CONTAMINANT MONITORING OF BIOTA DOWNSTREAM OF A RADIOACTIVE LIQUID WASTE TREATMENT FACILITY, LOS ALAMOS NATIONAL LABORATORY

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ABSTRACT Small mammals, plants, and sediments were sampled at one upstream location (Site 1) and two downstream locations (Site 2 and Site 3) from the National Pollution Discharge Elimination System (NPDES) outfall #051-051 in Mortandad Canyon, Los Alamos National Laboratory, Los Alamos, New Mexico. The purpose of the sampling was to identify radionuclides potentially present, to quantitatively estimate and compare the amount of radionuclide uptake at specific locations (Site 2 and Site 3) within Mortandad Canyon to an upstream site (Site 1), and to identify the primary mode (inhalation/ingestion or surface contact) of contamination to small mammals. Three composite samples of at least five animals per sample were collected at each site. The pelt was separated from the carcass of each animal and both were analyzed independently. In addition, three composite samples were also collected for plants and sediments at each site. Samples were analyzed for americium (^{241}Am), strontium (^{90}Sr), plutonium (^{238}Pu and ^{239}Pu), and total uranium (U). With the exception of total U, all mean radionuclide concentrations in small mammal carcasses and sediments were significantly higher at Site 2 than Site 1 or Site 3. No differences were detected in the mean radionuclide concentration of plant samples between sites. However, some radionuclide concentrations found at all three sites were higher than regional background. No differences were found between mean carcass radionuclide concentrations and mean pelt radionuclide concentrations, indicating that the two primary modes of contamination may be equally occurring.

KEYWORDS: radionuclides, contamination, vegetation, rodents, waste sites

INTRODUCTION

Mortandad Canyon has been used for disposal of liquid waste since 1963 [1] and, as part of the Environmental Surveillance Program at Los Alamos National Laboratory (LANL), water and sediment samples have been routinely taken from this canyon. These data are published annually in LANL's *Environmental Surveillance Report* [2]. Although chemical analyses of sediment samples and water can tell us the concentration of a chemical substance present, they are not sufficient to assess or describe the availability and toxicity of contaminants to biota. These analytical parameters do not take into account factors that determine the bioavailability and the physiology and biochemistry of an organism. Resident wildlife populations at contaminated sites can be used to monitor effects on the populations and subsequently the ecosystem [3-6]. Small mammals have been frequently used to monitor the presence of contaminants and have been found to be effective biomonitors. They have a relatively short life span (generally less than one year) and a small home range. In addition, they are usually easy to capture and, depending on the habitat, abundant [6].

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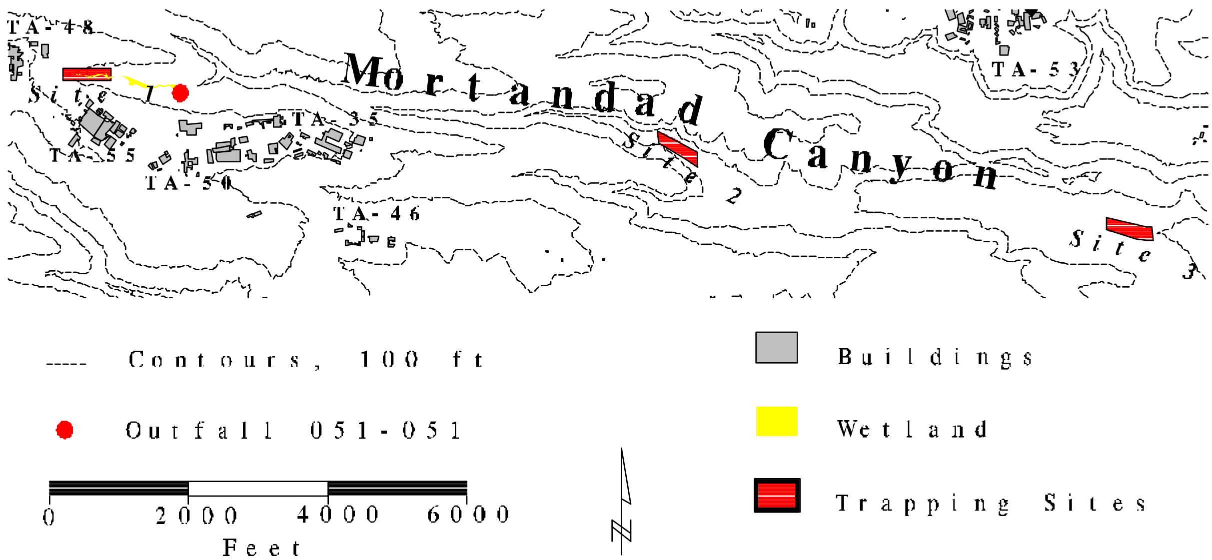

FIGURE 1. SITE LOCATIONS WITHIN MORTANDAD CANYON.

This study describes the collection of small mammals, plants, and sediments within Mortandad Canyon at LANL, and was used to 1) identify radionuclides potentially present in small mammals, plants, and sediments, 2) quantitatively estimate and compare the amount of radionuclide uptake at specific locations (Site 3 and Site 2) within the Mortandad Canyon to an upstream site (Site 1) by sampling carcasses and pelts of small mammals, and overstory and understory vegetation, 3) determine the primary mode of contamination for small mammals, either by surface contact or through ingestion or inhalation, 4) determine if correlations exist between contaminant concentrations in sediments, plant materials, and small mammals, and 5) estimate small mammal densities at each site and control site for estimating potential contaminant loads within the small mammal community. Data collected at the two downstream sites within Mortandad Canyon were compared to an upstream site within upper Mortandad Canyon.

PROCEDURES

Site selection

Three sites were selected for sampling and trapping within Mortandad Canyon (Figure 1). Two sites (Sites 2 and 3) were selected below National Pollution Discharge Elimination System (NPDES) outfall #051-051. One site (Site 1) was selected above the outfall and served as the upstream sample site.

