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Radionuclide Contaminant Analysis of Small Mammals at Area G, TA-54, 1994

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RADIONUCLIDE CONTAMINANT ANALYSIS OF SMALL MAMMALS AT AREA G, TA-54, 1994

by

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ABSTRACT

Small mammals were sampled at two waste burial sites (1 and 2) at Area G, TA-54 and a control site outside Area G (Site 3) to identify radionuclides that are present within surface and subsurface soils at waste burial sites, to compare the amount of radionuclide uptake by small mammals at waste burial sites to a control site, and to identify the primary mode of contamination to small mammals, either through surface contact or ingestion/inhalation. Three composite samples of at least five animals per sample were collected at each site. Pelts and carcasses of each animal were separated and analyzed independently. Samples were analyzed for ^{241}Am, ^{90}Sr, ^{238}Pu, ^{239}Pu, total U, and gamma spectroscopy (including ^{137}Cs). Significantly higher (parametric t-test at p=0.05) levels of total U, ^{241}Am, ^{238}Pu, ^{239}Pu, and ^{40}K were detected in pelts as compared to the carcasses of small mammals at TA-54. Concentrations of other measured radionuclides in carcasses were nearly equal to or exceeded the mean concentrations in the pelts. Our results show higher concentrations in pelts compared to carcasses which is similar to what has been found at waste burial/contaminated sites outside of Los Alamos National Laboratory. Site 1 had significantly higher (alpha=0.05, F=0.0095) total U concentrations in carcasses than Sites 2 and 3. Site 2 had significantly higher (alpha=0.05, F=0.0195) ^{239}Pu concentrations in carcasses than either Site 1 or Site 3. A significant difference in ^{90}Sr concentration existed between Sites 1 and 2 (alpha=0.05, F=0.0681) and concentrations of ^{40}K at Site 1 were significantly different from Site 3.

INTRODUCTION

A solid, low-level radioactive disposal facility has been operating at Area G, TA-54 since 1957 and has been used to dispose of various wastes including tritium waste, transuranic waste, volatile organic compounds, and mixed waste. Environmental monitoring of air, soil, water runoff, and vegetation has been in place to examine potential migration of contaminants. Recently, there has been no sampling to determine contaminant concentration of small mammals within the boundaries of Area G. Consequently, the collection and analysis of small mammals at TA-54, Area G, was

initiated as part of the Enhanced Environmental Annual Surveillance program at Area G by the Environmental, Safety, and Health Division in collaboration with the Solid Waste Management Group. The program is intended to provide data to aid in meeting requirements of DOE Order 5400.1, which specifies monitoring of existing operations at radioactive waste burial sites.

Rodents can affect the distribution of radionuclides at radioactive waste burial sites through their burrowing activities (Arthur et.al. 1987). Burrowing activity and mound building can expose contaminated soils which can then be dispersed by wind and water erosion (Winsor and Whicker 1980). Predators of small mammals can also disperse radioactive material in their feces, urine, or regurgitated pellets (Eisler 1994). Burrowing animals can also alter the soil profile and change the physical and chemical processes in the soil profile resulting in movements of buried contaminants (Hakonson et.al. 1982). In addition, small mammals utilizing waste burial sites can be contaminated through direct contact of contaminated soil or by ingestion of soil (i.e., soil consumption during pelt grooming) or from foraging on plant resources (O'Farrell and Gilbert 1975) and could subsequently become a form of contaminant transport off site via predation from predator species (Craig et.al. 1979).

The collection and analysis of burrowing, small mammals at two waste burial sites (Sites 1 and 2) within Area G, TA-54, Los Alamos National Laboratory, were used to 1) identify radionuclides potentially present within surface and subsurface soils at waste burial sites within Area G by sampling of burrowing, nocturnal small mammal tissues, 2) quantitatively estimate and compare the amount of radionuclide uptake at specific waste burial sites within Area G to a control site (Site 3) by sampling carcasses of burrowing, nocturnal small mammals, 3) determine the primary mode of contamination to small mammals, either by surface contact or through ingestion, and 4) estimate small mammal densities at each waste burial site and the control site for use in estimating potential contaminant loads within the rodent population. Data collected from the waste burial

sites was compared to a control site. A general description of Area G and the various wastes buried within its boundaries is given in Eklund (1995).

METHODOLOGY

Three sites were selected for sampling (trapping) within Area G (Figure 1) with respect to ongoing disposal operations. These sites were defined as follows:

1) Recently disturbed/contaminated site: a shallow earth-covered transuranic uranium drum storage site built on top of old previously filled disposal pits; vegetation not well established and consists of plant species associated with disturbed ground.

2) Partially disturbed/contaminated waste burial site: this site has established vegetation with a mixture of native plants and plant species associated with disturbed ground.

3) Control site, undisturbed/uncontaminated: no waste operations occurring at this site; consists of well-established native plant species associated with a piñon pine/juniper woodland

Site 1 is located on a recent waste storage earthen mound with a lack of well established vegetation, Site 2 was located on a waste burial site where vegetation has become well established, and Site 3 is located west of the check-in facility for Area G. Site 3, located within a piñon-juniper woodland and adjacent to the operating disposal site, was selected as the control site. Vegetation samples were also collected at various locations within and near Area G waste burial sites (Fresquez, et.al. 1995), including two locations at Site 1 of the small mammal sampling areas. When applicable, results of vegetation sampling are presented in the text of this report.

A grid design consisting of 100 snap traps placed approximately 10 m apart in a 10 x 10 design was used to collect animals at each of the three sites. Snap trapping took place over 3 to 4 nights

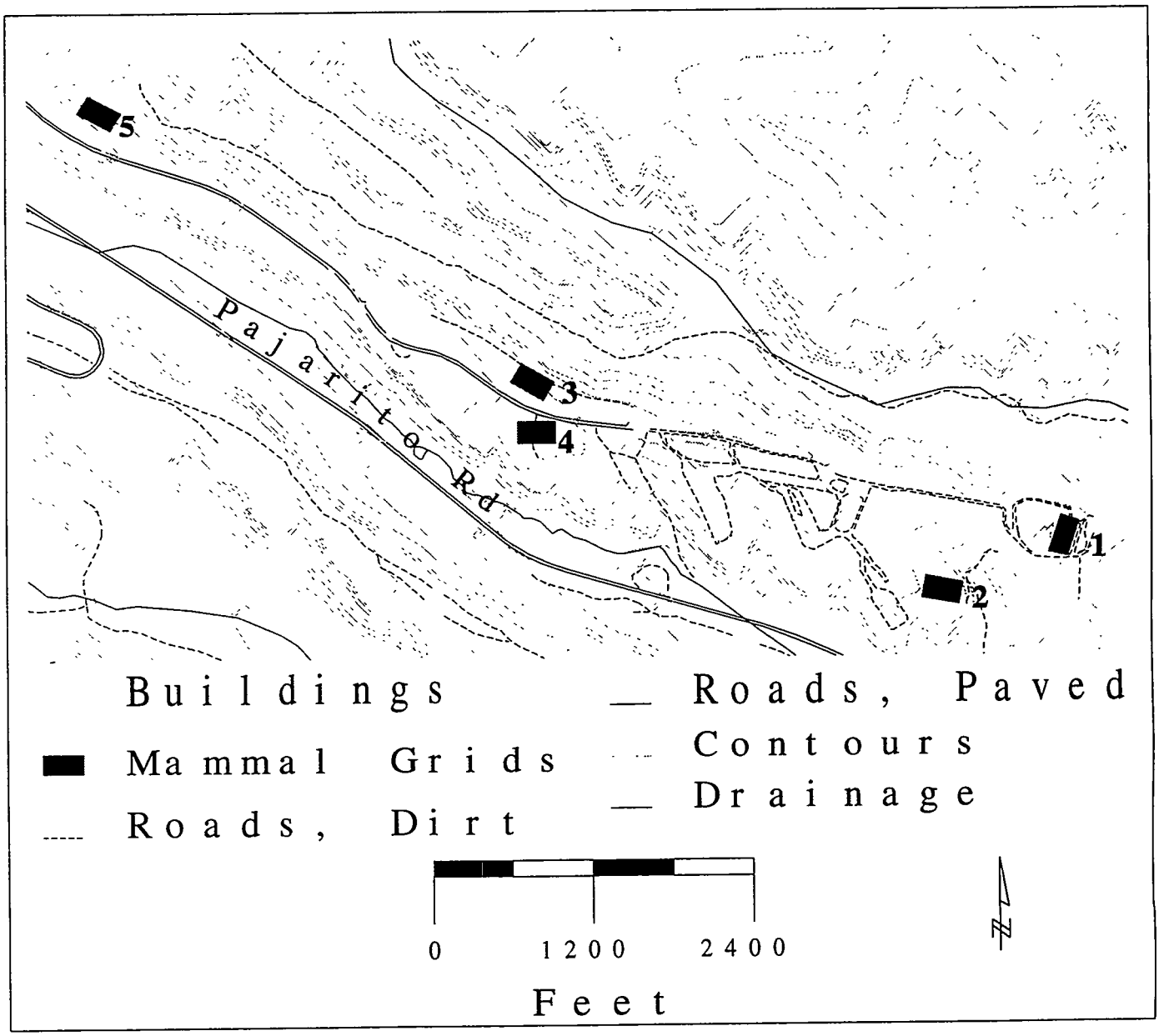


Figure 1. Locations of sites of small mammal grids at Area G. (Sites 4 and 5 were later added because of low capture rates at Site 3.)

(until at least 15 animals were captured at each site). Procedures for handling and field processing of small mammals with respect to potential infection of hantavirus, are given in Mills, et.al, and Biggs and Bennett. These same safety procedures were followed for collecting tissue samples from snap-trapped animals. At least 15 rodents were captured at Sites 1 and 2. However, low capture rates at Site 3 necessitated additional sampling in the vicinity of that location (identified as Sites 4 and 5 on Figure 1). Additional snap traps were placed in similar habitat adjacent to Site 3 and west of the Area G controlled access gate to ensure that a sufficient sample size was obtained for analysis. Snap traps were baited and set in late afternoon and checked in early morning. Traps with animals were taken to a central processing station where pelts were removed. Precautions during handling were taken to minimize cross contamination from carcass to pelt while removing pelts. All external hair was removed from appendages.

Three (3) composite samples were collected at each site with each sample consisting of a minimum 5 animals. The pelt was separated from the carcass of each animal and analysis was run on the pelt and carcass separately for each radionuclide. Due to total ashed weight, the three composite samples of pelts were combined for each site for a total of one sample per site only. The samples were placed into 1-L glass beakers. The beaker contents were covered with tin foil and ashed at 500°C for 120 hr. The sample ash was pulverized and homogenized before it was submitted to a LANL analytical laboratory for the analysis of ^{241}Am, ^{90}Sr, ^{238}Pu, ^{239}Pu, total U, gamma spectropscopy (including ^{137}Cs). All methods of radiochemical analysis have been described previously (Salazar 1984). Results are reported on a per ash weight basis (g/ash). There were insufficient amounts of pelts to analyze the composite samples separately due to a minimum amount of ash required to conduct the analysis. In these cases, the composite samples were combined for each site. Analysis of pelts and carcasses separately allowed for a more accurate determination of radionuclide concentration (ingestion/inhalation or external body surface).

The Statistical Analysis System (SAS) was used to analyze all data sets (SAS/STAT User's Guide 1988). A univariate test was used to determine if carcass radionuclide means were normally distributed within each site. Most means were normally distributed, therefore a parametric t-test was used to determine if the means of each radionuclide were equal between carcasses and pelts. This was not conducted by site since only one pelt sample per site existed. An Analysis of Variance (ANOVA) was used to determine if any significant differences in the amount of radionuclide in carcass samples existed between sites (the ANOVA generates an alpha [probability] at the 0.05 level) and Duncan's multiple range test was used to identify where the significant differences occurred between the sites.

Rodent densities were estimated using Leslie's regression method (Seber 1982) applied to each grid where daily total number of captures were plotted against the cumulative daily captures. Confidence intervals were calculated at 90% using the general method (Seber 1982).

