at a particular level is generally more strict than the same level being specified for public water supply, since the former definition covers a broader array of water sources. It is also important to note that Rocky Flats has been decommissioned and has ceased to exist as an operating facility, unlike Los Alamos, where the radionuclides in question will continue be used for the foreseeable future, according to present government plans.

[15] It is noted again here that the Colorado tritium level appears to have been calculated using FGR 11 and that the value calculated today, using FGR 13 would be 400 pCi/L instead of the 500 pCi/L in the Colorado standards.

[16] The federal drinking water limit for gross alpha excludes uranium and radon. A separate limit was set for uranium. See 40 CFR 141.66 as well as the definition of gross alpha in 40 CFR 141.2.

- A 70 year lifetime risk with water use at 2L per day using prevailing risk calculation methods is an appropriate method to approach the setting of specific contaminant levels.

The above lessons apply directly to the specific situation under consideration in regard to the segments of the Rio Grande that are the subject of 20.6.4.114B. There is a significant source of man-made radionuclides in the part of the Rio Grande Basin at issue: Los Alamos National Laboratory. For practical purposes, it is the only source of man-made radionuclide pollutants that could affect public water supply in that area. The proposed diversion of water for public use in the basin could result in a great increase in the number of people who would be using the water and hence, potentially at risk. Therefore a new situation is about to arise that requires a greater stringency in public health protection from the most prevalent radionuclides. The aim would be to ensure that public water authorities are able to maintain a safe public water supply.

In these circumstances, a level of $10^{-6}$ for lifetime risk is not only justified, it has precedent in the DOE agreement with the State of Colorado and in the developing precedent in Canada. This is not an issue that will easily fade away since drinking water is among the most sensitive of issues that arouses public concern. If NMED and the New Mexico Water Quality Commission should choose to retain the usual $10^{-5}$ risk level, the adoption of a $10^{-6}$ level is likely to continue to be advocated both because it is justified in the circumstances and because there is precedent for it. The following questions will naturally arise:

*If the Department of Energy's agreement with the State of Colorado has a $10^{-6}$ risk level for waters associated with Rocky Flats, why should the public in New Mexico be protected to a lower standard of care? Indeed, another question is also germane: In view of the runoff of the radionuclides in question at much higher levels from canyons associated with LANL, why have the State of New Mexico and LANL not yet negotiated an agreement that would protect all New Mexico public water supplies downstream of LANL to ambient levels of man-made radionuclides associated with LANL?*

A strong argument can and should be made that, if the public in any state takes on the risk of having nuclear weapons facilities and the radioactive materials and wastes that have come to characterize their environs, then the environmental, water, and health authorities at the state and federal levels have a corresponding obligation to ensure that there is stringent standard of care. In a state that has no plutonium facilities the level for plutonium whether it is 15 pCi/L or 1.5 pCi/L or 0.15 pCi/L hardly matters since the public in that state is practically guaranteed that plutonium in the water will remain much less than 0.15 pCi/L. But with LANL as a neighbor and storm water runoff having levels of plutonium and other contaminants that are sometimes more than 100 times higher than that indicated by the $10^{-6}$ risk level,[17] it seems critical to settle the issue once and for all prior to the widespread use of the sections of the Rio Grande Basin downstream of LANL for domestic water supply.

[17] The LANL Draft Site Wide Environmental Impact Statement had data showing americium-241, plutonium-238, and plutonium239/240 levels of 40 pCi/L, 50 pCi/L, and 30 pCi/L respectively in the Mortandad Canyon. The average for all the canyons for these radionuclides was 15, 15, and 10 pCi/L respectively. SWEIS data as cited in Makhijani 2006.

I strongly recommend that NMED and the Commission adopt a risk level for setting man-made criteria levels as $10^{-6}$ for the sections of the Rio Grande Basin under consideration in 20.4.6.114B. The criteria levels for the pollutants considered by NMED would then be as shown in Table 2:

Table 2: Criteria contaminant levels for some man-made radionuclides

| Radionuclide | pCi/L |
|---|---|
| Americium-241 | 0.19 |
| Cesium-137 | 0.64 |
| Plutonium239/240 | 0.15 |
| Strontium-90 | 0.35 |
| Tritium | 400 |

Note: Values are rounded to two significant figures, except for tritium, where the value is rounded to one significant figure, following the NMED practice in its table.