Site 1 was located 0.483 km (0.26 miles) upstream from the NPDES outfall in a wetland area dominated by cattails. Site 2 was located 2.1 km (1.3 miles) from the NPDES outfall in a riparian/mixed conifer area that receives ephemeral flowing water. Site 3 was located below the sediment trap in Mortandad Canyon, 4.0 km (2.5 miles) from the NPDES outfall. The site was located in a typically dry canyon with a shrub/grassland habitat.

Small mammal collection

A grid design consisting of 100 snap traps placed approximately 10 m apart in a 5-traps-wide by 20-traps-long design was used to collect animals at each of the three sites. The grid was centered over the stream (drainage channel). Snap trapping took place over three to five nights (or 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*. [7] and Biggs and Bennett [8]. The same safety procedures were followed for collecting tissue samples from snap-trapped animals. 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 composite samples were collected at each site with each sample consisting of a minimum of five animals.

The pelt was separated from the carcass of each animal. Pelts and carcasses were analyzed separately for cesium (^{137}Cs), ^{90}Sr, ^{238}Pu, ^{239}Pu, and total U. The samples were then placed into one liter glass beakers. The beaker contents were covered with tin foil and ashed at 500ºC 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 Uranium, and ^{137}Cs. Tritium analysis was not run on the small mammal samples. All methods of radiochemical analyses have been described previously [9]. Results are reported on a per ash weight basis (g ash). In some cases, there were insufficient amounts of pelts to analyze 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. Separate analysis of pelt and carcass allowed for a more accurate determination of radionuclide concentration (ingestion, inhalation, or external body surface).

Plants

Plants were collected at all three sites within the small mammal grid. Three samples of understory (grasses and forbs) and overstory (shrubs and trees) vegetation were taken for each site and placed in one gallon zip lock bags. Understory vegetation was clipped at the ground surface around each trap and placed into a one gallon zip lock bag. All collected understory species were identified.

Overstory shrub species were collected in a similar fashion. Branches of overstory shrub species adjacent to small mammal traps were cut and placed into a one gallon zip lock bag to form a sample. Three samples were collected from each site. All collected overstory species were identified.

The overstory and understory plant samples were removed from the one gallon zip lock bags, placed into one liter glass beakers and distilled for ^{3}H analysis. 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 analyses of ^{241}Am, ^{90}Sr, ^{238}Pu, ^{239}Pu, total U, and ^{137}Cs. All methods of radiochemical analyses have been described previously [9]. Results are reported on a per ash weight basis (g ash).

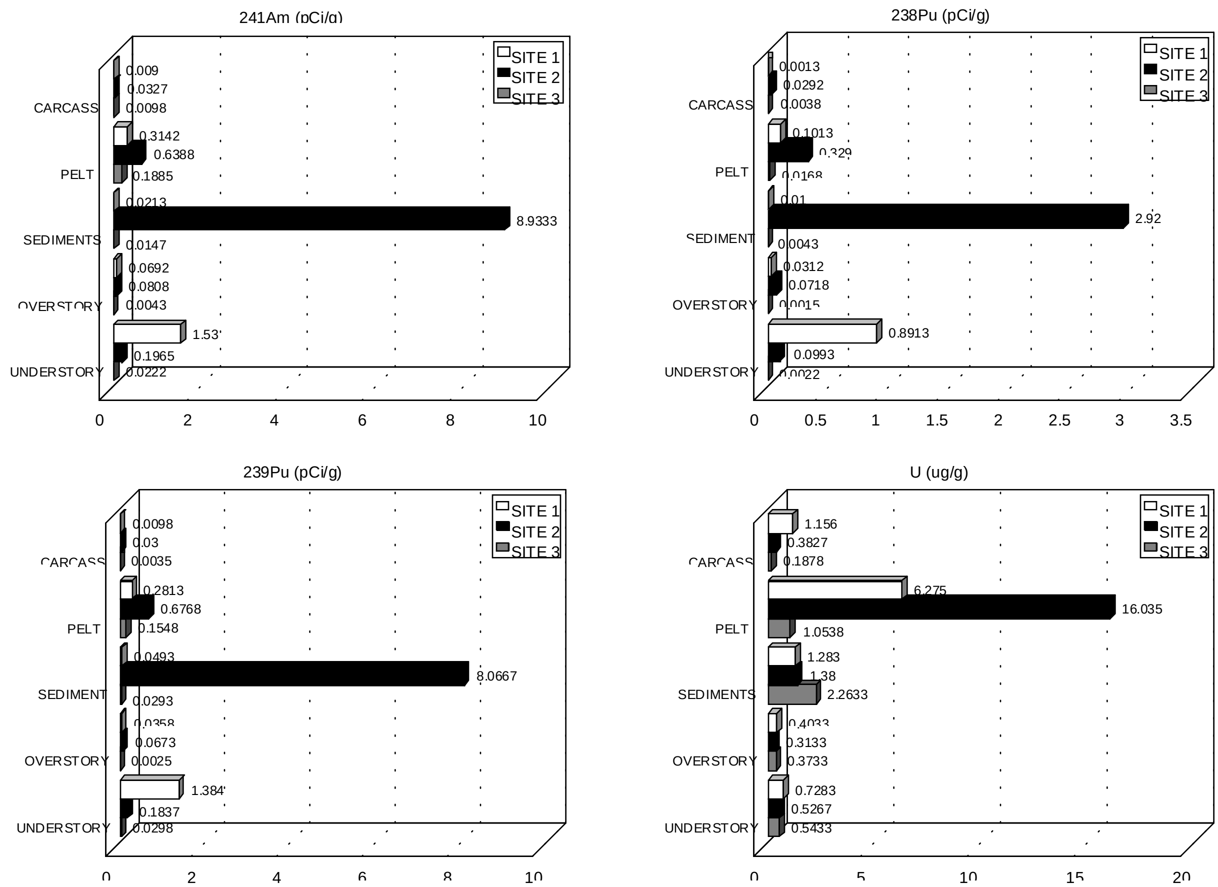

Figure 2. (continued on next page) Mean concentrations of radionuclides in plants, rodents, and sediments of Mortandad Canyon, 1994 (to convert pCi/g to Bq/kg, multiply by 37).

