Attachment 1

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The Pu model used:

45% of transferred Pu to bone; $T_{1/2}$ = 100y
45% of transferred Pu to liver; $T_{1/2}$ = 40y
10% of transferred Pu to other; $T_{1/2}$ = 0.1 y

Daily Pu intake:

1 g/d of soil (median value 5.4 pCi/g) = 5400 fCi/d
3000 g/d of food at 4×10^{-5} pCi/g = 120 fCi/d
Total ∿ 5,500 fCi/d

1g/d soil (mean value 10 pCi/g) = 10,000 fCi/d
3000 g/d food at 4×10^{-5} pCi/g = 120 fCi/d
Total ∿ 10,000 fCi/d

Table 1. The liver and bone Pu burden for the above model conditions for various gut transfer factors (GTF) after 7 years intake at 5500 fCi/d and 2 years of no intake.[a]

	Pu Burden, fCi				
Gut transfer factor	Liver Burden		Bone Burden		Total
	Ingestion	Inhalation	Ingestion	Inhalation	
10^{-4}	6.5×10^{2}	2.1×10^{3}	6.8×10^{2}	2.2×10^{3}	5.6×10^{3}
5×10^{-4}	3.3×10^{3}	2.1×10^{3}	3.4×10^{3}	2.2×10^{3}	1.1×10^{4}
10^{-3}	6.5×10^{3}	2.1×10^{3}	6.8×10^{3}	2.2×10^{3}	1.8×10^{4}
10^{-2}	6.5×10^{4}	2.5×10^{3}	6.8×10^{4}	2.6×10^{3}	1.4×10^{5}
10^{-1}	6.5×10^{5}	6.6×10^{3}	6.8×10^{5}	6.9×10^{3}	1.3×10^{6}

[a] Inhalation values are based in the model described in UCRL-53225; intake = 44.7 fCi/d.

Table 2. The liver and bone Pu burdens for the above model conditions for various gut transfer factors (GTF) after 7 years intake at 10,000 fCi/d and 2 years of no intake.[a]

	Pu Burden, fCi				
Gut transfer	Liver Burden		Bone Burden		
factor	Ingestion	Inhalation	Ingestion	Inhalation	Total
10^{-4}	1.2×10^{3}	2.1×10^{3}	1.3×10^{3}	2.2×10^{3}	6.8×10^{3}
5×10^{-4}	6.0×10^{3}	2.1×10^{3}	6.3×10^{3}	2.2×10^{3}	1.7×10^{4}
10^{-3}	1.2×10^{4}	2.1×10^{3}	1.3×10^{4}	2.2×10^{3}	2.9×10^{4}
10^{-2}	1.2×10^{5}	2.5×10^{3}	1.3×10^{5}	2.6×10^{3}	2.6×10^{5}
10^{-1}	1.2×10^{6}	6.6×10^{3}	1.3×10^{6}	6.9×10^{6}	2.5×10^{6}

[a] Inhalation values are based in the model described in UCRL-53225; intake = 44.7 fCi/d.

Table 3. Liver Pu burdens as a function of soil intake and gut transfer factor (GTF) after 7 years intake of 5500 fCi/d and 2 years of no intake.

	Soil intake g/d[a]						
Gut transfer factor	1	2	3	4	5	10	20
10^{-4}	6.5×10^{2}	1.3×10^{3}	2×10^{3}	2.6×10^{3}	3.3×10^{3}	6.5×10^{3}	1.3×10^{4}
5×10^{-4}	3.3×10^{3}	6.6×10^{3}	9.9×10^{3}	1.3×10^{3}	1.7×10^{4}	3.3×10^{4}	6.6×10^{4}
10^{-3}	6.5×10^{3}	1.3×10^{4}	2×10^{4}	2.6×10^{4}	3.3×10^{5}	6.5×10^{5}	1.3×10^{6}
10^{-2}	6.5×10^{4}	1.3×10^{5}	2×10^{5}	2.6×10^{5}	3.3×10^{5}	6.5×10^{5}	1.3×10^{6}
10^{-1}	6.5×10^{5}	1.3×10^{6}	2×10^{6}	2.6×10^{6}	3.3×10^{6}	6.5×10^{6}	1.3×10^{7}

[a] Pu concentrations in the soil = 5.4 pCi/g

Table 4. Pu organ burden in fCi for 7 years of intake.[a]

Year	Bone		Liver		Total fCi
	Ingestion	Inhalation	Ingestion	Inhalation	
1	90	81	90	81	340
2	180	220	178	218	796
3	268	414	264	410	1356
4	357	657	350	647	2011
5	444	940	433	922	2739
6	530	1256	515	1226	3527
7	618	1598	596	1554	4366
8	680	1910	652	1848	5090
9	675	2165	641	2084	5565

