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ANIMAL INVESTIGATION PROGRAM 1977 ANNUAL REPORT: NEVADA TEST SITE AND VICINITY

U.S. ENVIRONMENTAL PROTECTION AGENCY
Environmental Monitoring and Support Laboratory
Las Vegas, Nevada 89114

July 1979

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by

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ABSTRACT

Data are presented from the radioanalysis of tissues collected from cattle, mule deer, desert bighorn sheep, rabbits, feral horses, and other wildlife that resided on or near the Nevada Test Site during 1977. Routine activities and special investigations of the Animal Investigation Program are also discussed.

Other than the naturally occurring potassium-40, gamma-emitting radionuclides were detected infrequently with the exception of short-lived radionuclides found in samples from animals collected after September 21 (the date of a nuclear test by the People's Republic of China).

Strontium-90 concentrations in bones from deer, cattle, and desert bighorn sheep continued the downward trend of recent years. Tritium concentrations were generally within expected environmental limits with the exception of animals exposed to sources of contamination, e.g., Sedan Crater, drainage ponds from Area 12 tunnels. Radionuclide tissue concentrations were generally higher in the tissues of animals residing in Area 15 than in similar animals collected from other Nevada Test Site areas.

Statistical analyses were made of plutonium-239 levels reported in cattle tissue collected from 1971 through 1977. These data are displayed graphically and reveal that activity levels in lungs, liver, and bone are significantly related to the age of the cattle. Activity levels did not change significantly in the ingesta and lungs during this time period but did tend to increase for bone and liver. Activity levels in the ingesta are significantly higher in the fall than in the spring.

Hypothetical dose estimates to man were calculated on the basis of the daily consumption of 0.5 kilogram of liver or muscle from animals that contained peak radionuclide levels. The highest postulated dose was 8.6 millirems for tritium in tissues from a mule deer. This dose is about 2 percent of the 500 millirems per year radiation protection standard for individuals in the general population. All other postulated doses for consumption of the tissue containing other radionuclides are about 0.1 percent or less of this guide.

The movements of 17 mule deer outfitted with collars containing a radiotransmitter unit were monitored on a weekly basis. During the winter months, all deer left their summer range on the mesas of the Nevada Test Site and migrated 40 to 60 kilometers south and west to Timber Mountain or south to Shoshone Mountain. Three of the animals left the Nevada Test Site in the Beatty Wash area.

A statistical estimate was made of the Nevada Test Site deer population in selected areas utilizing the marked deer as a basis for this estimate. These estimates were 82 deer in the Echo Peak area, 32 in the Dead Horse Flats area, 10 in Area 20, and 43 in the Rainier Mesa area.

No gross or microscopic lesions were found in necropsied animals that could be directly attributed to the effects of ionizing radiation.

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INTRODUCTION

Since 1964, the U.S. Environmental Protection Agency's Environmental Monitoring and Support Laboratory has conducted the Animal Investigation Program for the U.S. Department of Energy and its predecessor agencies. Previous reports (Fountain 1961; Smith and Giles, 1970, 1974, and 1975; and Smith et al., 1976, 1977a, 1977b, 1978a, and 1978b) have detailed the history, evolution, and accomplishments of the Animal Investigation Program since its inception in 1957. During 1977, the basic objectives of this program remained as follows:

1. To conduct surveillance of domestic and wild animals on and around the Nevada Test Site to assess the radionuclide burden present in their tissues and to detect pathological effects from the burdens.

2. To investigate alleged damage to domestic animals and wildlife resulting from the nuclear testing activities of the Nevada Operations Office of the U.S. Department of Energy.

3. To maintain public relations through education and veterinary advice to the off-site population.

4. To conduct special ad hoc investigations.

Progress in achieving these objectives and summaries of the data collected during 1977 are presented in this report.

SAMPLE COLLECTION

Animals sampled during 1977 included cattle, mule deer, rabbits, coyotes, eagles, a mountain lion, and a feral horse from the Nevada Test Site, and desert bighorn sheep that range the mountainous areas to the south and east of the Nevada Test Site. Animals sampled included those that died from natural causes or by accident, those collected through the cooperation of licensed hunters, and those that were sacrificed as part of the routine sampling activities of the program.

Sacrificed animals, killed either by rifle or shotgun fire, were usually necropsied immediately after death and any gross pathological conditions noted. Animals collected by other means were also necropsied if a prosector was available. If advanced postmortem changes had not occurred, the adrenals, eyes, heart, kidneys, liver, lungs, muscle, spleen, thyroid, gonads, and lesions (if any) were sampled and prepared for histopathological evaluation. If fresh blood was available, heparinized samples were collected for hematological examination. Tissues collected for radioanalysis from large animals included rumen or stomach contents, liver, lungs, tracheobronchial lymph nodes, muscle, thyroids, blood, kidneys, fetus (if present), and bone (femurs or hock). Tissues collected for radioanalysis from each rabbit included bone from entire skeleton, muscle, skin, entire gastrointestinal tract, and composited internal organs (liver, lungs, kidneys, and spleen).

Nevada Test Site cattle sampled during the year included 12 from the Area 18 beef herd and 2 (a Holstein cow and a Hereford steer) from the Area 15 experimental farm. Sampling information for all the cattle sampled is presented in table 1. Unless otherwise noted, each animal sampled spent its entire life grazing on the Area 18 range of the Nevada Test Site.

Figure 1 shows the locations of the herds and facilities. The management of the beef herd and soil and range surveys of the Area 18 grazing area have been published previously (Smith 1970, Leavitt 1970, and Brown and Mason 1968).

Tissue samples were collected from eight Nevada Test Site mule deer (Odocoileus hemionus) during 1977. (See table 2 for sampling information.) Six of the deer were sampled after being struck by motor vehicles, and two were collected by hunting. Six jackrabbits (Lepus Californicus) and one coyote (Canis latrans) were collected at Area 15 experimental farm. Other Nevada Test Site animals sampled included five jackrabits, one feral horse (Equus caballus), one coyote, two golden eagles (Aquila chrysaetos), and one mountain lion (Felix concolor). Collection locations are noted on figure 1.

TABLE 1. SAMPLING INFORMATION FOR NEVADA TEST SITE CATTLE, 1977

Animal No.	Sex	Age (yrs)	Breed	Weight (kg)	Date Sampled	Remarks
1	F	12.5	Hereford	538	05/12/77	Aged Hereford cow.
2	M	3	Hereford	427	05/12/77	Steer in good condition.
3	F	9	Hereford	445	05/12/77	Pregnant cow--7-month-old fetus. Extremely wild and aggressive.
4	M	1	Hereford	218	05/12/77	A yearling steer in fair condition.
5	M	1	Hereford	132	05/12/77	A yearling steer in fair condition.
6	M	1	Hereford	241	05/12/77	A yearling steer in fair condition.
7	F	4.5	Hereford	442	10/14/77	Barren cow in excellent condition. Resembled a steer in conformation.
8	F	4.5	Hereford	428	10/14/77	A mature lactating cow in good condition. Had actinobacillosis lesion of left mandible that was ruptured while going through the chute.
9	F	11	Hereford	373	10/14/77	A mature lactating cow. Unusually belligerent and aggressive.
10	M	1.5	Hereford	270	10/14/77	A yearling steer in good condition.
11	M	0.5	Hereford	160	10/14/77	A 6-month-old calf in good condition.
12	M	0.33	Hereford	100	10/14/77	A 4-month-old calf in good condition.
251	F	5	Holstein	850	09/22/77	Area 15 dairy cow sacrificed as surplus to needs.
761	M	6	Hereford	839	04/25/77	Rumen-fistulated steer maintained at Area 15. Tympanites was cause of death. No necropsy was performed.

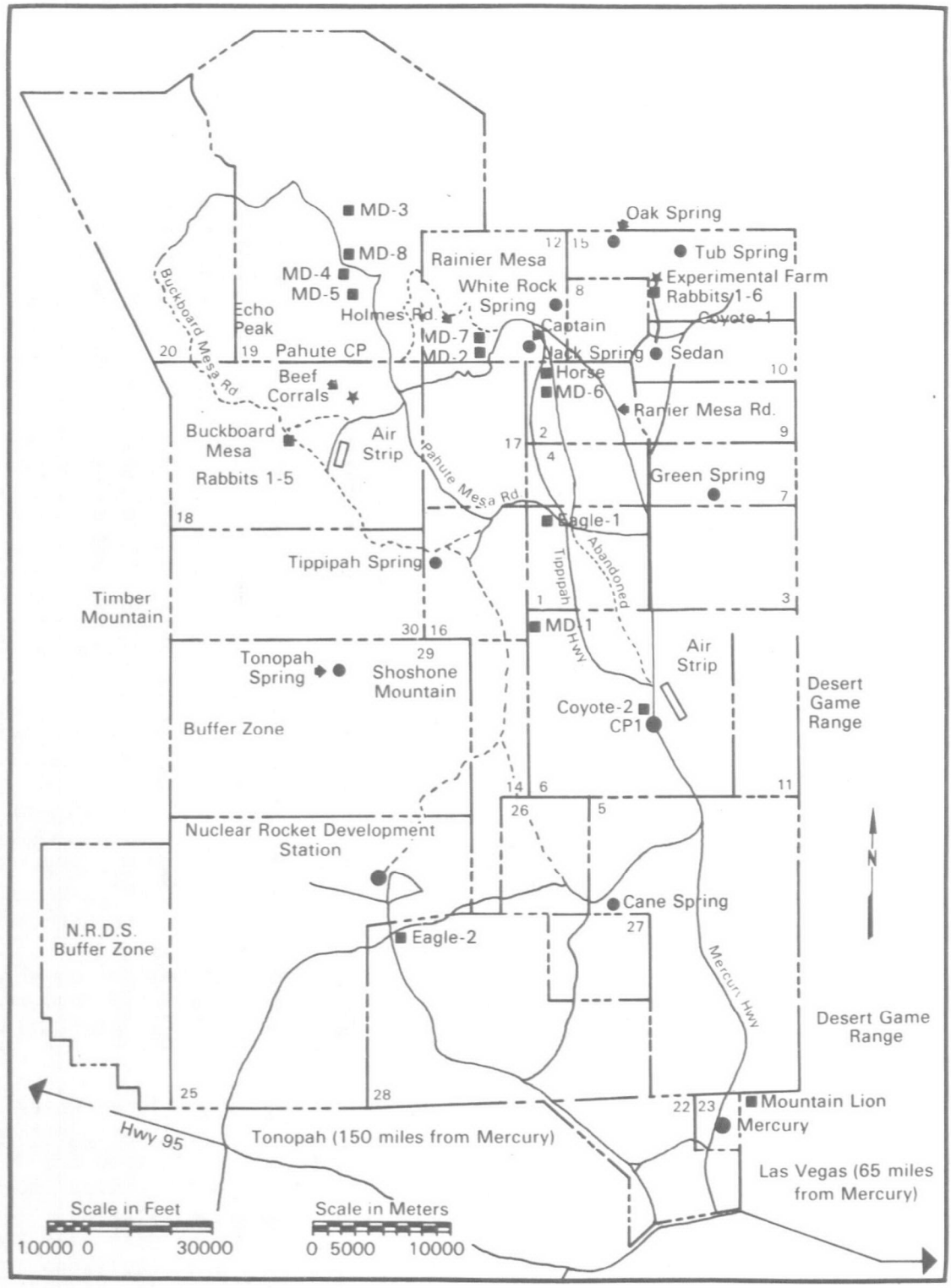

Figure 1. Location of sampling sites and facilities on the Nevada Test Site.

TABLE 2. SAMPLING INFORMATION FOR NEVADA TEST SITE WILDLIFE, 1977

Animal No.	Sex	Estimated Age (yrs)	Estimated Weight (kg)	Date Collected	Remarks
Mule Deer-1	M	7+	73	04/07/77	Collected on Mine Mountain Road on E. side of Mine Mountain by the ore oven.
Mule Deer-2	F	Mature	45	05/05/77	Road kill on N. Tunnel Access Road, Area 12.
Mule Deer-3	M	1	39	07/06/77	Road kill on Dead Horse Flat Road, 1 mi. N. of intersection.
Mule Deer-4	M	Mature	73	07/16/77	Road kill on Pahute Mesa Road, Area 19, intersection with Echo Peak Road.
Mule Deer-5	M	2-3	82	09/21/77	Collected on Echo Peak. Deer had radio collar yellow 1 and blue 4. First captured July 13, 1976.
Mule Deer-6	M	Mature	--	10/17/77	Road kill on Tippipah Highway 2 to 3 mi. S. of Area 12.
Mule Deer-7	F	1.5	45	11/20/77	Road kill intersection of Stockade Wash Road and Holmes Road.
Mule Deer-8	M	1	36	11/03/77	Road kill between Dead Horse Flat Road and Power Substation, Area 19.
Horse-1	F	10+	363	01/10/77	Road kill 2.5 mi. S. of Area 12 Camp on Tippipah Highway.
Rabbit-1-A15	F	Mature	∿2	04/03/77	Jackrabbit, collected Area 15.
Rabbit-2-A15	F	Mature	∿2	04/03/77	Jackrabbit, collected Area 15.
Rabbit-3-A15	F	Mature	∿2	04/03/77	Jackrabbit, collected Area 15.
Rabbit-4-A15	F	Mature	∿2	04/03/77	Jackrabbit, collected Area 15.
Rabbit-5-A15	F	Mature	∿2	04/03/77	Jackrabbit, collected Area 15.

(continued)

TABLE 2. SAMPLING INFORMATION FOR NEVADA TEST SITE WILDLIFE, 1977 (continued)

Animal No.	Sex	Estimated Age (yrs)	Estimated Weight (kg)	Date Collected	Remarks
Rabbit-6-A15	M	Mature	∿2	04/03/77	Jackrabbit, collected Area 15.
Rabbit-1-A18	F	Mature	∿2	04/03/77	Jackrabbit, collected Airport Road, Area 18.
Rabbit-2-A18	F	Immature	∿2	04/03/77	Jackrabbit, collected halfway to intersection N. end of strip on Airport Road.
Rabbit-3-A18	M	Mature	∿2	04/03/77	Jackrabbit, collected S. of corrals by intersection Airport Road.
Rabbit-4-A18	F	Mature	∿4	04/03/77	Jackrabbit, collected by turnoff from Buckboard Mesa Road going to Buckboard Mesa.
Rabbit-5-A18	Unk	Unk	∿5	04/03/77	Jackrabbit, collected Buckboard Mesa Road 1 mi. N. of turnoff to Buckboard Mesa.
Mountain lion	F	Unk	--	04/02/77	Carcass was less than a month old. Found by warehouse Mercury Base Camp. Cause of death unknown.
Eagle-1-NTS		Unk	--	05/06/77	Killed by flying into power line at Pahute Mesa Road and Tippipah Highway. Found by CETO personnel and given to U.S. Fish and Wildlife Service for removal of claws and feathers. They later returned to EPA.
Eagle-2-NTS	M	Unk	--	07/20/77	Eagle found by CETO personnel and given to the University of Nevada, Las Vegas, for live mounting. Soft tissue and bone returned to EPA. No history on bird.
Coyote-1-NTS	F	0.5	10	07/09/77	Collected by hunting, Area 15 experimental farm.
Coyote-2-NTS	M	0.2	5	09/21/77	Trapped in Sandia Compound in Area 6. Had a broken leg from being struck with rock. Euthanized with overdose of nicotine alkaloid injected via capture gun.

Unk = Unknown

Through the cooperation of state and federal wildlife officials and participating hunters, tissue samples were collected from 20 mature desert bighorn sheep (Ovis canadensis nelsoni) rams during the annual hunt. The sampling information for these animals is presented in table 3 and the collection sites are shown in figure 2. Most of the animals were collected from Clark County in southern Nevada with 11 coming from the Desert National Wildlife Range or the Nellis Air Force Range which are contiguous to the Nevada Test Site. One ram was collected from west-central Nevada near Lone Mountain in Esmeralda County.

TABLE 3. SAMPLING INFORMATION FOR DESERT BIGHORN SHEEP, 1977

Animal No.	Sex	Estimated Age (yrs)	Date Collected	Samples Collected	Remarks
1	M	10	12/15/77	Bone, Lung	Hunter kill, Mule Deer Ridge, Desert National Wildlife Range (DNWR).
2	M	7	11/22/77	Bone, Kidney, Liver, Lung	Hunter kill, South of Wamp Spring, DNWR.
3	M	5	12/03/77	Bone, Kidney Liver, Lung	Hunter kill, Eldorado Range.
4	M	7	12/09/77	Bone, Kidney	Hunter kill, Mule Deer Ridge, DNWR.
5	M	12	11/20/77	Bone, Kidney, Liver, Lung	Hunter kill, Tim Spring, Pintwater Range.
6	M	10	11/27/77	Bone, Kidney, Lung	Hunter kill, Sawmill Canyon, Sheep Range.
7	M	5	12/26/77	Bone, Kidney, Liver, Lung	Hunter kill, 4 mi. N. of Indian Canyon, Pintwater Range.
8	M	4-5	12/13/77	Bone, Kidney, Liver, Lung	Hunter kill, Davis Spring, Mormon Peak.
9	M	5	12/18/77	Bone, Kidney, Lung	Hunter kill, Quartz Peak.
10	M	9	12/17/77	Bone, Kidney, Liver, Lung	Hunter kill, Meadow Valley Range.
11	M	7	12/08/77	Bone, Kidney, Lung	Hunter kill, DNWR.
12	M	11	12/02/77	Bone, Liver, Lung	Hunter kill, Tri Canyon.
13	M	5	11/27/77	Bone, Kidney, Liver, Lung	Hunter kill, Las Vegas Range.