The NMED list omits some long-lived man-made alpha-emitting transuranic radionuclides present at LANL from this list, including plutonium-238. While perhaps not as important as the ones in Table 2 above, it is important to have a combined limit that would cover them. I therefore propose that a row be added to the table that specifies that the maximum level criterion for all long-lived alpha-emitting transuranic radionuclides would be 0.15 pCi/L. This would include plutonium-238, plutonium-239/240, plutonium-242, americium-241, americium-243, curium-244, and neptunium-237. The table in the amendments should therefore read as in Table 3 below:

Table 3: Criteria contaminant levels for some man-made radionuclides

| Radionuclide | pCi/L |
|---|---|
| Americium-241 | 0.19 |
| Cesium-137 | 0.64 |
| Plutonium239/240 | 0.15 |
| Strontium-90 | 0.35 |
| Tritium | 400 |
| Long-lived Alpha TRU (Note 1) | 0.15 |

Note 1: The category long-lived alpha-emitting TRU (transuranic radionuclides) includes the combined total of plutonium-238, plutonium-239/240, plutonium-242, americium-241, americium-243, curium-244, and neptunium-237.

The proposed lifetime risk level of $10^{-6}$ and the associated public health criteria for the radionuclides listed in Table 3 will not pose any undue burdens on public water supply systems in the sections of the Rio Grande Basin that are the subject of NMAC 20.6.4.114B. The main purpose here is public health protection. The other goal is to help New Mexico set a new course in its relationship with DOE and LANL so that an agreement similar to the one relating to Rocky Flats could be arrived at so long as LANL is operating and during decommissioning, should radionuclide operations cease there at some future point in time. Of course, it is essential that along with the levels specified in Table 3, appropriate minimum detection limits should be

adopted for the measurements to be meaningfully interpreted. The limits of detection should be at least a factor of four below the levels in Table 3. This should be specified in the proposed amendments just below the table in 20.6.4.114B as follows:

> In making measurements for meeting the purposes of this section, the detection limits employed should not exceed 25 percent of the concentrations specified in the table above. Detection limits should be reported along with measurement results.

**B. Combined values for radionuclides**

The proposed 20.6.4.114B does not make any specification that the levels in the table are maximum levels in case a single radionuclide is present. This is implied in setting a maximum risk level and making each value correspond to that level. However, it is necessary to specify maximum contaminant levels in case more than one contaminant is present. The normal practice is to require that the ratio of the level each contaminant to the maximum allowable level for that contaminant summed over all contaminants should not exceed 1. Hence, I recommend that the following language be added to the amendment:

> When more than one of the above specified radionuclides are present, the purpose of health protection means that sum of the ratios of the actual concentration values to the criteria limits should not exceed 1:
>
> $C_1/C_{1L} + C_2/C_{2L} + \ldots\ldots + C_n/C_{nL} \leq 1$

where

$C_i$ is the measured level of the $i^{th}$ contaminant and
$C_{iL}$ is the maximum level for the $i^{th}$ contaminant set as a public health criterion level.

**C. Purpose of Contaminant Level Specification**

In December 2008, NMED stated that "the following criteria are applicable to the public water supply use" in referring to radionuclide contaminant values.[18] While not explicitly written in the language of a maximum contaminant level (MCL), the statement that the "criteria" were "applicable" to public water supplies indicates the intent that the criteria values were, in practice, to be treated as MCLs. In its petition about the Amendments, the Buckman Direct Diversion Board accepted the language that the criteria be "applicable to the public water supply use." Its comment in this regard was that the values be calculated on a 12-month rolling average basis,[19] which is a reasonable request, since NMED had not specified the averaging method or period in its proposed amendments in 2008.

