719224

~~SECRET~~

This document consists of 36 pages.
Number 4 of 6 Copies, Series A.

BEST COPY AVAILABLE

PLUTONIUM EXCRETION ANALYSIS

Classification Cancelled
~~Or Changed To~~
By Authority Of Div. of Classification
By JKHardsock/cb Date 5/10/74

~~SECRET~~

1145177

[redacted]

PROVENANCE

REPOSITORY:	OFFICE OF HUMAN RADIATION EXPERIMENTS (OHRE)
COLLECTION:	PLUTONIUM INJECTION INVESTIGATION FILES (OHRE 1)
BOX:	2
FOLDER:	PLUTONIUM INJECTIONS - ROCHESTER - GEN INFORMATION

1145171A

[redacted]

INDEX OF FIGURES AND TABLES

Figures		Page No.
1	Mean Urinary Excretion of Plutonium in % Injection Dose By Subjects H_p-1 through H_p-10 and H_p-12 by Days after Injection	9
2	Mean Fecal Excretion of Plutonium in % Injection Dose By Subjects H_p-1 through H_p-10 and H_p-12 By Days after Injection	10
3	Mean Urinary-Fecal Excretion of Plutonium in % Injection Dose By Subjects H_p-1 through H_p-10 and H_p-12 By Days after Injection	11
4	Mean Urinary Excretion Curve of Plutonium in % Injection Dose and Error Bands Derived From Fitted Curve By Days after Injection	12
5	Mean Fecal Excretion Curve of Plutonium in % Injection Dose and Error Bands Derived from Fitted Curve By Days after Injection	13
6	Mean Urinary-Fecal Excretion Curve of Plutonium in % Injection Dose and Error Bands Derived from Fitted Curve By Days after Injection	14
7	Plutonium Content of Blood Samples in % Injection Dose of Subjects H_p-1 through H_p-10 and H_p-12 By Days after Injection	15
8	Mean Urinary Excretion of Plutonium vs. Mean Fecal Excretion Matched By Time in % Injection Dose r=.76	16
9	Plutonium Content of Blood vs. Urinary-Fecal Excretion for H_p-1 through H_p-10 and H_p-12 Matched By Time r=.77	17

Tables		
I	Body Weight - Blood Volume - Injected Initial Dose of Plutonium of H_p Subjects	18
II	Urinary Excretion of Plutonium in % Injection Dose per 24 Hours By Subjects H_p-1 through H_p-10 and H_p-12 for Entire Period of Observation (Total Injection Dose approximately 5 micrograms of Plutonium per Subject)	19

1145178

[redacted]

INDEX OF FIGURES AND TABLES

Tables		Page No.
III	Fecal Excretion of Plutonium in % Injection Dose per 24 Hours by Subjects H_p-1 through H_p-10 and H_p-12 for Entire Period of Observation (Total Injection Dose approximately 5 micrograms of Plutonium per Subject)	21
IV	Plutonium Content of Blood Samples in % Injected Dose in Total Blood Volume from Subjects H_p-1 through H_p-10 and H_p-12 (Total Injection Dose approximately 5 micrograms of Plutonium per Subject)	24
V	Observed and Theoretical Means and Standard Deviations for Amount of Plutonium (in % Injection Dose) Excreted from Urine	26
VI	Observed and Theoretical Means and Standard Deviations for Amount of Plutonium (in % Injection Dose) Excreted from Feces	28
VII	Observed and Theoretical Means and Standard Deviations for Amount of Plutonium (in % Injection Dose) Excreted from Urine and Feces	30
VIII	Mean Urinary, Fecal, and Urinary-Fecal Plutonium Excretion in % Injection Dose for the Period following the 22nd Day after Injection for Varying No. of H_p Subjects Based on Available Data	32
IX	Amount of Plutonium Excreted in Urine, Feces, and Combination Urine and Feces By Subject for Entire Period of Observation	34
X	Integrated Values for Urinary-Fecal Excretion of Plutonium in % Injection Dose at Various Times Based On Fitted Equation	35
XI	Chauvenet's - Rejection Criterion Testing Abnormality of H_p-4	36

March 14, 1947

To: Dr. Bassett
From: Statistics Division

Re: Plutonium Excretion Analysis

Chapter I - INTRODUCTION

This report is based on data obtained from a study of the bodily disposition of an injection of approximately 5 micrograms of plutonium into 11 subjects (H_p's). Three measures were taken from each subject. These are: (1) urinary excretion of plutonium (2) fecal excretion of plutonium and (3) plutonium content of the blood. These measures were obtained daily for a period of 22 days after injection and then at irregular intervals. The major analysis presented below is based on the first 22 post-injection days. The observed individual measurements are presented in Tables I through IV.

Chapter II - SUMMARY

The report presented below can be summarized with the following tentative conclusions:

(1) The rate of excretion of plutonium after injection of 5 micrograms is very small varying from a mean of .470% for the first day to .045% on the 22nd day. The fall in rate of excretion is rather rapid during the first 10 days; thereafter it decreases very gradually. The amount excreted is related to the plutonium content of the blood.

(2) The urinary and fecal excretions are highly correlated. The amount of urinary excretion is directly associated with the amount of fecal excretion.

(3) There is a high degree of association between the plutonium content of the blood and the excretions.

Certain interesting speculations can be made about the data on the basis of curves fitted to the initial 22 days:

(1) If the curves fitted to the values for the first 22 days continue to express the relationship between amount excreted and the passage of time, it would take 50 years to excrete 15%. There is this same probability (of unknown degree) that the dose would not be excreted during a normal life span. The half-time value, or the length of time it would take to excrete 50% of the injected material, based upon the fitted equation is, in terms of years, a 6 digit number.

1145180

[redacted]

SECRET

(2) The mean urinary excretion value at say 30 days as a basis for diagnosing exposure to an initial injection of 5 micrograms, as a result of the data studied, might be the extrapolated mean, .014% ± .007%.

Chapter III - FIGURES AND TABLES

Figures 1, 2 and 3 present plots of the daily post-injection means of urinary, fecal, and urinary-fecal excretion of plutonium in per cent (%) injection dose. Figures 4, 5 and 6 depict the "theoretical"* curves which were fitted to the data and their "error bands". Figure 7 presents the plutonium content of daily post-injection blood samples in % injection dose for the 11 subjects and also their daily means.

As noted above, the fitted curves were based on the first 22 days after injection when measures were available for all 11 subjects. The observed means are presented beyond the 22nd day for the available readings and are based on from 1-9 individual measures. The "theoretical" curves extend beyond the 22nd day but in this region the curves are merely extrapolated extensions of the curves for the first 22 days.

A plot of the plutonium content (in % injection dose) of blood samples by days after injection is presented in Figure 7. When the number of individual readings was 5 or larger, means were calculated and are shown on the graph.

Tables V, VI, VII and VIII present the observed and "theoretical" means of the various measures, standard deviations, and the approximated fiducial limits. The remainder of the tables will be referred to in the subsequent discussion.

Chapter IV - DISCUSSION

An attempt was made to fit mathematical curves to the mean urinary, fecal, and urinary-fecal excretions of plutonium in % injection dose for the first 22 days after injection. These curves were based on a consideration of the relationship between the per cent excreted and the number of days after injection. The type of equation which seemed to best fit the observed means was found to be the negative power function

$$Y = aX^{-b}$$

where Y = amount of plutonium excreted (expressed as % injection dose)
X = time after injection in days
and a and b are constants derived from the observed data by the method of least squares

* The derivation of the "theoretical" or calculated curves is discussed below.

[redacted]

The numerical equations obtained are as follows:

(1) Urinary Excretion

$$Y = \frac{.358}{X^{.9430}}$$

(2) Fecal Excretion

$$Y = \frac{.348}{X^{.7821}}$$

(3) Urinary-Fecal Excretion

$$Y = \frac{.742}{X^{.8744}}$$

As can be seen from a comparison of the observed and "theoretical" means (derived from the equations above) in Tables 5, 6 and 7, these curves fit the observed values very closely especially from the 7th to the 22nd day. Beyond the 22nd day the fitted curves also fall rather closely to the few observed values.