(continued)

TABLE 3. SAMPLING INFORMATION FOR DESERT BIGHORN SHEEP, 1977 (continued)

Animal No.	Sex	Estimated Age (yrs)	Date Collected	Samples Collected	Remarks
14	M	12	11/20/77	Bone, Kidney Liver, Lung	Hunter kill, 1 mi. N. of Moak Peak, Morman Range.
15	M	7	11/18/77	Bone, Kidney, Liver, Lung	Hunter kill, 2 mi. N. of White Rock, DNWR.
16	M	6	11/17/77	Bone, Kidney, Liver, Lung	Hunter kill, Oatmeal Spring, Monte Cristo, Silver Peak.
17	M	6	11/25/77	Bone, Kidney, Liver, Lung	Hunter kill, S.W. of Echo Bay.
18	M	10	12/03/77	Bone, Kidney, Lung	Hunter kill, Table Top Mountain.
19	M	8	12/31/77	Bone, Liver, Lung	Hunter kill, 2 mi. N. of White Sage, DNWR.
20	M	6	11/22/77	Bone	Hunter kill, Davis Spring, Mormon Peak.

*DNWR = Desert National Wildlife Range.

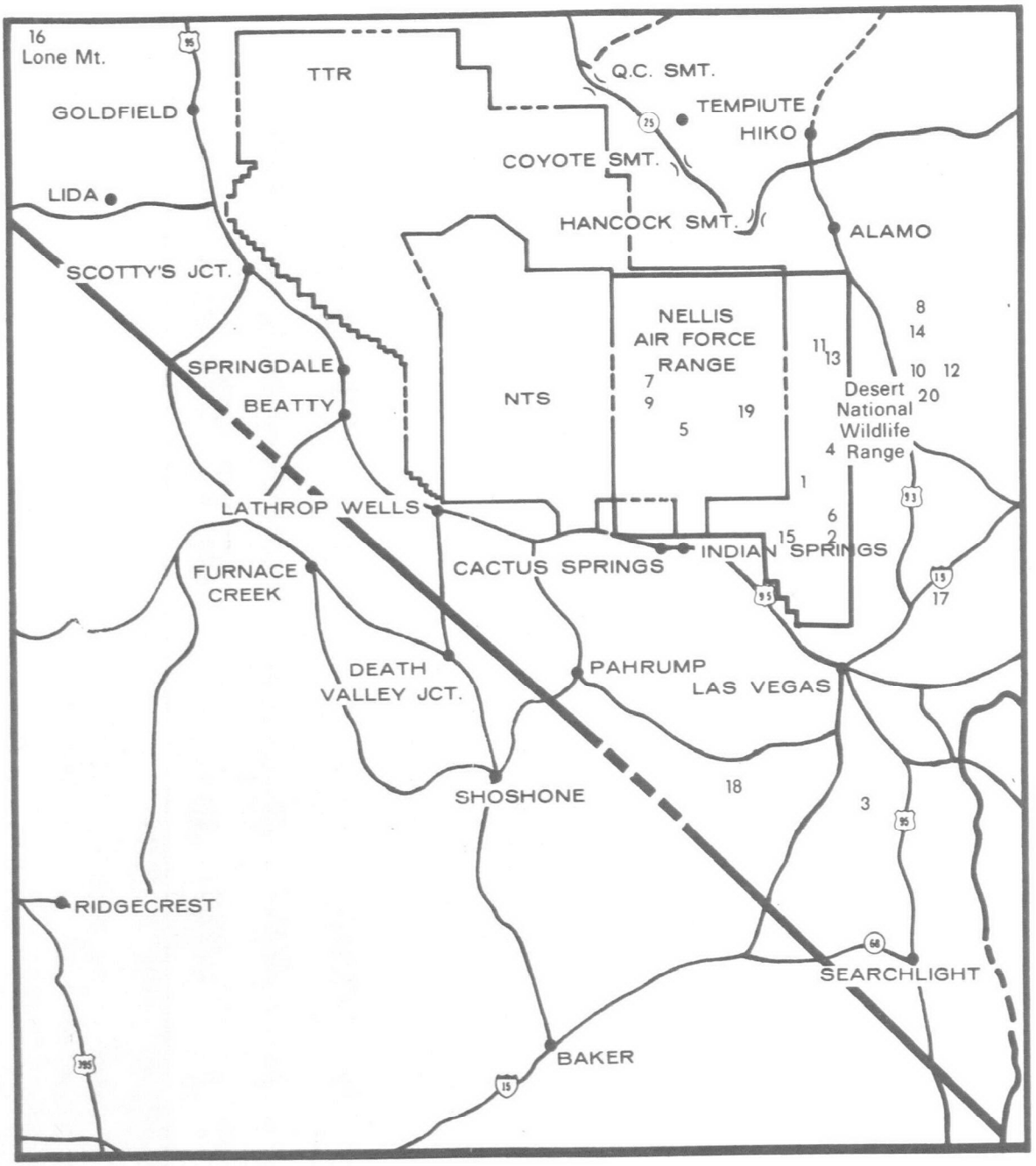

Figure 2. Approximate collection sites of 1977 desert bighorn sheep.

ANALYTICAL PROCEDURES AND METHODS

Samples of soft tissues and rumen contents were analyzed by gamma spectrometry. A sample of blood or tissues was collected from each animal and analyzed for tritium. The bone was analyzed for strontium-89 and -90 and plutonium-238 and -239. Selected soft tissues were also analyzed for plutonium content. All of the analyses for strontium, tritium, and the gamma-emitting radionuclides were performed by the Methods Development and Analytical Support Branch of the Environmental Monitoring and Support Laboratory-Las Vegas (EMSL-LV). The plutonium analyses were performed at the Albuquerque Laboratory of the Eberline Instrument Corporation.

Rumen contents and soft tissues of sufficient volume were placed in 200-milliliter aluminum containers with a 10-percent Formalin® solution as a preservative. The containers were then sealed and stored for gamma analysis. Those of smaller volume, i.e., thyroid gland, tracheobronchial lymph nodes, etc., were first macerated in a blender, then brought to volume by suspending in agar. These samples were also sealed in 200-milliliter aluminum containers. Muscle, liver, lungs, kidneys, and fetal samples were analyzed for approximately 1,200 minutes on lithium-drifted germanium detectors calibrated at approximately 0.5 kiloelectronvolts per channel in the 60-kiloelectronvolts to 2-megaelectronvolts range. These detectors are connected to a Nuclear Data 6620 computerized gamma spectral accumulation and analysis system. Other tissue samples such as thyroids, tracheobronchial lymph nodes, skin, and gonads, as well as rumen or stomach and gastrointestinal contents, were analyzed for 1,000 minutes on a 4- by 4-inch NaI (Tl) crystal connected to 200 channels of a 400-channel pulse-height analyzer calibrated at 10 kiloelectronvolts (keV) per channel.

Tissues for strontium and plutonium analyses were prepared by ashing. Plutonium was analyzed by alpha spectrometry using plutonium-236 as an internal tracer. Details of these analytical procedures have been published by Talvitie 1971, 1972; Wish and Rowell 1956; Mitchell 1960; Hagan and Arrhenius 1963; and Major et al., 1975. Other radionuclide analytical procedures used at the EMCL-LV were described previously (Johns 1975).

Quality assurance samples were included in each group of samples submitted for plutonium analyses. These were either duplicate samples collected from sacrificed animals and submitted under a blind identification number or similar tissue samples purchased at a local market and to which a known amount of plutonium was added. The data from the former type of quality assurance samples are included in the data tables of the appendixes while the data from the spiked samples are presented in table 4.

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TABLE 4. QUALITY ASSURANCE RESULTS

Tissue	ACTIVITY ADDED		ACTIVITY REPORTED	
	^{238}Pu (pCi/Sample)	^{239}Pu (pCi/Sample)	^{238}Pu (pCi/Sample)	^{239}Pu (pCi/Sample)
Liver	0	0	0.15 ± 0.010	0.68 ± 0.19
Liver	0	10.8	0.64 ± 0.21	10.0 ± 0.7
Liver	0	1.4	0.59 ± 0.24	2.4 ± 1.2
Liver	0	0.72	0.42 ± 0.21	1.4 ± 0.70
Liver	0	4.2	<0.53	5.2 ± 2.7
Muscle	0	0	<0.37	0.93 ± 0.56
Muscle	0	0.72	0.29 ± 0.22	1.2 ± 0.36
Muscle	0	0.38	<0.15	<0.38
Muscle	0	6.9	0.51 ± 0.34	12.5 ± 1.7
Muscle	0	2.8	<0.42	3.5 ± 0.71
Liver	0	0	<0.20	<0.20
Liver	0	0	<0.35	<0.35
Liver	0	0.95	<0.03	0.93 ± 0.31
Liver	0	2.7	<0.23	2.1 ± 0.35
Liver	0	0.37	<0.22	0.33 ± 0.22
Liver	0	0.95	<0.23	0.92 ± 0.23
Liver	0	2.7	<0.29	1.7 ± 0.29
Liver	0	0.37	<0.27	0.54 ± 0.27

The activity values for plutonium-239 listed in this report are actually the sum of the individual isotopic activities of plutonium-239 and -240. The alpha emissions of these two isotopes cannot be separately identified (resolved) by alpha spectrometric analysis.

All data are reported within the 95 percent confidence level counting error and are corrected to time of sample collection. Results which show a net sample activity less than the two-sigma counting error are reported as less than the activity calculated. That activity in this report is defined as the minimum detectable activity. The approximate minimum detectable activities and analytical procedures are summarized in appendix A.

Tissue and lesion samples collected for histopathological examination were first fixed with a 10-percent Formalin solution. They were then dehydrated with alcohol and embedded in paraffin prior to sectioning with a microtome. A 5-micrometer section was placed on a glass slide, stained with hematoxylin and eosin, and delivered to a pathologist for interpretation.

When fresh blood was available, 2 milliliters were withdrawn from the jugular vein and placed in a heparinized tube, and two blood-smear slides were made. These were airmailed to the ICN Medical Laboratories, Inc., of Portland, Oregon, where a complete blood-cell count was made.

RESULTS AND DISCUSSION

NEVADA TEST SITE CATTLE

The analytical results from tissues collected from the Area 18 Nevada Test Site beef cattle during May and October are presented in the tables of appendix B. Data from other Nevada Test Site cattle tissues are listed in appendix C.

The only gamma-emitting radionuclide consistently detected in all Nevada Test Site cattle tissues was the naturally occurring potassium-40. At both sampling periods, detectable levels of cesium-137 were infrequently reported in either ingesta or soft-tissue samples. The highest level reported was 47 ± 11 picocuries per kilogram found in the kidney of a calf sampled in October. Zirconium-95 was found in only two ingesta samples from the spring sacrifice but, along with ruthenium-103 and cerium-141, was consistently detected in the fall ingesta samples. Two of the lung samples collected in the fall also contained detectable levels of zirconium-95. Levels of iodine-131, ranging from 650 to 770 picocuries per gram, were reported in all thyroid samples collected from the Nevada Test Site beef cattle during October. Iodine-131 was also present in the thyroids of Area 15 cattle sampled on September 30. The presence of these short-lived radionuclides (iodine-131, zirconium-95, ruthenium-103, and cerium-141) in the fall samples is believed to be from worldwide fallout associated with the atmospheric nuclear test conducted by the Peoples' Republic of China on September 21 at 0300 hours EDT (Monitoring Operations Division 1978).

Detectable levels of tritium were not found in any of the blood samples collected from the Area 18 beef cattle. However, the blood of cow number 251 from Area 15 contained 4,300 ± 350 picocuries per liter. The source of this cow's tritium is thought to be the Sedan Crater which is approximately 3 kilometers from the farm. Similar tritium values have been reported for Area 15 cattle in previous years (Smith and Giles 1975; Smith et al., 1976, 1977a, and 1977b).

As shown in figure 3, strontium-90 values in femur samples from Area 18 beef animals averaged 3.4 picocuries per gram of bone ash with a range of 2.4 to 4.3 picocuries per gram of ash. These values are quite consistent with those reported in recent years. Strontium-89 was not detected in any of the animals' femurs.

Plutonium-238 is present in the environment primarily as a result of the burnup of the SNAP-9-A power source (Krey and Krajewski 1972; Hardy et al.,

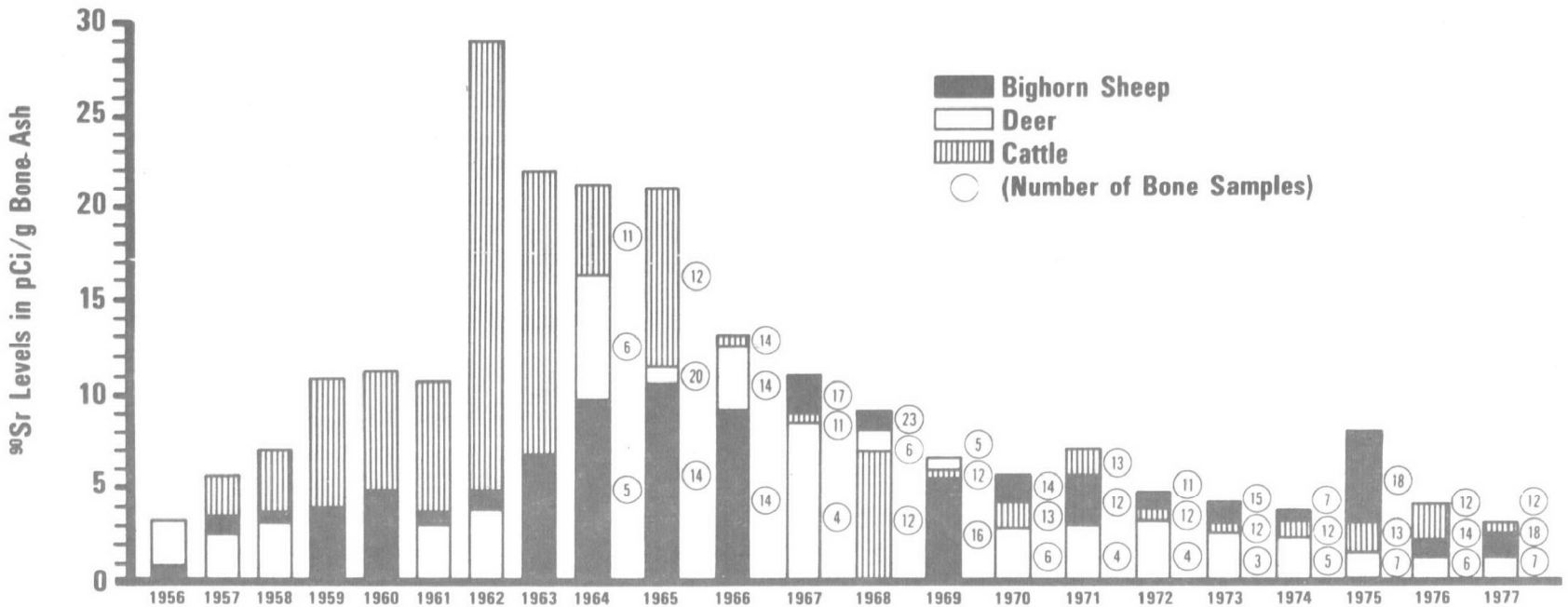

Figure 3. Annual averages of ^{90}Sr in bones of cattle, deer, and desert bighorn sheep 1956-1977.

1972). The expected ratio of plutonium-239 to plutonium-238 is roughly 25. However, this expected ratio is seldom reached in the animal tissues listed in the appendixes of this report. The ratios present are quite variable, but generally range between 5 and 10. It has been postulated (Patterson et al., 1974; and Matlock et al., 1976) that plutonium-238 may be more rapidly solubilized and thus potentially more mobile under environmental conditions than is plutonium-239. Thus, it is possible that the plutonium 239:238 ratios for animal tissue may be lower than the ratios for fallout and soil. Few apparently incongruous plutonium values were noted this year; values for similiar tissues fell within a relatively narrow range, especially if large sample sizes were available.

The median values of plutonium data from the tables in appendixes B and C are summarized in table 5. As in previous years (1973 through 1976), it was noted that increased actinide levels were present in rumen contents sampled in October. This increased activity was also noted in the lungs and tracheobronchial lymph nodes. It is postulated that the increases are related to range conditions at that time of year, i.e. forage is scant and dry, and more soil is probably ingested and inhaled during the grazing process.

TABLE 5. MEDIAN VALUES OF PLUTONIUM CONCENTRATIONS IN SELECTED TISSUES FROM NEVADA TEST SITE BEEF CATTLE (pCi/kg wet wt)

Tissue	^{238}Pu		^{239}Pu	
	May	October	May	October
Lungs	0.34	0.54	1.0	2.9
Tracheobronchial lymph nodes	<3.2	5.7	<9.8	11.4
Muscles	<0.4	<0.22	<0.4	<0.32
Livers	<0.36	0.42	<0.93	1.9
Rumen contents	0.79	1.1	4.8	7.1
Reticulum sediments	<12	240	32	980
Femurs	<2.6	<0.69	<3.9	<1.0

Unusually high ash percentages were reported for the tracheobronchial lymph nodes from several of the Area 18 cattle (see appendix table B-2). The wet weight of these tracheobronchial lymph nodes seldom exceeds 30 grams. Any

loss of moisture from these samples while in storage would result in a spurious ash-weight determination. Therefore the analytical values reported for the samples may be questionable.

Fetal tissues frequently contained detectable levels of plutonium (especially plutonium-238) which indicates transfer across the placental membranes.

STATISTICAL ANALYSES OF PLUTONIUM-239 ACTIVITIES IN CATTLE TISSUES 1971-1977

Plutonium activity levels in range cattle tissues and ingesta have been reported annually since 1971. Sufficient data have been accumulated to attempt statistical interpretation and to detect significant trends and relationships. The relationships considered were: (1) trends, if any, in plutonium activity levels in cattle tissues or ingesta from 1971 to 1977, (2) relations between age of the animals and plutonium activity levels, and (3) differences in plutonium activity levels for samples collected in the spring versus the fall.

Statistical analysis of data collected over long periods of time has considerable appeal. It is also relatively easy to perform the calculations on a set of numbers and make inferences. However, the validity of the conclusions is limited by the quality of the numbers generated in the first place. This study covers a period of 7 years with both spring and fall sample collections being made. During this time, sample collection techniques have remained pretty much the same, but analytical procedures have changed. Some samples were counted for longer periods than others, different personnel were involved, sample sizes varied, instruments changed, and even laboratories doing the analyses changed. Ideally, all of these factors should be considered and their effect on the result determined before any conclusions are drawn. It has not been possible, however, to factor all these variables into the following statistical analysis so caution and a thorough reading are advised.