Sediments

At each of the three locations, five subsamples were collected of sediments. Samples were collected across the stream bed channel at the 0- to 5-cm (0- to 2-in.) depth with stainless steel scoops. Each subsample was composited in a zip lock bag, mixed thoroughly, and poured into labeled 500-ml polybottles. Sample bottles containing sediment samples were placed into individual zip lock bags and transferred to the Laboratory in locked ice chests under full chain-of-custody protocols. Samples were submitted to CST-9 on the same day. All methods of radiochemical analyses have been described previously [9]. Results are reported on a per gram of dry weight basis (g dry).

Statistical analysis and density estimates

The Statistical Analysis System (SAS) was used to analyze all data sets [10]. A univariate test was used to determine if sample (pelt, carcass, understory, overstory, and sediments) 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 carcass and pelt and overstory and understory. An Analysis of Variance (AOV)

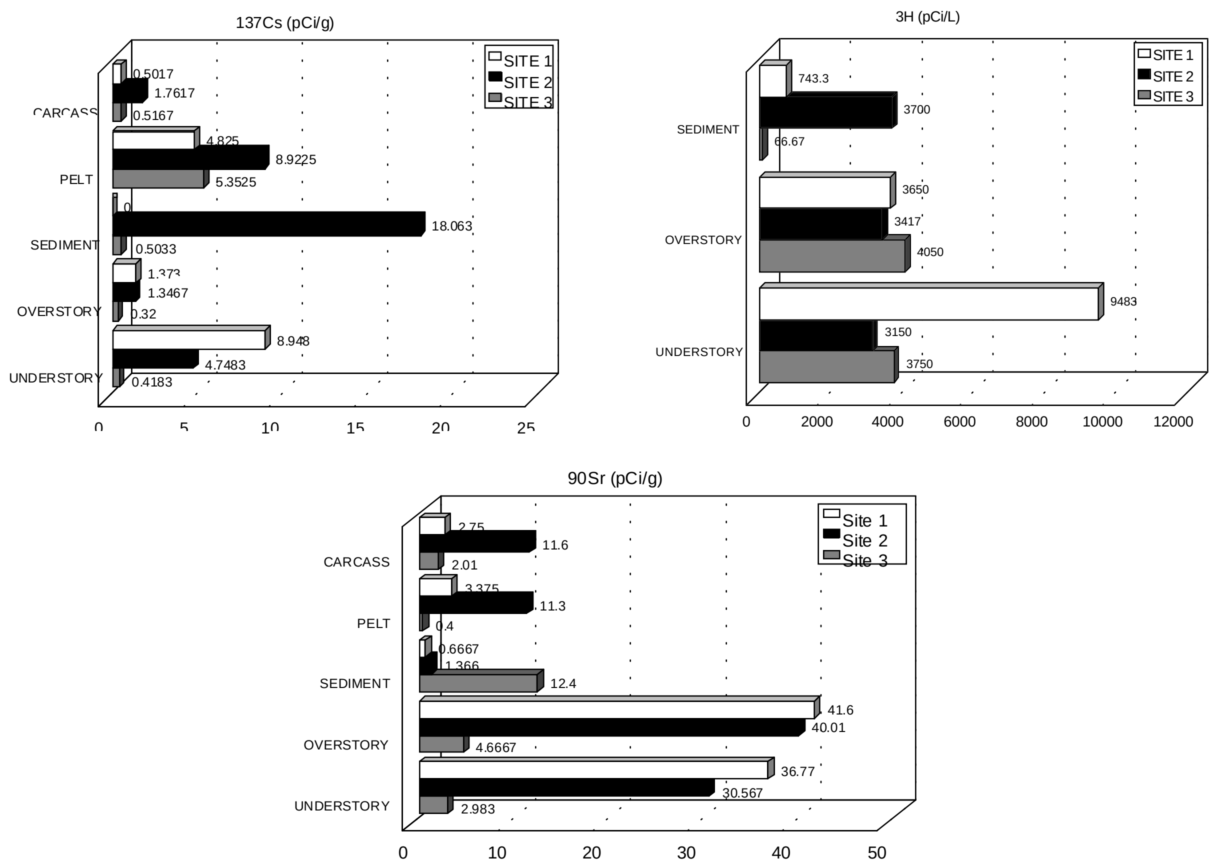

FIGURE 2. (CONTINUED FROM PREVIOUS PAGE)

was used to determine if any significant differences in the amount of radionuclide in samples (pelt, carcass, understory, overstory, and sediment) existed between sites, and Duncan's multiple range test (MRT) was used to identify where the significant differences (alpha = 0.05) occurred between sites. In addition, the SAS procedure, CORR, was used to compute correlation coefficients (R) between radionuclide concentrations of each sample type (sediment, vegetation, and small mammals). Statistical correlations were determined at the 0.05 level.

Small mammal densities were estimated using Leslie's regression method [11] applied to each site where daily total number of captures were plotted against the cumulative daily captures. Confidence intervals were calculated at 90% using the general method [11].

RESULTS

Contaminant analysis

Results of data analyses presented are for the radionuclides ^{241}Am, ^{238}Pu, ^{239}Pu, ^{90}Sr, ^{137}Cs, total U, and tritium (^{3}H). Tritium analysis was performed for plants (overstory and understory) and sediments only. Small mammals were not analyzed for tritium because of concerns of blood-borne pathogens. The mean concentrations of radionuclides found in sediments, plants (overstory and understory), and small mammal (carcass and pelt) tissues by site (1, 2, and 3) are found in Figure 2.

Small mammal samples

A t-test was performed on the mean concentrations of radionuclides (^{241}Am, ^{238}Pu, ^{239}Pu, ^{90}Sr, ^{137}Cs, and total U) of small mammal pelts (n = 4) and carcasses (n = 6) by sites. Tables 1 and 2 list the mean, standard error, and sample size for radionuclide concentrations found in carcass and pelt, respectively. There was no statistical difference in the mean concentrations of radionuclides in pelt and carcass at any of the sites with the exception of ^{239}Pu at Site 3. The mean concentration of ^{239}Pu in small mammal pelt samples at Site 3 was significantly different from the concentration of ^{239}Pu found in carcass tissue at Site 3 (t-test, T = -6.4197**,** p = 0.0076). The mean concentration of ^{239}Pu in pelts at Site 3 was 5.735 Bq/kg ash (0.155 pCi/g ash) and the mean concentration in carcasses was 0.148 Bq/kg ash (0.004 pCi/g ash).