Despite the fact that it is rather hazardous to speculate about the course of those trends beyond the observed periods, it may be of interest to extrapolate. In this way, some idea of the rate of excretion beyond the 22-day period may be obtained if the curves fitted to the initial 22 days continue to express the relationship between the amount excreted and the passage of time. Some of these hypothetical values are entered in Tables 5, 6 and 7. As can be seen the fitted curves very rapidly become asymptotic to the base line so that the rate of excretion soon becomes very minute.

The σ's and the approximated fiducial limits of $\pm 3\sigma$ are also presented. These fiducial limits give a rough test of the reliability of the means. A fiducial limit at the 1% level, for example, can be interpreted as follows: Values at or beyond the limits expressed might be expected to occur by chance with the probability of 1/100 if a great number of similar investigations were undertaken.

The "theoretical" equations as given above express an amount likely to be excreted on a given day. In order to reproduce the accumulated amount excreted up to and including a given day, the equations may be integrated. The integration results in a value yielding the area under the curve. This value approximates the accumulated total in as much as the abscissa is expressed in discrete units of single days. Because of geometric considerations, this is obtained by integrating from limits of $1/2 \longrightarrow n + 1/2$ days.

[redacted]

1145182

The integrated expressions follow:

(1) Urinary Excretion

$$A = .358 \int_{1/2}^{n+1/2} X^{-.9430}\, dX = .358 \left(\frac{X^{.0570}}{.0570} \right)_{1/2}^{n+1/2} = (.358)(16.863)$$

(2) Fecal Excretion

$$A = .348 \int_{1/2}^{n+1/2} X^{-.7821}\, dX = .348 \left(\frac{X^{.2179}}{.2179} \right)_{1/2}^{n+1/2} = (.348)(3.942)$$

(3) Urinary-Fecal Excretion

$$A = .742 \int_{1/2}^{n+1/2} X^{-.8744}\, dX = .742 \left(\frac{X^{.1256}}{.1256} \right)_{1/2}^{n+1/2} = (.742)(7.299)$$

Table IX presents the actual amount of plutonium in % injection dose excreted from urine, feces, and urine-feces during the first 22 days for each subject and the "theoretic" amount as determined by integration. Table X is a listing of the "theoretic" values of urinary-fecal excretions of plutonium in % injection dose for various time periods. It may be noted that according to the "theoretical" equations only about 15% of approximate 5 microgram initial dose of the material is excreted in 50 years.

Correlation between mean urinary and mean fecal excretions of plutonium is $r=.76$. This is for 11 subjects for the first 22 days. If the first 2 days are excluded the correlation is $r=.98$. Since individual variability and errors of measurement are likely to be largest at this time it may be advisable to omit the first 2 days. There would seem, then, to be a very high degree of association between the two excretions. Figure 8 is a scatter diagram showing this relationship.

Another correlation which was obtained was that between mean plutonium content of blood samples and mean urinary-fecal excretions in %

injection dose. Here too there seems to be a high degree of association between these variables as might be expected since both measurements tend to show decreasing values with time. The correlation is r=.99 for the available 6 pairs of values. When this correlation was done with the available individual matched readings rather than with the means, r=.77. Figure 9 is a scatter diagram of the individual matched readings--blood content vs. urinary-fecal excretion.

Another problem studied at request was the possibility that H_p-4 was an abnormal subject and that the measurements yielded by her were significantly different from the other subjects. In as much as all techniques for rejecting extreme variates are arbitrary, it was decided to apply Chauvenet's* Criterion which is very commonly employed by statisticians to obtain the probability of a measure not belonging to a sample at hand. H_p-4's results of this test when the blood was studied are shown in Table XI. It can be seen that at 4 hours, 10 and 15 days after injection her measurements would be rejected as abnormal if the criterion of rejection is agreed to. At 3 days, 6 days and 22 days, however, H_p-4 falls within the region of acceptability as part of the population under consideration. On this basis there seems to be legitimate grounds for regarding this subject as somewhat atypical of the remainder of the sample.

Helen M. Baldwin
Leonard S. Kogan

See:
* "The Treatment of Experimental Data", Worthing and Geffner, 1943, J. Wiley & Sons, Inc. p.170-171 for further discussion of this criterion.

1145184

SECRET

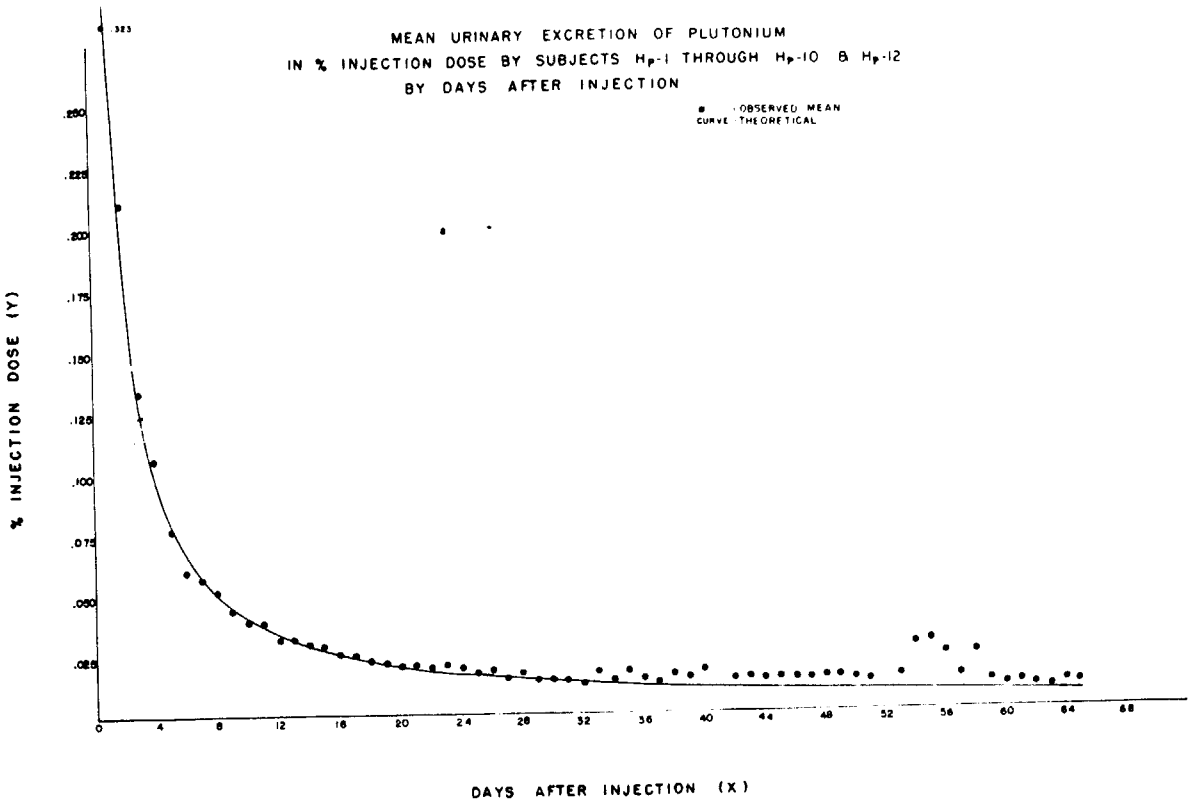

Figure 1

SECRET

[redacted]