Since only bone, lung, liver, and ingesta samples had consistent plutonium-239 levels, statistical analyses of these sample data are considered in this report. The plutonium activity levels in muscle were generally below the limit of detection so the data could not be meaningfully analyzed. The total amount of available plutonium data on range cattle was reviewed and screened. Only positive activity values were considered. All fetus data were dropped since there were only a few fetuses sampled and their activity levels were reflected in the cow. For samples which were analyzed in duplicate, only the mean was used. Counting errors were not included. These screenings were conducted to simplify the statistical procedures and final data interpretation.

The lung, liver, and bone data sets were checked for normality by plotting on log probability paper. Since the data approximated a straight line, all plutonium activity data were converted to natural logs (ln) for statistical analysis. Thus, the means on the graphs in figures 4, 6, 8, and 10 are the means of ln transformed data or geometric means. The asterisks in figures 6 through 9 signify the probability level: * = 95%, ** = 99%.

A total of 80 range cattle were sampled for lung tissue during the period 1971 to 1977. Positive plutonium-239 activity levels were reported for 77 of these animals. The initial analysis conducted was to determine whether the activity levels of samples collected in the spring differed from those collected in the fall. The ln of the plutonium-239 activity levels were regressed with the year of collection. The comparison of regression lines for spring data versus fall data indicated there was no significant difference in the slope or intercept of the regression lines. Therefore, spring and fall data were combined.

A multilinear regression test was then applied to the lung tissue data with animal age and year of collection being the independent variables and the ln of the lung activity being the dependent variable. Since the regression was highly significant, regressions were run to determine whether age, year, or both were significant factors. The data indicate there is no significant trend [F = 0.000; 1,75 degrees of freedom (df)] in residue levels over the 7 years of data collection (figure 4). The reported residue levels of plutonium-239 in lung tissues have neither decreased nor increased since 1971.

The regression of animal age versus the ln of the plutonium activity in lung tissue indicates a very high degree of significance (F = 46; 1,75 df). The plot of the data and regression line (figure 5) show that plutonium-239 levels in lung tissues increase with the age of the animal.

Fifty-eight of the 87 beef animals sampled had detectable plutonium-239 activity levels in the bone (femur) samples. Statistical analyses of these 58 samples indicated there is no significant difference in the plutonium activity of spring versus fall samples. This comparison was conducted using the same procedure as for lungs. Spring and fall data were combined for further analyses.

The multilinear regression comparing animal age and year of collection with ln plutonium-239 activity was highly significant. The separate comparison of collection year versus ln plutonium activity showed a significant association (F = 5.3; 2,55 df) at the 95 percent probability level with no significant lack of fit. Figure 6 shows that the reported plutonium-239 activity in bone samples has increased from 1971 to 1977.

Animal age is also significantly related to plutonium-239 activity in bone. The F of 15.6 (1,56 df) is significant at the 99 percent probability level. Plutonium-239 activity in bone increases with animal age (figure 7).

Sixty three of the 82 animals sampled for liver had detectable levels of plutonium-239 activity and were used in the following analyses. The comparison of plutonium activity for samples collected in the spring versus fall did show a statistically significant difference in slopes but not in elevation. Since the data were widely scattered, they were combined for ease of interpretation.

Multilinear regression of age and year versus plutonium-239 activity resulted in a significant regression. The separate effects show that both animal age and year of collection are related to plutonium activity in liver

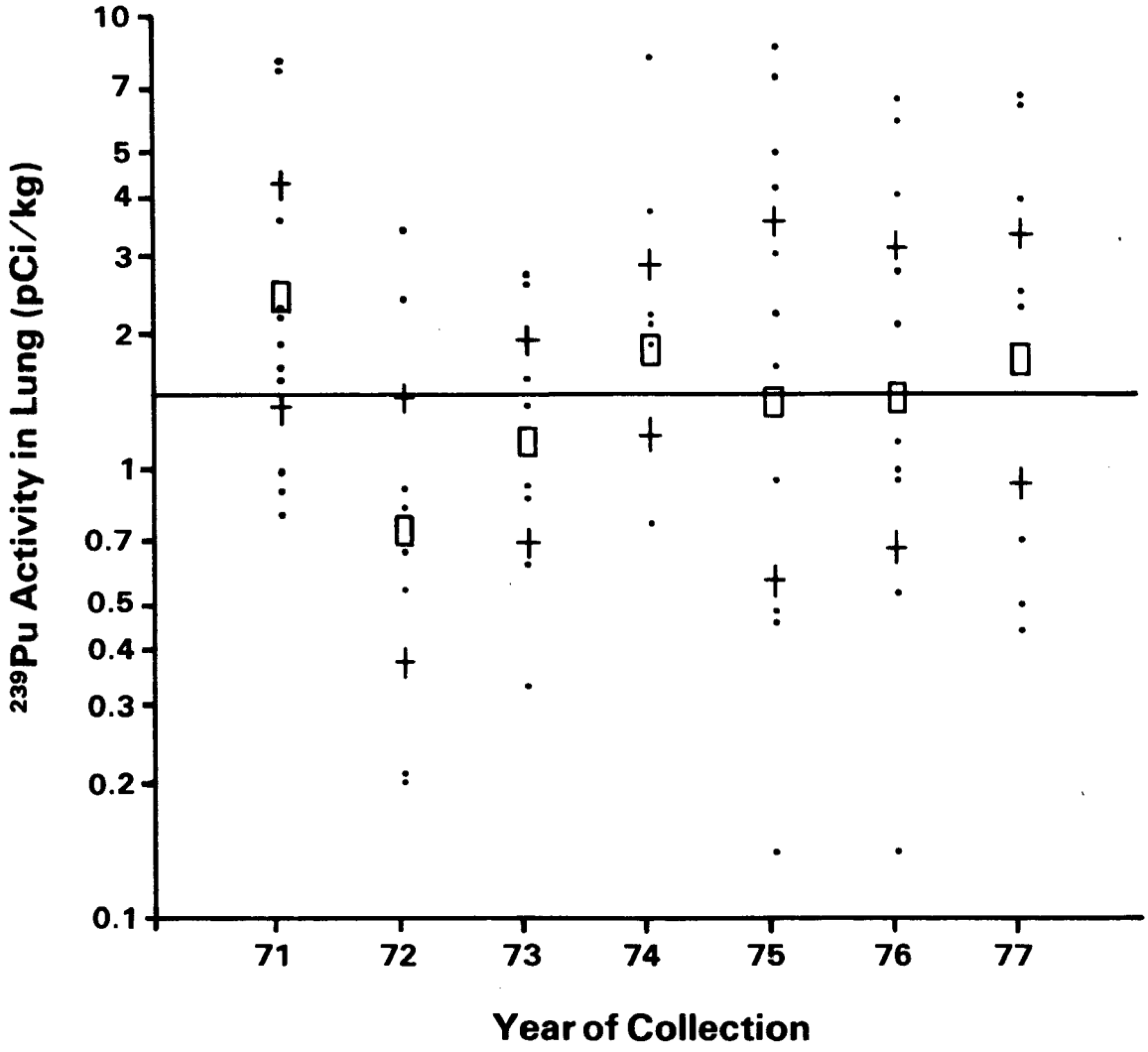

Figure 4. Linear regression of ln ^{239}Pu activity in beef cattle lung vs. year of sample collection with ln means and 95% confidence intervals. (F = 0.00; 1,75 df)

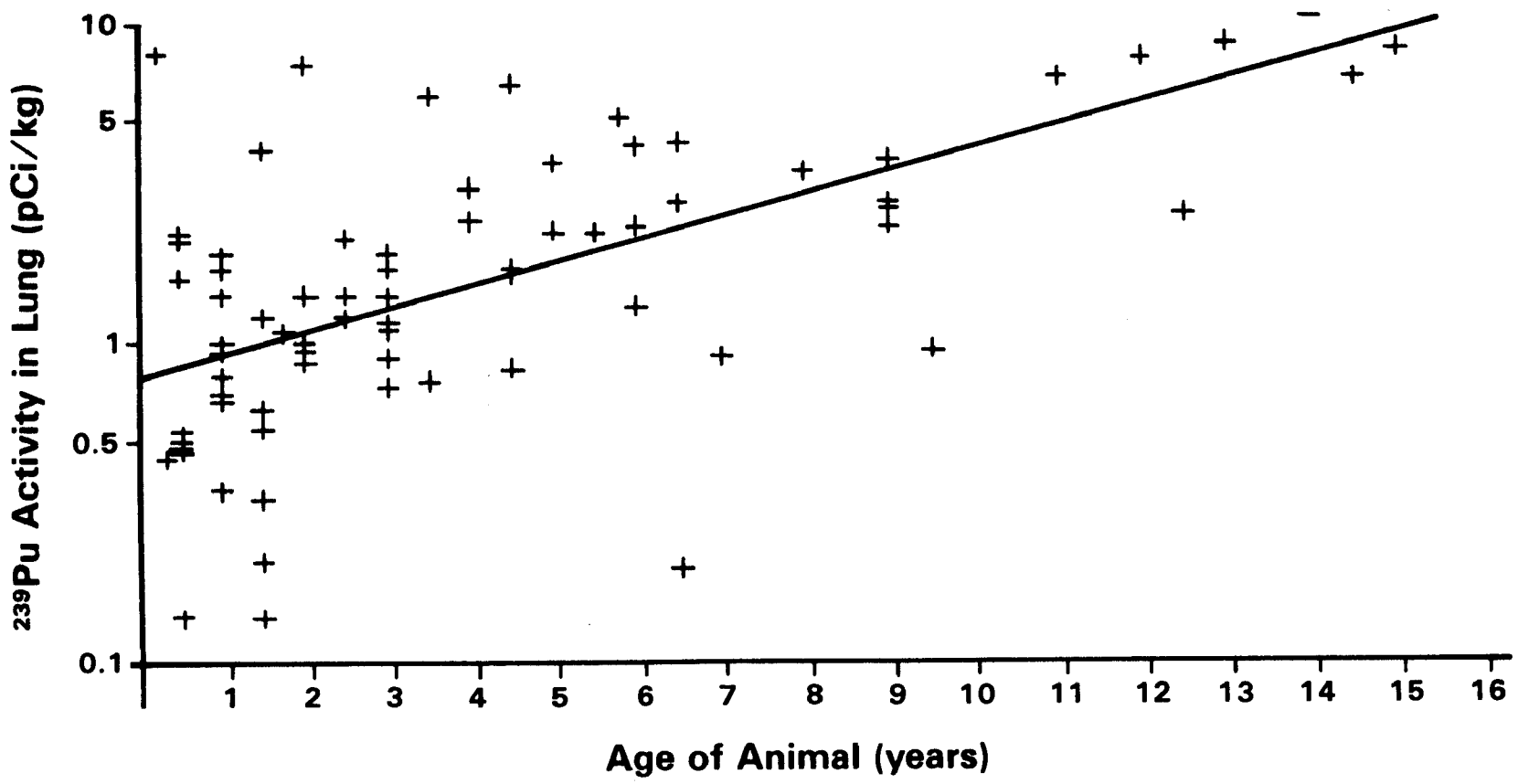

Figure 5. Linear regression of ln ^{239}Pu activity in beef cattle lung vs. animal age. (F = 45.94; 1,75 df)

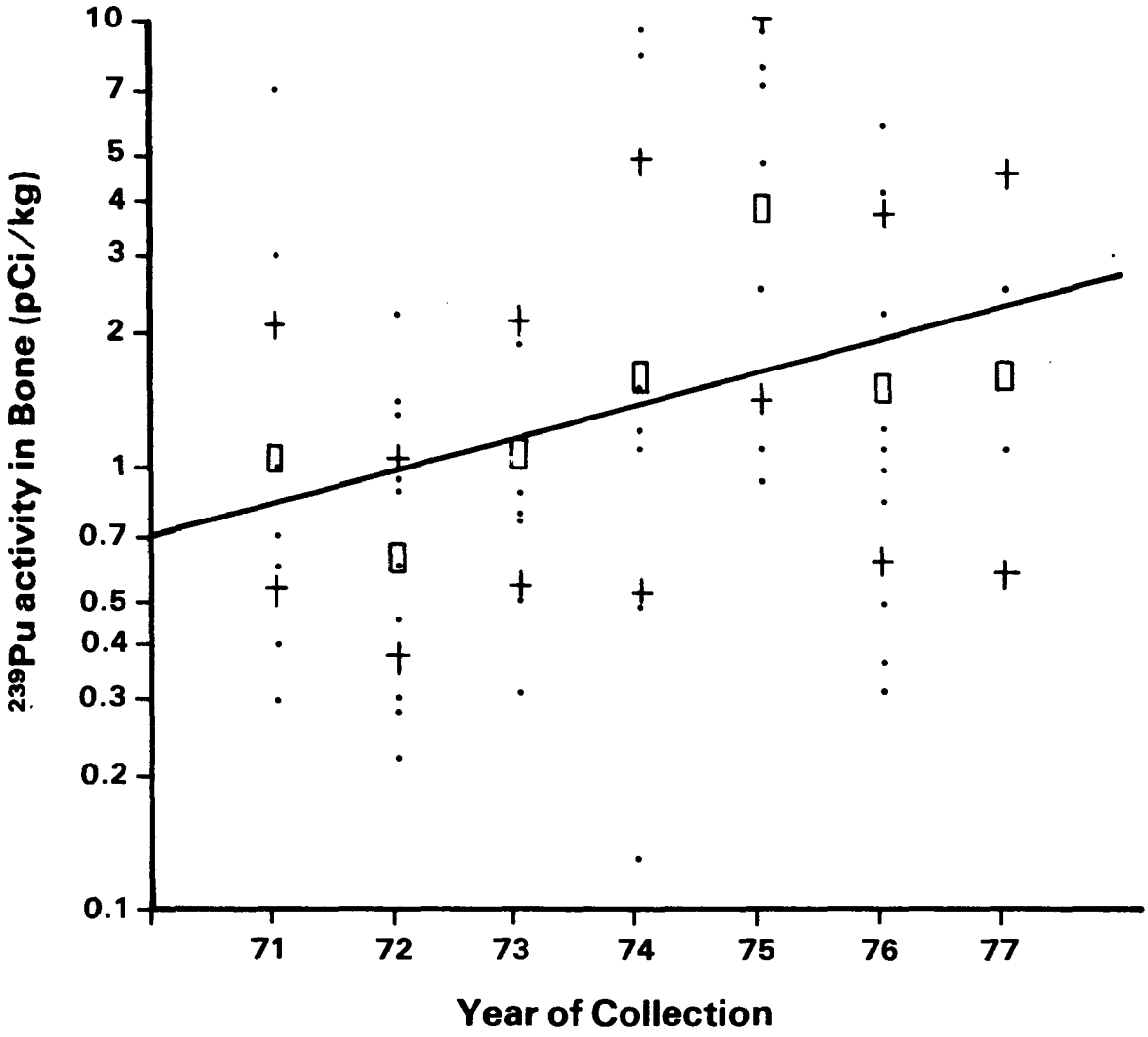

Figure 6. Linear regression of ln ^{239}Pu activity in beef cattle bone vs. year of collection with means and 95% confidence intervals. (F = 5.26; 1,56 df)

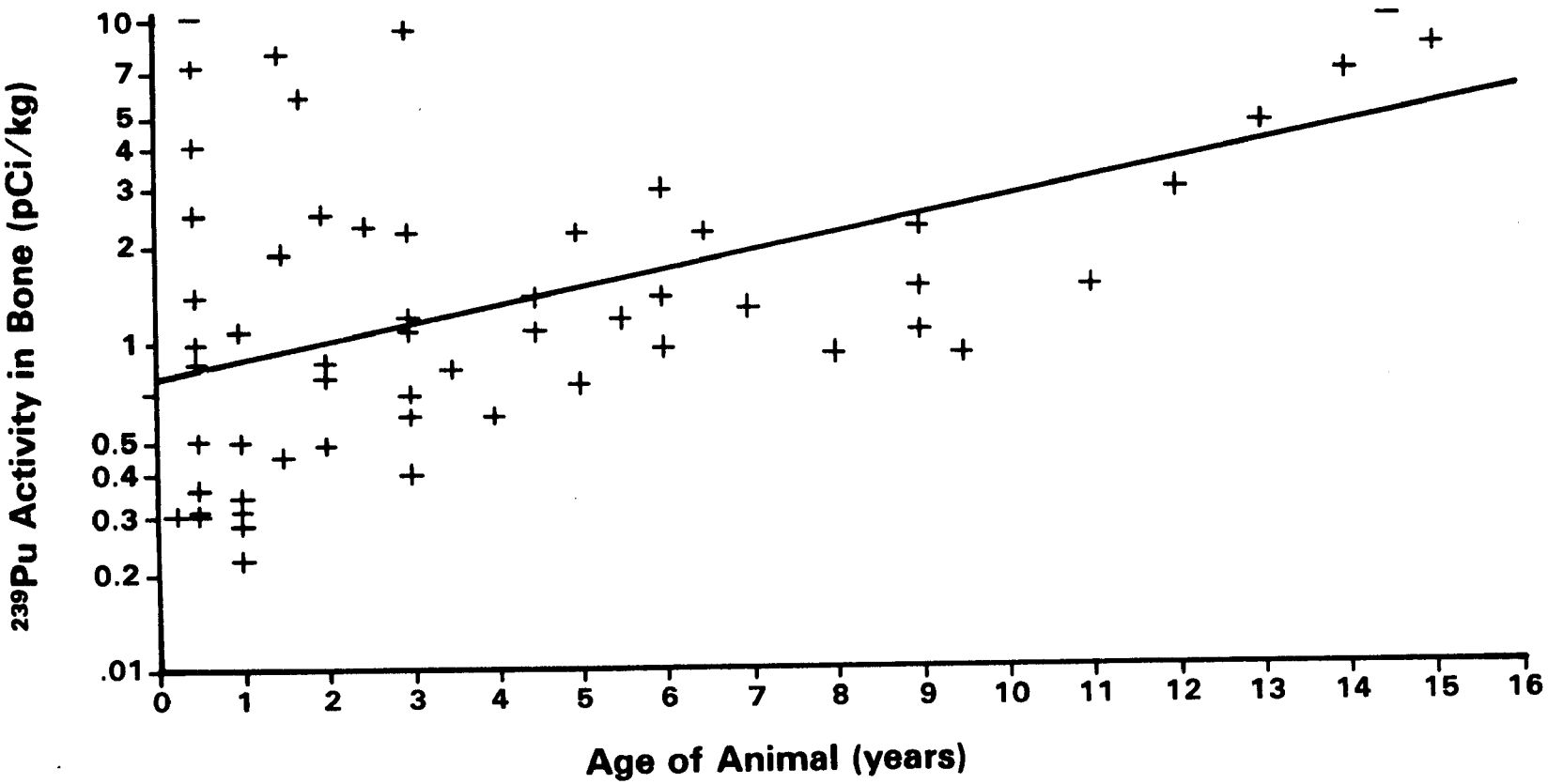

Figure 7. Linear regression of ln ^{239}Pu activity in beef cattle bone vs. animal age. ($F = 15.58$; 1,56 df)

samples. The regression of the year the sample was colelcted versus the ln of the reported plutonium-239 activity in liver resulted in a highly significant F ratio (F = 8.14; 1,61 df), but there is also a significant lack of fit (F = 2.45, 5,56 df). Figure 8 shows the regression line has positive slope suggesting that plutonium activity levels in cattle liver samples have increased from 1971 to 1977. The figure also shows that a straight line does not adequately describe the data.