RESULTS

Density Estimates

Deer mice (*Peromyscus maniculatus*) was the only small mammal species captured at Sites 1 and 2. Deer mice and pinyon mice (*P. trueii*) were captured at the control site. The highest densities of animals occurred on Sites 1 and 2 with very low capture rates at the control site. Because of the low capture rates at Site 3, additional locations were trapped adjacent to it. Density estimates of rodents occurring at Sites 1 and 2 were calculated by regressing the number of daily captures onto the cumulative number of captures for each day. Rodent density of Site 3 is based on total number of animals captured due to no new captures being recorded on the last day of trapping. The density of the trapping area is based on a 100 m by 100 m grid with an additional 5 m boundary strip to help account for animals being drawn into the grid due to the bait. Therefore the total effective trapping area is approximately 1.21 ha. Table 1 gives the estimated density (# animals/ha) of each site sampled after adjustment for the total effective trapping area.

Table 1. Rodent Density Estimate of Area G (Sites 1 and 2) and Control (Site 3).

SITE 1	DAY	NO. OF CAPTURES	NO. OF TRAPS
	1	13	100
	2	6	100
	3	5	100
DENSITY ESTIMATE (# animals/ ha)	23.84		
VAR(N) ESTIMATE	13.24		
90% CONFIDENCE INTERVAL	Lower 90% Limit 4.08		Upper 90% Limit 61.85

SITE 2	DAY	NO. OF CAPTURES	NO. OF TRAPS
	1	17	100
	2	6	100
	3	1	100
DENSITY ESTIMATE (# animals/ ha	20.67		
VAR(N) ESTIMATE	0.60		
90% CONFIDENCE INTERVAL	Lower 90% Limit 17.09		Upper 90% Limit 27.04

SITE 3	DAY	NO. OF CAPTURES	NO. OF TRAPS
	1	4	100
	2	0	100
	3	—	—
DENSITY ESTIMATE (# animals/ ha)	3.31*		

* no new captures were recorded after the first night of trapping, therefore, a third night of trapping was not conducted; this estimate is treated as a "complete census" of rodents at the site.

Radionuclide Analysis

Results of data analysis presented in this paper are primarily for the radionuclides total U, ^{241}Am, ^{238}Pu and ^{239}Pu, ^{90}Sr, ^{137}Cs, Bi^{214}, ^{60}Co, ^{152}Eu, ^{40}K, and ^{208}Tl (Table 2). A total of 27 radionuclides were analyzed using gamma spectroscopy. However, results are presented only for those that showed detectable activity based on the gamma spectroscopy. These included ^{137}Cs, ^{214}Bi, ^{60}Co, ^{152}Eu, ^{40}K, and ^{208}Tl. A complete list of radionuclides analyzed and the analytical results are given in Appendix A.

Table 2. Summary of Analytical Results for Radionuclides Showing Detectable Activity.

SITE	SAMPLE NUMBER	RADIOISOTOPE	SAMPLE TYPE	ANALYTICAL RESULT (μg/g or pCi/g)[1]	ANALYTICAL UNCERTAINTY
1	1	^{241}Am	Carcass	0.01	0.03
1	2	^{241}Am	Carcass	0.009	0.03
1	3	^{241}Am	Carcass	0.012	0.03
1	1	^{241}Am	Pelt	0.052	0.03
1	1	^{238}Pu	Carcass	0.137	0.031
1	2	^{238}Pu	Carcass	0.173	0.037
1	3	^{238}Pu	Carcass	0.012	0.03
1	1	^{238}Pu	Pelt	0.506	0.035
1	1	^{239}Pu	Carcass	0.034	0.02
1	2	^{239}Pu	Carcass	0.023	0.015
1	3	^{239}Pu	Carcass	0.02	0.02
1	1	^{239}Pu	Pelt	0.089	0.02
1	1	^{90}Sr	Carcass	1.7	0.2
1	2	^{90}Sr	Carcass	3.4	0.2
1	3	^{90}Sr	Carcass	2.8	0.3
1	1	^{90}Sr	Pelt	0.9	0.5
1	1	^{137}Cs	Carcass	0.04	0.06
1	2	^{137}Cs	Carcass	0.04	0.06
1	3	^{137}Cs	Carcass	0.04	0.06
1	1	^{137}Cs	Pelt	0.02	0.03
1	1	^{214}Bi	Carcass	0.41	0.13
1	2	^{214}Bi	Carcass	0.72	0.16
1	3	^{214}Bi	Carcass	0.58	0.15
1	1	^{214}Bi	Pelt	0.42	0.14
1	1	^{60}Co	Carcass	0.94	0.17
1	2	^{60}Co	Carcass	1.01	0.15
1	3	^{60}Co	Carcass	1.12	0.16
1	1	^{60}Co	Pelt	0.99	0.15
1	1	^{152}Eu	Carcass	2.24	0.55
1	2	^{152}Eu	Carcass	2.36	0.56
1	3	^{152}Eu	Carcass	2.66	0.63
1	1	^{152}Eu	Pelt	1.97	0.52
1	1	^{40}K	Carcass	50.15	5.78

Table 2 (cont.).

SITE	SAMPLE NUMBER	RADIOISOTOPE	SAMPLE TYPE	ANALYTICAL RESULT (μg/g or pCi/g)[1]	ANALYTICAL UNCERTAINTY
1	2	^{40}K	Carcass	49.47	5.73
1	3	^{40}K	Carcass	47.19	5.5
1	1	^{40}K	Pelt	43.45	5.14
1	1	^{208}Tl	Carcass	0.22	0.07
1	2	^{208}Tl	Carcass	0.25	0.06
1	3	^{208}Tl	Carcass	0.26	0.07
1	1	^{208}Tl	Pelt	0.26	0.07
2	1	total U	Carcass	0.318	0.032
2	2	total U	Carcass	0.397	0.040
2	3	total U	Carcass	0.316	0.038
2	1	total U	Pelt	1.362	0.136
2	1	^{241}Am	Carcass	0.099	0.030
2	2	^{241}Am	Carcass	0.034	0.030
2	3	^{241}Am	Carcass	0.019	0.030
2	1	^{241}Am	Pelt	1.14	0.071
2	1	^{238}Pu	Carcass	0.033	0.010
2	2	^{238}Pu	Carcass	0.001	0.004
2	3	^{238}Pu	Carcass	0.006	0.002
2	1	^{238}Pu	Pelt	0.237	0.030
2	1	^{239}Pu	Carcass	0.121	0.017
2	2	^{239}Pu	Carcass	0.072	0.010
2	3	^{239}Pu	Carcass	0.042	0.006
2	1	^{239}Pu	Pelt	1.269	0.079
2	1	^{90}Sr	Carcass	1.7	0.2
2	2	^{90}Sr	Carcass	0.6	0.2
2	3	^{90}Sr	Carcass	1.3	0.2
2	1	^{90}Sr	Carcass	1.3	0.8
2	1	^{137}Cs	Carcass	0.01	0.02
2	2	^{137}Cs	Carcass	0.03	0.05
2	3	^{137}Cs	Carcass	0.06	0.09
2	1	^{137}Cs	Pelt	0.03	0.05
2	1	^{214}Bi	Carcass	0.49	0.12
2	2	^{214}Bi	Carcass	0.41	0.11
2	3	^{214}Bi	Carcass	0.50	0.14
2	1	^{214}Bi	Pelt	0.44	0.13

Table 2 (cont.).

SITE	SAMPLE NUMBER	RADIOISOTOPE	SAMPLE TYPE	ANALYTICAL RESULT (μg/g or pCi/g)[1]	ANALYTICAL UNCERTAINTY
2	1	^{60}Co	Carcass	0.94	0.12
2	2	^{60}Co	Carcass	0.91	0.14
2	3	^{60}Co	Carcass	0.96	0.17
2	1	^{60}Co	Pelt	0.96	0.15
2	1	^{152}Eu	Carcass	2.89	0.64
2	2	^{152}Eu	Carcass	2.13	0.54
2	3	^{152}Eu	Carcass	2.39	0.56
2	1	^{152}Eu	Pelt	2.94	0.71
2	1	^{40}K	Carcass	43.87	5.22
2	2	^{40}K	Carcass	46.35	5.35
2	3	^{40}K	Carcass	45.39	5.32
2	1	^{40}K	Pelt	40.22	4.86
2	1	^{208}Tl	Carcass	0.20	0.06
2	2	^{208}Tl	Carcass	0.15	0.05
2	3	^{208}Tl	Carcass	0.21	0.07
2	1	^{208}Tl	Pelt	0.16	0.06
3	1	total U	Carcass	0.252	0.025
3	2	total U	Carcass	0.174	0.017
3	3	total U	Carcass	0.267	0.027
3	1	total U	Pelt	0.979	0.196
3	1	^{241}Am	Carcass	0.009	0.030
3	2	^{241}Am	Carcass	0.003	0.030
3	3	^{241}Am	Carcass	0.007	0.030
3	1	^{241}Am	Pelt	0.014	0.030
3	1	^{238}Pu	Carcass	0.012	0.030
3	2	^{238}Pu	Carcass	0.006	0.030
3	3	^{238}Pu	Carcass	0.001	0.030
3	1	^{238}Pu	Pelt	0.003	0.030
3	1	^{239}Pu	Carcass	0.003	0.020
3	2	^{239}Pu	Carcass	0.001	0.020
3	3	^{239}Pu	Carcass	0.005	0.020
3	1	^{239}Pu	Pelt	0.037	0.020
3	1	^{90}Sr	Carcass	2.0	0.3
3	2	^{90}Sr	Carcass	1.8	0.3
3	3	^{90}Sr	Carcass	1.9	0.2

Table 2 (cont.).

SITE	SAMPLE NUMBER	RADIOISOTOPE	SAMPLE TYPE	ANALYTICAL RESULT (µg/g or pCi/g)[1]	ANALYTICAL UNCERTAINTY
3	1	^{90}Sr	Pelt	1.8	0.6
3	1	^{137}Cs	Carcass	0.12	0.05
3	2	^{137}Cs	Carcass	0.02	0.03
3	3	^{137}Cs	Carcass	0.06	0.09
3	1	^{137}Cs	Pelt	0.02	0.03
3	1	^{214}Bi	Carcass	0.30	0.14
3	2	^{214}Bi	Carcass	0.52	0.14
3	3	^{214}Bi	Carcass	0.39	0.18
3	1	^{214}Bi	Pelt	0.56	0.24
3	1	^{60}Co	Carcass	0.43	0.12
3	2	^{60}Co	Carcass	2.42	0.28
3	3	^{60}Co	Carcass	0.42	0.09
3	1	^{60}Co	Pelt	1.28	0.28
3	1	^{152}Eu	Carcass	0.17	0.26
3	2	^{152}Eu	Carcass	2.72	0.65
3	3	^{152}Eu	Carcass	0.10	0.15
3	1	^{152}Eu	Pelt	0.03	0.05
3	1	^{40}K	Carcass	22.58	2.7
3	2	^{40}K	Carcass	46.52	5.48
3	3	^{40}K	Carcass	28.92	3.08
3	1	^{40}K	Pelt	529.19	40.64
3	1	^{208}Tl	Carcass	0.17	0.06
3	2	^{208}Tl	Carcass	0.22	0.06
3	3	^{208}Tl	Carcass	0.16	0.06
3	1	^{208}Tl	Pelt	0.33	0.11

[1] Total U in measurements of µg/g; all other contaminant measurements are in pCi/g.

All carcass means were normally distributed (Table 3) with the exception of ^{137}Cs in Site 1, total U in Site 2, and ^{60}Co and ^{152}Eu in Site 3.

Table 3. Probability Values for Normality Test on Mean Concentration of Radionuclides by Carcass.

CONTAMINANT	P Value*		
	SITE 1	SITE 2	SITE 3
total U	0.5399	0.0413	0.2879
^{241}Am	0.6368	0.3386	0.6368
^{238}Pu	0.4099	0.2783	0.8995
^{239}Pu	0.2500	0.7364	0.9916
^{90}Sr	0.6786	0.7016	0.9916
^{137}Cs	0.0000	0.7803	0.7803
214Bi	0.8931	0.1939	0.8001
^{60}Co	0.7562	0.7803	0.0083
^{152}Eu	0.5367	0.6555	0.0447
^{40}K	0.4222	0.7523	0.4935
^{208}Tl	0.4632	0.2982	0.8774

* less than 0.05 indicates non-normal distribution

The mean concentration of each radionuclide found in carcasses and pelts by site is given in Tables 4 and 5, respectively, and shown in Figure 2. For most sites, the mean concentration of radionuclides in carcasses were lower than the concentrations found in pelts[1] for total U, ^{241}Am, ^{238}Pu, and ^{239}Pu. For the remaining radionuclides, concentrations in carcasses were usually nearly equal to or exceeded the mean concentrations in the pelts. An ANOVA test was used to determine if the mean radionuclide concentrations in carcasses were different between sites and Duncan's multiple range test used to show where the differences occurred. The results are discussed below.