It is noteworthy that the Buckman Direct Diversion Board, the party that would be directly impacted by the amended Section 20.6.4.114B is willing to accept the criteria values as de facto

[18] NMED 2009, p. 37.
[19] Buckman Board 2009, p. 2.

drinking water standards. It did not request a loosening of the language.[20] Yet, NMED did loosen the language in its revision of the amendments in July 2009. The section now states that the criteria would be "applicable to the public water supply use **for monitoring and public disclosure purposes only**."[21]

While monitoring and public disclosure are worthy, even essential goals, they will not by themselves suffice to protect public health. In the case of Colorado, the state requires that the levels of 0.15 pCi/L for americium-241 and plutonium and 500 pCi/L for tritium shall not be exceeded due to "municipal, agricultural, or industrial activities."[22] It is recognized that these values were arrived at in the context of a specific agreement regarding the cleanup of Rocky Flats between the DOE and the State of Colorado.[23] However, in view of the fact that LANL is essentially the only source of the pollutants in the sections of the Rio Grande Basin under consideration, it is reasonable and equitable for New Mexico to protect those sections of the Basin by taking its cue from the DOE-Colorado agreement.[24]

It is essential, in the context of a proposed large expansion of the use of water in sections of the Rio Grande Basin, that language be included in the amendments that would allow the State of New Mexico to actually fulfill its responsibilities in regard to public health protection and ensuring the purity of drinking water supply. At a minimum, the final sentence in the paragraph prefacing the proposed table of contaminant levels in 20. 6.4.114B should be replaced with:

> In addition, the following criteria based on a 12-month rolling average are to be viewed as maximums for the purposes of public health protection and as such should not be exceeded in public water supplies. The specified levels should also be used as criteria for monitoring and public disclosure purposes. In the event that the levels are exceeded, the New Mexico Water Quality Commission shall investigate the causes and provide a report to the Governor of New Mexico within three months of the exceedance of the criterion level, along with a set of recommended remedies so that public health protection may be protected to the level indicated by the maximum levels in the table..

I also recommend that the State of New Mexico to pursue an agreement with LANL and the Department of Energy that, in case levels in surface water and in spring outcrops approach those specified in the criteria, LANL will take corrective actions so as to reduce the concentrations to levels below the levels specified in the table. Note that the agreement that DOE arrived at with the State of Colorado regarding the two creeks that are associated with Rocky Flats is in the context of "action levels"[25] during decommissioning. Since Los Alamos has both legacy contamination as well as ongoing operations, the levels should be permanent in the case of New Mexico.

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[20] Buckman Board 2009, p. 2.
[21] NMED 2009, p. 41, emphasis added.
[22] Colorado Reg. 38 2009, Table 2 (p. 35 of the tables section)
[23] Rocky Flats 2003, p. 5-7 and Table 1 (p. 5-25).
[24] As noted above, the DOE-Colorado agreement specifies strict criteria for few radionuclides (plutonium, americium-241 and tritium) apparently because these are the only ones present in significant amounts at of Rocky Flats that would be at risk of increased runoff during decommissioning. The list specified in Table 3 above would be the correspondingly relevant one for LANL.
[25] Colorado Reg. 38 2009, p. 133.

## D. Reasonableness of the proposed levels

A significant issue is whether the maximum levels proposed above as public health criteria could be achieved without excessive cost to the water authorities in terms of remediation. The independent assessment done on this issue by Dr. Kerry Howe indicates that this could be done.[26] The Howe report is done mainly in the context of existing federal drinking water standards. However, it also concluded that a level of 0.15 pCi/L for long-lived alpha-emitting transuranic radionuclides could also be met.[27]

The only contaminant that could not be filtered out or otherwise reduced by treatment (were that to be necessary, and that is not at present indicated) is tritium. However, tritium is at about background levels of 20 to 50 pCi/L in the Rio Grande Basin waters in question, which is well below the proposed level of 400 pCi/L. However, there is still a risk of tritium of Los Alamos origin that could migrate offsite. The table below is reproduced from LANL's 2007 Environmental Surveillance report.