Animal age is also significantly related (F = 5.32; 1,61 df) to plutonium activity levels as shown in figure 9. The liver tissue of the older beef cattle generally has a higher level of plutonium activity than that of young animals.

The rumen content data considered for this report were from beef animals collected in the fall 1971 through fall 1977. Spring and fall data were plotted separately and the means of the ln transformed data (geometric mean) for the fall of each year were higher than for the spring (figure 10). Linear regressions lines were calculated for each data set but there was a significant lack of fit. That is, a straight line regression does not fit the data. The plutonium-239 activity in ingesta appears to have fluctuated from year to year, but no trend in activity levels is apparent. The variable and transient nature of data on plutonium activity in ingesta precludes an accurate assessment of trends.

In summary, the data on the plutonium-239 activities in beef cattle tissues and rumen contents have been statistically analyzed to determine trends in plutonium activity levels. The data show that activity levels have significantly increased from 1971 to 1977 in bone and liver tissues. No change in activity levels was detected for lung tissue or rumen contents.

Practical reasons for the increase with time in the plutonium activity in bone and liver samples are difficult to determine. Surface testing of nuclear weapons in the grazed areas ceased in 1962, so there should have been no significant new sources of contamination.

The possibility exists, however, of plutonium becoming more soluble and thus more available to plants and subsequently to cattle. The activity in lung tissues would not be expected to increase since there is no increased probability of particle inhalation.

Initially, plutonium is relatively unavailable to the roots of plants since it is deposited on the soil surface. With weathering, physical mixing of the soil and chemical reactions, the plutonium is transported to the root zone for plant uptake (Romney et al., 1970; Essington et al., 1976). This process may take considerable time in an arid environment, but nuclear testing in the cattle grazing area (Area 18) ceased in 1962.

Surface deposition of particulate plutonium typically accounts for the majority of plutonium in and on plants; relatively little is incorporated. Stanley et al. (1975) have shown, however, that nearly 100 percent of ingested

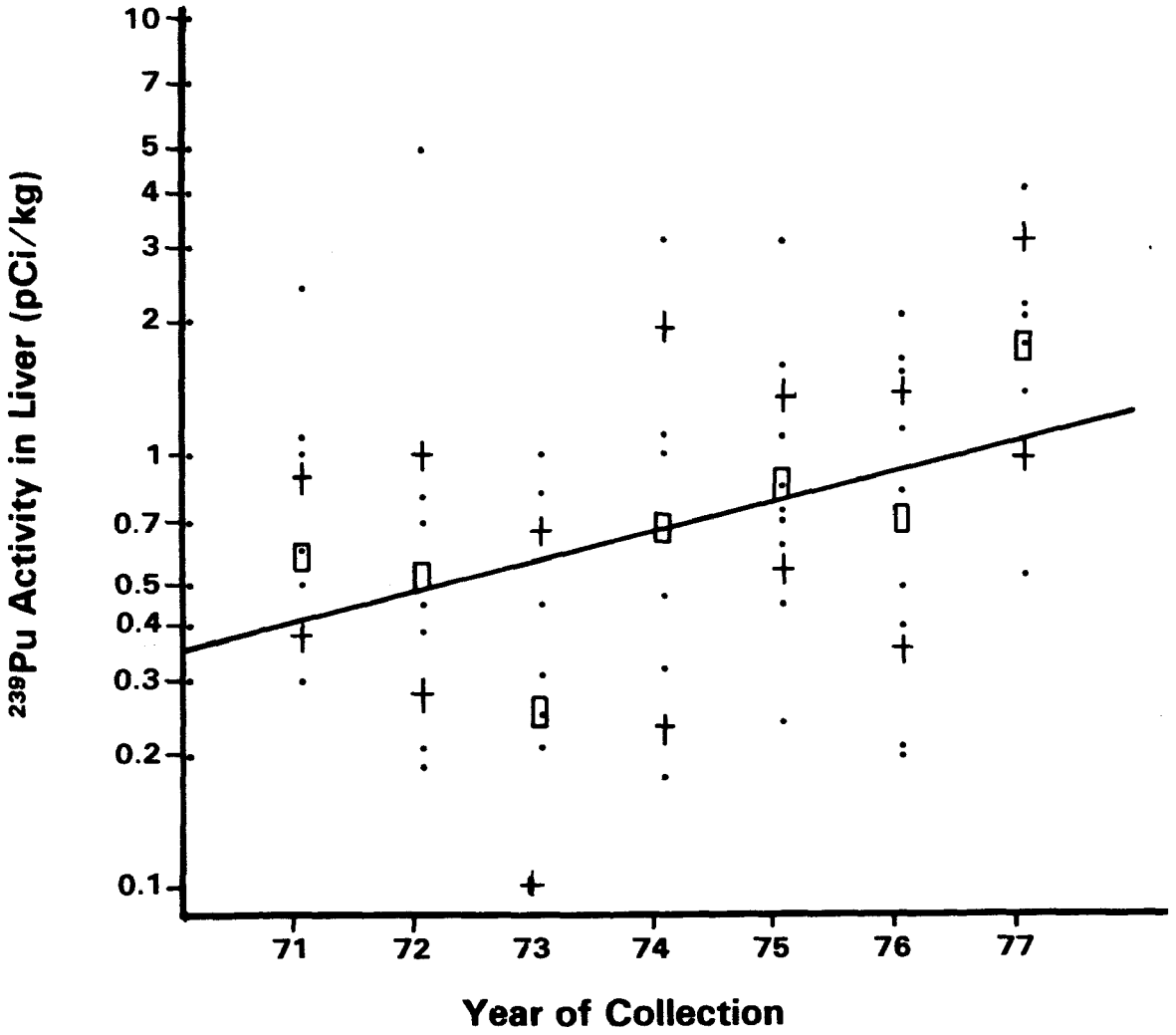

Figure 8. Linear regression of ln ^{239}Pu activity in beef cattle liver vs. year of sample collection with means and 95% confidence intervals. ($F = 8.14$; 1,61 df, but regression not linear, $F = 2.48$; 5,56 df)

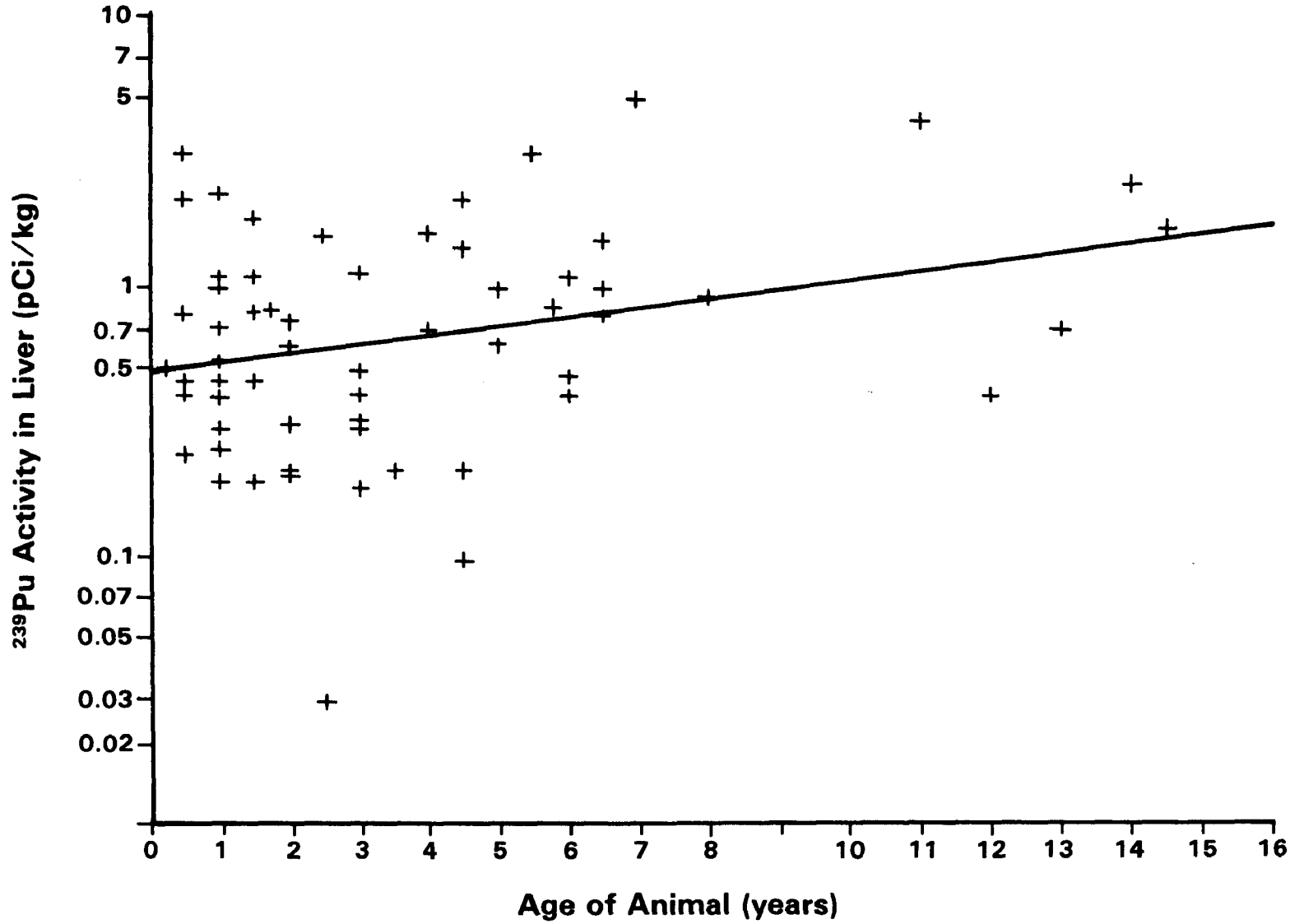

Figure 9. Linear regression of ln ^{239}Pu activity in beef cattle liver vs. animal age. ($F = 5.32$; 1,61 df)

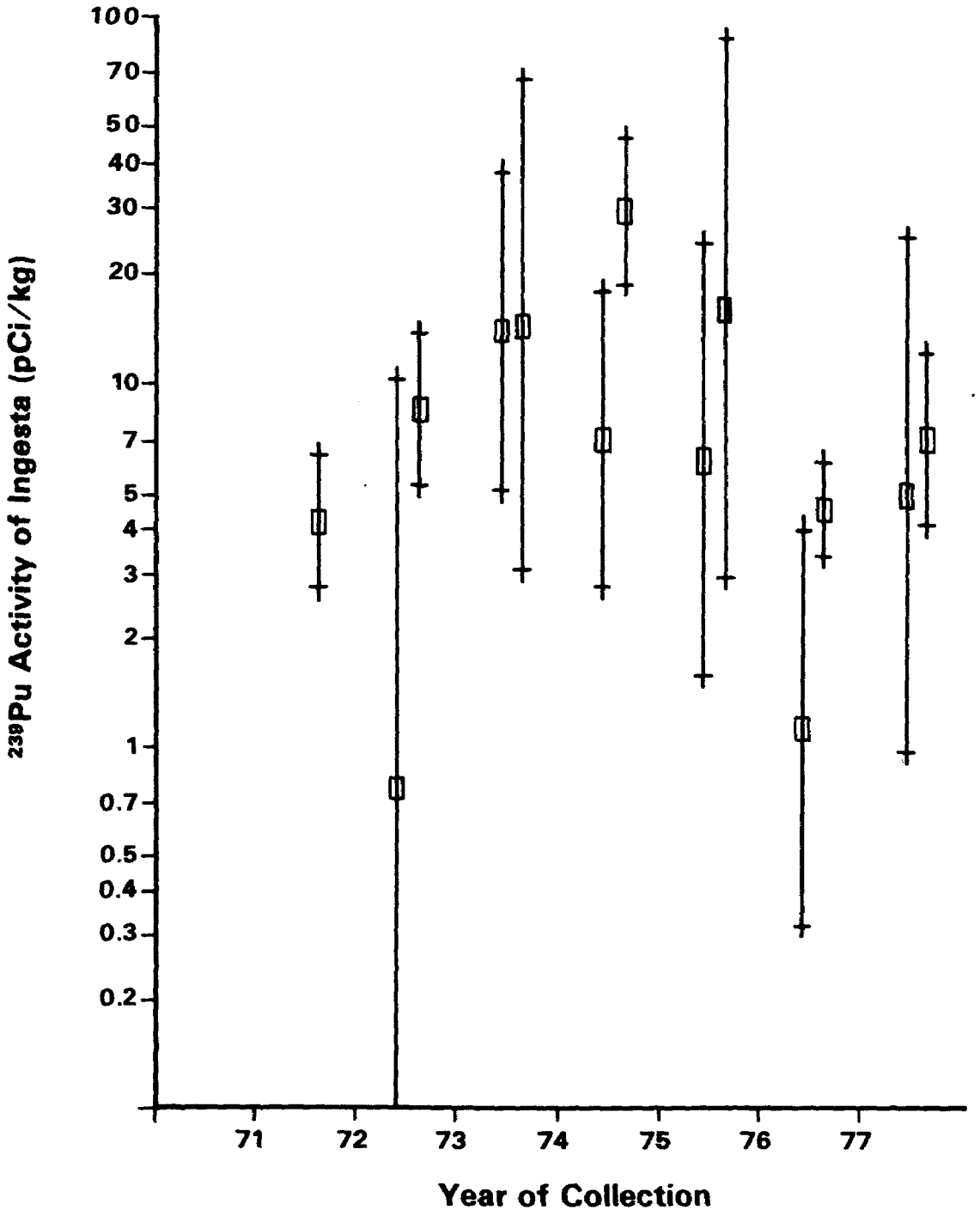

Figure 10. Plot of ln means and 95% confidence intervals for ^{239}Pu activity in ingesta of beef cattle spring and fall data.

plutonium dioxide is excreted in the feces and is quite unavailable biologically. However, biologically incorporated plutonium is thought to be considerably more available and might be responsible for most of the liver and bone activity levels (personal communication, Julius Barth). The trend data presented here are not complete or accurate enough to prove this hypothesis, but Barth's interpretation is certainly plausible.

If the solubility of plutonium does not increase, the levels in cattle tissues should have decreased or remained constant. The average age of the cattle sampled did not change appreciably with time. The data were not corrected for average age, but the variation of ±1 year appears negligible.

The change in analyzing laboratory could have introduced a bias. The Environmental Monitoring and Support Laboratory-Las Vegas performed all the analyses through 1974 and part of those for 1975, while the Eberline Instrument Corporation performed the remainder of the analyses in 1975 and all of the 1976 and 1977 analyses. A visual comparison of plutonium levels in the various tissues for the years 1974 and 1976 does not suggest a significant bias in analytical results.

Detection limits did change over the 7 years of the study, but had no significant effect on lung or ingesta data. Essentially all of these samples contained positive activity levels. An examination of the lower limit of detection (LLD) for the 14 sampling periods (spring and fall) reveals that the LLD did change substantially on several occasions for both liver and bone. In most cases, this change had the effect of eliminating data but did not cause an appreciable increase in the mean value for the year. In some cases, the mean of the reported "less than" values was greater than the reported positive detections for the same period. The LLD for bone samples collected in spring 1977 was quite high, but since there were no positive values reported at that time, the calculated mean was unaffected.

Plutonium activity levels for all three tissues (liver, bone, and lungs) are significantly related to animal age. As age increases, so does the plutonium activity in the tissues.

The higher plutonium-239 activities noted in the fall ingesta samples were not reflected in the tissues collected at the same time. There was also no significant association in plutonium activity levels for the three tissues within the same animal. The activity levels of each tissue are independent of each other.

NEVADA TEST SITE MULE DEER

The analytical results from tissues collected from Nevada Test Site mule deer are listed in the tables of appendix D. As was the case for the Nevada Test Site cattle, the only gamma-emitting radionuclide consistently detected was the naturally occurring potassium-40. Cesium-137 was occasionally detected in the soft tissues and rumen contents. The maximum concentration

observed in the soft tissues was 25 ± 6.1 picocuries per kilogram in the kidney collected from a mature buck. Levels of zirconium-95, which were frequently found in the rumen contents, increased several-fold in samples collected after September 17, 1977, the date of an atmospheric nuclear test by the Peoples' Republic of China. Zirconium-95 was also reported in the lungs and liver of animal number 8 which was sampled on November 3.

Tritium levels in the aqueous portion of the kidney tissue ranged, with one exception, between <240 and 440 picocuries per liter. Tissues from animal number 2 and its fetus both contained 480,000 picocuries per liter. This animal was collected on the N Tunnel Access Road and evidently had been drinking from ponds formed by the drainage waters from the tunnel test areas of Rainier Mesa. These drainage ponds and the Sedan Crater are the principle sources of tritium on the Nevada Test Site (Monitoring Operations Division, 1978).