Total U

There were no significant differences in total U in carcasses between Sites 2 and 3. However, Site 1 had significantly higher (alpha=0.05, P=0.0095) total U concentrations in carcasses than Sites 2 and 3 and was over two times higher than the control Site, 3.

[1] Only one composite pelt sample was analyzed per site due to low total ashed weight of combined samples.

Table 4. Mean Radionuclide Concentrations for Small Mammal Carcass Samples.

	SITE 1			SITE 2			SITE 3		
RADIONUCLIDE	N	Mean	SE	N	Mean	SE	N	Mean	SE
^{214}Bi	3	0.57	0.089	3	0.467	0.029	3	0.403	0.064
^{241}Am	3	0.01	0.001	3	0.051	0.025	3	0.006	0.002
^{238}Pu	3	0.107	0.049	3	0.013	0.010	3	0.006	0.003
^{137}Cs	3	0.04	0.000	3	0.033	0.015	3	0.067	0.029
^{60}Co	3	1.023	0.052	3	0.937	1.090	3	1.09	0.665
^{152}Eu	3	2.42	0.125	3	2.470	0.223	3	0.997	0.862
^{208}Tl	3	0.243	0.012	3	0.187	0.019	3	0.217	0.026
^{239}Pu	3	0.026	0.004	3	0.078	0.023	3	0.003	0.001
U	3	0.487	0.054	3	0.344	0.027	3	0.231	0.029
^{90}Sr	3	2.6	0.498	3	1.2	0.321	3	1.9	0.058
^{40}K	3	48.94	0.895	3	45.2	0.722	3	32.67	7.161

1 Radionuclide concentrations for U are measured µg/g; all other contaminants are measured in pCi/g.

Table 5. Radionuclide Concentrations[1] for Small Mammal Pelt Samples.

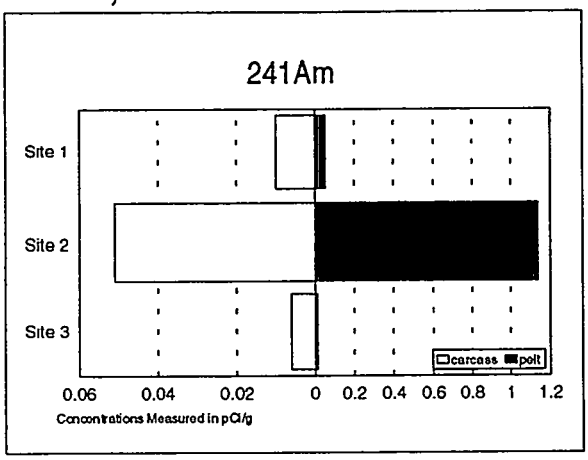
	SITE 1		SITE 2		SITE 3	
RADIONUCLIDE	N	CONCENTRATION	N	CONCENTRATION	N	CONCENTRATION
^{214}Bi	1	0.42	1	0.44	1	0.56
^{241}Am	1	0.052	1	1.14	1	0.014
^{238}Pu	1	0.506	1	0.237	1	0.003
^{137}Cs	1	0.02	1	0.03	1	0.02
^{60}Co	1	0.99	1	0.96	1	1.28
^{152}Eu	1	1.97	1	2.94	1	0.03
^{208}Tl	1	0.26	1	0.16	1	0.33
^{239}Pu	1	0.089	1	1.269	1	0.037
U	1	1.931	1	1.362	1	0.979
^{90}Sr	1	0.9	1	1.3	1	1.8
^{40}K	1	43.45	1	40.22	1	529.19

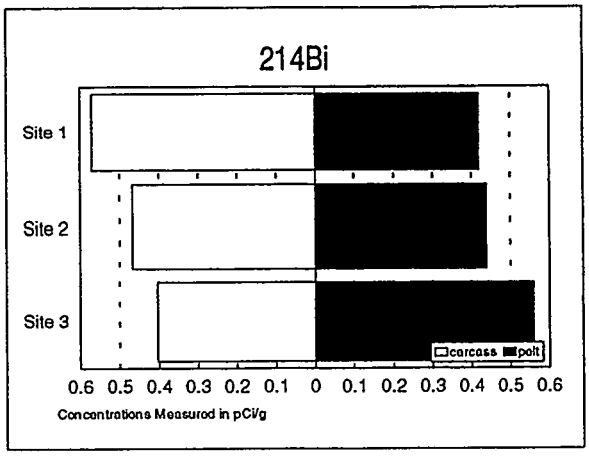
1 Radionuclide concentrations for U are measured µg/g; all other contaminants are measured in pCi/g.

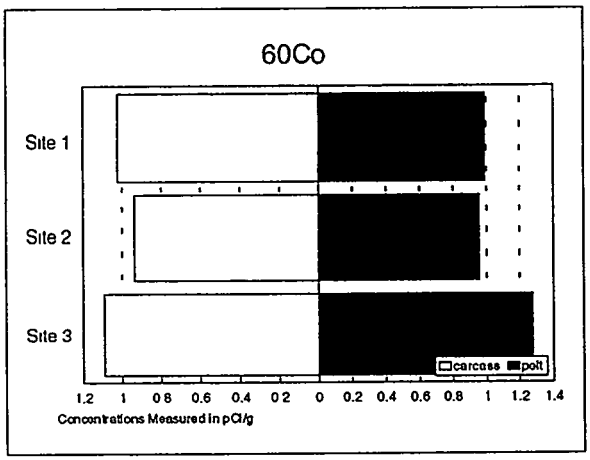
^{241}Am, ^{238}Pu, ^{137}Cs, ^{214}Bi, ^{152}Eu, ^{60}Co, ^{208}Tl

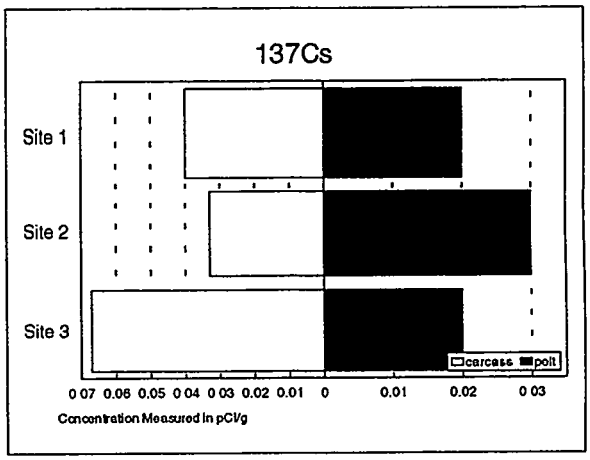
There were no significant differences (alpha=0.05) in concentrations of ^{241}Am (P=0.1267), ^{238}Pu (P=0.0846), ^{137}Cs (P=0.4607), ^{214}Bi (P=0.2697), ^{152}Eu (P=0.1539), ^{60}Co (P=0.9612), or ^{208}Tl (P=0.2076) in rodent carcasses between sites.

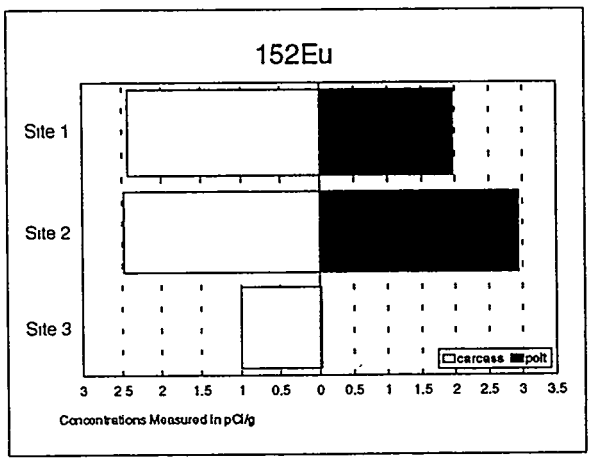
Figure 2. Radionuclide Concentrations in Small Mammals by Site, TA-54, Area G.











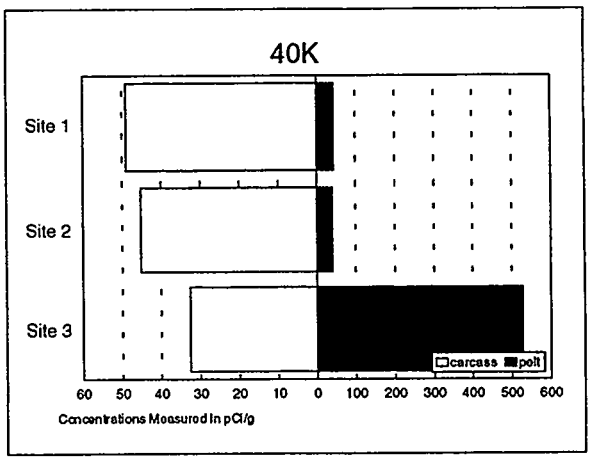
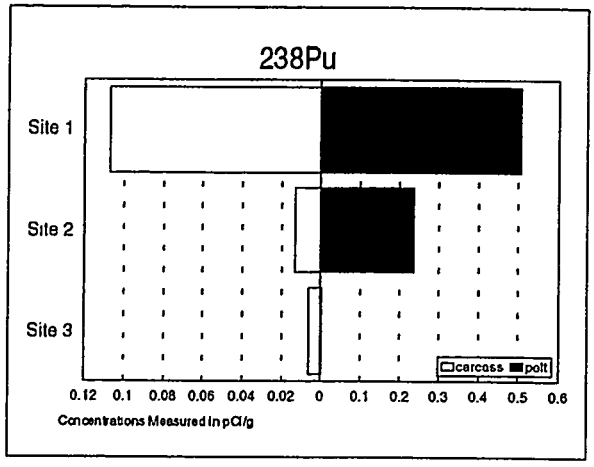
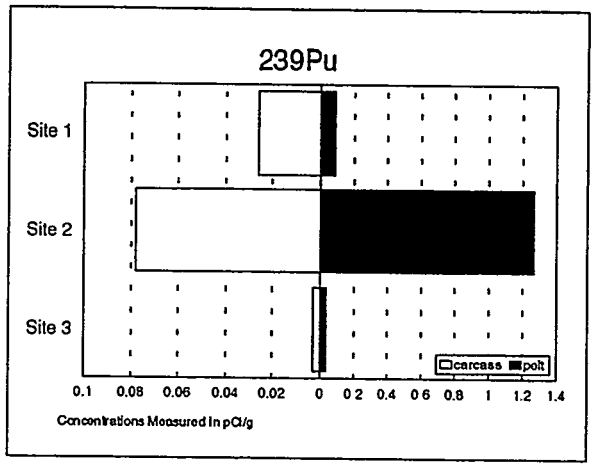
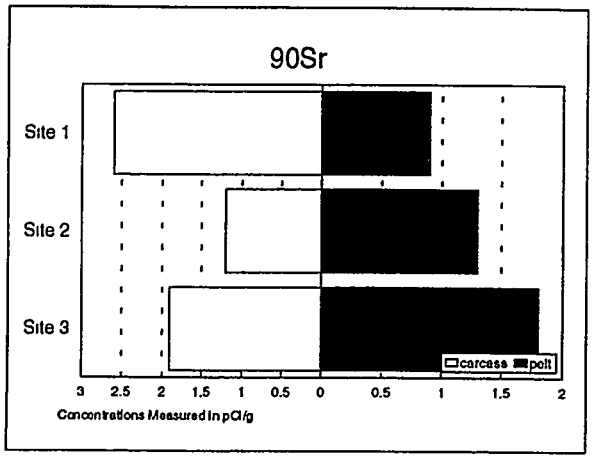
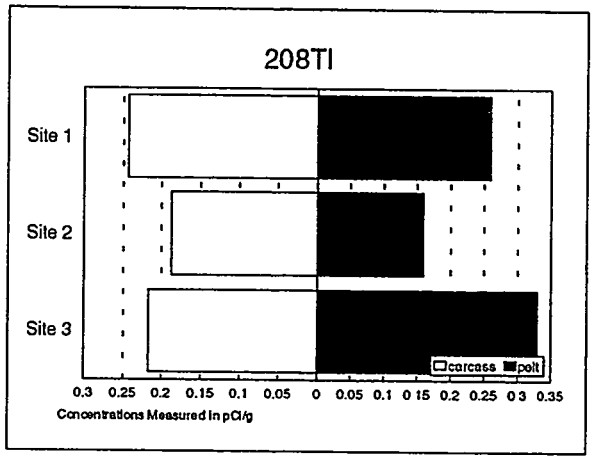


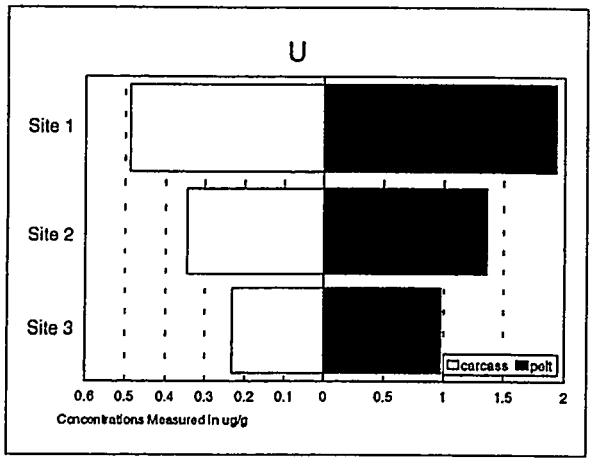
Figure 2 (cont.). Radionuclide Concentrations in Small Mammals by Site, TA-54, Area G.