1145185

SECRET

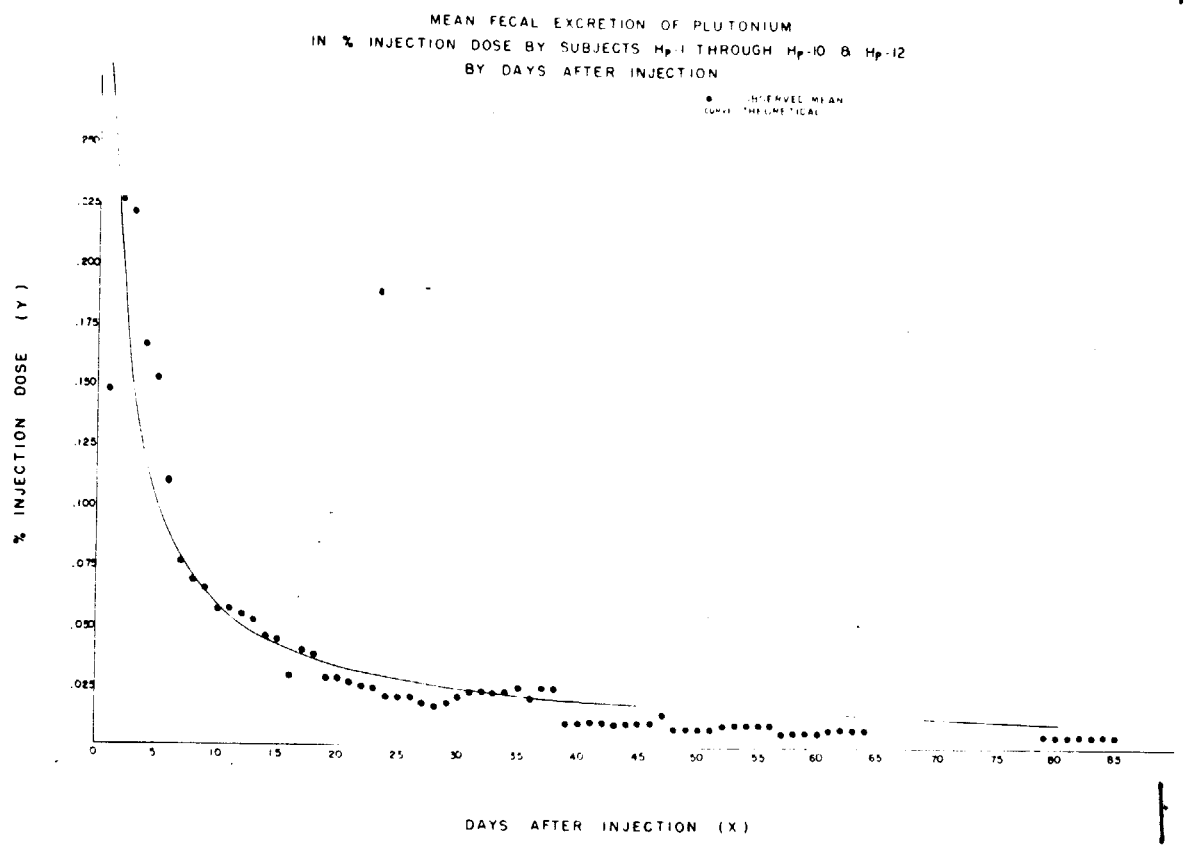

Figure 2

SECRET

[redacted]

1145186

SECRET

1145187

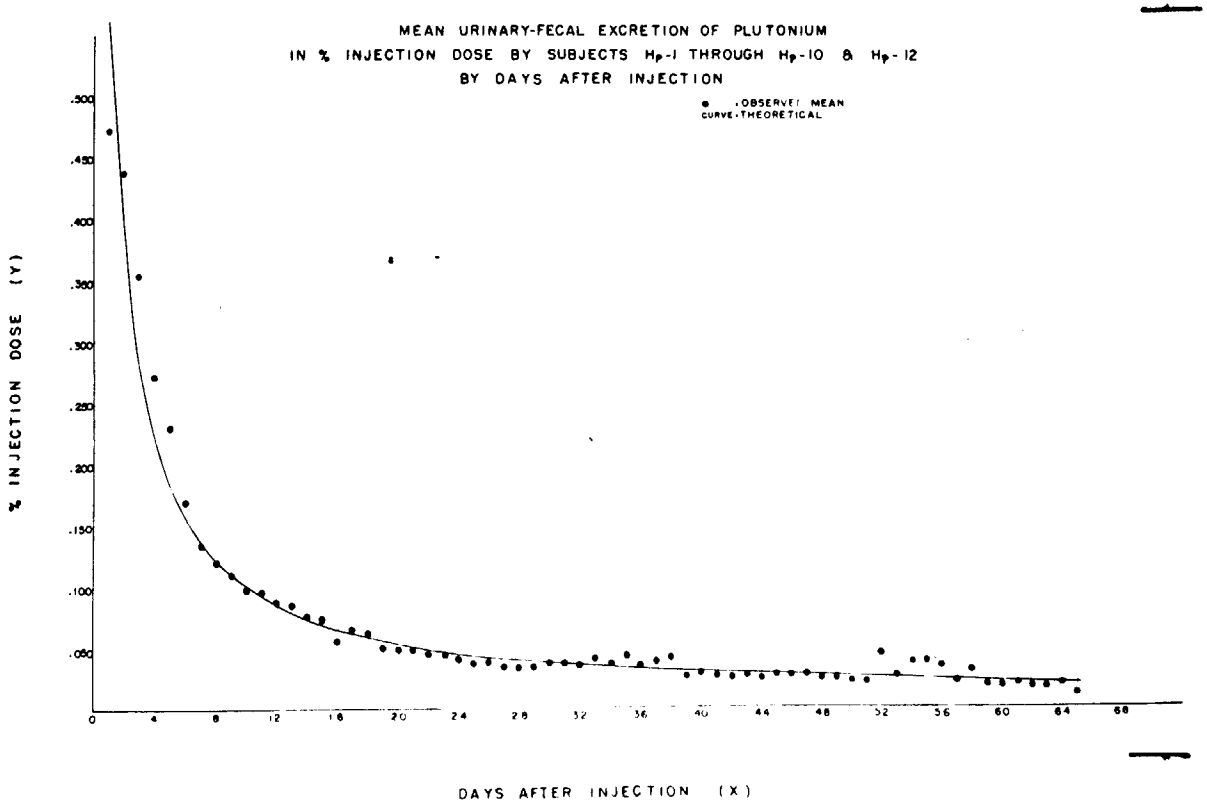

Figure 3

SECRET

[redacted]

SECRET

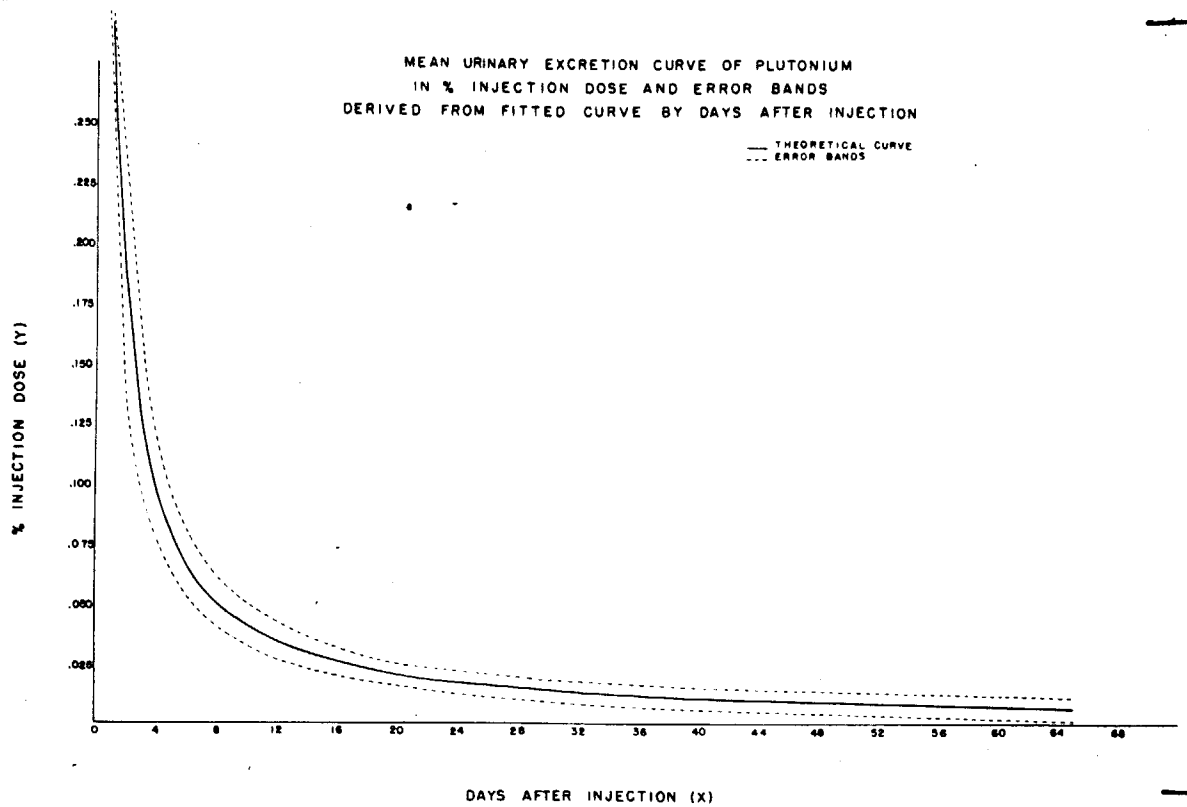

Figure 4

SECRET

[redacted]

