Battelle
Pacific Northwest Laboratories

Project Number

Internal Distribution

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File/LB

409837

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Date July 9, 1979

To W. J. Bair/R. O. Gilbert

From B. A. Napier

Subject ENEWETOK DOSE ASSESSMENT REVIEW

I have reviewed the methodology and results of calculations performed by Lawrence Livermore Laboratory for future inhabitants of Enewetok Atoll. In general, I concur with their methods and conclusions. However, I have some questions and suggestions for the next draft of the LLL document.

I used slightly modified versions of our computer codes PABLM and MAXI to calculate 30- and 50-year accumulated doses and maximum annual doses. I also used the code DACRIN to try to duplicate some inhalation dose results. I needed to modify the first two codes in order to accommodate the specific diet of the Marshall Islands. The codes PABLM and MAXI basically incorporate the recommendations of ICRP-2, and DACRIN uses the ICRP Task Group on Lung Dynamics model. I took plant concentration to soil concentration ratio data from the LLL document where available, and assumed conservative values elsewhere.

The doses calculated are for an adult male only. I did not have time to modify the codes further for children and women. I did reduce the masses of all organs by a uniform 15% to account for the smaller size of Marshall Islanders from the standard man. I attempted to incorporate as many of the Livermore assumptions as I could, to try to follow their exposure scenarios. All ingestion doses therefore allow an 80-year period initially during which no radionuclides are ingested.

I did calculate external irradiation doses based on soil concentrations, even though this was really not necessary since the reported values were based on actual measurements. I was able to come comfortingly close (±10%) to their results. Livermore reports only contributions from ^{60}Co and ^{137}Cs + D. Our program indicated a small calculated contribution from ^{152}Eu, but never more than a few percent. Since it has a short halflife, it is probably not worth worrying about.

There is not sufficient data presented in the LLL rough draft to predict doses from isotopes of plutonium, even though they do present dose results. I believe they may have predicted plutonium concentrations based on a Pu/Am ratio, but no confirmations of this appears in the report.

There is not sufficient data presented in the LLL report to predict inhalation doses from any radionuclide. No resuspension data is given for the inhalation pathway. I have used a resuspension factor of $10^{-3}m^{-1}$, based on work by Anspaugh, and allowed only the top centimeter of soil to be available for resuspension. Since the inhalation doses vary directly with resuspension, these are somewhat arbitrary values. Though the initial inhalation doses are relatively small, at long times they will come to be the controlling pathway. The remaining radionuclides (actinides) contribute mainly via the inhalation pathway.

There is not sufficient data to predict doses from aquatic foods; i.e., clams, crabs, or fish. Livermore dismisses the doses as insignificant, but under certain circumstances, the Marshallese diet contains large quantities of fish. Other researchers have mentioned fish, etc. as pathways deserving of attention. I think more data or analysis of aquatic foods should be presented to back up any assumptions made.

No data are presented at all for radionuclide concentrations on the southern islands of the atoll. These data are important, since for the first 8 years the diet of the northern islands is supplemented by crops grown on the southern islands, and some scenarios use southern-island-grown crops. I have been assuming that all concentrations are negligible in comparison with the northern islands; i.e., essentially zero.

For the ingestion pathways, I used exclusively our modifications of the ICRP-2 methodology. Therefore, our doses have some inherent differences. I have checked their models against ours and can reconcile almost all differences easily.

Our models include a total-body contribution from ^{90}Sr. Joe Soldat tells me that the ICRP-2 model I use probably overestimates the ^{90}Sr total-body contribution. The Bennett model used by LLL is only for bone marrow. Our bone model is for hard mineral bone. If I use our model for predicting the ^{90}Sr concentration in mineral bone and apply the bone/marrow dose ratio of Spiers (1972) and UNSCEAR of 0.32, our ^{90}Sr doses compare well (between ±10-25%). This is pretty good considering totally different uptake models are used.

My doses from ^{137}Cs + D are uniformly higher than those presented by LLL. This is because I use the ICRP-2 model and they use the ICRP-10 double-exponential model. This results in their long-term dose commitments being 85% of ours. If this 0.85 is factored in, I am within ±10% of their answer for total body. My ^{137}Cs bone results are still slightly higher, since, for my model, bone has a 140-day biological halflife as opposed to a 115-day biological halflife for total body used by ICRP-10.

The only radionuclide I am having trouble reconciling is ^{241}Am. My ingestion doses are about one order of magnitude lower than LLL's, even if I take their increased gut-to-blood transfer coefficient into account. A preliminary check of inhalation dose from ^{241}Am does not show this problem. While this may reflect that I am only approximating the air concentration, I am going to have to more closely examine our actinide model and parameters.

I have only a few minor complaints about the rest of the dose presentation. There is no concentration ratio data for arrowroot plants. These plants become a major fraction of the diet during famine conditions.

If they are using the TGLM lung model, it might be nice to present lung dose results elsewhere than Appendix B. This would make it easier to see how ingestion and external pathways dominate the doses.

The data in the last set of tables in Appendix D need to be more clearly labeled. Units and definition of the percent variation (by island?) would make life easier.

The year during which the maximum annual dose occurs is useful. I do not always get the total body and bone to peak in the same year. (They don't either, but it is not obvious from the dose tables.) It would be easy to put this on the tables and I think the reader needs it.

I have not tried to duplicate all the possible diet/residence scenarios they presented. I have only tried in the limited time available to audit the dose methods and assumptions. As a rule, they look o.k.

I have included a table of accumulated doses to illustrate how my calculations compare with Livermore's. This is one of the spot-checks I have made. The ^{90}Sr bone doses include the 0.32 correction and the ^{137}Cs total body doses include the 0.85 correction.

I will be out of town the week of July 9-13, but will be available for questions after the 15th.

BAN:cs

NOTE TO DICK GILBERT: I have been unable to contact Bill Phillips. My phone and his seem to be on different wires (?).

Comparison of PNL Dose Results with Those Calculated by LLL

Values from Table 20
Adult Males, Engebi Island, Famine Conditions

Radionuclide	30-Year Dose				50-Year Dose			
	Body		Bone		Body		Bone	
	LLL	PNL	LLL	PNL	LLL	PNL	LLL	PNL
Ingestion Pathway								
^{137}Cs	7.2+0	7.8+0	7.2+0	1.0+1	1.1+1	1.2+1	1.1+1	1.6+1
^{90}Sr			8.5-1	6.4-1			1.4+0	1.3+0
^{241}Am			1.5-2	1.8-3			3.9-2	6.2-3
External Gamma Exposure								
$^{137}Cs+^{60}Co$	2.2+0	2.4+0	2.2+0	2.4+0	2.9+0	3.2+0	2.9+0	3.2+0
Inhalation Pathway								
^{241}Am			3.3-2	2.3-2			9.0-2	6.0-2