^{239}Pu

No significant differences in concentrations of ^{239}Pu in carcasses occurred between Sites 1 and 3 but Site 2 had significantly higher (alpha=0.05, P=0.0195) ^{239}Pu concentrations in carcasses than either Site 1 or Site 3. Mean concentrations in carcasses at Site 2 (0.078 pCi/g) were 3 and 26 times higher than Sites 1 and 3, respectively.

^{90}Sr

A significant difference in concentration of ^{90}Sr existed between Sites 1 and 2 (alpha=0.05, P=0.0681) where the mean concentration of Site 1 was over two times that of Site 2.

^{40}K

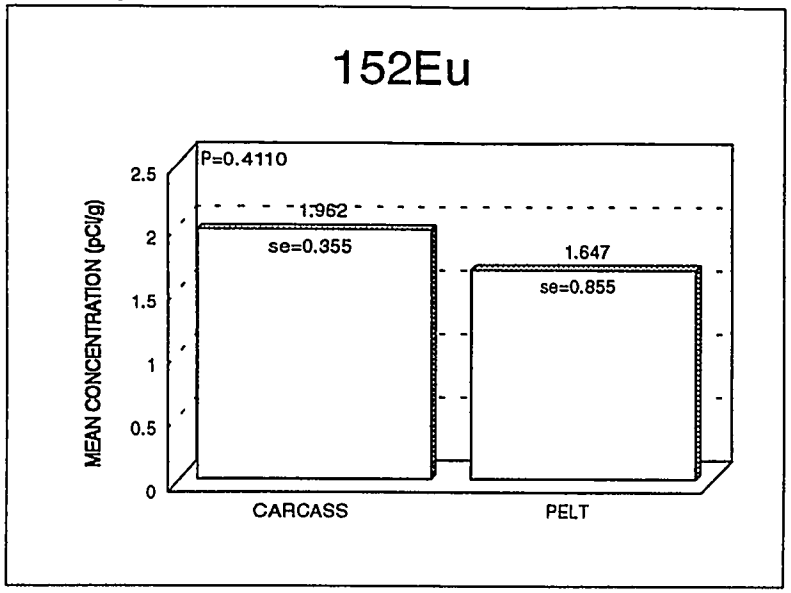
Site 1 was significantly different from Site 3 for concentrations of ^{40}K (P=0.0742).

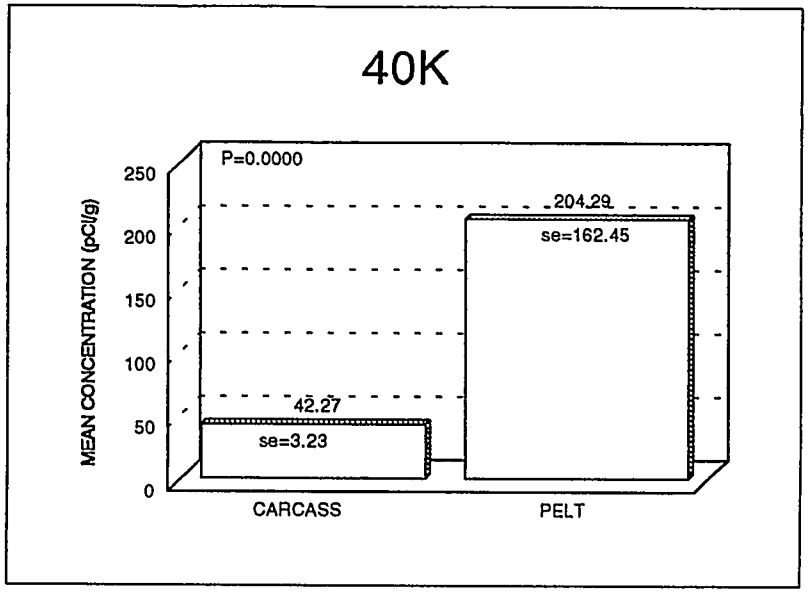
Analysis was conducted on overall mean concentrations of radionuclides to determine if differences existed between pelts and carcasses (Figure 3). The analysis was not conducted by site due to only one pelt sample per site being analyzed. For all sites combined, significant differences between pelt and carcass concentrations occurred for total U, ^{241}Am, ^{238}Pu, ^{239}Pu, and ^{40}K, and in all cases, pelts had a higher concentration of radionuclides. There were no significant differences in radionuclide measurements in our studies between pelts and carcasses for ^{90}Sr, ^{137}Cs, ^{214}Bi, ^{60}Co, ^{152}Eu, and ^{208}Tl.

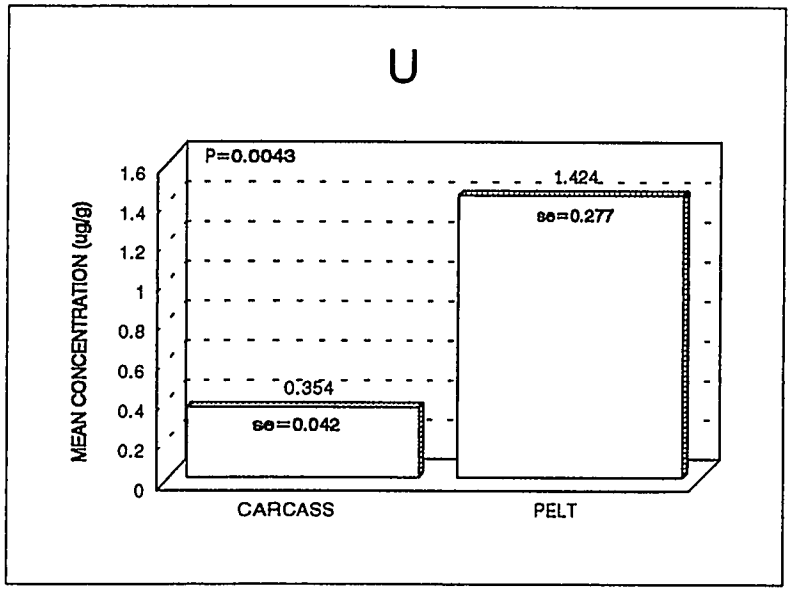
DISCUSSION

This study was intended to establish baseline measurements of radionuclide concentrations in small mammals at Area G, TA-54, during the summer of 1994. The data can then be used to modify future studies at Area G to better identify radionuclide transport and concentration loads in and around the site.

Figure 3. Overall Mean Contaminant Concentrations in Pelts and Carcasses.







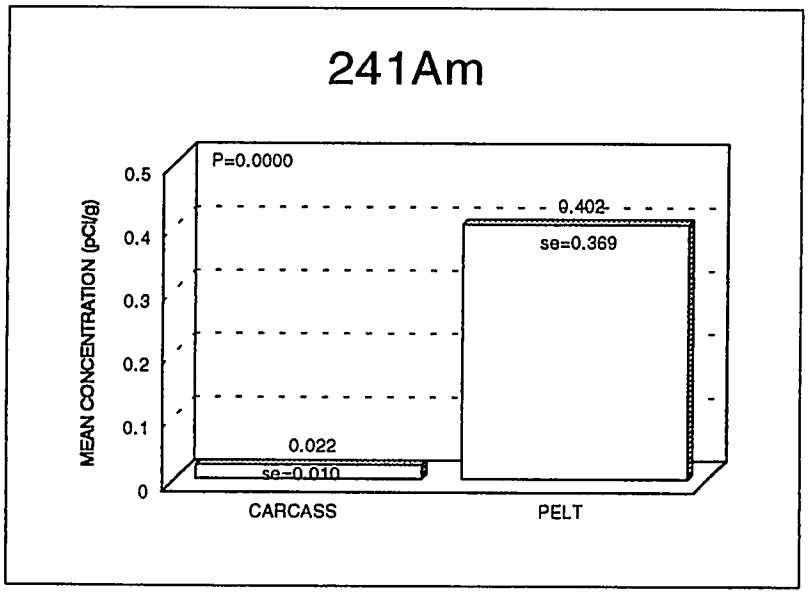
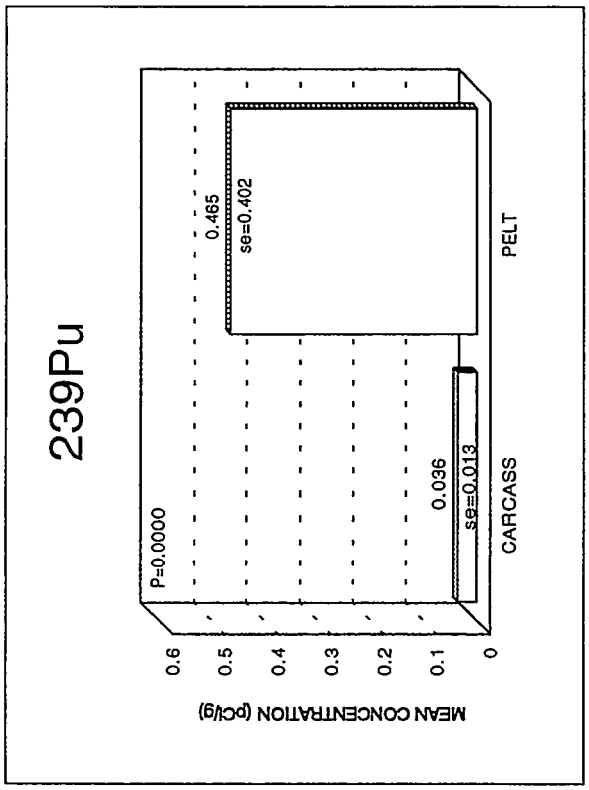
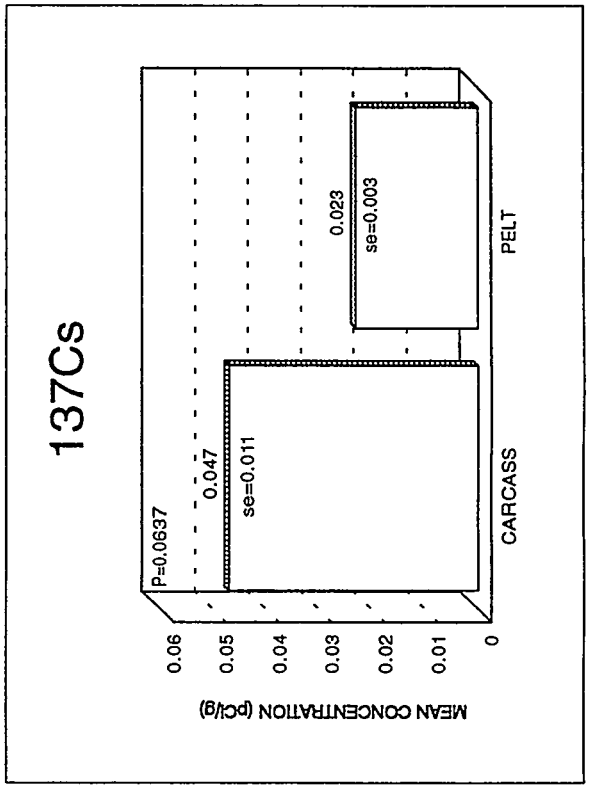
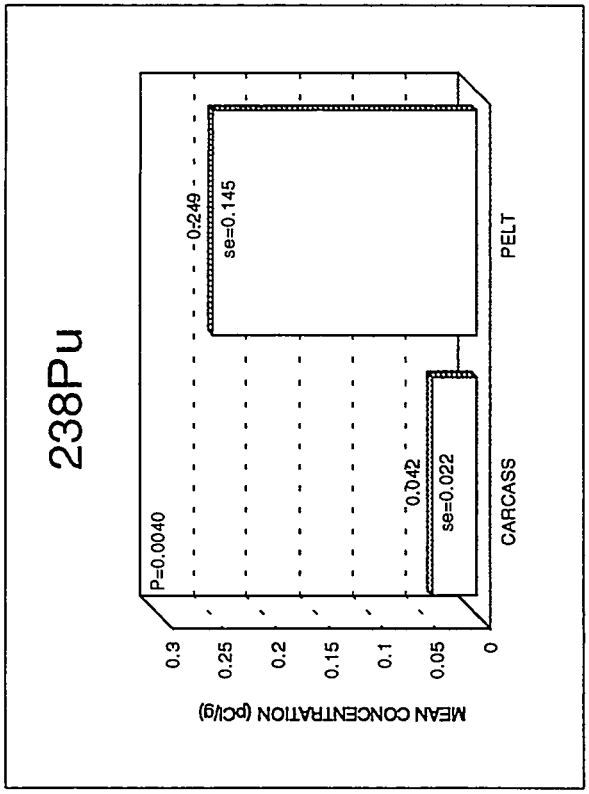