Executive Summary

**Table ES-5**
**Estimated Annual Average Unfiltered Surface Water Concentrations of Radionuclides in Selected Canyons Compared with the Biota Concentration Guides (pCi/L)**

| Radionuclide | BCG[a] | Acid Canyon above Pueblo Canyon | Lower Pueblo Canyon | DP Canyon below TA-21 | Los Alamos Canyon between DP Canyon and NM 4 | Los Alamos Canyon at Rio Grande | Mortandad Canyon below Effluent Canyon | Maximum percent of BCG[a] |
|---|---|---|---|---|---|---|---|---|
| Am-241 | 400 | 0.59 | 0.08 | 0.4 | 0.3 | 0.02 | 0.9 | 0.2% |
| Cs-137[b] | 20,000 | ND[c] | ND | ND | 2 | ND | 10 | 0.05% |
| H-3 | 300,000,000 | 17 | 1.6 | 23 | 16 | 22 | 853 | < 0.01% |
| Pu-238 | 200 | 0.04 | 0.00 | 0.03 | 0.03 | ND | 1.5 | 0.7% |
| Pu-239/240 | 200 | 5.6 | 22 | 0.2 | 0.6 | 0.2 | 2 | 11% |
| Sr-90 | 300 | 0.5 | 0.02 | 35 | 2 | 0.08 | 1.9 | 12% |
| U-234 | 200 | 1.0 | 3 | 2 | 0.9 | 1.4 | 1.0 | 1% |
| U-235/236 | 200 | 0.06 | 0.01 | 0.01 | 0.05 | 0.09 | 0.05 | 0.1% |
| U-238 | 200 | 0.8 | 2 | 2 | 0.8 | 1.0 | 0.9 | 1% |
| Ra-226 | 4 | 1.0 | 1.1 | ND | ND | ND | 0.6 | 28% |

[a] BCG = DOE Biota Concentration Guides
[b] The BCG for cesium-137 is a site-specific modified BCG
[c] ND indicates no analytical laboratory detection in 2007

Source: LANL 2007, Table ES-5 (p. 18)

The values of runoff from Mortandad canyon for americium-241, plutonium-238, plutonium-239/240, strontium-90, cesium -137, and H-3 (tritium) are all above $10^{-6}$ risk levels shown in

[26] Howe 2008.
[27] Howe 2008, p. 28.

Table 3. Some other values (at other locations) of americium-241, plutonium-239/240, cesium-137, and strontium-90 are also above the $10^{-6}$ levels in Table 3. The worst contamination reported is for plutonium-239/240 in Lower Pueblo Canyon (22 pCi/L) and for Sr-90 in DP Canyon below TA-21 [Technical Area 21] (35 pCi/L), which are both above the present EPA drinking water standard.[28] Natural radionuclides, which are the uranium and radium isotopes, all appears to be at ambient, natural background levels for the most part, except possibly for uranium in the Lower Pueblo and DP canyons. Note that these values are for unfiltered water and filtration and treatment would be expected to significantly reduce the concentrations (except for tritium), even apart from any dilution, prior to use as domestic water supply as indicated in Howe 2008.

In conclusion:

1. Strict public health criteria levels for man-made radionuclides in drinking water downstream of LANL are needed; these should be set at levels shown in Table 3 corresponding to a $10^{-6}$ lifetime risk level.
2. The State of New Mexico should begin negotiations with the Department of Energy for LANL remediation and for adoption of discharge practices that would keep surface water flowing from the site and water in springs associated with the site to levels below those shown in Table 3.

[28] 40 CFR 141.66 2008.

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# Curriculum Vita of Arjun Makhijani

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A recognized authority on energy issues, Dr. Makhijani is the author and co-author of numerous reports and books on energy and environment related issues, including two published by MIT Press. He was the principal author of the first study of the energy efficiency potential of the US economy published in 1971. He is the author of *Carbon-Free and Nuclear-Free: A Roadmap for U.S. Energy Policy* (2007).

In 2007, he was elected Fellow of the American Physical Society. He was named a Ploughshares Hero, by the Ploughshares Fund (2006); was awarded the Jane Bagley Lehman Award of the Tides Foundation in 2008 and the Josephine Butler Nuclear Free Future Award in 2001; and in 1989 he received The John Bartlow Martin Award for Public Interest Magazine Journalism of the Medill School of Journalism, Northwestern University, with Robert Alvarez. He has many published articles in journals and magazines as varied as *The Bulletin of the Atomic Scientists, Environment, The Physics of Fluids, The Journal of the American Medical Association,* and *The Progressive*, as well as in newspapers, including the *Washington Post*.