AOVs and Duncan's MRT (MRT was only run when a significant difference was detected) were performed on mean radionuclide concentrations found in carcass and pelt samples of small mammals at the three sites. All radionuclide (^{241}Am, ^{238}Pu, ^{239}Pu, ^{90}Sr, ^{137}Cs, and total U) concentrations in pelts were not statistically different between Sites 1, 2, and 3 (alpha = 0.05). The F statistics and probabilities generated from the AOV are listed in Table 3. Differences were detected for some radionuclide concentrations in small mammal carcasses between sites.

Mean concentrations (^{241}Am, ^{238}Pu, ^{239}Pu, ^{90}Sr, and ^{137}Cs) in small mammal carcasses were found to be significantly higher at Site 2. Radionuclide concentrations in carcasses were not found to be significantly different between Sites 1 and 3. Mean concentration of total U in the small mammal carcass sample was not found to be significantly different between the three sites. The F statistic and probability generated by the AOV are listed in Table 4. Table 5 lists the

TABLE 1. RADIONUCLIDE CONCENTRATIONS OF RODENT CARCASSES OF MORTANDAD CANYON, 1994.

	SITE 3 (2.5 miles downstream from NPDES outfall 051-051)			SITE 2 (1.3 miles downstream from NPDES outfall 051-051)			SITE 1 (0.26 miles upstream from NPDES outfall 051-051)		
RADIONUCLIDE	N	MEAN	SE	N	MEAN	SE	N	MEAN	SE
^{3}H[a]	*			*			*		
^{241}Am (pCi/g ash) [b]	6	0.0098	0.0050	6	0.0327	0.1019	6	0.0090	0.0029
^{238}Pu (pCi/g ash)	6	0.0038	0.0024	6	0.0292	0.0065	6	0.0013	0.0008
^{239}Pu (pCi/g ash)	6	0.0035	0.0012	6	0.0300	0.0079	6	0.0098	0.0032
^{137}Cs (pCi/g ash)	6	0.5167	0.1886	6	1.7617	0.5188	6	0.5017	0.1487
^{90}Sr (pCi/g ash)	6	2.9830	0.2688	6	11.650	2.0776	6	2.7500	0.5482
Total U (µg/g ash)	6	0.1878	0.0248	6	0.3827	0.8973	6	1.1560	0.8571

[a]Tritium analysis was not conducted on rodent tissues due to potential infection of rodent blood-borne virus from handling procedures.

[b]To convert pCi/g to Bq/kg, multiply by 37.

results from the Duncan's MRT.

Plant samples

T-tests were performed to determine if the mean radionuclide (^{241}Am, ^{238}Pu, ^{239}Pu, ^{90}Sr, ^{137}Cs, ^{3}H, and total U) concentrations in plant understory (n = 6) and overstory (n = 6) were statistically different from each other at each of the sampling sites. Table 6 and Table 7 list the mean, standard error, and sample size for radionuclide concentrations found in understory and overstory plant samples, respectively. There was no statistical difference in the mean concentrations of radionuclides in overstory and understory at any sites with the exception of ^{90}Sr at Site 3. The mean concentration of ^{90}Sr in plant overstory samples at Site 3 was significantly different than the concentration of ^{90}Sr found in understory samples at Site 3 (t-test, T = 2.6096**,** $p = 0.046$). The mean concentration of ^{90}Sr in plant overstory samples at Site 3 was 461.76 Bq/kg ash (12.48 pCi/g ash) and the mean concentration in plant understory samples was172.79 Bq/kg ash (4.67 pCi/g ash).

Table 6 and Table 7 also list the regional background level for understory and overstory for each analyzed radionuclide. For understory samples, all mean radionuclide concentrations from all three sites were generally higher than the regional background level with the exception of ^{238}Pu at Site 3 which was lower than the regional background. Mean radionuclide concentrations found in overstory samples were also generally higher than the regional background levels. However, ^{238}Pu and total U were lower than background at Site 3, and total U was also lower than background at Site 2.

AOVs were performed on the mean concentration of radionuclides found in overstory and understory plant species to determine if concentrations were statistically different between the sampling sites and where the difference occurred. At the probability level of 0.05, no statistical differences were detected in the mean

TABLE 2. RADIONUCLIDE CONCENTRATIONS OF RODENT PELTS OF MORTANDAD CANYON, 1994.

	SITE 3 (2.5 miles downstream from NPDES outfall 051-051)			SITE 2 (1.3 miles downstream from NPDES outfall 051-051)			SITE 1 (0.26 miles upstream from NPDES outfall 051-051)		
RADIONUCLIDE	N	MEAN	SE	N	MEAN	SE	N	MEAN	SE
^{3}H[a]	*			*			*		
^{241}Am (pCi/g ash)[b]	4	0.1885	0.0576	4	0.6388	0.3636	4	0.3142	0.1928
^{238}Pu (pCi/g ash)	4	0.1675	0.3430	4	0.3290	0.1650	4	0.1013	0.0665
^{239}Pu (pCi/g ash)	4	0.1548	0.2352	4	0.6768	0.3523	4	0.2813	0.1352
^{137}Cs (pCi/g ash)	4	5.3525	3.8694	4	8.9225	10.132	4	4.8250	5.0060
^{90}Sr (pCi/g ash)	4	2.0150	0.9500	4	11.350	5.9504	4	3.3750	1.3720
Total U (µg/g ash)	4	1.0538	0.1684	4	16.035	13.492	4	6.2750	5.4770

[a]Tritium analysis was not conducted on rodent tissues due to potential infection of rodent blood-borne virus from handling procedures.

[b]To convert pCi/g to Bq/kg, multiply by 37.

radionuclide concentrations of understory and overstory plants between sites (MRT was not performed because no significance was detected). Table 8 lists the F statistic, radionuclide, and the probability generated from the AOV for the plant samples.