Figure 3 (cont.). Overall Mean Contaminant Concentrations in Pelts and Carcasses.







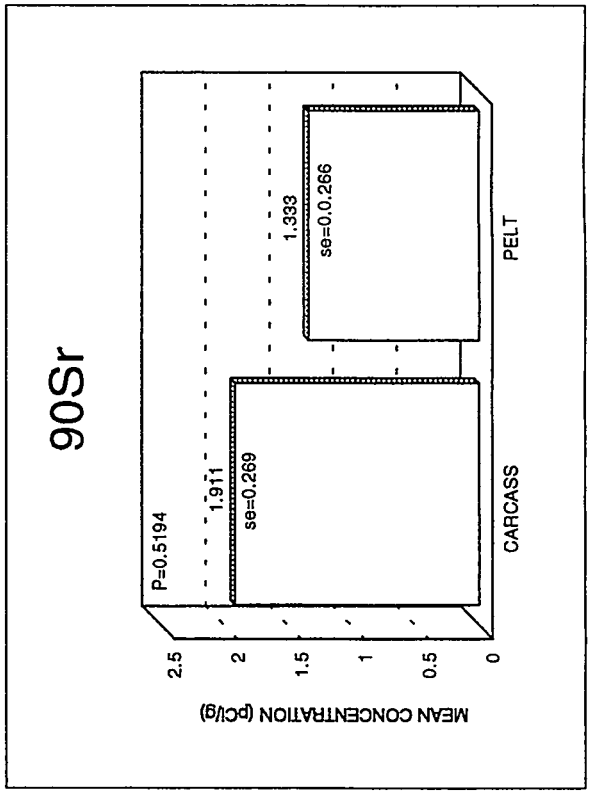
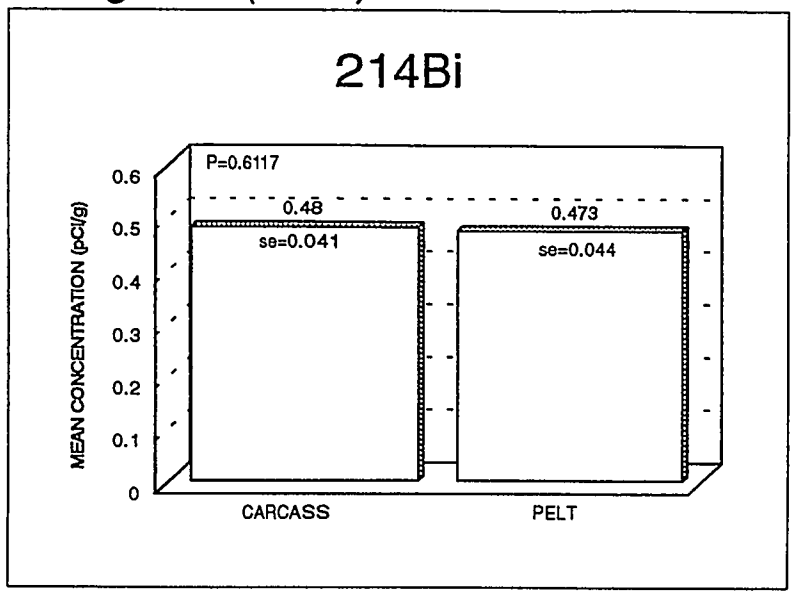
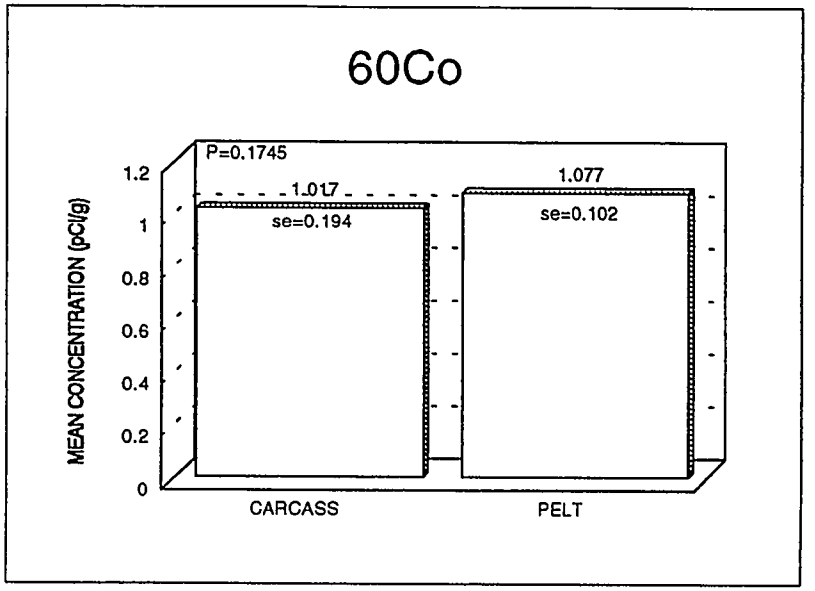
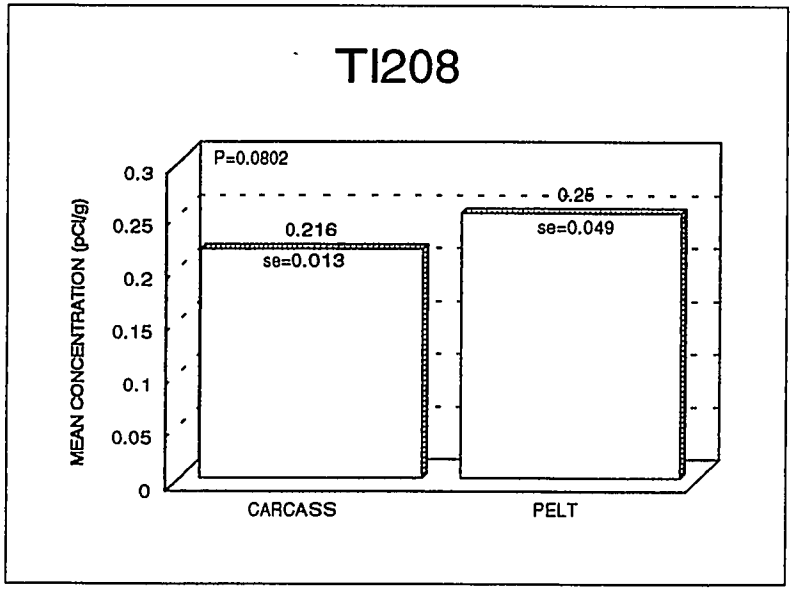


Figure 3 (cont.). Overall Mean Contaminant Concentrations in Pelts and Carcasses.







As shown in Table 1, higher densities of rodents were recorded for the two sites within Area G, both of which are located on predisturbed ground. Typically, at other predisturbed locations within Laboratory boundaries, small mammal densities have been higher than in undisturbed habitats. The low densities recorded for the control site is also typical of other studies conducted on mesa top habitats within Laboratory boundaries, especially within pinyon pine/juniper woodlands. The primary species collected at Sites 1 and 2 was deer mice. Deer mice are a more "opportunistic" species compared to other mice expected to occur in the vicinity of Area G and are therefore more likely to invade and populate the disturbed sites.

Our studies generally showed greater amounts of radionuclides in the pelts of animals compared to the carcass. In studies conducted at waste burial sites or contaminated sites outside of the Laboratory, similar results were found. Markham et.al. (1978) found higher concentrations of ^{238}Pu, ^{239}Pu, and ^{241}Am in the pelts and gastrointestinal tracts compared to the carcass and lungs. Studies conducted at the Idaho National Engineering Laboratory on waste disposal sites also showed the highest concentration of ^{238}Pu, $^{239+240}Pu$, ^{241}Am, ^{90}Sr, and ^{137}Cs in pelt samples (Arthur et al., 1987).

Total U was shown to occur in significantly higher concentrations (in carcasses) at Site 1 compared to Sites 2 and 3. Also, Site 2 had higher concentrations of ^{239}Pu compared to Site 1 or 3. Total U concentrations in vegetation collected at Site 1 indicate a range of 1.23 to 1.72 pCi/g ash (Fresquez et al. 1995) whereas concentrations in small mammal carcasses were less than 0.5 pCi/g ash. Vegetation collected at Site 1 had ^{90}Sr concentrations ranging from 2.0 to 3.3 pCi/g ash (Fresquez et al. 1995). The mean concentration of ^{90}Sr in small mammal carcasses at Site 1 was 2.6 pCi/g ash, well within the range of concentrations found in vegetation at that location. Additional studies and further monitoring of these sites will more accurately access if correlation's exist between radionuclide concentrations in vegetation and rodents. This information coupled with determining the mode (surface contact, inhalation/ingestion) of contamination to the animal

can help to identify potential pathways of contaminants in a particular plant/animal community by examining if radionuclides are ingested, inhaled, or picked up via surface contact. Additional studies that are currently being conducted elsewhere at the Laboratory, coupled with past data collected at the Laboratory, will be used to more closely examine the relationship between food habits of small mammals and radionuclide uptake via vegetation. Knowledge of densities, food habits, and population dynamics will also help to estimate contaminant loads within the biota at the waste site as well as potential transport off the site. The information can also be used to gain a better understanding on the distribution of radionuclides within the biotic community of Area G and its impact, if any, on biotic communities surrounding Area G.

ACKNOWLEDGMENTS

We would like to thank field crew members Mary Salisbury, Eric Pacheco, and Laura Payne for their hard work and patience while collecting field data. We owe thanks to Mary Mullin for her help in calculating density estimates. We thank Louisa Lujan-Pacheco and Hector Hinojosa, CIC-1, for editing the manuscript and Eric Vold, CST-14, for his assistance in site selection for trapping and for reviewing this manuscript. We would also like to thank Teralene Foxx, Acting Group Leader, ESH-20, for her support in attaining funds for this project. Finally, we would like to thank CST-14, The Solid Waste Management Program, for their support in funding this project.