1145188

SECRET

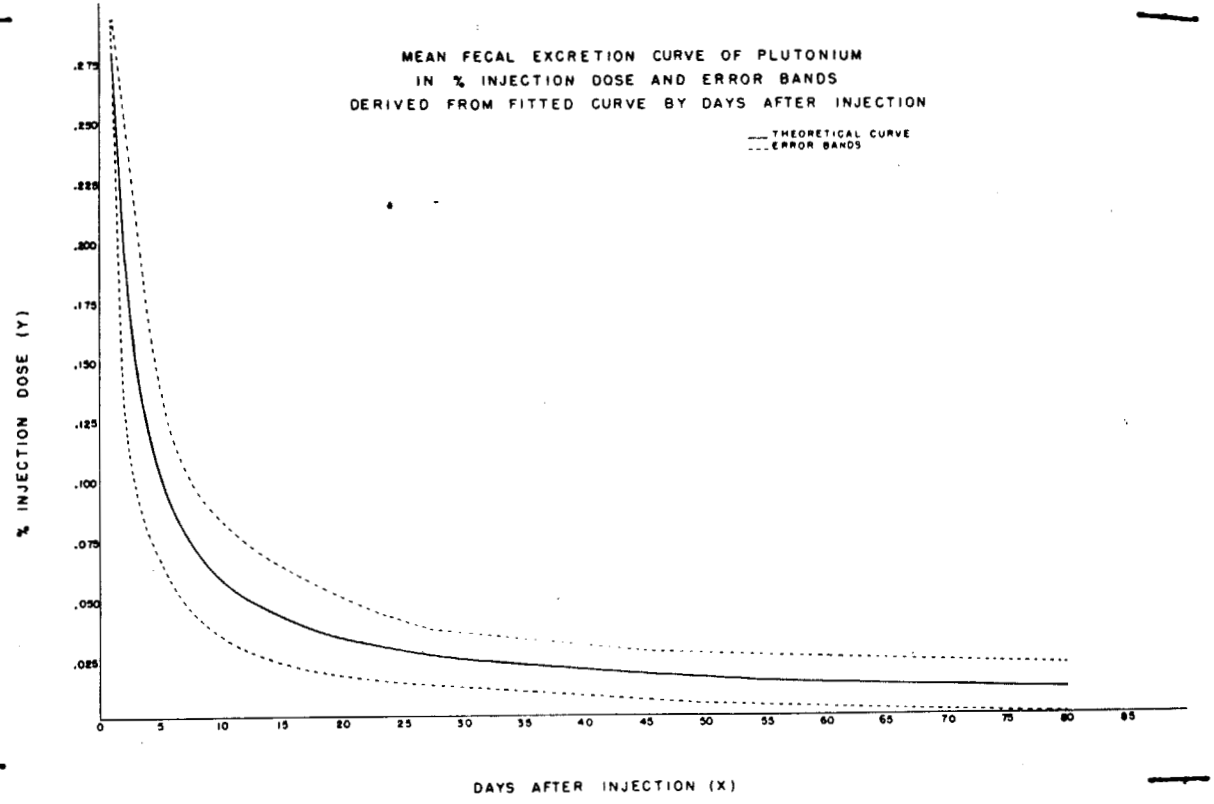

Figure 5

SECRET

[redacted]

1145189

1145190

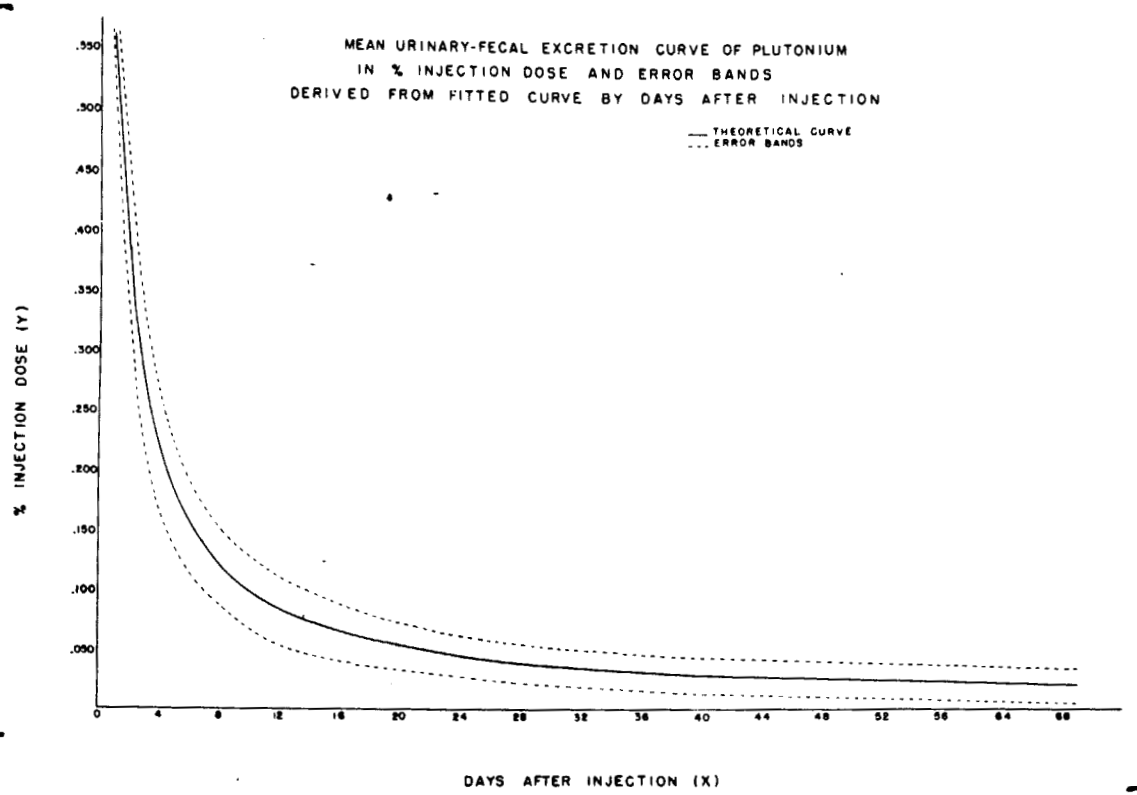

Figure 6

[redacted]