Dr. Makhijani has testified before Congress, and has appeared on ABC World News Tonight, the CBS Evening News, CBS 60 Minutes, NPR, CNN, and BBC, among others. He has served as a consultant on energy issues to utilities, including the Tennessee Valley Authority, the Edison Electric Institute, the Lawrence Berkeley Laboratory, and several agencies of the United Nations.

***Education:***

- Ph.D. University of California, Berkeley, 1972, from the Department of Electrical Engineering. Area of specialization: plasma physics as applied to controlled nuclear fusion. Dissertation topic: multiple mirror confinement of plasmas. Minor fields of doctoral study: statistics and physics.
- M.S. (Electrical Engineering) Washington State University, Pullman, Washington, 1967. Thesis topic: electromagnetic wave propagation in the ionosphere.
- Bachelor of Engineering (Electrical), University of Bombay, Bombay, India, 1965.

***Current Employment:***

- 1987-present: President and Senior Engineer, Institute for Energy and Environmental Research, Takoma Park, Maryland. (part-time in 1987).
- February 3, 2004-present, Associate, SC&A, Inc., one of the principal investigators in the audit of the reconstruction of worker radiation doses under the Energy Employees Occupational Illness Compensation Program Act under contract to the Centers for Disease Control and Prevention, U.S. Department of Health and Human Services.

***Other Long-term Employment***

- 1984-88: Associate Professor, Capitol College, Laurel, Maryland (part-time in 1988).
- 1983-84: Assistant Professor, Capitol College, Laurel, Maryland.
- 1977-79: Visiting Professor, National Institute of Bank Management, Bombay, India. Principal responsibility: evaluation of the Institute's extensive pilot rural development program.
- 1975-87: Independent consultant (see page 2 for details)
- 1972-74: Project Specialist, Ford Foundation Energy Policy Project. Responsibilities included research and writing on the technical and economic aspects of energy conservation and supply in the U.S.; analysis of Third World rural energy problems; preparation of requests for proposals; evaluation of proposals; and the management of grants made by the Project to other institutions.
- 1969-70: Assistant Electrical Engineer, Kaiser Engineers, Oakland California. Responsibilities included the design and checking of the electrical aspects of mineral industries such as cement plants, and plants for processing mineral ores such as lead and uranium ores. Pioneered the use of the desk-top computer at Kaiser Engineers for performing electrical design calculations.

***Professional Societies:***

- Institute of Electrical and Electronics Engineers and its Power Engineering Society
- American Physical Society (Fellow)
- Health Physics Society
- American Association for the Advancement of Science

***Awards and Honors:***

- The John Bartlow Martin Award for Public Interest Magazine Journalism of the Medill School of Journalism, Northwestern University, 1989, with Robert Alvarez
- The Josephine Butler Nuclear Free Future Award, 2001
- Ploughshares Hero, Ploughshares Fund, 2006
- Elected a Fellow of the American Physical Society, 2007, *"For his tireless efforts to provide the public with accurate and understandable information on energy and environmental issues"*
- Jane Bagley Lehman Award of the Tides Foundation, 2007/2008

***Invited Faculty Member, Center for Health and the Global Environment, Harvard Medical School***: Annual Congressional Course, *Environmental Change: The Science and Human Health Impacts*, April 18-19, 2006, Lecture Topic: An Update on Nuclear Power - Is it Safe?

***Consulting Experience, 1975-1987***
Consultant on a wide variety of issues relating to technical and economic analyses of alternative energy sources; electric utility rates and investment planning; energy conservation; analysis of energy use in agriculture; US energy policy; energy policy for the Third World; evaluations of portions of the nuclear fuel cycle.

Partial list of institutions to which I was a consultant in the 1975-87 period:

- Tennessee Valley Authority
- Lower Colorado River Authority
- Federation of Rocky Mountain States
- Environmental Policy Institute
- Lawrence Berkeley Laboratory
- Food and Agriculture Organization of the United Nations
- International Labour Office of the United Nations
- United Nations Environment Programme
- United Nations Center on Transnational Corporations
- The Ford Foundation
- Economic and Social Commission for Asia and the Pacific
- United Nations Development Programme

***Languages:*** English, French, Hindi, Sindhi, and Marathi.

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