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APPENDIX A

RAW DATA PRINTOUTS OF RADIONUCLIDE CONCENTRATIONS IN SMALL MAMMAL CARCASSES AND PELTS, AREA G, 1994

REPORT NUMBER: 30877

********** CST ANALYTICAL REPORT **********

Prepared by: AKS on 11-Jan-1995

ANALYSIS: SR-90 REQUEST NUMBER: 18705 MATRIX: BZ ANALYST: RICHARD PETERS PROGRAM CODE: M36A

OWNER: Philip R. Fresquez GROUP: ESH-20 MAIL-STOP: K490 PHONE: 7-0815

ANALYTICAL TECHNIQUE: PC ANALYTICAL PROCEDURE: ER 190 NOTEBOOK: PAGE:

CUSTOMER SAMPLES:

CUSTOMER NUMBER	SAMPLE NUMBER	ANALYTICAL RESULT	ANALYTICAL UNCERTAINTY	UNITS	COMPLETION DATE	COMMENT
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6222-2C	94.20469	0.6	0.2	PCI/G	1/11/95	
6222-3C	94.20470	1.3	0.2	PCI/G	1/11/95	
6222-P	94.20471	1.3	0.8	PCI/G	1/11/95	
6211-P	94.20472	0.9	0.5	PCI/G	1/11/95	
6211-1C	94.20473	1.7	0.2	PCI/G	1/11/95	
6211-2C	94.20474	3.4	0.2	PCI/G	1/11/95	
6211-3C	94.20475	2.8	0.3	PCI/G	1/11/95	
6243-2C	94.20476	1.8	0.3	PCI/G	1/11/95	
6243-3C	94.20477	1.9	0.2	PCI/G	1/11/95	
6243-1C	94.20478	2.	0.3	PCI/G	1/11/95	
6243-P	94.20479	1.8	0.6	PCI/G	1/11/95	

REPORT NUMBER: 29717

********** CST ANALYTICAL REPORT **********

Prepared by: CEA on 29-Nov-1994

REQUEST NUMBER: 18705 MATRIX: BZ ANALYST: RICHARD PETERS PROGRAM CODE: M36A

OWNER: Philip R. Fresquez GROUP: ESH-20 MAIL-STOP: K490 PHONE: 7-0815

NOTEBOOK: PAGE:

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CUSTOMER NUM	SAMPLE NUM	ANALYSIS	ANALYTICAL TECHNIQUE	ANALYTICAL RESULT	ANALYTICAL UNCERTAINTY	UNITS	COMPLETION DATE	COMMENT
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6222-1C	94.20468	PU-238	RAS	0.0329	0.01	PCI/G	11/17/94	31%
6222-1C	94.20468	PU-239	RAS	0.1212	0.017	PCI/G	11/17/94	31%
6222-2C	94.20469	AM-241	RAS	0.034	0.03	PCI/G	11/17/94	86%
6222-2C	94.20469	PU-238	RAS	0.0008	0.0036	PCI/G	11/17/94	48%
6222-2C	94.20469	PU-239	RAS	0.0719	0.0104	PCI/G	11/17/94	48%
6222-3C	94.20470	AM-241	RAS	0.019	0.03	PCI/G	11/17/94	87%
6222-3C	94.20470	PU-238	RAS	0.0056	0.0024	PCI/G	11/17/94	84%
6222-3C	94.20470	PU-239	RAS	0.0416	0.0055	PCI/G	11/17/94	84%
6222-P	94.20471	AM-241	RAS	1.14	0.071	PCI/G	11/17/94	83%
6222-P	94.20471	PU-238	RAS	0.237	0.03	PCI/G	11/17/94	74%
6222-P	94.20471	PU-239	RAS	1.269	0.079	PCI/G	11/17/94	74%
6211-P	94.20472	AM-241	RAS	0.052	0.03	PCI/G	11/17/94	54%
6211-P	94.20472	PU-238	RAS	0.506	0.035	PCI/G	11/17/94	83%
6211-P	94.20472	PU-239	RAS	0.089	0.02	PCI/G	11/17/94	83%
6211-1C	94.20473	AM-241	RAS	0.01	0.03	PCI/G	11/17/94	72%
6211-1C	94.20473	PU-238	RAS	0.137	0.031	PCI/G	11/17/94	8%
6211-1C	94.20473	PU-239	RAS	0.034	0.02	PCI/G	11/17/94	8%
6211-2C	94.20474	AM-241	RAS	0.009	0.03	PCI/G	11/17/94	83%
6211-2C	94.20474	PU-238	RAS	0.1725	0.037	PCI/G	11/17/94	12%
6211-2C	94.20474	PU-239	RAS	0.0231	0.0147	PCI/G	11/17/94	12%
6211-3C	94.20475	AM-241	RAS	0.012	0.03	PCI/G	11/17/94	92%
6211-3C	94.20475	PU-238	RAS	0.012	0.03	PCI/G	11/17/94	73%
6211-3C	94.20475	PU-239	RAS	0.02	0.02	PCI/G	11/17/94	73%
6243-2C	94.20476	AM-241	RAS	0.003	0.03	PCI/G	11/17/94	99%
6243-2C	94.20476	PU-238	RAS	0.006	0.03	PCI/G	11/17/94	29%
6243-2C	94.20476	PU-239	RAS	0.001	0.02	PCI/G	11/17/94	29%
6243-3C	94.20477	AM-241	RAS	0.007	0.03	PCI/G	11/17/94	89%
6243-3C	94.20477	PU-238	RAS	0.001	0.03	PCI/G	11/17/94	79%
6243-3C	94.20477	PU-239	RAS	0.005	0.02	PCI/G	11/17/94	79%
6243-1C	94.20478	AM-241	RAS	0.009	0.03	PCI/G	11/17/94	85%
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REPORT NUMBER: 29431

********** EM-9 ANALYTICAL REPORT **********

Prepared by: AKS on 16-Nov-1994

ANALYSIS: U REQUEST NUMBER: 18705 MATRIX: BZ ANALYST: RICHARD PETERS PROGRAM CODE: M36

OWNER: Philip R. Fresquez GROUP: ESH-20 MAIL-STOP: K490 PHONE: 7-0815

ANALYTICAL TECHNIQUE: KPA ANALYTICAL PROCEDURE: NOTEBOOK: PAGE:

CUSTOMER SAMPLES:

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6222-3C	94.20470	0.316	0.038	UG/G	11/16/94	
6222-P	94.20471	1.362	0.136	UG/G	11/16/94	
6211-P	94.20472	1.931	0.193	UG/G	11/16/94	
6211-1C	94.20473	0.384	0.038	UG/G	11/16/94	
6211-2C	94.20474	0.565	0.057	UG/G	11/16/94	
6211-3C	94.20475	0.513	0.051	UG/G	11/16/94	
6243-2C	94.20476	0.174	0.017	UG/G	11/16/94	
6243-3C	94.20477	0.267	0.027	UG/G	11/16/94	
6243-1C	94.20478	0.252	0.025	UG/G	11/16/94	
6243-P	94.20479	0.979	0.196	UG/G	11/16/94	

REPORT NUMBER: 33850

********** CST ANALYTICAL REPORT **********

Prepared by: YIG on 21-Apr-1995

REQUEST NUMBER: 18705 MATRIX: BZ ANALYST: SAMMY GARCIA PROGRAM CODE: M36A

OWNER: Philip R. Fresquez GROUP: ESH-20 MAIL-STOP: M887 PHONE: 7-0815

NOTEBOOK: PAGE:

CUSTOMER SAMPLES:

CUSTOMER NUM	SAMPLE NUM	ANALYSIS	ANALYTICAL TECHNIQUE	ANALYTICAL RESULT	ANALYTICAL UNCERTAINTY	UNITS	COMPLETION DATE	COMMENT
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6222-1C	94.20468	BI-214	G	0.49	0.12	PCI/G	4/12/95	
6222-1C	94.20468	CE-144	G	0.46	0.69	PCI/G	4/12/95	
6222-1C	94.20468	CO-57	G	0.07	0.03	PCI/G	4/12/95	
6222-1C	94.20468	CO-60	G	0.94	0.12	PCI/G	4/12/95	
6222-1C	94.20468	CS-134	G	0.04	0.06	PCI/G	4/12/95	
6222-1C	94.20468	CS-137	G	0.01	0.02	PCI/G	4/12/95	
6222-1C	94.20468	EU-152	G	2.89	0.64	PCI/G	4/12/95	
6222-1C	94.20468	K-40	G	43.87	5.22	PCI/G	4/12/95	
6222-1C	94.20468	LA-140	G	0.0		PCI/G	4/12/95	
6222-1C	94.20468	MN-54	G	0.11	0.06	PCI/G	4/12/95	
6222-1C	94.20468	NA-22	G	0.22	0.08	PCI/G	4/12/95	
6222-1C	94.20468	NP-237	G	0.09	0.14	PCI/G	4/12/95	
6222-1C	94.20468	PA-231	G	1.61	2.42	PCI/G	4/12/95	
6222-1C	94.20468	PA-233	G	0.82	1.23	PCI/G	4/12/95	
6222-1C	94.20468	PB-210	G	0.0	2.7	PCI/G	4/12/95	
6222-1C	94.20468	PB-212	G	0.17	0.07	PCI/G	4/12/95	
6222-1C	94.20468	PB-214	G	0.24	0.08	PCI/G	4/12/95	
6222-1C	94.20468	RA-223	G	42.86	64.29	PCI/G	4/12/95	
6222-1C	94.20468	RA-224	G	0.11	0.17	PCI/G	4/12/95	
6222-1C	94.20468	RA-226	G	0.79	1.19	PCI/G	4/12/95	
6222-1C	94.20468	RN-219	G	0.79	0.3	PCI/G	4/12/95	
6222-1C	94.20468	RU-106	G	0.08	0.12	PCI/G	4/12/95	
6222-1C	94.20468	SE-75	G	0.08	0.12	PCI/G	4/12/95	
6222-1C	94.20468	TL-208	G	0.2	0.06	PCI/G	4/12/95	
6222-1C	94.20468	ZN-65	G	0.75	1.13	PCI/G	4/12/95	
6222-2C	94.20469	BA-140	G	42.55	63.83	PCI/G	4/12/95	
6222-2C	94.20469	BI-212	G	0.18	0.27	PCI/G	4/12/95	
6222-2C	94.20469	BI-214	G	0.41	0.11	PCI/G	4/12/95	
6222-2C	94.20469	CE-144	G	0.41	0.62	PCI/G	4/12/95	
6222-2C	94.20469	CO-57	G	0.05	0.08	PCI/G	4/12/95	
6222-2C	94.20469	CO-60	G	0.91	0.14	PCI/G	4/12/95	
6222-2C	94.20469	CS-134	G	0.01	0.02	PCI/G	4/12/95	
6222-2C	94.20469	CS-137	G	0.03	0.05	PCI/G	4/12/95	
6222-2C	94.20469	EU-152	G	2.13	0.54	PCI/G	4/12/95	
6222-2C	94.20469	K-40	G	46.35	5.35	PCI/G	4/12/95	