Sediment samples

AOVs and Duncan's MRTs were performed to test if the mean concentration (Table 9) of radionuclides (^{241}Am, ^{238}Pu, ^{239}Pu, ^{90}Sr, ^{137}Cs, ^{3}H, and total U) in sediment samples were statistically different between the three sites. Mean concentrations of ^{241}Am, ^{238}Pu, ^{239}Pu, ^{90}Sr, ^{137}Cs, and ^{3}H in sediment samples were statistically higher at Site 2. However, concentrations of total U found in sediment samples were statistically higher at Site 3 compared to Site 1 and Site 2. Table 10 lists the F statistic and probability generated from the AOV, and Table 11 lists the results from the Duncan's MRTs.

Table 9 also lists the regional background level for sediments for each radionuclide analyzed. At all three sites, mean radionuclide concentrations found in sediment samples were generally higher than the regional background levels. However, ^{238}Pu and ^{241}Am were lower than background at Site 3, and ^{241}Am was also lower than background at Site 1.

Correlations between plants, small mammals, and soil samples

Because of small sample size and large variances of the samples, correlation analysis was not performed. However, after the 1995 samples are collected and analyzed, correlation analysis will be performed on the entire data set (samples from 1994 and 1995) and will be reported in the 1995 report.

TABLE 3. RESULTS OF THE AOV FOR PELT SAMPLES.

Radionuclide	F value	Probability
^{241}Am	0.94	0.4267
^{238}Pu	2.38	0.1475
^{239}Pu	1.56	0.2628
^{137}Cs	0.10	0.9019
^{90}Sr	2.00	0.1914
Total U	0.82	0.4716

TABLE 4. RESULTS OF THE AOV FOR SMALL MAMMAL CARCASS SAMPLES.

Radionuclide	F value	Probability
^{241}Am	3.95	0.0418
^{238}Pu	14.63	0.0003
^{239}Pu	7.78	0.0048
^{137}Cs	4.80	0.0245
^{90}Sr	16.46	0.0002
Total U	1.04	0.3760

TABLE 5. RESULTS OF THE DUNCAN'S MRT FOR SMALL MAMMAL CARCASS SAMPLES.

Radio-nuclide	Duncan Grouping[a]	Mean (pCi/g ash)[b]	N	Site
^{241}Am	A	0.03267	6	2
	B	0.00983	6	3
	B	0.00900	6	1
^{238}Pu	A	0.02917	6	2
	B	0.00383	6	3
	B	0.00133	6	1
^{239}Pu	A	0.03000	6	2
	B	0.00983	6	1
	B	0.00350	6	3
^{137}Cs	A	1.762	6	2
	B	0.517	6	3
	B	0.502	6	1
^{90}Sr	A	11.650	6	2
	B	2.983	6	3
	B	2.750	6	1

[a]Means with the same Duncan Grouping letters are not significantly different.

[b]To convert pCi/g to Bq/kg, multiply by 37.

Species composition, density estimates, and biomass of small mammals

Determining population characteristics of small mammals will aid in identifying potential contaminant loads and transport routes of radionuclides through the ecosystem. These population characteristics include home range estimates, rodent biomass, and food habits of contaminated organisms. Based on data collected from this study, densities and biomass of rodents can be estimated. Home range estimates are based on studies conducted in similar habitats on similar species.

Rodent densities were estimated using Leslie's regression method [11] applied to each site where daily total number of captures was plotted against the cumulative daily captures. Confidence intervals were calculated at 90% using the general method [11]. Table 12 lists all small mammal species captured during trapping sessions in Mortandad Canyon during 1994, including incidental captures of diurnal species. Table 13 lists each species by the location they were captured in, either Site 1 (upstream Mortandad Canyon), Site 2 (middle Mortandad Canyon), or Site 3 (lower Mortandad Canyon). Deer mice and brush mice were captured in all trapping locations. Shrews were only captured in the upper location of the canyon where surface water is most prevalent, and voles were captured in the middle and upper sites indicating more moist conditions compared to the lower site. Although pocket gophers were only caught in the lower site, mounds and burrows typical of pocket gophers were observed at Site 2.

TABLE 6. RADIONUCLIDE CONCENTRATIONS OF UNDERSTORY PLANT SPECIES OF MORTANDAD CANYON, 1994.

	SITE 3 (2.5 miles downstream from NPDES outfall 051-051)			SITE 2 (1.3 miles downstream from NPDES outfall 051-051)			SITE 1 (0.26 miles upstream from NPDES outfall 051-051)			REGIONAL BACK-GROUND
RADIONUCLIDE	N	MEAN	SE	N	MEAN	SE	N	MEAN	SE	USRSRL[b]
^{3}H (pCi/l)[a]	6	3,750	1,160	6	3,150	1,381	6	9,483	6,089	1,900
^{241}Am (pCi/g ash)[c]	6	0.0222	0.0177	6	0.1965	0.1620	6	1.5300	1.2720	0.004
^{238}Pu (pCi/g ash)	6	0.0022	0.0009	6	0.0993	0.0801	6	0.8913	0.6352	0.004
^{239}Pu (pCi/g ash)	6	0.0298	0.0203	6	0.1837	0.1576	6	1.3840	1.0459	0.003
^{137}Cs (pCi/g ash)	6	0.4183	0.1106	6	4.7483	4.2852	6	8.9480	4.7910	0.27
^{90}Sr (pCi/g ash)	6	4.6667	0.4462	6	30.567	12.629	6	36.770	14.420	2.2
Total U (μg/g ash)	6	0.5433	0.3913	6	0.5267	0.1414	6	0.7283	0.2259	0.44

[a]liter of tissue moisture.

[b]USRSRL = Understory regional statistical reference level (i.e., the upper-limit background concentration based on the mean + two counting uncertainties) from Fresquez, *et al.* [3].

[c]To convert pCi/g to Bq/kg, multiply by 37.