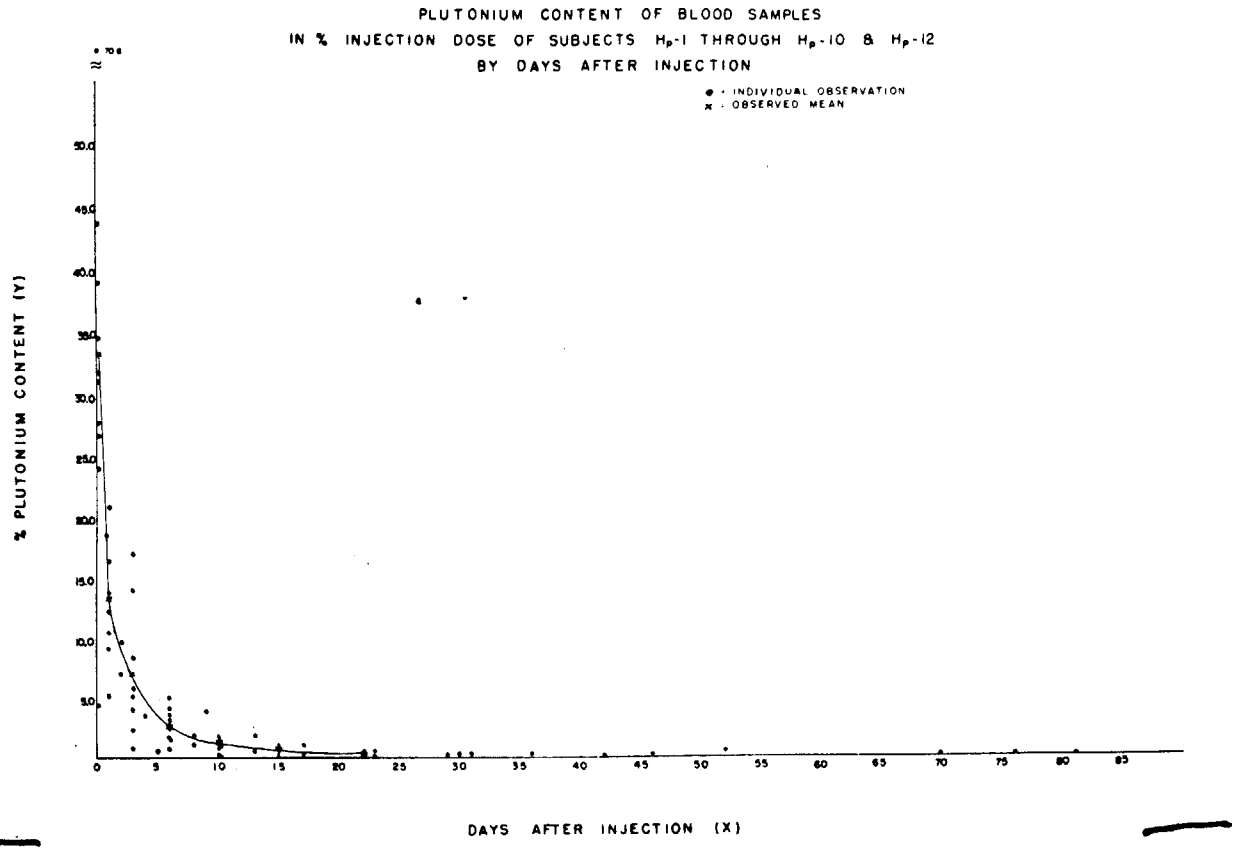

Figure 7

[redacted]

114519

SECRET

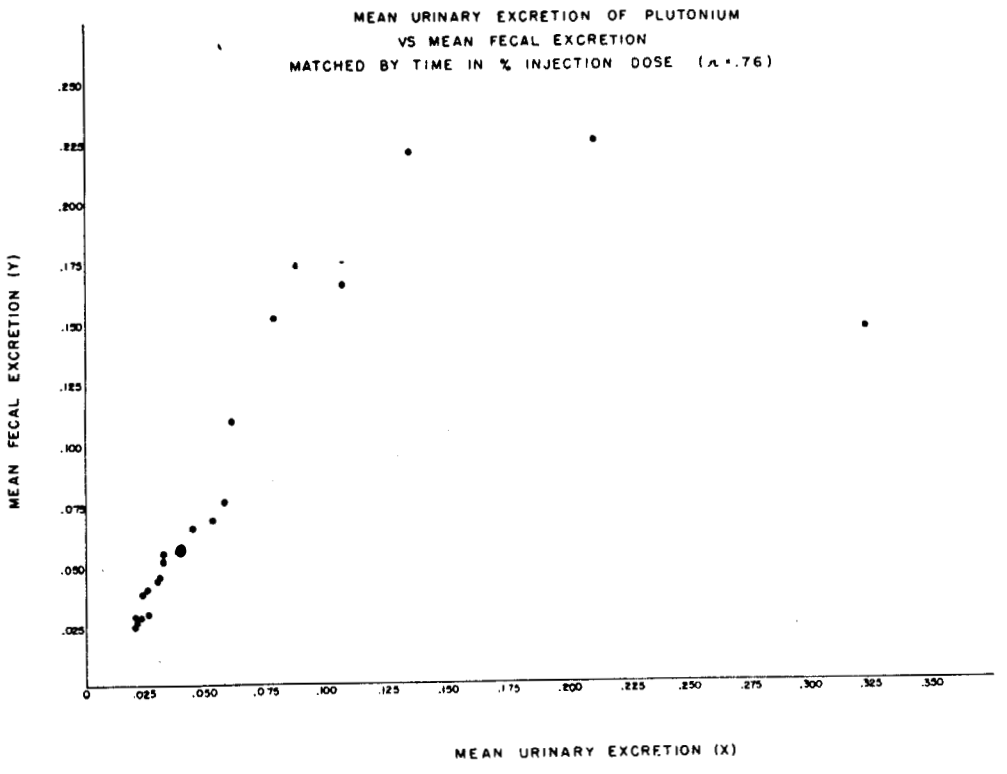

Figure 8

SECRET

[redacted]

1145192

SECRET

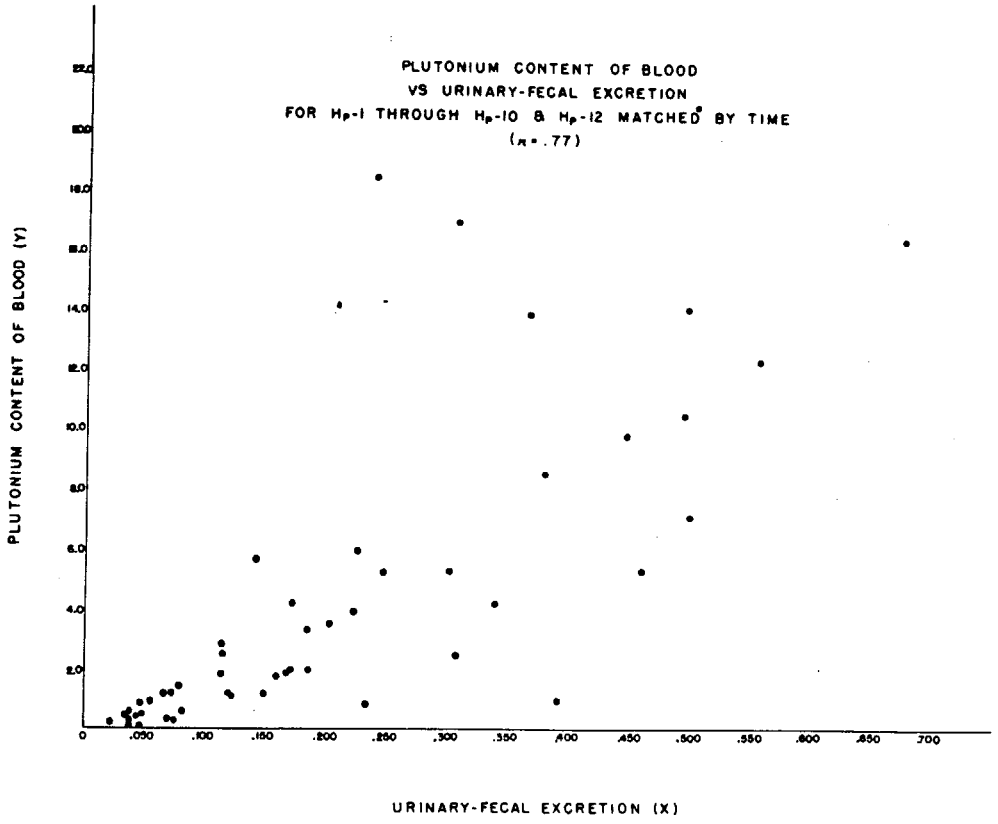

Figure 9

SECRET

1145193

Table I Body Weight - Blood Volume - Injected Initial Dose of Plutonium of H_p Subjects

Subject	Sex	Body Weights in Kg.	Total* g/blood	Total** ml/blood	Injected Dose of Pu in Micrograms	Injected Dose of Pu in c/m
H_p-1	M	71.3	4634	4413	4.6	321,500
H_p-2	M	68.5	4452	4240	5.0	350,000
H_p-3	F	64.4	4186	3986	4.9	343,725
H_p-4	F	55.9	3633	3460	4.9	344,200
H_p-5	M	60.4	3926	3739	5.1	353,675
H_p-6	M	49.1	3191	3039	5.3	369,500
H_p-7	F	74.9	4868	4636	6.3	439,250
H_p-8	F	53.1	3451	3287	6.5	454,500
H_p-9	M	63.9	4153	3955	6.3	432,000
H_p-10	M	72.8	4732	4506	6.1	424,000
H_p-12					4.7	330,000

*Total weight of blood taken as 6.5% of the total body weight.
**Specific gravity of blood taken as 1.05.