6222-2C	94.20469	LA-140	G	0.0		PCI/G	4/12/95
6222-2C	94.20469	MN-54	G	0.08	0.12	PCI/G	4/12/95
6222-2C	94.20469	NA-22	G	0.1	0.15	PCI/G	4/12/95
6222-2C	94.20469	NP-237	G	0.3	0.45	PCI/G	4/12/95
6222-2C	94.20469	PA-231	G	1.42	2.13	PCI/G	4/12/95
6222-2C	94.20469	PA-233	G	0.14	0.21	PCI/G	4/12/95
6222-2C	94.20469	PB-210	G	0.0	2.7	PCI/G	4/12/95
6222-2C	94.20469	PB-212	G	0.24	0.07	PCI/G	4/12/95
6222-2C	94.20469	PB-214	G	0.31	0.08	PCI/G	4/12/95
6222-2C	94.20469	RA-223	G	0.0		PCI/G	4/12/95
6222-2C	94.20469	RA-224	G	0.37	0.56	PCI/G	4/12/95
6222-2C	94.20469	RA-226	G	0.06	0.09	PCI/G	4/12/95
6222-2C	94.20469	RN-219	G	0.05	0.08	PCI/G	4/12/95
6222-2C	94.20469	RU-106	G	0.52	0.78	PCI/G	4/12/95
6222-2C	94.20469	SE-75	G	0.09	0.14	PCI/G	4/12/95
6222-2C	94.20469	TL-208	G	0.15	0.05	PCI/G	4/12/95
6222-2C	94.20469	ZN-65	G	0.8	0.22	PCI/G	4/12/95
6222-3C	94.20470	BA-140	G	34.02	51.03	PCI/G	4/12/95
6222-3C	94.20470	BI-212	G	0.3	0.45	PCI/G	4/12/95
6222-3C	94.20470	BI-214	G	0.5	0.14	PCI/G	4/12/95
6222-3C	94.20470	CE-144	G	0.23		PCI/G	4/12/95
6222-3C	94.20470	CO-57	G	0.06	0.03	PCI/G	4/12/95
6222-3C	94.20470	CO-60	G	0.96	0.17	PCI/G	4/12/95
6222-3C	94.20470	CS-134	G	0.05	0.08	PCI/G	4/12/95
6222-3C	94.20470	CS-137	G	0.06	0.09	PCI/G	4/12/95
6222-3C	94.20470	EU-152	G	2.39	0.56	PCI/G	4/12/95
6222-3C	94.20470	K-40	G	45.39	5.32	PCI/G	4/12/95
6222-3C	94.20470	LA-140	G	0.0		PCI/G	4/12/95
6222-3C	94.20470	MN-54	G	0.15	0.23	PCI/G	4/12/95
6222-3C	94.20470	NA-22	G	0.15	0.07	PCI/G	4/12/95
6222-3C	94.20470	NP-237	G	0.03	0.05	PCI/G	4/12/95
6222-3C	94.20470	PA-231	G	1.52	2.28	PCI/G	4/12/95
6222-3C	94.20470	PA-233	G	0.11	0.17	PCI/G	4/12/95
6222-3C	94.20470	PB-210	G	0.0	2.7	PCI/G	4/12/95
6222-3C	94.20470	PB-212	G	0.1	0.15	PCI/G	4/12/95
6222-3C	94.20470	PB-214	G	0.18	0.05	PCI/G	4/12/95
6222-3C	94.20470	RA-223	G	0.0		PCI/G	4/12/95
6222-3C	94.20470	RA-224	G	0.56	0.84	PCI/G	4/12/95
6222-3C	94.20470	RA-226	G	0.41	0.62	PCI/G	4/12/95
6222-3C	94.20470	RN-219	G	0.68	0.23	PCI/G	4/12/95
6222-3C	94.20470	RU-106	G	0.85	1.28	PCI/G	4/12/95
6222-3C	94.20470	SE-75	G	0.09	0.14	PCI/G	4/12/95
6222-3C	94.20470	TL-208	G	0.21	0.07	PCI/G	4/12/95
6222-3C	94.20470	ZN-65	G	0.62	0.21	PCI/G	4/12/95
6222-P	94.20471	BA-140	G	1.09	1.64	PCI/G	4/12/95
6222-P	94.20471	BI-212	G	1.25	0.61	PCI/G	4/12/95
6222-P	94.20471	BI-214	G	0.44	0.13	PCI/G	4/12/95
6222-P	94.20471	CE-144	G	0.21	0.32	PCI/G	4/12/95
6222-P	94.20471	CO-57	G	0.09	0.03	PCI/G	4/12/95
6222-P	94.20471	CO-60	G	0.96	0.15	PCI/G	4/12/95
6222-P	94.20471	CS-134	G	0.08	0.03	PCI/G	4/12/95
6222-P	94.20471	CS-137	G	0.03	0.05	PCI/G	4/12/95
6222-P	94.20471	EU-152	G	2.94	0.71	PCI/G	4/12/95
6222-P	94.20471	K-40	G	40.22	4.86	PCI/G	4/12/95
6222-P	94.20471	LA-140	G	0.0		PCI/G	4/12/95
6222-P	94.20471	MN-54	G	0.07	0.11	PCI/G	4/12/95
6222-P	94.20471	NA-22	G	0.19	0.29	PCI/G	4/12/95
6222-P	94.20471	NP-237	G	0.41	0.62	PCI/G	4/12/95
6222-P	94.20471	PA-231	G	0.35	0.53	PCI/G	4/12/95
6222-P	94.20471	PA-233	G	0.75	1.13	PCI/G	4/12/95

6222-P	94.20471	PB-210	G	0.0	2.7	PCI/G	4/12/95
6222-P	94.20471	PB-212	G	0.11	0.06	PCI/G	4/12/95
6222-P	94.20471	PB-214	G	0.11	0.05	PCI/G	4/12/95
6222-P	94.20471	RA-223	G	3.71	5.57	PCI/G	4/12/95
6222-P	94.20471	RA-224	G	0.53	0.8	PCI/G	4/12/95
6222-P	94.20471	RA-226	G	0.01	0.02	PCI/G	4/12/95
6222-P	94.20471	RN-219	G	1.09	1.64	PCI/G	4/12/95
6222-P	94.20471	RU-106	G	0.34	0.51	PCI/G	4/12/95
6222-P	94.20471	SE-75	G	0.07	0.11	PCI/G	4/12/95
6222-P	94.20471	TL-208	G	0.16	0.06	PCI/G	4/12/95
6222-P	94.20471	ZN-65	G	0.17	0.26	PCI/G	4/12/95
6211-P	94.20472	BA-140	G	9.94	14.91	PCI/G	4/12/95
6211-P	94.20472	BI-212	G	0.63	0.95	PCI/G	4/12/95
6211-P	94.20472	BI-214	G	0.42	0.14	PCI/G	4/12/95
6211-P	94.20472	CE-144	G	0.33	0.5	PCI/G	4/12/95
6211-P	94.20472	CO-57	G	0.01	0.03	PCI/G	4/12/95
6211-P	94.20472	CO-60	G	0.99	0.15	PCI/G	4/12/95
6211-P	94.20472	CS-134	G	0.05	0.08	PCI/G	4/12/95
6211-P	94.20472	CS-137	G	0.02	0.03	PCI/G	4/12/95
6211-P	94.20472	EU-152	G	1.97	0.52	PCI/G	4/12/95
6211-P	94.20472	K-40	G	43.45	5.14	PCI/G	4/12/95
6211-P	94.20472	LA-140	G	0.0		PCI/G	4/12/95
6211-P	94.20472	MN-54	G	0.04	0.06	PCI/G	4/12/95
6211-P	94.20472	NA-22	G	0.08	0.12	PCI/G	4/12/95
6211-P	94.20472	NP-237	G	0.33	0.5	PCI/G	4/12/95
6211-P	94.20472	PA-231	G	0.14	0.21	PCI/G	4/12/95
6211-P	94.20472	PA-233	G	0.08	0.12	PCI/G	4/12/95
6211-P	94.20472	PB-210	G	0.0	2.7	PCI/G	4/12/95
6211-P	94.20472	PB-212	G	0.33	0.09	PCI/G	4/12/95
6211-P	94.20472	PB-214	G	0.39	0.1	PCI/G	4/12/95
6211-P	94.20472	RA-223	G	4.61	6.92	PCI/G	4/12/95
6211-P	94.20472	RA-224	G	0.84	1.26	PCI/G	4/12/95
6211-P	94.20472	RA-226	G	0.22	0.33	PCI/G	4/12/95
6211-P	94.20472	RN-219	G	0.07	0.11	PCI/G	4/12/95
6211-P	94.20472	RU-106	G	0.34	0.51	PCI/G	4/12/95
6211-P	94.20472	SE-75	G	0.03	0.05	PCI/G	4/12/95
6211-P	94.20472	TL-208	G	0.26	0.07	PCI/G	4/12/95
6211-P	94.20472	ZN-65	G	0.14	0.21	PCI/G	4/12/95
6211-1C	94.20473	BA-140	G	0.0		PCI/G	4/12/95
6211-1C	94.20473	BI-212	G	0.58	0.87	PCI/G	4/12/95
6211-1C	94.20473	BI-214	G	0.41	0.13	PCI/G	4/12/95
6211-1C	94.20473	CE-144	G	0.24	0.36	PCI/G	4/12/95
6211-1C	94.20473	CO-57	G	0.05	0.02	PCI/G	4/12/95
6211-1C	94.20473	CO-60	G	0.94	0.17	PCI/G	4/12/95
6211-1C	94.20473	CS-134	G	0.04	0.06	PCI/G	4/12/95
6211-1C	94.20473	CS-137	G	0.04	0.06	PCI/G	4/12/95
6211-1C	94.20473	EU-152	G	2.24	0.55	PCI/G	4/12/95
6211-1C	94.20473	K-40	G	50.15	5.78	PCI/G	4/12/95
6211-1C	94.20473	LA-140	G	0.0		PCI/G	4/12/95
6211-1C	94.20473	MN-54	G	0.02	0.03	PCI/G	4/12/95
6211-1C	94.20473	NA-22	G	0.11	0.06	PCI/G	4/12/95
6211-1C	94.20473	NP-237	G	0.25	0.38	PCI/G	4/12/95
6211-1C	94.20473	PA-231	G	1.88	2.82	PCI/G	4/12/95
6211-1C	94.20473	PA-233	G	0.0		PCI/G	4/12/95
6211-1C	94.20473	PB-210	G	0.0	2.7	PCI/G	4/12/95
6211-1C	94.20473	PB-212	G	0.23	0.07	PCI/G	4/12/95
6211-1C	94.20473	PB-214	G	0.21	0.06	PCI/G	4/12/95
6211-1C	94.20473	RA-223	G	0.0		PCI/G	4/12/95
6211-1C	94.20473	RA-224	G	0.0	1.6	PCI/G	4/12/95
6211-1C	94.20473	RA-226	G	1.63	0.68	PCI/G	4/12/95

6211-1C	94.20473	RN-219	G	0.55	0.83	PCI/G	4/12/95
6211-1C	94.20473	RU-106	G	0.09	0.14	PCI/G	4/12/95
6211-1C	94.20473	SE-75	G	0.01	0.02	PCI/G	4/12/95
6211-1C	94.20473	TL-208	G	0.22	0.07	PCI/G	4/12/95
6211-1C	94.20473	ZN-65	G	0.61	0.17	PCI/G	4/12/95
6211-2C	94.20474	BA-140	G	9.79	14.69	PCI/G	4/12/95
6211-2C	94.20474	BI-212	G	0.59	0.89	PCI/G	4/12/95
6211-2C	94.20474	BI-214	G	0.72	0.16	PCI/G	4/12/95
6211-2C	94.20474	CE-144	G	0.4	0.6	PCI/G	4/12/95
6211-2C	94.20474	CO-57	G	0.1	0.03	PCI/G	4/12/95
6211-2C	94.20474	CO-60	G	1.01	0.15	PCI/G	4/12/95
6211-2C	94.20474	CS-134	G	0.07	0.03	PCI/G	4/12/95
6211-2C	94.20474	CS-137	G	0.04	0.06	PCI/G	4/12/95
6211-2C	94.20474	EU-152	G	2.36	0.56	PCI/G	4/12/95
6211-2C	94.20474	K-40	G	49.47	5.73	PCI/G	4/12/95
6211-2C	94.20474	LA-140	G	0.0		PCI/G	4/12/95
6211-2C	94.20474	MN-54	G	0.01	0.02	PCI/G	4/12/95
6211-2C	94.20474	NA-22	G	0.07	0.11	PCI/G	4/12/95
6211-2C	94.20474	NP-237	G	0.19	0.29	PCI/G	4/12/95
6211-2C	94.20474	PA-231	G	2.76	4.14	PCI/G	4/12/95
6211-2C	94.20474	PA-233	G	0.38	0.57	PCI/G	4/12/95
6211-2C	94.20474	PB-210	G	0.0	2.7	PCI/G	4/12/95
6211-2C	94.20474	PB-212	G	0.09	0.14	PCI/G	4/12/95
6211-2C	94.20474	PB-214	G	0.17	0.08	PCI/G	4/12/95
6211-2C	94.20474	RA-223	G	78.29	117.44	PCI/G	4/12/95
6211-2C	94.20474	RA-224	G	0.02	0.03	PCI/G	4/12/95
6211-2C	94.20474	RA-226	G	0.39	0.59	PCI/G	4/12/95
6211-2C	94.20474	RN-219	G	0.39	0.59	PCI/G	4/12/95
6211-2C	94.20474	RU-106	G	0.87	1.31	PCI/G	4/12/95
6211-2C	94.20474	SE-75	G	0.02	0.03	PCI/G	4/12/95
6211-2C	94.20474	TL-208	G	0.25	0.06	PCI/G	4/12/95
6211-2C	94.20474	ZN-65	G	0.07	0.11	PCI/G	4/12/95
6211-3C	94.20475	BA-140	G	25.8	38.7	PCI/G	4/12/95
6211-3C	94.20475	BI-212	G	0.75	1.13	PCI/G	4/12/95
6211-3C	94.20475	BI-214	G	0.58	0.15	PCI/G	4/12/95
6211-3C	94.20475	CE-144	G	0.28	0.42	PCI/G	4/12/95
6211-3C	94.20475	CO-57	G	0.1	0.03	PCI/G	4/12/95
6211-3C	94.20475	CO-60	G	1.12	0.16	PCI/G	4/12/95
6211-3C	94.20475	CS-134	G	0.04	0.06	PCI/G	4/12/95
6211-3C	94.20475	CS-137	G	0.04	0.06	PCI/G	4/12/95
6211-3C	94.20475	EU-152	G	2.66	0.63	PCI/G	4/12/95
6211-3C	94.20475	K-40	G	47.19	5.5	PCI/G	4/12/95
6211-3C	94.20475	LA-140	G	0.0		PCI/G	4/12/95
6211-3C	94.20475	MN-54	G	0.02	0.03	PCI/G	4/12/95
6211-3C	94.20475	NA-22	G	0.12	0.18	PCI/G	4/12/95
6211-3C	94.20475	NP-237	G	0.22	0.33	PCI/G	4/12/95
6211-3C	94.20475	PA-231	G	2.14	3.21	PCI/G	4/12/95
6211-3C	94.20475	PA-233	G	0.23	0.35	PCI/G	4/12/95
6211-3C	94.20475	PB-210	G	0.0	2.7	PCI/G	4/12/95
6211-3C	94.20475	PB-212	G	0.12	0.06	PCI/G	4/12/95
6211-3C	94.20475	PB-214	G	0.16	0.07	PCI/G	4/12/95
6211-3C	94.20475	RA-223	G	54.27	81.41	PCI/G	4/12/95
6211-3C	94.20475	RA-224	G	0.98	1.47	PCI/G	4/12/95
6211-3C	94.20475	RA-226	G	1.68	0.64	PCI/G	4/12/95
6211-3C	94.20475	RN-219	G	0.45	0.68	PCI/G	4/12/95
6211-3C	94.20475	RU-106	G	0.15	0.23	PCI/G	4/12/95
6211-3C	94.20475	SE-75	G	0.17	0.26	PCI/G	4/12/95
6211-3C	94.20475	TL-208	G	0.26	0.07	PCI/G	4/12/95
6211-3C	94.20475	ZN-65	G	0.82	1.23	PCI/G	4/12/95
6243-2C	94.20476	BA-140	G	87.81	131.72	PCI/G	4/12/95