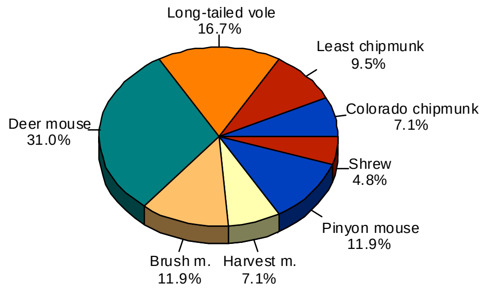

FIGURE 3. RELATIVE SPECIES COMPOSITION FOR SITE 1, MORTANDAD CANYON, 1994.

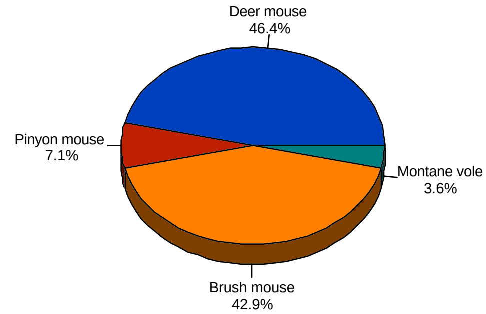

FIGURE 4. RELATIVE SPECIES COMPOSITION FOR SITE 2, MORTANDAD CANYON, 1994.

Figures 3, 4, and 5 show relative species composition, by site, for Mortandad Canyon for both trapping sessions combined. Figure 6 shows the percent daily capture rates based on the total number of animals captured divided by the total number of trap nights (one trap set for one night = one trap night).

Density estimates

During the first trapping session, the density of the trapping area for each site was based on a 50 m × 200 m grid with an additional 5 m boundary strip to help account for animals being drawn into the site due to the bait. During the second session, 50 m × 200 m grids were used for Sites 3 and 2. Therefore, the total effective trapping area is approximately 1.21 ha. Due to a low capture rate on the first night of trapping on Site 1, a 50 m × 400 m site was used for the remainder of the trapping session and,

TABLE 7. RADIONUCLIDE CONCENTRATIONS OF OVERSTORY PLANT SPECIES OF MORTANDAD CANYON, 1994.

	SITE 3 (2.5 miles downstream from NPDES outfall 051-051)			SITE 2 (1.3 miles downstream from NPDES outfall 051-051)			SITE 1 (0.26 miles upstream from NPDES outfall 051-051)			REGIONAL BACK-GROUND
RADIONUCLIDE	N	MEAN	SE	N	MEAN	SE	N	MEAN	SE	OSRSRL[b]
^{3}H (pCi/l)[a]	6	4050	1722	6	3417	1540	6	3650	1463	1800
241Am (pCi/g ash)	6	0.0043	0.0008	6	0.0808	0.0390	6	0.0692	0.0450	0.004
238Pu (pCi/g ash)	6	0.0015	0.0006	6	0.0718	0.0624	6	0.0312	0.0149	0.002
239Pu (pCi/g ash)	6	0.0025	0.0008	6	0.0673	0.5173	6	0.0358	0.0188	0.002
137Cs (pCi/g ash)	6	0.3200	0.0937	6	1.3467	0.9251	6	1.3730	0.5136	0.200
90Sr (pCi/g ash)	6	12.480	2.962	6	40.017	26.411	6	41.670	15.540	2.4
U (µg/g ash)	6	0.3733	0.1009	6	0.3133	0.0905	6	0.4033	0.0781	0.39

[a]liter of tissue moisture.

[b]OSRSRL = Overstory regional statistical reference level (i.e., the upper-limit background concentration based on the mean + two counting uncertainties) from Fresquez, *et al.* [3].

[c]To convert pCi/g to Bq/kg, multiply by 37.

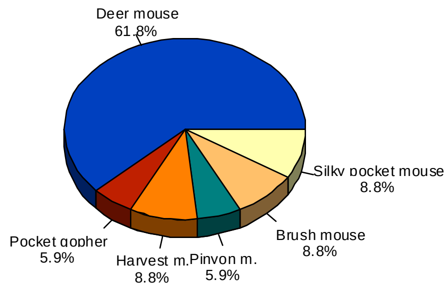

FIGURE 5. RELATIVE SPECIES COMPOSITION FOR SITE 3, MORTANDAD CANYON, 1994.

therefore, increased the effective trapping area to 2.46 ha. Table 14 gives the estimated density (#animals/ha) of each site sampled (both trapping sessions combined) after adjustment for the total effective trapping area for each of the sites.

Biomass estimates

Average weights for each species and all nocturnal species combined were calculated to obtain information on rodent biomass for

TABLE 8. RESULTS OF THE AOV FOR UNDERSTORY AND OVERSTORY PLANT SAMPLES.

Sample	Radio-nuclide	F value	Probability
Understory	^{241}Am	1.24	0.3168
	^{238}Pu	1.74	0.2089
	^{239}Pu	1.47	0.2606
	^{137}Cs	1.32	0.2963
	^{90}Sr	2.37	0.1278
	^{3}H	0.91	0.4239
	Total U	0.52	0.6055
Overstory	^{241}Am	1.44	0.2679
	^{238}Pu	0.91	0.4245
	^{239}Pu	1.04	0.3773
	^{137}Cs	0.96	0.4056
	^{90}Sr	0.85	0.4468
	^{3}H	0.04	0.9598
	Total U	0.26	0.7764

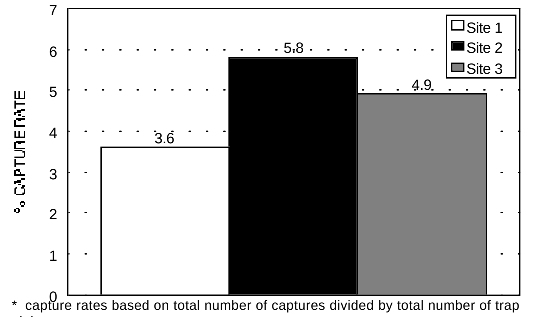

FIGURE 6. OVERALL CAPTURE RATES BY SITE FOR MORTANDAD CANYON, 1994. CAPTURE RATES ARE BASED ON TOTAL NUMBER OF CAPTURES DIVIDED BY TOTAL NUMBER OF TRAP NIGHTS.

each of the trapping sites (Figure 7). Sites 3 and 2 were very similar with an average weight of about 18.4 g, with Site 1 being higher at 22.8 g. Furthermore, Table 15 combines density estimates and average weight estimates for each site followed by a biomass calculation. Based on these biomass calculations, total estimated radionuclide loads can be determined for each site sampled (Table 16).