[a] Ingestion intake = 5500 fCi/d of Pu for 7 years

Inhalation intake = 44.7 fCi/d

GTF = 10^{-4}

45% of Pu body burden in bone; $T_{1/2}$ = 100 y

45% of Pu body burden in liver; $T_{1/2}$ = 40 y

See model in UCRL-53225 for inhalation intake of Pu

1. Comparison of the model results with recent observations by Moss and McInroy of LASL (see attachment 2).

Using Moss and McInroy's observations from LASL: daily urine activity of Pu when multiplied by 20,000 gives the liver Pu burden. Assume BNL observation of 60 fCi/l per 24 h.

$$60 \text{ fCi} \times 20{,}000 = 1.2 \times 10^6 \text{ fCi in the liver}$$

Regardless of whether the median or mean Pu soil concentration is used, the liver burden (Tables 1 and 2) of 8.6×10^3 fCi or 3.3×10^4, respectively, based on a GTF of 10^{-3} do not come close to the 1.2×10^6 fCi liver burden calculated based on the BNL 60 fCi/l per d of Pu and the empirical results observed by Moss and McInroy. Even with a GTF of 10^{-1} the results are less than reported by McInroy.

Assuming a GTF of 10^{-3} along with the above model, the quantity of soil which would have to be ingested to obtain liver burdens of Pu consistent with BNL and McInroy observations would be:

use 0-5 cm Pu concentration of 5.4 pCi/g

$$\text{Intake required} = \frac{1.2 \times 10^6 \text{ fCi}}{6.6 \times 10^3 \text{ fCi}} \quad 5500 \text{ fCi/d} = 1.0 \times 10^6 \text{ fCi/d}$$

$$\text{Soil required to supply Pu intake of } 10^6 \text{ fCi/d} = \frac{1.0 \times 10^6 \text{ fCi/d}}{5.4 \times 10^3 \text{ fCi/g}} = 185 \text{ g/d}$$

If the gut transfer were as high as 10^{-2} it would require consumption of nearly 19 g/d of soil and if the gut transfer were 10^{-4} then $\sim$1900 g/d (Table 3).

2. Compare the total Pu burden (liver + bone) calculated by the model to the observed urinary daily excretion.

If 60 fCi/l per day were taken as the average rate of excretion for that year, the total quantity excreted for the year would be 60 fCi/d x 365 d = 2.19×10^4 fCi.

The body burden B in year t, where t_o would be the time of removal from the atoll and thus B_o would be the body burden at the end of 7 y, will be

$$B_t = B_o \; (0.5 \; e^{\lambda_L t} + 0.5 \; e^{\lambda_B t})$$

where λ_L = rate constant for removal from liver

λ_B = rate constant for removal from bone

$\lambda_L = \frac{0.693}{40} = 00173 \; y^{-1}$

$\lambda_B = \frac{0.693}{100} = 0.00693 \; y^{-1}$

and uniform distribution is assumed between bone and liver.

$$B_1 - B_2 = 2.19 \times 10^4 \; fCi$$

Thus $B_1 - B_2 = 0.5 \; B_o \; [e^{-0.0173(1)} - e^{-0.0173(2)} + ^{-0.00693(1)}$

$$- e^{-0.00693(2)}] = 0.5 \; B_o \; [0.024] = 0.012 \; B_o = 2.19 \times 10^4 \; fCi$$

$$B_o = \frac{2.19 \times 10^4}{0.012} = 1.83 \times 10^6 \; fCi$$

Thus, the body burden based on current accepted fractional deposition and turnover times that would lead to an annual excretion of 2.19×10^4 fCi would require intakes of soil approaching 20g and GTF's approaching 0.1 to 1. Conversely, if one assumes a daily intake of 10,000 fCi/d plus 44.7 fCi/d by inhalation, the average daily excretion rate after 7 years of intake and 2 years of no intake should be about 3 fCi/d for a GTF of 10^{-4}, 4 fCi/d for a GTF of 10^{-3} and 12 fCi/d for a GTF of 10^{-2}.

Obviously this is not a rigorous analysis and several assumptions were made which are not exact but it does put the problem in perspective.

Another approach to the current dilemma is to look at the body burden from Table 1 for a GTF of 10^{-4}. The calculated body burden from inhalation and ingestion 2 y after removal from the atoll is 5.6×10^3 (liver plus bone). Thus at 60 fCi/d the entire body burden would be eliminated in about 90 days. Even for a GTF of 10^{-3} where the body burden would be 1.8×10^4 the entire body burden would be removed in less than a year. Obviously the excretion would not be constant but again it puts the problem in perspective because of the rapidity with which at least a major fraction of the body burden would be excreted.