6243-2C	94.20476	BI-212	G	0.41	0.62	PCI/G	4/12/95
6243-2C	94.20476	BI-214	G	0.52	0.14	PCI/G	4/12/95
6243-2C	94.20476	CE-144	G	0.11	0.17	PCI/G	4/12/95
6243-2C	94.20476	CO-57	G	0.08	0.03	PCI/G	4/12/95
6243-2C	94.20476	CO-60	G	2.42	0.28	PCI/G	4/12/95
6243-2C	94.20476	CS-134	G	0.13	0.05	PCI/G	4/12/95
6243-2C	94.20476	CS-137	G	0.02	0.03	PCI/G	4/12/95
6243-2C	94.20476	EU-152	G	2.72	0.65	PCI/G	4/12/95
6243-2C	94.20476	K-40	G	46.52	5.48	PCI/G	4/12/95
6243-2C	94.20476	LA-140	G	0.0		PCI/G	4/12/95
6243-2C	94.20476	MN-54	G	0.07	0.11	PCI/G	4/12/95
6243-2C	94.20476	NA-22	G	0.11	0.17	PCI/G	4/12/95
6243-2C	94.20476	NP-237	G	0.99	1.49	PCI/G	4/12/95
6243-2C	94.20476	PA-231	G	1.56	0.73	PCI/G	4/12/95
6243-2C	94.20476	PA-233	G	0.18	0.27	PCI/G	4/12/95
6243-2C	94.20476	PB-210	G	0.0	2.7	PCI/G	4/12/95
6243-2C	94.20476	PB-212	G	0.12	0.06	PCI/G	4/12/95
6243-2C	94.20476	PB-214	G	0.27	0.07	PCI/G	4/12/95
6243-2C	94.20476	RA-223	G	38.53	57.8	PCI/G	4/12/95
6243-2C	94.20476	RA-224	G	0.28	0.42	PCI/G	4/12/95
6243-2C	94.20476	RA-226	G	0.47	0.71	PCI/G	4/12/95
6243-2C	94.20476	RN-219	G	0.11	0.17	PCI/G	4/12/95
6243-2C	94.20476	RU-106	G	1.34	2.01	PCI/G	4/12/95
6243-2C	94.20476	SE-75	G	0.04	0.06	PCI/G	4/12/95
6243-2C	94.20476	TL-208	G	0.22	0.06	PCI/G	4/12/95
6243-2C	94.20476	ZN-65	G	1.34	2.01	PCI/G	4/12/95
6243-3C	94.20477	BA-140	G	4.73	7.1	PCI/G	4/12/95
6243-3C	94.20477	BI-212	G	0.52	0.78	PCI/G	4/12/95
6243-3C	94.20477	BI-214	G	0.39	0.18	PCI/G	4/12/95
6243-3C	94.20477	CE-144	G	0.08	0.12	PCI/G	4/12/95
6243-3C	94.20477	CO-57	G	0.01	0.02	PCI/G	4/12/95
6243-3C	94.20477	CO-60	G	0.42	0.09	PCI/G	4/12/95
6243-3C	94.20477	CS-134	G	0.1	0.04	PCI/G	4/12/95
6243-3C	94.20477	CS-137	G	0.06	0.09	PCI/G	4/12/95
6243-3C	94.20477	EU-152	G	0.1	0.15	PCI/G	4/12/95
6243-3C	94.20477	K-40	G	28.92	3.08	PCI/G	4/12/95
6243-3C	94.20477	LA-140	G	0.0		PCI/G	4/12/95
6243-3C	94.20477	MN-54	G	0.1	0.04	PCI/G	4/12/95
6243-3C	94.20477	NA-22	G	0.03	0.05	PCI/G	4/12/95
6243-3C	94.20477	NP-237	G	0.16	0.24	PCI/G	4/12/95
6243-3C	94.20477	PA-231	G	0.75	1.13	PCI/G	4/12/95
6243-3C	94.20477	PA-233	G	1.4	0.93	PCI/G	4/12/95
6243-3C	94.20477	PB-210	G	0.0	2.7	PCI/G	4/12/95
6243-3C	94.20477	PB-212	G	0.14	0.08	PCI/G	4/12/95
6243-3C	94.20477	PB-214	G	0.04	0.06	PCI/G	4/12/95
6243-3C	94.20477	RA-223	G	13.38	20.07	PCI/G	4/12/95
6243-3C	94.20477	RA-224	G	0.27	0.42	PCI/G	4/12/95
6243-3C	94.20477	RA-226	G	1.61	0.65	PCI/G	4/12/95
6243-3C	94.20477	RN-219	G	0.57	0.86	PCI/G	4/12/95
6243-3C	94.20477	RU-106	G	0.45	0.68	PCI/G	4/12/95
6243-3C	94.20477	SE-75	G	0.04	0.06	PCI/G	4/12/95
6243-3C	94.20477	TL-208	G	0.16	0.06	PCI/G	4/12/95
6243-3C	94.20477	ZN-65	G	0.06	0.09	PCI/G	4/12/95
6243-1C	94.20478	BA-140	G	40.6	29.67	PCI/G	4/12/95
6243-1C	94.20478	BI-212	G	0.99	0.66	PCI/G	4/12/95
6243-1C	94.20478	BI-214	G	0.3	0.14	PCI/G	4/12/95
6243-1C	94.20478	CE-144	G	0.07	0.11	PCI/G	4/12/95
6243-1C	94.20478	CO-57	G	0.01	0.02	PCI/G	4/12/95
6243-1C	94.20478	CO-60	G	0.43	0.12	PCI/G	4/12/95
6243-1C	94.20478	CS-134	G	0.01	0.02	PCI/G	4/12/95

6243-1C	94.20478	CS-137	G	0.12	0.05	PCI/G	4/12/95
6243-1C	94.20478	EU-152	G	0.17	0.26	PCI/G	4/12/95
6243-1C	94.20478	K-40	G	22.58	2.7	PCI/G	4/12/95
6243-1C	94.20478	LA-140	G	0.0		PCI/G	4/12/95
6243-1C	94.20478	MN-54	G	0.11	0.06	PCI/G	4/12/95
6243-1C	94.20478	NA-22	G	0.02	0.03	PCI/G	4/12/95
6243-1C	94.20478	NP-237	G	0.0	0.53	PCI/G	4/12/95
6243-1C	94.20478	PA-231	G	1.98	2.97	PCI/G	4/12/95
6243-1C	94.20478	PA-233	G	2.32	0.71	PCI/G	4/12/95
6243-1C	94.20478	PB-210	G	0.0	2.7	PCI/G	4/12/95
6243-1C	94.20478	PB-212	G	0.08	0.05	PCI/G	4/12/95
6243-1C	94.20478	PB-214	G	0.1	0.05	PCI/G	4/12/95
6243-1C	94.20478	RA-223	G	0.0		PCI/G	4/12/95
6243-1C	94.20478	RA-224	G	0.34	0.51	PCI/G	4/12/95
6243-1C	94.20478	RA-226	G	3.42	0.78	PCI/G	4/12/95
6243-1C	94.20478	RN-219	G	0.62	0.47	PCI/G	4/12/95
6243-1C	94.20478	RU-106	G	1.04	0.6	PCI/G	4/12/95
6243-1C	94.20478	SE-75	G	0.0	1.5	PCI/G	4/12/95
6243-1C	94.20478	TL-208	G	0.17	0.06	PCI/G	4/12/95
6243-1C	94.20478	ZN-65	G	0.1	0.15	PCI/G	4/12/95
6243-P	94.20479	BA-140	G	7.89	11.84	PCI/G	4/12/95
6243-P	94.20479	BI-212	G	1.18	1.77	PCI/G	4/12/95
6243-P	94.20479	BI-214	G	0.56	0.24	PCI/G	4/12/95
6243-P	94.20479	CE-144	G	0.35	0.53	PCI/G	4/12/95
6243-P	94.20479	CO-57	G	0.13	0.2	PCI/G	4/12/95
6243-P	94.20479	CO-60	G	1.28	0.28	PCI/G	4/12/95
6243-P	94.20479	CS-134	G	0.0	0.15	PCI/G	4/12/95
6243-P	94.20479	CS-137	G	0.02	0.03	PCI/G	4/12/95
6243-P	94.20479	EU-152	G	0.03	0.05	PCI/G	4/12/95
6243-P	94.20479	K-40	G	529.19	40.64	PCI/G	4/12/95
6243-P	94.20479	LA-140	G	0.0		PCI/G	4/12/95
6243-P	94.20479	MN-54	G	0.01	0.02	PCI/G	4/12/95
6243-P	94.20479	NA-22	G	0.08	0.12	PCI/G	4/12/95
6243-P	94.20479	NP-237	G	1.36	0.58	PCI/G	4/12/95
6243-P	94.20479	PA-231	G	6.84	3.04	PCI/G	4/12/95
6243-P	94.20479	PA-233	G	0.24	0.36	PCI/G	4/12/95
6243-P	94.20479	PB-210	G	0.0	2.7	PCI/G	4/12/95
6243-P	94.20479	PB-212	G	0.01	0.02	PCI/G	4/12/95
6243-P	94.20479	PB-214	G	0.22	0.33	PCI/G	4/12/95
6243-P	94.20479	RA-223	G	3.17	4.76	PCI/G	4/12/95
6243-P	94.20479	RA-224	G	0.35	0.53	PCI/G	4/12/95
6243-P	94.20479	RA-226	G	3.63	1.58	PCI/G	4/12/95
6243-P	94.20479	RN-219	G	0.84	1.26	PCI/G	4/12/95
6243-P	94.20479	RU-106	G	0.77	1.16	PCI/G	4/12/95
6243-P	94.20479	SE-75	G	0.0	1.5	PCI/G	4/12/95
6243-P	94.20479	TL-208	G	0.33	0.11	PCI/G	4/12/95
6243-P	94.20479	ZN-65	G	0.29	0.435	PCI/G	4/12/95

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