Home range estimates

Home range estimates for rodents are provided in Table 16. These estimates are based on data collected at other locations at the Laboratory but within similar habitats to what is found in Mortandad Canyon and, more specifically, in habitats similar to those where the sites were placed. These estimates are based primarily on species of the genus *Peromyscus* (deer mice, pinyon mice, brush mice). Estimates are provided according to general habitat types that are similar in vegetative composition to Mortandad Canyon (given in parenthesis under habitat type in Table 16).

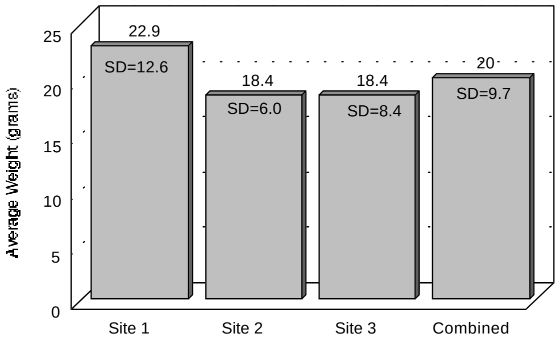

FIGURE 7. AVERAGE WEIGHTS OF NOCTURNAL SPECIES ANALYZED FOR RADIONUCLIDE CONCENTRATIONS, MORTANDAD CANYON, 1994.

DISCUSSION

This study was intended to 1) identify radionuclides potentially present in small mammals, plants, and sediments, 2) quantitatively estimate and compare the amount of radionuclide uptake at specific sites within the Mortandad Canyon by sampling carcasses and pelts of small mammals, sediments, and overstory and understory vegetation, 3) determine the primary mode of contamination for small mammals, either by surface contact or through ingestion and/or inhalation, and 4) estimate small mammal densities at each site for estimating potential contaminant loads within the small mammal community.

Generally, for all sediment and vegetation samples gathered at the three sites within Mortandad Canyon, mean radionuclide concentrations were elevated over regional background levels. Regional background levels were not available for small mammals, therefore a comparison to background was not possible.

However, small mammal radionuclide concentrations appear to be higher within Mortandad Canyon than at a waste burial site within Laboratory boundaries sampled during the same time frame [5]. For example, mean ^{90}Sr concentrations found in rodent carcass tissue from three sites within Technical Area (TA) 54 ranged from 44.4 Bq/kg ash (1.2 pCi/g ash) to 96.2 Bq/kg ash (2.6 pCi/g of ash), whereas mean concentrations of ^{90}Sr found in rodent

TABLE 9. RADIONUCLIDE CONCENTRATIONS IN SEDIMENTS OF MORTANDAD CANYON, 1994.

	SITE 3 (2.5 miles downstream from NPDES outfall 051-051)			SITE 2 (1.3 miles downstream from NPDES outfall 051-051)			SITE 1 (0.26 miles upstream from NPDES outfall 051-051)			REGIONAL BACK-GROUND
RADIONUCLIDE	N	MEAN	SE	N	MEAN	SE	N	MEAN	SE	RSRL[a]
^{3}H (pCi/l)	3	66.67	33.33	3	3,700	493.3	3	743.30	127.30	7.2
^{241}Am (pCi/g)[b]	3	0.0147	0.0058	3	8.9333	1.2441	3	0.0213	0.0047	0.023
^{238}Pu (pCi/g)	3	0.0043	0.0018	3	2.9200	0.3870	3	0.0100	0.0021	0.006
^{239}Pu (pCi/g)	3	0.0293	0.1090	3	8.0667	1.0105	3	0.0493	0.0355	0.023
^{137}Cs (pCi/g)	3	0.5033	0.1081	3	18.063	1.0280	3	-0.00	0.0208	0.44
^{90}Sr (pCi/g)	3	0.4000	0.1528	3	1.3667	0.1202	3	0.6667	0.2028	0.87
Total U (μg/g)	3	2.2633	0.1568	3	1.3800	0.1801	3	1.2830	0.0895	4.4

[a]Regional Statistical Reference Level; this is the upper-limit background concentration (mean + two std dev) from Purtymun, *et al.* [12].

[b]To convert pCi/g to Bq/kg, multiply by 37.

carcass tissue within Mortandad Canyon ranged from 101.75 Bq/kg ash (2.75 pCi/g ash) to 431.05 Bq/kg ash (11.65 pCi/g ash).

In 1995, a control site was selected near the southeastern part of the Laboratory and small mammal samples were taken. These samples are currently being analyzed for radionuclides. When the results are available, they will be compared to concentrations found in small mammal samples during 1994 and those taken in 1995.

There is evidence from the sediment and vegetation samples that another source, besides NPDES outfall 051-051, may be contributing to the elevated levels of radionuclides found within the sediments, plants, and small mammals sampled in Mortandad Canyon. One possible source of

TABLE 10. RESULTS OF THE AOV FOR SOIL SAMPLES.

Radionuclide	F value	Probability
^{241}Am	51.35	0.0002
^{238}Pu	56.66	0.0001
^{239}Pu	63.02	0.0001
^{137}Cs	296.96	0.0001
^{90}Sr	9.48	0.0139
^{3}H	42.97	0.003
Total U	13.46	0.061

TABLE 11. RESULTS OF THE DUNCAN'S MRT FOR SEDIMENT SAMPLES.