1145194

[redacted]

Table II

Urinary Excretion of Plutonium in % Injection Dose per 24 Hours by Subjects H_p-1 through H_p-10 and H_p-12 for Entire Period of Observation (Total Injection Dose approximately 5 micrograms of Plutonium per Subject)

Days after Injection	H_p-1	H_p-2	H_p-3	H_p-4	H_p-5	H_p-6	H_p-7	H_p-8	H_p-9	H_p-10	H_p-12
1	.181	.472	.569	.440	.296		.217	.377	.160	.414	.101
2	.146	.294	.289	.236	.166	.216	.212	.232	.085	.330	.103
3	.114	.174	.112	.221	.077	.127	.137	.128	.069	.218	.088
4	.094	.123	.107	.132	.052	.111	.096	.140	.066	.170	.078
5	.069	.116	.078	.116	.030	.076	.069	.083	.047	.089	.068
6	.066	.061	.043	.119	.020	.057	.059	.078	.052	.060	.044
7	.062	.062	.043	.077	.033	.044	.045	.066	.050	.079	.069
8	.055	.048	.049	.081	.026	.043	.037	.057	.032	.065	.080
9	.051	.046	.022	.095	.027	.032	.033	.047	.032	.051	.043
10	.045	.038	.027	.081	.022	.031	.023	.050	.035	.044	.038
11	.040	.048	.027	.075	.021		.018	.044	.026	.041	.038
12	.038	.039	.015	.072	.026	.024	.019	.023	.030	.038	.027
13	.034	.045	.020	.067	.023	.023	.019	.037	.027	.029	.030
14	.035	.036	.020	.058	.018	.020	.013	.035	.030	.029	.039
15	.034	.039	.028	.050	.015	.022	.012	.035	.030	.025	.029
16	.026	.024	.024	.033	.020	.017	.012	.036	.049	.021	.023
17	.027	.027	.021	.032	.020	.013	.011	.032	.038	.023	.029
18	.026	.020	.017	.037	.020	.015	.011	.029	.027	.021	.026
19	.025	.019	.018	.032	.018	.015	.010	.031	.029	.017	.029
20	.017	.021	.012	.025	.021	.013	.008	.032	.029	.018	.032
21	.017	.017	.019	.029	.020	.012	.010	.029	.032	.022	.025
22	.016	.015	.014	.035	.018	.012	.013	.021	.032	.016	.025
23	.025	.018	.014	.014			.008	.021	.032	.019	.039
24	.021	.014					.008	.025	.032	.016	.023
25	.013	.014		.011			.008	.023	.029	.016	.021
26		.017		.011			.007	.022	.032	.016	.023
27		.008		.008			.008	.028	.032	.014	.017
28		.009					.008	.023	.024	.013	.024
29		.009					.008	.019	.025	.014	.023
30		.008					.006	.021	.023	.014	.021
31		.007					.005	.017	.025	[redacted]	.021

1145195

Urinary Excretion of Plutonium Continued
Page 2

Days after Injection	H_p-1	H_p-2	H_p-3	H_p-4	H_p-5	H_p-6	H_p-7	H_p-8	H_p-9	H_p-10	H_p-12
32		.007					.007	.016	.024		.012
33		.009					.006	.015	.022		.037
34		.009					.006	.015	.020		.020
35							.006		.022		.026
36							.006	.015	.022		.018
37							.006	.011			.023
38								.016			.018
39								.012			.021
40								.017			.019
41								.019			.013
42								.014			.013
43								.016			.015
44								.014			.015
45								.013			.017
46								.015			
47								.014			.015
48								.014			.017
49								.018			.015
50								.014			
51								.013			
52											.035
53								.013			.019
54								.013			.043
55								.015			.043
56								.013			.036
57								.012			.018
58								.013			.036
59								.012			
60								.011			
61								.012			
62								.010			
63								.009			
64								.012			
65								.011			

1145196

[redacted]

Table III

Fecal Excretion of Plutonium in % Injection Dose per 24 Hours by Subjects H_p-1 through H_p-10 and H_p-12 for Entire Period of Observation (Total Injection Dose approximately 5 micrograms of Plutonium per Subject)

Days after Injection	H_p-1	H_p-2	H_p-3	H_p-4	H_p-5	H_p-6	H_p-7	H_p-8	H_p-9	H_p-10	H_p-12
1	.052	.204	.018	.134	.004	.085	.148	.178	.333	.087	.370
2	.221	.204	.157	.274	.311	.085	.120	.266	.389	.087	.370
3	.241	.204	.157	.274	.311	.179	.087	.210	.389	.087	.297
4	.050	.317	.095	.306	.185	.179	.080	.080	.131	.110	.297
5	.105	.317	.099	.306	.110	.179	.055	.080	.131	.110	.183
6	.046		.070	.126	.110	.179	.055	.080	.131	.110	.183
7	.021		.070	.126	.110	.037	.055	.080	.131	.110	.020
8	.021	.120	.070	.126	.064	.037	.055	.070	.131	.034	.020
9	.021	.120	.070	.126	.051	.037	.032	.070	.131	.034	.020
10	.021	.084	.027	.117	.051	.037	.032	.070	.131	.034	.020
11	.046	.084	.027	.117	.052	.023	.032	.070	.118	.034	.020
12	.046	.084	.027	.117	.052	.023	.032	.045	.118	.034	.020
13	.046	.084	.027	.117	.032	.023	.023	.045	.118	.034	.020
14	.046	.062	.023	.085	.032	.023	.023	.045	.118	.022	.020
15	.035	.062	.023	.085	.032	.015	.023	.045	.118	.022	.023
16	.035	.062	.023	.040	.017	.015	.023	.032	.414*	.022	.023
17	.035	.062	.023	.040	.017	.015	.016	.032	.157	.022	.023
18	.035	.055	.016	.040	.017	.015	.016	.025	.157	.022	.023
19	.015	.055	.016	.028	.017	.015	.016	.025	.055	.012	.053
20	.015	.055	.016	.028	.020	.015	.016	.025	.055	.012	.053
21	.015	.055	.016	.028	.020	.010	.008	.025	.055	.012	.053
22	.015	.022	.006	.028	.020	.010	.008	.045	.055	.012	.053
23	.017	.022	.006	.026			.008	.045	.052	.012	.026
24	.017	.022					.008	.009	.052	.012	.026
25		.022					.011	.009	.052	.006	.026
26		.021					.011	.009	.052	.006	.016
27		.021					.011	.009	.043	.006	.016
28								.009	.043	.006	.016
29								.018	.043	.006	.016
30								.018	.035		.016
31											

* Excluded from Calculations

Fecal Excretion of Plutonium Continued
Page 2

Days after Injection	H_p-1	H_p-2	H_p-3	H_p-4	H_p-5	H_p-6	H_p-7	H_p-8	H_p-9	H_p-10	H_p-12
32								.018	.035		.016
33								.018	.035		.016
34								.018	.035		.016
35								.018	.035		.022
36								.018			.022
37								.028			.022
38								.028			.022
39								.011			
40								.011			
41								.011			
42								.011			
43								.011			.008
44								.011			.008
45								.014			.008
46								.014			.008
47								.014			
48								.008			
49								.008			
50								.008			
51								.008			
52								.010			
53								.010			
54								.010			
55								.010			
56								.010			
57								.007			
58								.007			
59								.007			
60								.007			
61								.008			
62								.008			
63								.008			

1145198

[redacted]

Fecal Excretion of Plutonium Continued
Page 3

Days after injection	H_p-1	H_p-2	H_p-3	H_p-4	H_p-5	H_p-6	H_p-7	H_p-8	H_p-9	H_p-10	H_p-12
64								.008			
79				.006			.005				
80				.006			.005				
81				.006			.005				
82				.006			.005				
83							.006				
84							.006				
85							.006				

23

1145199

[redacted]

Table IV

Plutonium Content of Blood Samples in % Injected Dose in Total Blood Volume from Subjects H_p-1 through H_p-10 and H_p-12
(Total Injection Dose approximately 5 micrograms of Plutonium per Subject)