The average strontium-90 concentration found in hock bones was 1.9 picocuries per gram of ash. This compares closely to the 2.1 picocuries per gram ash average found in 1976 and continues the slowly declining trend observed in recent years. Strontium-89 was not detected in any of the bone samples analyzed.

The median values of plutonium levels in selected tissues from Nevada Test Site mule deer are shown in table 6. These levels are similar to those reported in 1975 and 1976. Plutonium-239 was detected in the gonads of 2 of 5 mule deer sampled. These values of 1.4 and 1.5 picocuries per kilogram were slightly higher than levels reported in other soft tissues collected from the same animals.

TABLE 6. MEDIAN VALUES OF PLUTONIUM CONCENTRATIONS IN 1977 NEVADA TEST SITE DEER TISSUES (pCi/kg wet wt)

Tissue	^{238}Pu	^{239}Pu
Lungs	0.40 ± 0.31	0.52 ± 0.29
Muscles	<0.55	<0.59
Livers	<0.45	<0.45
Rumen Contents	0.86 ± 0.29	1.4 ± 0.57
Bones	<2.2	2.2 ± 2.2

DESERT BIGHORN SHEEP

Desert bighorn sheep that inhabit areas contiguous to the Nevada Test Site were sampled through the cooperation of licensed hunters. Analytical data from selected tissues are listed in the tables of appendix E. Muscle samples were not collected as the meat was retained by the participating hunters.

Rumen contents were not collected as a comprehensive 20-year report on the food habits of desert bighorn sheep was published by Brown et al. (1978).

Other than the naturally occurring potassium-40, gamma-emitting radionuclides were infrequently reported. Only one of 18 lungs analyzed contained a positive value for zirconium-95 (150 ± 130 picocuries per kilogram). This value is probably related to worldwide fallout from the Chinese test of September 17, 1977. Cesium-137 was found in 3 of 13 liver samples (maximum value of 26 ± 10 picocuries per kilogram) and 4 of 16 kidney samples (maximum value of 100 ± 26 picocuries per kilogram).

Tritium levels in the aqueous portion of 16 kidneys sampled ranged from <270 to 810 picocuries per liter with a median value of 430 picocuries per liter. These values are considered to be within environmental limits as the tritium concentrations for the Las Vegas area ranged between <300 to 700 picocuries per liter of atmospheric water (Monitoring Operations Divison, 1978).

The average strontium-90 concentration found in the hock bones sampled was 3.3 picocuries per gram of ash. As shown in figure 3, this value is similar to those reported in recent years. As in recent years, the strontium-90 levels were higher in the desert bighorn sheep than in the other two ruminant species (deer and cattle) sampled on the Nevada Test Site. This may be related to the increased age of the sampled population (a legal kill must be a male of at least 7 years of age) and to the increased precipitation observed in the higher elevations where the desert bighorn sheep reside.

The median values of plutonium levels found in selected tissue samples are shown in table 7. Detectable levels of plutonium-238 and plutonium-239 were seldom found in the livers and lungs sampled, and the minimum detectable activities were higher than those reported for deer and cattle. This is probably because the sheep tissue sample sizes (collected by hunters) were much smaller than those collected from the other species. Plutonium-238 was found in 12 of 20 bone samples (range of 1.9 to 6.5 picocuries per kilogram wet weight) and plutonium-239 in only 2 of 20 (range of <1.9 to 6.2 picocuries per kilogram wet weight). However, the counting error was equal to the activity reported for most of the positive plutonium-238 values; consequently, the findings are of questionable significance.

NEVADA TEST SITE COYOTES

Two immature coyotes were sampled during 1977, one from the Area 15 farm and one from Area 6. The analytical results from selected tissues of these animals are listed in the tables of appendix F.

The coyote from Area 15 contained significantly higher levels of all radionuclides detected. Levels of plutonium and strontium in the Area 15 animal were usually from 10 to 20 times higher than those found in similar

TABLE 7. MEDIAN VALUES OF PLUTONIUM CONCENTRATIONS IN 1977 DESERT BIGHORN SHEEP TISSUES (pCi/kg wet wt)

Tissue	^{238}Pu	^{239}Pu
Lungs	<1.4	<1.4
Livers	<1.4	<2.0
Bones	<2.9	<2.7

tissues collected from the Area 6 animal. Similar levels were found in Area 15 coyotes sampled in 1972 (Smith et al., 1976) and in 1975 (Smith et al., 1978a).

Cesium-137 levels were approximately 3 times greater in tissues from the Area 15 coyote, i.e., muscle levels were 150 ± 36 versus 62 ± 14 picocuries per kilogram, liver levels were 170 ± 41 versus 47 ± 7.1 picocuries per kilogram, and stomach content levels were 480 ± 80 versus 140 ± 50 picocuries per kilogram.

Tritium levels in the Area 15 coyote were also elevated; 18,000 ± 510 picocuries per liter of tissue water. As in the case of the Area 15 cattle, the source of this tritium was believed to be the Sedan Crater.

NEVADA TEST SITE RABBITS

Area 18 Rabbits

In March, five Area 18 jackrabbits were collected and selected tissues sampled. The analytical data are presented in the tables of appendix G.

The concentrations of gamma-emitting radionuclides (potassium-40, cesium-137, and zirconium-95) detected were of similar magnitude to those found in corresponding tissues collected from the beef cattle which also graze this area. Tritium levels (ranging from 320 to 750 picocuries per liter) in the aqueous portion of the rabbits' muscle tissues were not greatly different from those found in the cattle and were considered to be within normal environmental limits. Strontium-90 values ranged from 2.8 to 15 picocuries per gram of bone ash with a median value of 3.6 picocuries per gram. Two of the rabbits had values of 10 and 15 picocuries per gram of ash, respectively. Strontium-89 was not detected in the bones of any of the rabbits.

The median values of plutonium in selected tissues are shown in table 8. Plutonium levels were similar to those reported for beef cattle.

TABLE 8. MEDIAN VALUES OF PLUTONIUM CONCENTRATIONS IN 1977 NEVADA TEST SITE RABBIT TISSUES (pCi/kg wet wt)

Tissue	AREA 18		AREA 15	
	^{238}Pu	^{239}Pu	^{238}Pu	^{239}Pu
Muscles	0.29 ± 0.23	<0.37	0.33 ± 0.22	1.1 ± 0.43
Internal Organs	0.73 ± 0.38	1.8 ± 0.72	<2.3	4.3 ± 1.1
G.I. Tract	<0.98	6.4 ± 1.5	3.5 ± 1.4	100 ± 15
Skin	3.0 ± 1.5	23.0 ± 3.6	30.0 ± 7.5	1,300 ± 150
Bone	<1.4	<1.4	<1.9	<3.8

Area 15 Rabbits

Also in March, six jackrabbits from the Area 15 experimental farm were collected and sampled. Analytical data from their tissues are summarized in the tables of appendix H.

Similar spectra and concentrations of gamma-emitting radionuclides were observed in the tissues as were found in the Area 15 jackrabbits. Tritium concentrations in the aqueous portion of the Area 18 rabbit tissues were generally an order of magnitude greater with a median value of 3,600 picocuries per liter and a range of 690 to 16,000 picocuries per liter.

Strontium-90 values ranged from 0.67 to 11 picocuries per gram of bone ash with a median value of 6.0 picocuries per gram. Again, strontium-89 was not detected.

Table 8 presents the median values of plutonium represented for selected tissues. Plutonium concentrations in the bones and internal tissues were similar to those from the Area 18 rabbits. However, the levels in tissues subject to environmental contamination (skin and gastrointestinal tract) are greatly elevated in animals from Area 15.

These findings and those noted for the Area 15 cattle and coyote plus data from Area 15 animals presented in previous reports (Smith et al., 1977b, 1978a, and 1978b) indicate that the environs of Area 15 contain elevated levels of tritium and plutonium when compared to other Nevada Test Site areas that are frequently sampled by the Animal Investigation Program.

OTHER NEVADA TEST SITE WILDLIFE

Other Nevada Test Site animals that were sampled on a limited basis were a feral horse, a mountain lion, and two golden eagles. Most of these animals were accident victims and were not found for some time after death. The

resulting advanced postmortem changes precluded any intensive sampling. The analytical data from these animals are listed in appendix I.

No unexpected radionuclides were detected and the levels were generally similar to those found in previous years or in other species. However, the aqueous portion of the muscle from eagle number 2 contained 2,400 ± 310 picocuries of tritium per liter. The source of this tritium is unknown as the bird was found with a fractured wing in Area 400. It was kept in captivity in the Civil Effects Test Operations Building in Mercury, Nevada, for approximately 45 days before its death. It was fed road-killed rabbits picked up between Mercury and Area 400.

The bone sample from the aged feral horse contained 21 ± 1.2 picocuries of strontium per gram of ash. This high level is probably related to its advanced age as similar levels have occasionally been found in other aged Nevada Test Site animals (Smith et al., 1977).

NEVADA TEST SITE WATERS

Several natural springs that serve as a source of water for wildlife were sampled during 1977. These waters were analyzed for gamma-emitting radionuclides and tritium and the analytical results are presented in table 9. Detectable levels of tritium and gamma-emitting radionuclides other than naturally occurring potassium-40 were not reported in any of the spring waters.

NECROPSY AND HISTOPATHOLOGICAL EXAMINATIONS

All sacrificed animals were necropsied and selected tissue and lesion samples were collected for histopathological evaluation. The gross and microscopic pathology observed are summarized in appendix J. Also included in this appendix are the results of hematology examination when performed. All blood samples were collected prior to death.

TABLE 9. TRITIUM AND GAMMA ANALYSES OF SAMPLES FROM NEVADA TEST SITE SPRINGS, 1977

		WATER ANALYSES	
		Gamma Analysis	
Spring Name	Date	K (g/kg)	H (pCi/l)
Cane	05/13	GSN	<270
Captain Jack	07/05	GSN	<260
Green	06/02	GSN	<250
Tippipah	04/07	GSN	<270
Topopah	05/18	GSN	<270
White Rock	04/25	0.4 ± 0.2	<250

GSN = Gamma spectrum negligible

As in previous years, sarcocysts were detected in cattle cardiac muscle tissues. This is a ubiquitous parasite of both warm- and cold-blooded vertebrates and is considered to have little clinical significance (Merck and Company, 1973).

The incidence of other clinical conditions encountered, actinobacillosis (number 8) and ocular squamous cell carcinoma (number 1), was felt to be within normal limits for the populations examined. Occasionally observed histologic findings; e.g., hemosiderosis of the spleen, capsular melanosis of the adrenal, and hyperplasia of the tracheobronchial lymph nodes were felt to be within normal levels by the examining pathologist. No pathology, gross or microscopic, was observed that could be directly attributed to ionizing radiation.

HYPOTHETICAL DOSE ESTIMATES

Although meat from animals living on the Nevada Test Site is not available for consumption by the general public, the dose to a standard man based on a postulated consumption of the meat can be calculated. The dose estimates are not presented as an implication of potential doses, but rather to place the reported radionuclide concentrations in perspective. The dose estimates are based on the techniques and parameters of the International Commission on Radiological Protection (1959, 1968) and Dillman (1969). The estimates were from the maximum observed concentrations of the radionuclides in edible tissues of the cattle and deer sampled (summarized in table 10), and the postulated consumption of 500 grams (about 1 pound) of the meat each day for a year. Less than detectable values have been used when they are the maximum value.

The International Commission for Radiological Protection (1959) and the U.S. Department of Energy (1977) present different dose criteria for various parts of the body that are based on estimates of relative radiosensitivity. The National Council on Radiation Protection and Measurements (1971) recognizes this philosophy, but recommends simplifying the guides for the general population, and uses the minimum guide (0.5 rem per year to the whole body for an individual in an uncontrolled area) for all body organs. The National Council on Radiation Protection and Measurements emphasizes that this is a simplifying administrative decision, rather than a reduction of the guides based on new technical information.

Table 10 presents a summary of the maximum observed concentrations in edible tissues of the animals. The indicated error terms are the two-sigma counting error. The total analytical errors or uncertainties (two-sigma) for the plutonium and uranium results are estimated to be about 200 femtocuries per kilogram for results of several hundered femtocuries per kilogram, or several times the indicated counting errors. Thus, differences between values, when the values are under several hundred femtocuries per kilogram, have limited statistical significance given the total analytical uncertainties of the results.

TABLE 10. SUMMARY OF PEAK RADIONUCLIDE CONCENTRATIONS IN SELECTED TISSUES FROM NEVADA TEST SITE CATTLE AND MULE DEER, 1977

Nuclide	AREA 18 CATTLE MAY 1977				AREA 18 CATTLE OCTOBER 1977				NTS MULE DEER 1977			
	Muscle (pCi/kg*)	Liver (pCi/kg*)	Thyroid (pCi/g)	Blood (pCi/l)	Muscle (pCi/kg*)	Liver (pCi/kg*)	Thyroid (pCi/g)	Blood (pCi/l)	Muscle (pCi/kg*)	Liver (pCi/kg*)	Thyroid (pCi/g)	Blood (nCi/l)
^{131}I	<MDA	<MDA	<MDA	NA	<MDA	<MDA	770 ± 13	NA	<MDA	<MDA	<MDA	NA
^{238}Pu	1.2 ± 0.5	0.24 ± 0.12	NA	NA	0.27 ± 0.21	0.69 ± 0.35	NA	NA	0.66 ± 0.33	0.54 ± 0.43	NA	NA
^{239}Pu	7.3 ± 0.9	2.2 ± 0.4	NA	NA	1.8 ± 0.6	4.1 ± 1.2	NA	NA	1.3 ± 0.66	0.97 ± 0.54	NA	NA
^{137}Cs	16 ± 5.3	<MDA	NA	NA	<MDA	<MDA	NA	NA	23 ± 8.5	17 ± 7.2	NA	NA
^{95}Zr	<MDA	<MDA	NA	NA	<MDA	<MDA	NA	NA	<MDA	220 ± 74	NA	NA
^{3}H	NA	NA	NA	<270	NA	NA	NA	<290	NA	NA	NA	480 ± 2.8

*Wet weight
<MDA = less than minimum detectable activity
NA = Not analyzed

Table 11 indicates postulated doses based on the data for maximum concentrations for the various nuclides summarized in table 10. The column on the right indicates the respective fraction of the radiation protection standard of 500 millirems per year for the various postulated doses. The doses from plutonium, uranium, and to a lesser extent, cesium-137, are not delivered in 1 year. For practical purposes, however, the integrated doses for a 1-year ingestion period are related to the yearly guide. Postulated doses for iodine-131 and zirconium-95 have not been calculated since they are reported as short-term transients resulting from foreign testing and would not be present in the indicated concentration over a period of a year.

The highest postulated dose, 8.6 millirems, is for tritium as a result of ingesting meat from a mule deer. All of the other postualted doses are about 1 millirem or less and are similar to those estimated for 1976 (Smith et al., 1978b). The maximum dose estimate from plutonium-239 is somewhat higher that past estimates, but reflects only a single high result (see table B-3). This result may be an anomaly.

The maximum postulated dose to man from any single radionuclide is about 2 percent of the guide of 500 millirems per year, based on tritium from mule deer kidney. It is postulated that the concentration of tritium in edible portions of mule deer tissues would be similar to that in the kidney.

TABLE 11. POSTULATED DOSE TO MAN FOLLOWING INGESTION OF SELECTED TISSUES FOR 1 YEAR, 1977

Nuclide	Human Organ for Which Dose was Calculated	Animal Tissue Containing Maximum Concentration	pCi/kg of Tissue	Dose Factor mrem:pCi/da (1-yr ingestion)*	Dose (mrem)	Percent 0.5 rem
$^{3}H^{\dagger}$	Body water	NTS Mule Deer, kidney	480,000 ± 2,800	3.6×10^{-5}	8.6	2.0
^{137}Cs	Whole body tissue	NTS Mule Deer, muscle	23 ± 8.5	0.022	0.25	<0.1
^{238}Pu	Bone	Area 18 Cattle, muscle	1.2 ± 0.5	0.27	0.16	<0.1
^{239}Pu	Bone	Area 18 Cattle, muscle	7.3 ± 0.9	0.32	1.2	0.2

*The doses from uranium and plutonium-238 and -239, and to a lesser extent cesium-137, are not delivered within the 1-year ingestion period, but, for simplification, the doses have been related to the guide for 1 year. The doses for plutonium are actually for a 50-year period, but it should be recognized that the doses are resulting from ingestion over a 1-year period.

The tritium concentration was for kidney. It is assumed the muscle concentration (water plus organic) per kilogram was equal to that of the kidney.

OTHER ACTIVITIES

AREA 18 BEEF HERD

During 1977, the Animal Investigation Program's beef herd continued to graze in Area 18, which contains the surface ground zeros of several atmospheric nuclear tests conducted in the sixties. Area 18 was also in the fallout pattern of several underground devices detonated to produce excavations under the Plowshare Program, and was downwind from the effluent of nuclear reactor tests conducted in Area 400.

Semiannual roundups of the herd were made in May and October. At each roundup, all captured cattle were examined, weighed, and sprayed for ectoparasites. During the October 1977 roundup, 120 cattle, including 21 calves, were identified. The calves were transported to Area 15 where they were weaned, branded, vaccinated, identified with ear tags and tattoos, and, when necessary, dehorned, and the males castrated.

Selected animals were placed on an excess property list in an effort to reduce the herd to a more manageable size. However, the drought conditions that prevailed in the western states prevented any agency or institution from picking them up as there was insufficient forage available for their own herds.

DEER MIGRATION STUDY

As described previously (Smith et al., 1978a), a sizable mule deer herd resides in the mountainous regions of the Nevada Test Site during the summer months. The location of this herd during the winter months is of interest to both the U.S. Department of Energy and the Nevada Department of Fish and Game as these animals could be harvested by the general public if they eventually reach unrestricted lands. A study designed to determine the migration patterns of this herd through tracking of individual deer outfitted with collars containing miniature radio transmitters was begun in 1975 and continued through 1977.

Between July 21 and October 21, 19 deer were captured either by chemical restraint of free-ranging animals (Smith et al., 1978a) or by trapping (Giles 1979). Thirteen of these deer were outfitted with radiotransmitting collars, ear tags, and reflective identification numbers suspended from a collar. Six deer were fitted with visual markers only. Two of these were small fawns and the other four were bucks whose necks were too large for the radio

transmitters. Deer number five, originally captured in 1976, was sacrificed and sampled after he had been followed for a 1-year period and had completed a normal migration cycle.