Radio-nuclide	Duncan Grouping[a]	Mean (pCi/g)[b]	N	Site
^{241}Am	A	8.933	3	2
	B	0.021	3	1
	B	0.015	3	3
^{238}Pu	A	2.920	3	2
	B	0.010	3	1
	B	0.004	3	3
^{239}Pu	A	8.067	3	2
	B	0.049	3	1
	B	0.029	3	3
^{137}Cs	A	18.063	3	2
	B	0.503	3	3
	B	-0.000	3	1
^{90}Sr	A	1.367	3	2
	B	0.667	3	1
	B	0.400	3	3
^{3}H	A	3,700	3	2
	B	743.3	3	1
	B	66.7	3	3
Total U	A	2.263	3	3
	B	1.380	3	2
	B	1.283	3	1

[a]Means with the same Duncan Grouping letters are not significantly different.

[b]To convert pCi/g to Bq/kg, multiply by 37.

TABLE 12. SMALL MAMMAL SPECIES CAPTURED IN MORTANDAD CANYON, 1994.

Least chipmunk	*Eutamias minimus*
Colorado chipmunk	*Eutamias quadrivatattus*
Long-tailed vole	*Microtus longicaudus*
Montane vole	*Microtus montanus*
Silky pocket mouse	*Perognathus flavus*
Brush mouse	*Peromyscus boylii*
Deer mouse	*Peromyscus maniculatus*
Pinyon mouse	*Peromyscus trueii*
Harvest mouse	*Reithrodontomys megalotis*
Shrew	*Sorex* sp.
Valley pocket gopher	*Thomomys bottae*

TABLE 13. SMALL MAMMAL SPECIES CAPTURED IN MORTANDAD CANYON, BY LOCATION.

Species	Site 3	Site 2	Site 1
Least chipmunk			x
Colorado chipmunk		x	
Long-tailed vole			x
Montane vole		x	
Silky pocket mouse	x		
Brush mouse	x	x	x
Deer mouse	x	x	x
Harvest mouse	x		x
Shrew			x
Valley pocket gopher	x		

the elevated levels could be the result of an accidental spill from a radioactive liquid-waste line that occurred during the summer of 1974 near the headwaters of Mortandad Canyon [13]. However, the residual contamination was cleaned up to undetectable limits [14]. During 1995, an additional upstream study site was selected to further evaluate the possibility of another point source. Currently, 1995 samples are being analyzed for radionuclides.

With the exception of total U, all mean radionuclide concentrations in small mammal carcasses and sediments were significantly higher at Site 2 than Site 1 or Site 3. Site 2 is the closest site to outfall 051-051. However, Site 3 (furthest site from outfall 051-051) had some radionuclide concentrations above regional background values (refer to Tables 6, 7, and 9). In 1995, an additional site was placed below Site 3 to further describe the extent of the contamination. Currently, these samples are waiting for chemical analysis.

TABLE 14. RODENT DENSITY ESTIMATE OF MORTANDAD CANYON, SITES 1, 2, AND 3.

SITE 3	DAY	NO. OF CAPTURES 1st session	2nd session	NO. OF TRAPS	
	1	9	12	100	
	2	3	4	100	
	3	3	2	100	
	4	1	-	100	
DENSITY ESTIMATE (# animals /ha)	14.1				
STANDARD ERROR	0.9				
SITE 2	**DAY**	**NO. OF CAPTURES 1st session**	**2nd session**	**NO. OF TRAPS**	
	1	9	6	100	
	2	5	3	100	
	3	4	2	100	
DENSITY ESTIMATE (# animals/ha)	14.7				
STANDARD ERROR	4.4				
SITE 1	**DAY**	**NO. OF CAPTURES 1st session**	**2nd session**	**NO. OF TRAPS 1st**	**2nd**
	1	4	13	100	200
	2	7	8	100	200
	3	1	*	100	
	4	3		100	
DENSITY ESTIMATE (# animals/ha)	11.1				
STANDARD ERROR	2.6				

* 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.

CONCLUSIONS

Determining whether contamination is greater in pelts than carcasses, or vice versa, can help to identify potential pathways of contaminants (ingestion, inhalation, or surface contact). Our study showed there was no statistical difference between the radionuclide concentrations in rodent carcasses and pelts at three sites within Mortandad Canyon (exception of ^{239}Pu at Site 1), indicating that all three modes of contamination may be equally occurring.

Other studies [5, 15, 16] conducted at waste disposal areas have shown higher radionuclide concentrations in rodent pelts than in rodent carcasses, indicating the mode of contamination to be largely from surface contact. Further data collected in Mortandad Canyon and data from other studies being conducted elsewhere at the Laboratory will be used to more closely examine the modes of contamination.

Knowledge of densities, food habitats, and population dynamics will help to estimate

TABLE 15. BIOMASS ESTIMATES FOR MORTANDAD CANYON, 1994.

SITE	DENSITY (# animals/ha)	AVG WEIGHT (g)	BIOMASS ESTIMATE (g/ha)
3	14.1	18.4	259.4
2	14.7	18.4	270.5
1	11.1	22.9	254.2

TABLE 16. HOME RANGE ESTIMATES OF NOCTURNAL BURROWING RODENTS AT LOS ALAMOS NATIONAL LABORATORY.

HABITAT TYPE	SPECIES	HOME RANGE EST.	STANDARD ERROR
Dry canyon-shrub, grass mixture w/some ponderosa pine component (Site 1)	Brush mouse	23 meters	8.04
Dry canyon-shrub, grass mixture w/some ponderosa pine component (Site 1)	Brush mouse Deer mouse Long-tailed vole shrew	24.6 meters	13.4
Moist canyon-mixture of grass/shrub/riparian overstory (Site 2)	Deer mouse	34.0 meters	14.6
Moist canyon-mixed conifer w/riparian veg. and perennial water (Site 3)	Deer mouse	37.6 meters	17.9
Moist canyon-mixed conifer w/riparian veg. and perennial water (Site 3)	Deer mouse	36.0 meters	21.0
Moist canyon-mixed conifer w/riparian veg. and perennial water (Site 3)	Deer mouse Brush mouse Shrew Long-tailed vole	28.3 meters	13.5

contaminant loads within the biota within Mortandad Canyon. Estimated densities and biomass were calculated for all three sites within Mortandad Canyon. Densities and biomass estimates were similar between the three sites. Home range estimates coupled with biomass estimates can aid in determining contamination loads as well as determining movement of radionuclides off-site.

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