Days after Injection	H_p-1	H_p-2	H_p-3	H_p-4	H_p-5	H_p-6	H_p-7	H_p-8	H_p-9	H_p-10	H_p-12
1/6	39.00		24.00	70.60	26.70	31.10	27.60	31.90	34.60	43.70	4.50
3/4	18.50										
1		16.40			5.28	9.30	13.90	12.30	10.50	20.90	
2		7.10	9.80								
3		8.50		14.10	0.98	2.49	5.91	4.19	5.27	17.00	
4			3.58								
5					0.56						
6	2.80	3.60	1.84	5.20		0.85	2.51	1.75	3.31	4.16	
7											
8		1.97	1.20								
9				3.90							
10	1.20				0.33	0.32	0.96	1.16	1.87	1.46	
11											
12											
13			0.52	1.98							
14											
15					0.09	0.22	0.56	0.60	1.20	0.865	
16											
17			0.43	1.23							
18											
19											
20											
21											
22		0.59			0.15	0.21					
23			0.21	0.61							
29							0.31				
30										0.305	
31											0.43
36									0.36		
42								0.14			
46											0.38

1145200

[redacted]

Plutonium Content of Blood Samples Continued
Page 2

Days after Injection	H_p-1	H_p-2	H_p-3	H_p-4	H_p-5	H_p-6	H_p-7	H_p-8	H_p-9	H_p-10	H_p-12
52											0.63
70											0.19
76				0.26							
81							0.10				

[redacted]

Table V

Observed and Theoretical* Means and Standard Deviations
for Amount of Plutonium (in °/o Injection Dose) Excreted from Urine

Days After Injection	MEAN Observed	N	Theoretic	σ Observed	Theoretic	Fiducial Limits (1 °/o) $M_o \pm 3\sigma_o$		Error Bands $M_o \pm 2S.E.^{**}_{m_o}$ (5 °/o)	
1	.323	10	.358	.155	.155	.788	0	.452	.264
2	.210	11	.186	.072	.079	.426	0	.234	.138
3	.133	11	.127	.052	.052	.289	0	.159	.095
4	.106	11	.097	.034	.034	.208	.004	.117	.077
5	.077	11	.079	.023	.026	.146	.008	.095	.063
6	.060	11	.066	.025	.025	.135	0	.080	.052
7	.057	11	.057	.015	.015	.102	.012	.067	.047
8	.052	11	.050	.018	.018	.106	0	.060	.040
9	.044	11	.045	.020	.020	.104	0	.057	.033
10	.039	11	.041	.016	.016	.087	0	.051	.031
11	.038	10	.037	.017	.019	.089	0	.049	.025
12	.032	11	.034	.015	.016	.077	0	.044	.024
13	.032	11	.032	.014	.014	.074	0	.040	.024
14	.030	11	.030	.013	.013	.069	0	.038	.022
15	.029	11	.028	.005	.011	.044	.014	.034	.022
16	.026	11	.026	.010	.010	.056	0	.032	.020
17	.025	11	.025	.008	.008	.049	.001	.029	.021
18	.023	11	.023	.007	.007	.044	.002	.027	.019
19	.022	11	.022	.007	.007	.043	.001	.026	.018
20	.021	11	.021	.008	.008	.045	0	.025	.017
21	.021	11	.020	.007	.007	.042	0	.024	.016
22	.020	11	.019	.008	.008	.044	0	.023	.015
23	.021	9	.019						
24	.020	7	.018						
25	.017	8	.017						
26	.018	7	.017						
27	.016	7	.016						
28	.017	6	.015						
29	.016	6	.015						
30	.016	6	.014						
31	.015	5	.014						
32	.013	5	.014						
35	.018	5	.012						
40	.018	2	.011						
45	.015	2	.010						
50	.014	1	.009						
55	.029	2	.008						
60	.011	1	.007						
65	.011	1	.007						
70			.006						
75			.006						
80			.006						
100			.005						
125			.004						
150			.003						

1145202

[redacted]

Observed and Theoretical Means (Continued)

Days After Injection	MEAN Observed	MEAN N	MEAN Theoretic	σ Observed	σ Theoretic	Fiducial Limits (1 °/o) $M_o \pm 3\sigma_o$	Error Bands $M_o \pm 2S.E._{m_o}$ (5 °/o)
175			.003				
200			.002				
250			.002				
300			.002				
350			.001				
400			.001				
500			.001				
600			.0009				
1500			.0004				
3000			.0002				
5000			.0001				

* Based on Equation $Y = \frac{.358}{\dot{X}^{.9430}}$

** $S.E._{m_o} = \frac{\sigma_o}{\sqrt{N}}$

o= Observed
o= Calculated

[redacted]

Table VI

Observed and Theoretical* Means and Standard Deviations for Amount of Plutonium (in °/o Injection Dose) Excreted from Feces

Days After Injection	MEAN Observed	N	Theoretic	σ Observed	Theoretic	Fiducial Limits (1 °/o) $M_o \pm 3\sigma_o$		Error Bands $M_o \pm 2S_o E^{**}_{Hc}$ (5 °/o)	
1	.147	11	.348	.119	.119	.504	0	.420	.276
2	.226	11	.202	.107	.100	.547	0	.262	.142
3	.221	11	.148	.094	.083	.503	0	.198	.098
4	.166	11	.118	.099	.099	.463	0	.178	.058
5	.152	11	.099	.087	.087	.413	0	.151	.047
6	.109	10	.086	.048	.056	.253	0	.120	.052
7	.076	11	.076	.042	.046	.202	0	.104	.048
8	.068	11	.068	.041	.041	.191	0	.092	.044
9	.065	11	.062	.043	.043	.194	0	.088	.036
10	.057	11	.058	.039	.039	.174	0	.082	.034
11	.057	10	.053	.036	.036	.165	0	.075	.031
12	.054	11	.050	.036	.036	.162	0	.072	.028
13	.052	11	.047	.037	.037	.163	0	.069	.025
14	.045	11	.044	.032	.032	.141	0	.064	.024
15	.044	11	.042	.032	.032	.140	0	.062	.022
16	.029	10	.040	.014	.014	.071	0	.048	.032
17	.040	11	.038	.041	.041	.163	0	.062	.014
18	.038	11	.036	.041	.041	.161	0	.060	.012
19	.028	11	.035	.018	.018	.082	0	.045	.025
20	.028	11	.033	.017	.017	.079	0	.043	.023
21	.027	11	.032	.019	.019	.084	0	.044	.020
22	.025	11	.031	.018	.018	.079	0	.041	.021
23	.024	9	.030						
24	.021	7	.029						
25	.021	6	.028						
26	.021	6	.027						
27	.018	6	.026						
28	.017	5	.026						
29	.018	4	.025						
30	.021	4	.024						
31	.023	3	.024						
32	.023	3	.023						
35	.025	3	.022						
40	.011	1	.019						
45	.011	2	.018						
50	.008	1	.016						
55	.010	1	.015						
60	.007	1	.014						
65			.013						
70			.013						
75			.012						
80	.006	2	.011						
100			.010						
125			.008						
150			.007						
175			.006						
200			.006						
250			.005						

1145204

[redacted]

Observed and Theoretical Means (Continued)

Days After Injection	MEAN Observed	MEAN N	MEAN Theoretic	σ Observed	σ Theoretic	Fiducial Limits (1 %) $M_o \pm 3\sigma_o$	Error Bands $M_o \pm 2S.E._{m_o}$** (5 %)
300			.004				
350			.004				
400			.003				
500			.003				
600			.002				
1500			.001				
3000			.0006				
5000			.0004				

* Based on $Y = \frac{.348}{X^{.7821}}$

** $S.E._{m_o} = \frac{\sigma_o}{\sqrt{N}}$

o = Observed
c = Calculated

[redacted]

Table VII

Observed and Theoretical* Means and Standard Deviations for Amount of Plutonium (in %/o Injection Dose) Excreted from Urine and Feces