All of the 14 radio-equipped animals from the Echo Peak area, which included four animals with transmitters applied in 1976, migrated south into Area 30, Timber Mountain, and/or the 40-Mile Canyon areas (see figure 11). Three of these deer moved from the Nevada Test Site into the area southwest of Timber Mountain, which is known as Beatty Wash. A doe that traveled the greatest distance initially moved from Echo Peak to the southern part of 40-Mile Canyon. She then moved to the western portion of Skull Mountain south of the Nuclear Reactor area, where she stayed 3 or 4 days before moving back into 40-Mile Canyon. She moved a total distance of 58 kilometers, line of sight, from her point of capture.

Three animals from Rainier Mesa were captured and equipped with radiotransmitter collars. One of these was a doe that was first captured in October 1975 and recaptured in July 1977 within 100 meters of the original capture site. Another was a crippled buck with a fractured leg that had healed in a misaligned position. Despite its handicap, this animal was able to travel and was in good physical condition. All of the Rainier Mesa animals moved to Shoshone Mountain during the late fall of 1977 and remained there until their return to Rainier Mesa in June 1978.

In contrast to the pattern observed during the mild winter of 1976 (Smith et al., 1978b), marked deer did not remain on Rainier Mesa or in the Echo Peak areas during the winter months. All the deer were on their winter range by the middle of December and did not return to the summer range until the middle of June. Individual deer dispersed over a wide area within their winter ranges and extensive movements occurred between the weekly sightings. This differs markedly from the summer observations in which deer seldom moved a kilometer between weekly sightings.

One deer died of unknown causes while on Timber Mountain in an inaccessible area. Two unsuccessful attempts were made to recover the radio and determine the cause of death.

Six of the deer captured at the trap sites were imobilized with M-99. Due to the long induction time (15 to 25 minutes), it was decided to use this drug only on the trapped deer and continue with Sernylan® on the free-ranging animals.

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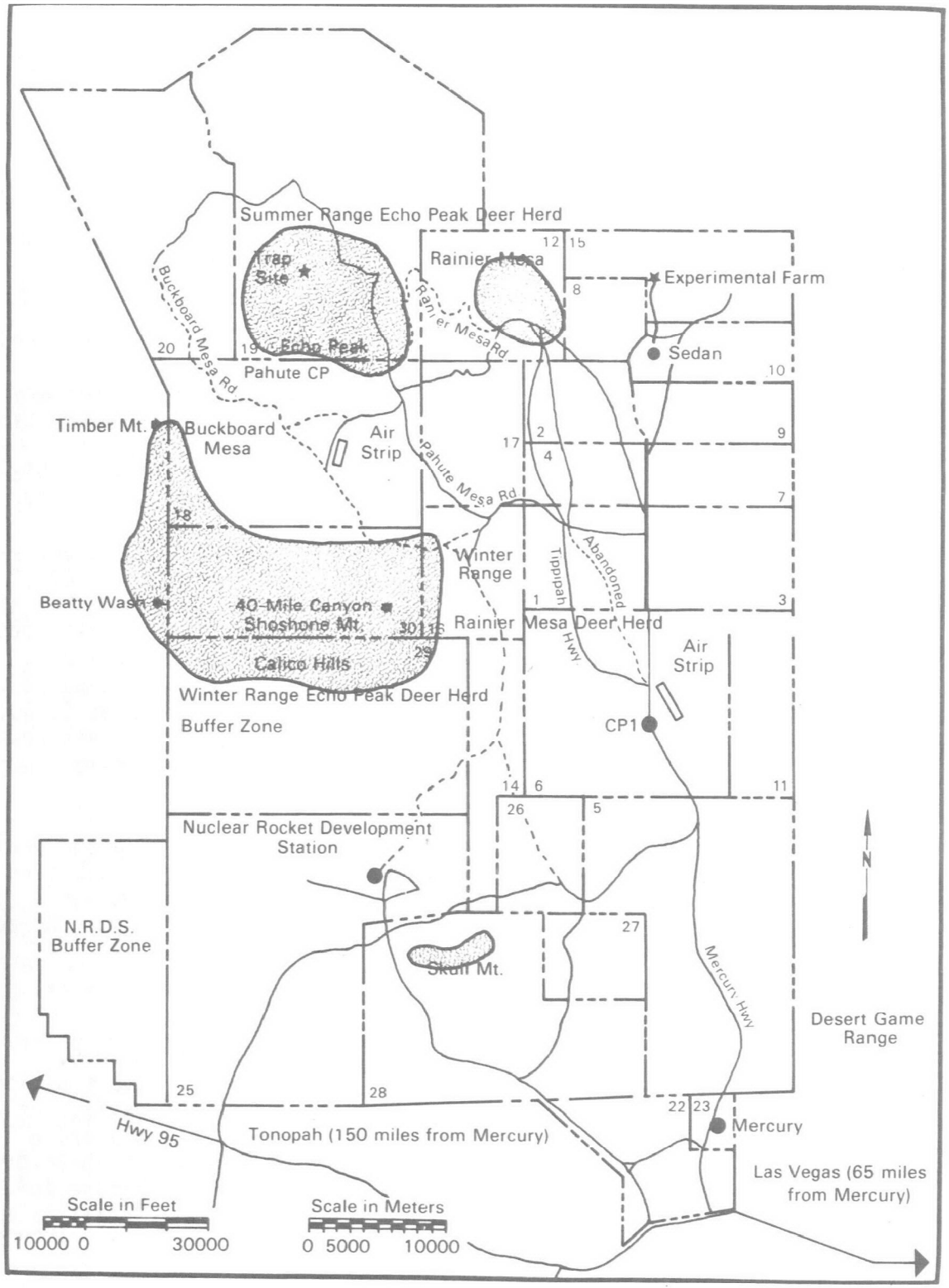

Figure 11. 1977 Nevada Test Site mule deer migration areas.

NEVADA TEST SITE MULE DEER POPULATION ESTIMATES

A spin-off benefit of the deer migration study was the establishment of a sizeable number of identifiable deer on the Nevada Test Site. It was decided to utilize this base population to derive a statistically valid estimate of the deer population of the Nevada Test Site.

The initial problem called for estimates of yearly population size for each of several subgroups (bucks, does, etc.) on each of the several areas of the Nevada Test Site. It was also desired to estimate migration between areas and monthly or seasonal trends. The data available were weekly counts of marked and unmarked animals in each area.

The Jolly-Seber estimation algorithm can yield all the estimates desired in an unbiased, statistically robust, and efficient manner. However, the field conditions do not match the inherent underlying assumptions necessary for Jolly-Seber estimates. The major difficulty is that for each observation period all captured unmarked animals must be marked in order to use the Jolly-Seber estimates. This condition cannot be satisfied when, as in this study, the "capture" is the visual counting of a deer herd many yards away.

It was therefore necessary to significantly alter the original objectives by deleting the estimates of migration and trends. A simple Lincoln (or Peterson) index calculation was done for each week for each population on each area (Seber 1973). It was necessary to derive separate population estimates for each week because there was some observed migration of marked animals. Simple yearly means, standard deviations, and confidence limits on population size for each weekly data are presented in table 12. These estimates included an average of 82 deer in the Echo Peak area, 32 in the Dead Horse Flats area, and at least 10 additional animals in Area 20. An average of 43 animals were thought to be in the Rainier Mesa area.

These population estimates are based on weekly sightings during the period of July through September and are restricted to areas readily accessible to vehicular traffic and where marked deer are present. However, it seems logical that these population estimates could be extrapolated to other Nevada Test Site areas with similar water sources and habitat.

INVESTIGATIONS AND OTHER STUDIES

During 1977, there were no livestock damage claims against the U.S. Department of Energy that required investigation. However, an investigation was made of the deaths of five beef animals that strayed into Area 51. As the animals had been dead for 7 to 10 days, a necropsy was not possible and a definite cause of death was not determined. The deaths appeared to have been sudden. Analyses of the sources of their drinking water were negative for common toxins. There has been no recurrence of deaths of other cattle in the area.

TABLE 12. DEER POPULATION ESTIMATES BY THE LINCOLN INDEX METHOD

	Echo Peak Section Area 19		Dead Horse Flats Section Area 19		Area 20		Rainier Mesa Section Area 12	
	Bucks	Does	Bucks	Does	Bucks	Does*	Bucks	Does
Mean	54.5	27.6	21.2	10.3	7.0		21.6	21.5
S.D.	12.9	15.0	10.8	4.4	4.0		10.3	14.5
C.I.	28.7-80.3	26-57.5	16-42.8	4-19.1	4-15		5-42.2	4-50.6

*No marked does in this area.
S.D. = Standard Deviation
C.I. = Confidence Interval (95%)

During August, 21 mourning doves (Zenodia macroura) were captured at the Area 15 farm and leg bands applied. No returns of these bands or of those applied during 1976 have been reported. Hopefully, returns in the future will give an indication of the migratory pattern of these birds from the Nevada Test Site.

Rehabilitation of the natural springs of the Nevada Test Site continued with the repair of flood damage at White Rock and Captain Jack springs. A new waterline was installed at Captain Jack spring and the metal reservoir was secured by bolting it to the bedrock.

PUBLIC INFORMATION

The off-site public information program continued by direct contact with ranchers, by public displays, by lectures to civic organizations, and by briefings of groups touring the Environmental Monitoring and Support Laboratory-Las Vegas or the Nevada Test Site facilities. During 1977, the objectives and findings of the Animal Investigation Program were presented to 569 Nevada Test Site visitors in 17 different tour groups. Approximately 200 additional drop-in visitors to the farm received informal briefings.

A rumen-fistulated steer, "Big Sam," was the feature attraction at an educational exhibit at the Clark County Southern Nevada Youth Fair held in March at the Las Vegas Convention Center. An estimated 10,000 to 15,000 people visited the display and heard "Big Sam's" taped story and received literature on the Animal Investigation Program's objectives and findings (see appendix K).

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APPENDIX A. SUMMARY OF ANALYTICAL PROCEDURES AND MINIMUM DETECTABLE ACTIVITIES

Type of Analysis	Analytical Equipment	Counting Period (min)	Analytical Procedures	Sample Size	Minimum Detectable Activities (pCi/total sample)*
Gamma Spectroscopy	Lithium-drifted germanium detectors calibrated at approximately 0.5 keV per channel input to 4096 channels resident in the core of the PDP 11/20 computer.	~1,200	Radionuclide concentrations quantitated from gamma spectrum by PDP 11/20 computer using a least squares technique.	200-ml aluminum cans	For: ^{54}Mn, ^{60}Co, ^{95}Zr, ^{103}Ru, ^{124}Sb, ^{132}Te, ^{131}I, ^{134}I, ^{137}Cs, ^{140}Ba 7 pCi For: ^{125}Sb, ^{141}Ce - 30 pCi For: ^{65}Zn, ^{106}Ru, ^{144}Ce - 20 pCi For: ^{181}W - 85 pCi For: ^{241}Am - 35 pCi For: ^{22}Na - 4 pCi For: K - 0.08 g
$^{89-90}Sr$	Low-background thin-window, gas-flow proportional counter with a 5.7-cm diameter window (80 μg/cm^2).	50	Chemical separation by ion exchange. Separated sample counted successively; activity calvulated by simultaneous equations.	2 g of ash	For: ^{89}Sr - 5 pCi ^{90}Sr - 2 pCi
^{3}H	Automatic liquid scintillation counter with output printer.	200	Sample prepared by distillation.	5 ml	~0.2 pCi/ml H_2O
$^{238-239}Pu$ ^{234}, ^{235}, ^{238}U	Alpha spectrometer with silicon surface barrier detectors operated in vacuum chambers.	400-1,400	Ash sample is digested with acid, purified by solvent extraction and/or ion exchange, electroplated on stainless steel planchet, and counted by alpha spectrometer.	100 g - 1 kg wet weight 1 - 10 g ash	For all isotopes - ~0.02 pCi

*The minimum detectable activities in terms of total activity per sample for standard geometries and counting times are based on a combination of a number of technical experiments and operational experience. By means of experimentation, the minimum detectable activities were defined as those activities which produced ± 100 percent deviations at the 95 percent confidence level. These values are approximations and are applicable to ideal conditions and simple complexes of nuclides. Complex spectra or spectra showing naturally occurring radionuclides can raise the minimum detectable activities considerably. The detection limit for each sample is defined as that radioactivity which equals the two-sigma counting error.

TABLE B-1. PLUTONIUM CONCENTRATIONS IN LUNGS, BEEF CATTLE, AREA 18, NTS, 1977

MAY 1977				OCTOBER 1977			
Animal No.	^{238}Pu (pCi/g Ash) (pCi/kg*)	^{239}Pu (pCi/g Ash) (pCi/kg*)	Ash (%)	Animal No.	^{238}Pu (pCi/g Ash) (pCi/kg*)	^{239}Pu (pCi/g Ash) (pCi/kg*)	Ash (%)
1	<0.02 <0.26	0.19 ± 0.03 2.5 ± 0.4	1.3	7	0.012 ± 0.005 0.64 ± 0.27	0.12 ± 0.02 6.4 ± 1.1	5.4
2	<0.02 <0.37	0.1 ± 0.02 1.9 ± 0.4	1.9	8	0.006 ± 0.004 0.33 ± 0.22	0.03 ± 0.01 1.7 ± 0.55	5.5
3	0.02 ± 0.01 0.34 ± 0.17	0.14 ± 0.03 2.3 ± 0.5	1.7	9	0.012 ± 0.006 0.67 ± 0.34	0.12 ± 0.02 6.7 ± 1.1	5.6
Fetus 3	0.009 ± 0.004 0.4 ± 0.2	0.006 ± 0.003 0.25 ± 0.15	4.5	10	0.014 ± 0.008 0.79 ± 0.45	0.07 ± 0.02 4.0 ± 1.1	5.7
4	0.02 ± 0.01 0.14 ± 0.07	0.1 ± 0.02 0.7 ± 0.14	0.7	11	<0.004 <0.18	0.011 ± 0.005 0.5 ± 0.23	4.6
5	<0.02 <0.4	<0.02 <0.4	2.0	12	0.006 ± 0.003 0.44 ± 0.22	0.006 ± 0.003 0.44 ± 0.22	7.3
6	<0.02 <0.2	0.1 ± 0.05 1.0 ± 0.5	1.0				
Median	<0.02 0.34	0.1 1.0	1.7		0.009 0.54	0.05 2.9	5.6
Range	0.009-<0.02 0.14-0.4	0.006-0.19 0.25-2.5	0.7-4.5		<0.004-0.014 <0.18-0.79	0.006-0.12 0.44-6.7	4.6-7.3

*Wet weight

TABLE B-2. PLUTONIUM CONCENTRATIONS IN TRACHEOBRONCHIAL LYMPH NODES, BEEF CATTLE, AREA 18, NTS, 1977

MAY 1977				OCTOBER 1977			
Animal No.	^{238}Pu (pCi/g Ash) (pCi/kg*)	^{239}Pu (pCi/g Ash) (pCi/kg*)	Ash (%)	Animal No.	^{238}Pu (pCi/g Ash) (pCi/kg*)	^{239}Pu (pCi/g Ash) (pCi/kg*)	Ash (%)
1	0.05 ± 0.02 2.9 ± 1.2	1.2 ± 0.14 71 ± 25	5.9	7	0.69 ± 0.34 7.4 ± 3.6	14 ± 1.8 150 ± 19	1.1
2	<0.02 <1.3	0.26 ± 0.15 17 ± 10	6.5	8	0.11 ± 0.07 2.4 ± 1.5	0.44 ± 0.14 9.7 ± 3.1	2.2
3	0.09 ± 0.04 7.3 ± 3.3	1.2 ± 0.15 100 ± 12	8.1	9	0.18 ± 0.08 15 ± 6.8	1.9 ± 0.3 160 ± 26	8.5
4	<0.02 <1.1	<0.02 <1.1	5.9	10	<0.02 <4	0.08 ± 0.035 13 ± 5.8	16.5
5	<0.1 <3.5	<0.02 <0.71	3.5	11	<0.006 <1.5	<0.006 <1.5	25.7
6	<0.09 <12	<0.02 <2.5	13	12	0.04 ± 0.02 12 ± 5.8	0.02 ± 0.01 5.8 ± 2.9	29
Median	<0.07 <3.2	<0.14 <9.8	6.2		0.075 5.7	0.26 11.4	12.5
Range	<0.02-<0.1 <1.1-<12	<0.02-1.2 <0.71-100	3.5-13		<0.006-0.69 <1.5-15	<0.006-14 <1.5-160	1.1-29

*Wet weight

TABLE B-3. PLUTONIUM CONCENTRATIONS IN MUSCLES, BEEF CATTLE, AREA 18, NTS, 1977

MAY 1977				OCTOBER 1977			
Animal No.	^{238}Pu (pCi/g Ash) (pCi/kg*)	^{239}Pu (pCi/g Ash) (pCi/kg*)	Ash (%)	Animal No.	^{238}Pu (pCi/g Ash) (pCi/kg*)	^{239}Pu (pCi/g Ash) (pCi/kg*)	Ash (%)
1	<0.02 <0.76	<0.02 <0.76	3.8	7	0.003 ± 0.002 0.18 ± 0.12	0.03 ± 0.01 1.8 ± 0.6	6
2	<0.02 <0.59	<0.02 <0.59	2.9	8	<0.003 <0.15	<0.006 <0.31	5.1
3	<0.02 <0.4	<0.02 <0.4	2	9	0.005 ± 0.004 0.27 ± 0.21	<0.002 <0.13	5.3
Fetus 3	0.02 ± 0.01 1.2 ± 0.5	<0.001 <0.057	5.2	10	<0.004 <0.19	0.007 ± 0.004 0.33 ± 0.19	4.7
4	<0.02 <0.35	<0.02 <0.35	1.8	11	<0.004 <0.24	0.009 ± 0.007 0.53 ± 0.42	6
5	<0.02 <0.22	<0.02 <0.22	1.1	12	0.01 ± 0.004 0.6 ± 0.2	<0.003 <0.18	6
6	0.02 ± 0.01 0.21 ± 0.1	0.71 ± 0.09 7.3 ± 0.9	1				
Median	<0.02 <0.4	<0.02 <0.4	2.3		<0.004 <0.22	<0.007 <0.32	5.7
Range	<0.02-0.02 0.21-1.2	<0.001-0.71 <0.057-7.3	1-5.2		<0.003-0.01 <0.15-0.6	<0.002-0.03 <0.13-1.8	4.7-6

*Wet weight

TABLE B-4. PLUTONIUM CONCENTRATIONS IN LIVERS, BEEF CATTLE, AREA 18, NTS, 1977

MAY 1977				OCTOBER 1977			
Animal No.	^{238}Pu (pCi/g Ash) (pCi/kg*)	^{239}Pu (pCi/g Ash) (pCi/kg*)	Ash (%)	Animal No.	^{238}Pu (pCi/g Ash) (pCi/kg*)	^{239}Pu (pCi/g Ash) (pCi/kg*)	Ash (%)
1	<0.02 <1.2	<0.02 <1.2	6.3	7	0.006 ± 0.003 0.42 ± 0.21	0.03 ± 0.01 2.1 ± 0.7	7
2	<0.02 <0.93	<0.02 <0.93	4.7	8	<0.004 <0.27	0.02 ± 0.01 1.4 ± 0.7	6.8
3	<0.02 <1	<0.02 <1	4.9	9	0.007 ± 0.005 0.41 ± 0.27	0.07 ± 0.02 4.1 ± 1.2	5.9
Fetus 3	0.004 ± 0.002 0.24 ± 0.12	<0.001 <0.062	6.9	10	0.003 ± 0.002 0.18 ± 0.12	0.03 ± 0.01 1.8 ± 0.6	6
4	<0.02 <0.28	0.16 ± 0.03 2.2 ± 0.4	1.4	11	0.01 ± 0.005 0.69 ± 0.35	0.03 ± 0.01 2.1 ± 0.7	7
5	<0.02 <0.36	<0.02 <0.36	1.8	12	0.01 ± 0.004 0.64 ± 0.26	<0.03 <0.19	6.4
6	<0.02 <0.35	0.03 ± 0.01 0.53 ± 0.18	1.8				
Median	<0.02 <0.36	<0.02 <0.93	4.7		0.007 0.42	0.03 1.9	6.6
Range	0.004-<0.02 0.24-<1.2	<0.001-0.16 <0.062-2.2	1.4-6.9		0.003-0.01 0.18-0.69	0.02-0.07 <0.19-4.1	5.9-7

*Wet weight

TABLE B-5. PLUTONIUM CONCENTRATIONS IN GONADS, BEEF CATTLE, AREA 18, NTS, 1977

MAY 1977				OCTOBER 1977			
Animal No.	^{238}Pu (pCi/g Ash) (pCi/kg*)	^{239}Pu (pCi/g Ash) (pCi/kg*)	Ash (%)	Animal No.	^{238}Pu (pCi/g Ash) (pCi/kg*)	^{239}Pu (pCi/g Ash) (pCi/kg*)	Ash (%)
Samples not collected for animals 1-6				7	0.07 ± 0.04 3.2 ± 1.9	0.09 ± 0.05 4.2 ± 2.3	4.6
				8	0.13 ± 0.09 2.5 ± 1.8	0.13 ± 0.09 2.5 ± 1.8	2
				9	<0.04 <1.6	<0.03 <1.2	4
				10	<0.003 <0.12	<0.004 <0.16	3.9
				11	0.02 ± 0.01 1.1 ± 0.53	<0.004 <0.21	5.4
				12	0.011 ± 0.008 0.46 ± 0.34	0.009 ± 0.007 0.38 ± 0.29	4.2
				Median	<0.03 <1.4	<0.02 <0.79	4.4
				Range	<0.003-0.13 <0.12-3.2	<0.004-0.13 <0.16-4.2	2-5.4

*Wet weight

TABLE B-6. PLUTONIUM CONCENTRATIONS IN RUMEN CONTENTS, BEEF CATTLE, AREA 18, NTS, 1977

MAY 1977				OCTOBER 1977			
Animal No.	^{238}Pu (pCi/g Ash) (pCi/kg*)	^{239}Pu (pCi/g Ash) (pCi/kg*)	Ash (%)	Animal No.	^{238}Pu (pCi/g Ash) (pCi/kg*)	^{239}Pu (pCi/g Ash) (pCi/kg*)	Ash (%)
1	<0.02 <0.29	0.06 ± 0.01 0.88 ± 0.15	1.5	7	0.07 ± 0.01 1.9 ± 0.28	0.45 ± 0.04 12 ± 1.1	2.8
2	0.06 ± 0.02 1.2 ± 0.4	1.1 ± 0.16 21 ± 3	2	8	0.04 ± 0.02 1.2 ± 0.59	0.43 ± 0.09 13 ± 2.7	3
3	<0.02 <0.5	0.05 ± 0.01 1.3 ± 0.3	2.5	9	0.06 ± 0.02 2.4 ± 0.81	0.15 ± 0.03 6.1 ± 1.2	4.1
4	0.17 ± 0.03 7.6 ± 1.3	0.91 ± 0.12 41 ± 5	4.5	10	0.012 ± 0.007 0.3 ± 0.19	0.13 ± 0.03 3.6 ± 0.83	2.8
5	0.03 ± 0.01 0.57 ± 0.19	0.19 ± 0.03 3.5 ± 0.5	1.9	11	0.008 ± 0.006 0.28 ± 0.21	0.13 ± 0.03 4.5 ± 1	3.5
6	0.07 ± 0.01 1.3 ± 0.2	0.27 ± 0.03 5 ± 0.5	1.9	12	0.02 ± 0.005 0.98 ± 0.21	0.19 ± 0.02 8.1 ± 0.85	4.3
Median	0.05 0.79	0.23 4.8	2		0.03 1.1	0.17 7.1	3.3
Range	<0.02-0.17 <0.29-7.6	0.05-1.1 0.88-41	1.5-4.5		0.008-0.07 0.28-2.4	0.13-0.45 3.6-13	2.8-4.3

*Wet weight

TABLE B-7. PLUTONIUM CONCENTRATIONS IN RETICULUM SEDIMENTS, BEEF CATTLE, AREA 18, NTS, 1977

MAY 1977				OCTOBER 1977			
Animal No.	^{238}Pu (pCi/g Ash) (pCi/kg*)	^{239}Pu (pCi/g Ash) (pCi/kg*)	Ash (%)	Animal No.	^{238}Pu (pCi/g Ash) (pCi/kg*)	^{239}Pu (pCi/g Ash) (pCi/kg*)	Ash (%)
1	0.34 ± 0.04 168 ± 20	0.58 ± 0.05 287 ± 25	50	7	2.3 ± 0.24 1,700 ± 180	93 ± 9.3 70,000 ± 7,000	75
2	<0.02 <14	<0.02 <14	68	8	0.27 ± 0.3 218 ± 24	0.94 ± 0.09 760 ± 72	81
3	<0.02 <14	0.03 ± 0.01 21 ± 7	71	9	0.09 ± 0.02 89 ± 20	0.4 ± 0.05 400 ± 49	99
4	<0.02 <10	0.26 ± 0.7 138 ± 37	53	10	0.5 ± 0.06 340 ± 41	25 ± 2.3 17,000 ± 1,600	69
5	<0.02 <8.4	0.09 ± 0.02 38 ± 8	42	11	0.47 ± 0.05 260 ± 28	2 ± 0.15 1,100 ± ± 80	56
6	<0.02 <10	0.05 ± 0.01 26 ± 5	13	12	0.24 ± 0.04 76 ± 13	0.97 ± 0.1 310 ± 32	32
Median	<0.02 <12	0.07 32	52.5		0.37 240	1.5 980	72
Range	<0.02-0.34 <8.4-168	<0.02-0.58 <14-287	13-71		0.09-2.3 76-1,700	0.4-93 310-70,000	32-99

*Wet weight

TABLE B-8. PLUTONIUM AND STRONTIUM CONCENTRATIONS IN FEMURS, BEEF CATTLE, AREA 18, NTS, MAY 1977

Animal No.	^{238}Pu (pCi/g Ash) (pCi/kg*)	^{239}Pu (pCi/g Ash) (pCi/kg*)	^{89}Sr† (pCi/g Ash) (pCi/kg*)	^{90}Sr† (pCi/g Ash) (pCi/kg*)	Ash (%)
1	<0.01 <2.9	<0.02 <5.9	<1.2 <370	3.3 ± 0.63 1,000 ± 190	30
Dupl. 1	<0.01 <2.9	<0.02 <5.8			30
2	<0.01 <2.3	<0.01 <2.3	<1.2 <270	3.6 ± 0.61 820 ± 140	23
3	<0.02 <5.5	<0.02 <5.5	<1.4 <380	2.8 ± 0.68 770 ± 190	28
Dupl. 3	<0.01 <2.8	<0.01 <2.8			28
Fetus 3	<0.01 <1.1	<0.01 <1.1	<1.1 <120	2.4 ± 0.52 260 ± 57	11
4	<0.01 <2.4	<0.02 <4.7	<1.4 <330	3.2 ± 0.71 760 ± 120	24
Dupl. 4	<0.01 <2.4	<0.01 <2.4			24
5	<0.02 <4	<0.02 <4	<1.3 <260	3.4 ± 0.7 670 ± 140	20
6	<0.01 <1.9	<0.02 <3.8	<1.2 <220	3.1 ± 0.63 580 ± 120	19
Median	<0.01 <2.6	<0.02 <3.9	<1.2 <270	3.2 760	24
Range	<0.01-<0.02 <1.1-<5.5	<0.01-<0.02 <1.1-<5.9	<1.1-<1.4 <120-<380	2.4-3.6 260-1,000	11-30

*Wet weight
†Strontium analysis by EMSL-LV

TABLE B-9. PLUTONIUM AND STRONTIUM CONCENTRATIONS IN FEMURS, BEEF CATTLE, AREA 18, NTS, OCTOBER 1977

Animal No.	^{238}Pu (pCi/g Ash) (pCi/kg*)	^{239}Pu (pCi/g Ash) (pCi/kg*)	^{89}Sr (pCi/g Ash) (pCi/kg*)	^{90}Sr (pCi/g Ash) (pCi/kg*)	Ash (%)
7	<0.002 <0.62	<0.003 <0.81	<8.5 <2,300	4.1 ± 0.8 1,700 ± 220	27
8	<0.002 <0.86	0.003 ± 0.003 1.1 ± 1.0	<2.4 <880	3 ± 0.7 1,100 ± 260	37
9	<0.003 <0.81	0.005 ± 0.003 1.5 ± 0.93	<9.3 <2,700	3.8 ± 0.9 1,100 ± 260	29
10	<0.003 <0.76	<0.003 <0.97	<8 <2,400	4.3 ± 0.8 1,300 ± 240	30
11	<0.002 <0.39	0.011 ± 0.004 2.5 ± 0.80	<4.3 <1,000	3.8 ± 0.83 870 ± 190	23
12	<0.002 <0.25	<0.003 <0.47	<2.3 <320	2.9 ± 0.7 400 ± 98	14
Median	<0.002 <0.69	<0.003 <1	<6.2 <1,700	3.8 1,100	28
Range	<0.002-<0.003 <0.25-<0.86	<0.003-0.011 <0.47-2.5	<2.4-<9.3 <320-<2,700	2.9-4.3 400-1,300	14-37

*Wet weight

TABLE B-10. PLUTONIUM CONCENTRATIONS IN WHOLE FETUS, BEEF CATTLE, AREA 18, NTS, 1977

Animal No.	^{238}Pu (pCi/g Ash) (pCi/kg*)	^{239}Pu (pCi/g Ash) (pCi/kg*)	Ash (%)
Fetus 8	0.01 ± 0.003 0.44 ± 0.13	0.09 ± 0.02 4 ± 0.88	4.4
Fetus 9	<0.015 <0.38	<0.006 <0.15	2.5

TABLE B-11. GAMMA-EMITTING RADIONUCLIDES AND TRITIUM CONCENTRATIONS IN SELECTED TISSUES, BEEF CATTLE, AREA 18, NTS, MAY 1977

	MUSCLE	LUNGS	LIVER	KIDNEY	RUMEN CONTENTS	THYROID	BLOOD
Animal No.	K (g/kg*) ^{137}Cs (pCi/kg*)	K (g/kg*)	K (g/kg*)	K (g/kg*) ^{137}Cs (pCi/kg*)	K (g/kg*) ^{137}Cs (pCi/kg*) ^{95}Zr (pCi/kg*)	K (g/kg*)	^{3}H (pCi/l)
1	3 ± 0.3 16 ± 5.3	12 ± 1.2	2.6 ± 0.3	6.3 ± 0.6 <MDA	2 ± 1.1 <MDA <MDA	3.6 ± 0.8	<270
2	8.7 ± 0.7 <MDA	3.5 ± 0.5	6.9 ± 0.6	2.4 ± 0.3 <MDA	<MDA <MDA <MDA	4.7 ± 1.3	<270
3	3.8 ± 0.3 <MDA	2.8 ± 0.4	3.3 ± 0.3	7.3 ± 0.7 <MDA	1.3 ± 0.6 <MDA 300 ± 140	<MDA	<270
Fetus 3	2.8 ± 0.3 <MDA	2 ± 0.2	3.4 ± 0.3	SNC	SNC	<MDA	SNC
4	8.7 ± 0.6 <MDA	10 ± 0.9	6.8 ± 0.6	6.8 ± 0.6 <MDA	1.4 ± 0.5 45 ± 24 <MDA	<MDA	<270
5	7.4 ± 0.7 <MDA	2.5 ± 0.4	3.4 ± 0.3	7.4 ± 0.7 <MDA	0.8 ± 0.4 <MDA 94 ± 46	<MDA	<270
6	8.4 ± 0.6 <MDA	3.2 ± 0.4	3.7 ± 0.3	3 ± 0.3 12 ± 6.7	2.4 ± 1.2 <MDA <MDA	<MDA	<270
Median	7.4 <MDA	3.2	3.4	6.6 <MDA	1.4 <MDA <MDA	<MDA	<270
Range	2.8-8.7 <MDA-16	2-12	2.6-6.9	2.4-7.4 <MDA-12	0.8-2.4 <MDA-45 <MDA-300	<MDA-4.7	<270

*Wet weight
<MDA = less than minimum detectable activity
SNC = Sample not collected

TABLE B-12. GAMMA-EMITTING RADIONUCLIDES AND TRITIUM CONCENTRATIONS IN SELECTED TISSUES, BEEF CATTLE, AREA 18, NTS, OCTOBER 1977

	MUSCLE	LUNGS	LIVER	KIDNEY	RUMEN CONTENTS	THYROID	BLOOD
Animal No.	K (g/kg*)	K (g/kg*) ^{95}Zr (pCi/kg*)	K (g/kg*)	K (g/kg*) ^{137}Cs (pCi/kg*)	K (g/kg*) ^{95}Zr (pCi/kg*) ^{103}Ru (pCi/kg*) ^{137}Cs (pCi/kg*) ^{141}Ce (pCi/kg*)	^{131}I (pCi/g*)	^{3}H (pCi/l)
7	8.8 ± 0.7	3.3 ± 0.4 160 ± 72	7.5 ± 0.6	2.1 ± 0.24 <MDA	1.6 ± 0.2 860 ± 80 150 ± 27 36 ± 12 280 ± 23	740 ± 13	<290
8	3.6 ± 0.46	8.3 ± 0.61 <MDA	8.2 ± 0.6	2.3 ± 0.23 <MDA	1.3 ± 0.23 1,900 ± 850 140 ± 31 28 ± 10 470 ± 20	700 ± 12	<290
9	3.9 ± 0.34	11 ± 1 1,400 ± 320	3.8 ± 0.3	2.3 ± 0.23 <MDA	1.9 ± 0.22 1,400 ± 98 210 ± 100 <MDA 150 ± 16	770 ± 13	<280
10	4.1 ± 0.3	11 ± 1 <MDA	3.2 ± 0.3	8.4 ± 0.65 <MDA	6 ± 0.6 320 ± 110 100 ± 63 <MDA 100 ± 54	710 ± 13	<290
11	5.3 ± 0.5	3 ± 0.4 <MDA	6.8 ± 0.7	2.3 ± 0.25 <MDA	10 ± 1 1,300 ± 170 110 ± 85 <MDA 540 ± 87	730 ± 14	<290
12	7.7 ± 0.7	3 ± 0.3 <MDA	8 ± 0.6	2.3 ± 0.24 47 ± 11	6.8 ± 0.7 2,300 ± 200 260 ± 37 <MDA 680 ± 83	650 ± 12	<290
Median	4.7	5.8 <MDA	7.2	2.3 <MDA	4 1,350 145 <MDA 380	720	<285
Range	3.6-8.8	3-11 <MDA-1,400	3.2-8.2	2.1-8.4 <MDA-47	1.3-10 320-2,300 100-260 <MDA-36 100-680	650-770	<280-<290

*Wet weight
<MDA = less than minimum detectable activity

TABLE C-1. PLUTONIUM AND STRONTIUM CONCENTRATIONS IN SELECTED TISSUES, OTHER CATTLE, NTS, 1977

Tissue Type	Animal No.	^{238}Pu (pCi/g Ash) (pCi/kg*)	^{239}Pu (pCi/g Ash) (pCi/kg*)	^{89}Sr (pCi/g Ash) (pCi/kg*)	^{90}Sr (pCi/g Ash) (pCi/kg*)	Ash (%)
Lungs	251	<0.003 <0.21	<0.004 <0.28	NA	NA	.7
Lungs	761	0.082 ± 0.024 1.4 ± 0.4	1.8 ± 0.12 30 ± 2	NA	NA	1.7
Muscles	251	<0.002 <0.12	0.01 ± 0.005 0.59 ± 0.3	NA	NA	5.9
Muscles	761	<0.02 <0.97	<0.02 <0.97	NA	NA	4.8
Liver	251	<0.005 <0.43	0.005 ± 0.004 0.43 ± 0.34	NA	NA	8.6
Liver	761	<0.02 <0.87	0.09 ± 0.009 3.9 ± 0.4	NA	NA	4.4
Femur	251	<0.002 <0.87	<0.002 <0.78	<2.4 <1,000	1.7 ± 0.6 710 ± 230	41
Femur	761	<0.002 <0.78	0.004 ± 0.002 1.2 ± 0.8	<1.1 <340	2.2 ± 0.44 700 ± 140	32
Rumen Content	251	0.009 ± 0.005 0.13 ± 0.07	0.27 ± 0.04 4.1 ± 0.6	NA	NA	1.5
Rumen Content	761	← SAMPLE NOT COLLECTED →				

*Wet weight
NA = Not analyzed

TABLE C-2. GAMMA-EMITTING RADIONUCLIDE AND TRITIUM CONCENTRATIONS IN SELECTED TISSUES, OTHER CATTLE, NTS. 1977

	MUSCLE	LUNGS	LIVER	KIDNEY	RUMEN CONTENTS	THYROID	BLOOD
Animal No.	K (g/kg*)	K (g/kg*)	K (g/kg*)	K (g/kg*)	K (g/kg*)	^{131}I (pCi/g*)	^{3}H (pCi/l)
251	3.4 ± 0.29	3.0 ± 0.42	7.8 ± 0.64	6.7 ± 0.63	1.7 ± 0.34	<MDA	4,300 ± 350
761	9.5 ± 0.7	3.3 ± 0.6	3.4 ± 0.4	SNC	SNC	SNC	<280
348†	SNC	SNC	SNC	SNC	SNC	9.3 ± 0.24	SNC
517†	SNC	SNC	SNC	SNC	SNC	6.3 ± 0.19	SNC
221†	SNC	SNC	SNC	SNC	SNC	12 ± 0.16	SNC

*Wet weight

†Animal numbers 348 and 221 were surplus Holstein dairy cows and animal number 517 was a surplus Hereford bull; these three animals were removed from the Area 15 herd on September 30. Thyroid samples were collected to monitor the iodine-131 in the worldwide fallout from the atmospheric nuclear detonation conducted by the People's Republic of China on September 17.