Days after Injection	MEAN Observed	N	MEAN Theoretic	σ Observed	σ Theoretic	Fiducial Limits (1 %/o) $M_o \pm 3\sigma_o$		Error Bands $M_o \pm 2S.E._{m_c}$** (5 %/o)	
1	.470	11	.742	.161	.176	.953	0	.848	.636
2	.436	11	.405	.089	.072	.703	.169	.449	.361
3	.354	11	.284	.086	.079	.612	.096	.332	.236
4	.272	11	.221	.078	.103	.506	.038	.283	.159
5	.229	11	.182	.073	.106	.448	.010	.246	.118
6	.169	11	.155	.044	.060	.301	.037	.191	.119
7	.133	11	.135	.032	.041	.229	.037	.165	.105
8	.120	11	.120	.032	.042	.216	.024	.146	.094
9	.109	11	.109	.034	.053	.211	.007	.141	.077
10	.096	11	.099	.030	.049	.186	.006	.129	.069
11	.095	11	.091	.029	.050	.182	.008	.121	.061
12	.086	11	.084	.029	.048	.173	0	.112	.056
13	.084	11	.079	.029	.048	.171	0	.107	.051
14	.075	11	.074	.025	.039	.150	0	.098	.050
15	.073	11	.070	.024	.039	.145	.001	.094	.046
16	.055	11	.066	.012	.018	.091	.019	.078	.054
17	.065	11	.062	.030	.047	.155	0	.090	.034
18	.061	11	.059	.030	.044	.151	0	.085	.033
19	.050	11	.057	.013	.022	.089	.011	.071	.043
20	.049	11	.054	.014	.024	.091	.007	.068	.040
21	.048	11	.052	.014	.023	.090	.006	.066	.038
22	.045	11	.050	.014	.024	.087	.003	.064	.036
23	.045	9	.048						
24	.041	7	.046						
25	.038	6	.044						
26	.039	7	.043						
27	.034	7	.042						
28	.034	6	.040						
29	.034	6	.039						
30	.037	6	.038						
31	.038	5	.037						
32	.036	5	.036						
35	.043	5	.033						
40	.029	2	.029						
45	.026	2	.027						
50	.022	1	.024						
55	.039	2	.022						
60	.018	1	.021						
65			.019						
70			.018						
75			.017						
80			.016						
100			.013						
125			.011						
150			.009						

1145206

SECRET

[redacted]

Observed and Theoretical Means (Continued)
Page 2

Days After Injection	MEAN Observed	MEAN Theoretic	σ Observed	σ Theoretic	Fiducial Limits (1 %) $M_o \pm 3\sigma_o$	Error Bands $M_o \pm 2S_oE_{\sigma m_o}$ (5 %) **
175		.008				
200		.007				
250		.006				
300		.005				
350		.004				
400		.004				
500		.003				
600		.003				
1500		.001				
3000		.0007				
5000		.0004				

* Based on $Y = \frac{.742}{X^{.8744}}$

** $S_oE_{\sigma m_o} = \frac{\sigma_o}{\sqrt{N}}$

o = Observed
c = Calculated

1145207

[redacted]

Table [illegible]

Mean Urinary, Fecal, and Urinary-Fecal Plutonium Excretion in % Injection Dose
for the Period following the [illegible] Day after Injection
For Varying No. of Z_p Subjects Based on Available Data

Days After Injection	Urinary Excretion Mean	Urinary Excretion N	Fecal Excretion Mean	Fecal Excretion N	Urinary-Fecal Excretion Mean
23	.021	9	.024	9	.045
24	.020	7	.021	7	.041
25	.017	8	.021	6	.038
26	.018	7	.021	6	.039
27	.016	7	.018	6	.034
28	.017	6	.017	5	.034
29	.016	6	.018	4	.034
30	.016	6	.021	4	.037
31	.015	5	.023	3	.038
32	.013	5	.023	3	.036
33	.018	5	.023	3	.041
34	.014	5	.023	3	.037
35	.018	5	.025	3	.043
36	.015	3	.020	2	.035
37	.013	4	.025	2	.038
38	.017	3	.025	2	.042
39	.016	2	.011	1	.027
40	.018	2	.011	1	.029
41	.016	2	.011	1	.027
42	.014	2	.011	1	.025
43	.016	2	.010	2	.026
44	.014	2	.010	2	.024
45	.015	2	.011	2	.026
46	.015	1	.011	2	.026
47	.014	2	.014	1	.028
48	.016	2	.008	1	.024
49	.016	2	.008	1	.024
50	.014	1	.008	1	.022
51	.013	1	.008	1	.021
52	.035	1	.010	1	.045
53	.016	2	.010	1	.026
54	.028	2	.010	1	.038
55	.029	2	.010	1	.039
56	.024	2	.010	1	.034
57	.015	2	.007	1	.022
58	.024	2	.007	1	.031
59	.012	1	.007	1	.019
60	.011	1	.007	1	.018
61	.012	1	.008	1	.020
62	.010	1	.008	1	.018
63	.009	1	.008	1	.017
64	.012	1	.008	1	.020
65	.011	1			
>>					
79			.006	2	

1145208

[redacted]

Mean Urinary, Fecal, and Urinary-Fecal Plutonium Excretion in % (Continued)

Days after Injection	Urinary Excretion		Fecal Excretion		Urinary-Fecal Excretion
	Mean	N	Mean	N	Mean
80			.006	2	
81			.006	2	
82			.006	2	
83			.006	1	
84			.006	1	
85			.006	1	

1145209

Table IX

Amount of Plutonium Excreted in Urine, Feces, and Combination Urine and Feces By Subject for Entire Period of Observation

Subject	Total Injection Dose in Micrograms	Total Amount of Pu Excreted During First 22 Days after Injection in °/o Injection Dose			Total Amount Pu Excreted by Urine after First 22 Days in °/o Injection Dose		Total Amount Pu Excreted by Feces after First 22 Days in °/o Injection Dose		Total °/o of Pu Excreted from Urine & Feces After First 22 Days	Total °/o of Pu Excreted for Entire Period Studied	
		Urine	Feces	Total	Total Days	Amount	Total Days	Amount	Amount	Days	Amount
I_p-1	4.6	1.218	1.183	2.401	3	.059	2	.034	.093	25	2.494
I_p-2	5.0	1.784	2.312	4.096	12	.129	5	.108	.237	34	4.333
I_p-3	4.9	1.574	1.076	2.650	1	.014	1	.006	.020	23	2.670
I_p-4	4.9	2.143	2.668	4.811	5	.044	60	.050	.094	82	4.905
I_p-5	5.1	.989	1.635	2.624	-	-	-	-	-	22	2.624
I_p-6	5.3	.923	1.236	2.159	-	-	-	-	-	22	2.159
I_p-7	6.3	1.084	.955	2.039	15	.103	63	.098	.201	85	2.240
I_p-8	6.5	1.642	1.643	3.285	43	.636	42	.531	1.167	65	4.452
I_p-9	6.3	1.007	3.152	4.159	14	.364	13	.555	.919	36	5.078
I_p-10	6.1	1.820	1.063	2.883	8	.122	8	.060	.182	30	3.065
I_p-12	4.7	1.064	2.164	3.228	36	.756	24	.352	1.108	58	4.336
Mean Observed	5.4	1.386	1.735	3.121							
Mean Integrated		1.462	1.776	3.316							

1145210

[redacted]

Table X Integrated Values for Urinary-Fecal Excretion of Plutonium in °/o Injection Dose at Various Times Based on $Y = \frac{.742}{X^{.8744}}$ *

Days After Injection	Years After Injection	Amount of Pu Excreted (in °/o Injection Dose)
10		2.518
20		3.221
22		3.316
30		3.658
60		4.474
90		4.988
120		5.336
150		5.673
180		5.927
210		6.151
240		6.346
270		6.524
300		6.677
330		6.825
360	1	6.961
720	2	8.083
1080	3	8.786
1440	4	9.312
1800	5	9.731
3600	10	11.108
5400	15	11.971
7200	20	12.614
10800	30	13.553
18000	50	14.812

* The integrated expression is:

$$= .742\left(\frac{X^{.1256}}{.1256}\right)^{n+1/2} = (.742)(7.299)$$

1145211

Table XI

Chauvenet's - Rejection Criterion
Testing Abnormality of H_p-4

Days After Injection	Mean	σ	Upper Limit	Lower Limit	Observed Value for H_p-4
1/6	33.37	16.774	65.24	.50	70.60
3	7.16	5.125	16.99	2.67	14.10
6	2.66	1.462	5.52	0	5.20
10	1.44	1.024	3.44	0	3.90
15	.70	.502	1.57	0	1.60
22	.35	.226	.73	0	.61