SNC = Sample not collected

TABLE D-1. PLUTONIUM CONCENTRATIONS IN SELECTED TISSUES, MULE DEER, NTS, 1977

LUNGS				GONADS			
Animal No.	^{238}Pu (pCi/g Ash) (pCi/kg*)	^{239}Pu (pCi/g Ash) (pCi/kg*)	Ash (%)	Animal No.	^{238}Pu (pCi/g Ash) (pCi/kg*)	^{239}Pu (pCi/g Ash) (pCi/kg*)	Ash (%)
1	<0.003 <0.11	<0.003 <0.12	3.5	1	<0.01 <0.08	<0.02 <0.16	0.8
2	<0.02 <0.68	<0.02 <0.68	3.4	2	← SAMPLE NOT COLLECTED →		
Fetus 2	0.02 ± 0.01 0.4 ± 0.31	<0.002 <0.058	2.7	3	<0.02 <0.9	<0.02 <0.9	4.7
3	<0.04 <0.59	<0.04 <0.59	1.5	4	0.03 ± 0.02 0.83 ± 0.63	0.06 ± 0.03 1.4 ± 0.83	2.4
4	0.009 ± 0.005 0.52 ± 0.29	0.009 ± 0.005 0.52 ± 0.29	5.8	5	← SAMPLE NOT COLLECTED →		
Dupl. 4	<0.004 <0.21	<0.005 <0.27	5.4	6	<0.02 <0.5	0.06 ± 0.03 1.5 ± 0.75	2.5
5	<0.004 <0.25	0.005 ± 0.002 0.32 ± 0.19	6.3	7	← SAMPLE NOT COLLECTED →		
6	0.004 ± 0.002 0.27 ± 0.14	0.01 ± 0.002 0.67 ± 0.14	6.7	8	<0.02 <2.6	<0.02 <2.6	13.1
7	<0.02 <1.2	<0.02 <1.2	5.8				
8	<0.02 <1.2	<0.02 <1.2	5.8				
Median	0.009 0.40	0.009 0.52	5.4		0.02 0.83	<0.02 1.4	2.5
Range	<0.003-<0.04 <0.11-<1.2	<0.002-<0.04 <0.058-<1.2	1.5-6.7		<0.01-0.03 <0.08-<2.6	<0.2-0.06 <0.16-<2.6	0.8-13.1

(continued)

TABLE D-1. PLUTONIUM CONCENTRATIONS IN SELECTED TISSUES, MULE DEER, NTS, 1977 (continued)

LIVERS				MUSCLE			
Animal No.	^{238}Pu (pCi/g Ash) (pCi/kg*)	^{239}Pu (pCi/g Ash) (pCi/kg*)	Ash (%)	Animal No.	^{238}Pu (pCi/g Ash) (pCi/kg*)	^{239}Pu (pCi/g Ash) (pCi/kg*)	Ash (%)
1	<0.01 <0.45	<0.01 <0.45	4.5	1	<0.01 <0.44	<0.01 <0.44	4.4
1	<0.01 <0.45	<0.01 <0.45	4.5	2	<0.02 <0.94	<0.02 <0.94	4.7
2	<0.02 <0.65	<0.02 <0.65	3.3	Dupl. 2	<0.06 <0.63	<0.04 <0.42	1.1
Fetus 2	<0.003 <0.11	<0.011 <0.45	4.2	Fetus 2	<0.01 <0.48	<0.01 <0.48	4.8
3	<0.02 <1.1	<0.02 <1.1	5.7	3	<0.02 <0.71	<0.02 <0.71	3.6
4	0.01 ± 0.008 0.54 ± 0.43	0.02 ± 0.01 0.97 ± 0.54	5.4	4	<0.02 <0.12	0.004 ± 0.003 0.24 ± 0.18	6.1
Dupl. 4	<0.005 <0.12	<0.003 <0.07	2.3	Dupl. 4	<0.007 <0.42	<0.005 <0.3	6
5	<0.004 <0.34	0.005 ± 0.002 0.43 ± 0.17	8.3	5	0.004 ± 0.003 0.3 ± 0.22	0.013 ± 0.004 0.97 ± 0.3	7.4
6	<0.003 <0.19	<0.008 <0.5	2.3	6	0.01 ± 0.005 0.66 ± 0.33	0.02 ± 0.01 1.3 ± 0.66	
7	<0.02 <0.31	<0.02 <0.31	3.5	7	← SAMPLE NOT COLLECTED →		
8	<0.02 <1.2	<0.02 <1.2	5.9	8	<0.02 <0.88	<0.02 <0.88	4.4
Median	<0.01 <0.45	<0.01 <0.45	3.9		<0.015 <0.55	<0.01 <0.59	4.75
Range	<0.003-0.02 <0.11-<1.2	<0.008-<0.02 <0.31-<1.2	2.3-8.3		<0.003-<0.06 <0.12-<0.88	<0.003-<0.02 <0.24-1.3	1.1-7.4

(continued)

TABLE D-1. PLUTONIUM CONCENTRATIONS IN SELECTED TISSUES, MULE DEER, NTS, 1977 (continued)

RUMEN CONTENTS			
Animal No.	^{238}Pu (pCi/g Ash) (pCi/kg*)	^{239}Pu (pCi/g Ash) (pCi/kg*)	Ash (%)
1	<0.003 <0.073	0.04 ± 0.008 1.1 ± 0.22	2.9
2	<0.02 <0.39	<0.02 <0.39	1.9
3	0.05 ± 0.04 0.67 ± 0.54	<0.02 <0.27	1.4
4	0.02 ± 0.01 1.1 ± 0.4	0.04 ± 0.01 2.9 ± 0.73	6.6
Fetus 4	<0.006 <0.32	0.01 ± 0.05 0.54 ± 0.27	5.4
5	0.07 ± 0.02 1.7 ± 0.47	0.26 ± 0.4 6.2 ± 0.96	2.4
6	0.01 ± 0.004 0.68 ± 0.27	0.04 ± 0.01 2.7 ± 0.68	6.8
7	0.03 ± 0.01 1.1 ± 0.35	0.48 ± 0.06 17 ± 2.1	3.5
8	0.03 ± 0.01 0.86 ± 0.29	0.05 ± 0.02 1.4 ± 0.57	2.9
Median	0.02 0.86	0.04 1.40	2.9
Range	<0.003-0.07 <0.073-1.7	0.01-0.48 0.27-17	1.9-6.8

*Wet weight
†Laboratory duplicate samples

TABLE D-2. PLUTONIUM AND STRONTIUM CONCENTRATIONS IN BONES (HOCK), MULE DEER, NTS. 1977

Animal No.	^{238}Pu (pCi/g Ash) (pCi/kg*)	^{239}Pu (pCi/g Ash) (pCi/kg*)	^{89}Sr (pCi/g Ash) (pCi/kg*)	^{90}Sr (pCi/g Ash) (pCi/kg*)	Ash (%)
1	<0.02 <5.2	<0.04 <10	<1.3 <350	1.8 ± 0.42 460 ± 110	26.1
2	<0.02 <5.4	<0.04 <10	<1.4 <370	2.7 ± 0.63 730 ± 170	27
Fetus 2	<0.02 <4.3	<0.04 <8.5	<1.2 <250	1.8 ± 0.52 370 ± 110	21
3	<0.007 <0.7	<0.013 <1.2	<1.2 <110	1.9 ± 0.62 180 ± 59	9.5
4	0.003 ± 0.002 0.89 ± 0.59	0.006 ± 0.003 2.1 ± 0.97	2.8 ± 2 970 660	2.4 ± 0.58 800 ± 190	33
5	0.005 ± 0.003 1.4 ± 0.76	0.01 ± 0.003 3.4 ± 1	<0.3 <890	1.4 ± 0.63 430 ± 190	30
6	<0.004 <1.2	<0.002 <0.72	<1.6 <520	1.3 ± 0.5 410 ± 160	32
7	← SAMPLE NOT COLLECTED →				
8	<0.01 <2.2	<0.01 <2.2	<7.3 <1,600	2 ± 0.64 450 ± 140	22
Dupl. 8	0.02 ± 0.01 4.4 ± 2.2	0.01 ± 0.01 2.2 ± 2.2	NA	NA	22
Median	<0.01 <2.2	0.01 2.2	<1.35 <445	1.85 445	27
Range	0.003-0.02 <0.7-4.4	<0.002-<0.04 <0.72-<10	<0.3-<7.3 <110-<1,600	1.3-2.7 180-800	9.5-33

*Wet weight
NA = Not analyzed

TABLE D-3. GAMMA-EMITTING RADIONUCLIDE AND TRITIUM CONCENTRATIONS IN SELECTED TISSUES, MULE DEER, NTS, 1977

	MUSCLE	LUNGS	LIVER	KIDNEY	RUMEN CONTENTS	THYROID	KIDNEY*
Animal No.	K (g/kg†) ^{137}Cs (pCi/kg†)	K (g/kg†) ^{95}Zr (pCi/kg†)	K (g/kg†) ^{137}Cs (pCi/kg†) ^{95}Zr (pCi/kg†)	K (g/kg†) ^{137}Cs (pCi/kg†)	K (g/kg†) ^{137}Cs (pCi/kg†) ^{95}Zr (pCi/kg†)	^{131}I (pCi/g†)	^{3}H (pCi/l)
1	7.7 ± 0.6 <MDA	11 ± 0.9 <MDA	3.1 ± 0.3 <MDA <MDA	2.1 ± 0.2 <MDA	3.6 ± 0.4 <MDA 94 ± 25	SNC	<240
2	8 ± 0.6 <MDA	14 ± 1.2 <MDA	3.6 ± 0.3 <MDA <MDA	3 ± 0.3 <MDA	6 ± 1.2 <MDA <MDA	SNC	480,000 ± 2,800
Fetus 2	SNA SNA	6.8 ± 0.7 <MDA	1.7 ± 0.2 <MDA <MDA	SNC	SNC	SNC	480,000 ± 3,500
3	3.9 ± 0.4 <MDA	11 ± 1.1 <MDA	8.9 ± 0.7 <MDA <MDA	2.7 ± 0.3 <MDA	5.3 ± 0.5 33 ± 26 310 ± 85	<MDA	440 ± 270
4	8.2 ± 0.6 <MDA	2.7 ± 0.2 <MDA	7.5 ± 0.6 <MDA <MDA	2.9 ± 0.3 25 ± 6.1	3.5 ± 0.4 23 ± 20 140 ± 62	SNC	<290
5	8.8 ± 0.7 <MDA	2.8 ± 0.4 <MDA	8 ± 0.6 <MDA <MDA	2.9 ± 0.5 <MDA	4.3 ± 0.4 <MDA 100 ± 32	<MDA	<290
6	3.7 ± 0.3 11 ± 8.6	2 ± 0.3 560 ± 120	7.5 ± 0.6 <MDA <MDA	3.5 ± 0.4 <MDA	3.7 ± 0.5 <MDA 1,800 ± 79	SNC	NA
7	SL	10 ± 0.9 <MDA	3.1 ± 0.2 17 ± 7.2 <MDA	SL	4.3 ± 0.4 69 ± 21 630 ± 48	SL	SL
8	3.8 ± 0.3 23 ± 8.5	10 ± 0.9 <MDA	2.8 ± 0.2 <MDA 220 ± 74	5.8 ± 0.7 <MDA	5.3 ± 1.3 <MDA 3,400 ± 200	SNC	<270
Median	7.7 <MDA	10 <MDA	3.6 <MDA <MDA	2.9 MDA	4.3 <MDA 94	<MDA	<290
Range	3.7-8.8 <MDA-23	2-14 <MDA-560	1.7-8.9 <MDA-17 <MDA-220	2.1-5.8 <MDA-25	3.5-6 <MDA-69 <MDA-3,400	<MDA	<240- 480,000

*Aqueous portion of kidney
†Wet weight
<MDA = less than minimum detectable activity
SNC = Sample not collected
SNA = Sample not analyzed
SL = Sample lost

TABLE E-1. PLUTONIUM CONCENTRATIONS IN LUNGS, DESERT BIGHORN SHEEP, 1977

Animal No.	^{238}Pu (pCi/g Ash) (pCi/kg*)	^{239}Pu (pCi/g Ash) (pCi/kg*)	Ash (%)
1	<0.02 <1.6	<0.02 <1.6	7.8
2	<0.02 <0.87	0.02 ± 0.01 0.87 ± 0.43	4.3
3	<0.02 <1.5	<0.02 <1.5	7.4
4	← SAMPLE NOT COLLECTED →		
5	<0.02 <1.3	<0.02 ± 0.01 <1.3 ± 0.64	6.4
6	<0.02 <1.1	<0.02 <1.1	5.3
7	<0.02 <1.1	<0.02 <1.1	5.4
8	<0.02 <1.1	<0.02 <1.1	5.4
9	<0.02 <0.88	<0.02 <0.88	4.4
10	<0.02 <1.0	<0.02 <1.0	5
11	<0.02 <1.6	<0.02 <1.6	8.1
12	<0.02 <1.8	<0.02 <1.8	9.1
13	<0.02 <2.4	<0.02 <2.4	11.9
14	<0.02 <2.7	<0.02 <2.7	13.7
15	<0.02 <2.7	<0.02 <2.7	13.6
16	0.02 ± 0.01 1.1 ± 0.53	<0.02 <1.1	5.3
17	<0.02 <1.2	<0.02 <1.2	6.0
18	<0.02 <1.6	<0.02 <1.6	8.2
19	<0.02 <2.2	<0.02 <2.2	11.2
20	← SAMPLE NOT COLLECTED →		
Median	<0.02 <1.4	<0.02 <1.4	6.9
Range	<0.02-0.02 <0.87-<2.7	<0.02-0.02 0.87-<2.7	4.3-13

*Wet weight

TABLE E-2. PLUTONIUM CONCENTRATIONS IN LIVER, DESERT BIGHORN SHEEP, 1977

Animal No.	^{238}Pu (pCi/g Ash) (pCi/kg*)	^{239}Pu (pCi/g Ash) (pCi/kg*)	Ash (%)
1	← SAMPLE NOT COLLECTED →		
2	<0.02 <1.4	0.03 ± 0.01 2.1 ± 0.71	7.1
3	<0.02 <2.2	<0.02 <2.2	10.8
4	← SAMPLE NOT COLLECTED →		
5	<0.02 <1.4	0.14 ± 0.03 9.9 ± 2.1	7.1
6	← SAMPLE NOT COLLECTED →		
7	<0.02 <0.58	<0.02 <0.58	2.9
8	<0.02 <1.3	<0.02 <1.3	6.5
9	← SAMPLE NOT COLLECTED →		
10	<0.02 <2.1	<0.02 <2.1	10.6
11	← SAMPLE NOT COLLECTED →		
12	<0.02 <1.4	0.02 ± 0.01 1.4 ± 0.71	7.1
13	<0.02 <1.5	0.02 ± 0.01 1.5 ± 0.77	7.7
14	<0.02 <2.0	<0.02 <2.0	9.9
15	<0.02 <0.75	<0.02 <0.75	3.7
16	<0.02 <2.8	<0.02 <2.8	14.1
17	<0.02 <0.77	<0.02 <0.77	3.8
18	← SAMPLE NOT COLLECTED →		
19	<0.02 <2.2	<0.02 <2.2	11.0
20	← SAMPLE NOT COLLECTED →		
Median	<0.02 <1.4	<<0.02 <2.0	7.1
Range	<0.02-<0.02 <0.58-2.8	<0.02-0.14 <0.58-9.9	2.9-14.1

*Wet weight

TABLE E-3. PLUTONIUM AND STRONTIUM CONCENTRATIONS IN BONES, DESERT BIGHORN SHEEP, 1977

Animal No.	^{238}Pu (pCi/g Ash) (pCi/kg*)	^{239}Pu (pCi/g Ash) (pCi/kg*)	^{89}Sr (pCi/g Ash) (pCi/kg*)	^{90}Sr (pCi/g Ash) (pCi/kg*)	Ash (%)
1	0.01 ± 0.01 2.7 ± 2.7	<0.01 <2.7	<4.1 <1,100	3.1 ± 0.67 840 ± 180	27
2	<0.01 <2.7	<0.01 <2.7	<6.3 <1,700	4.1 ± 0.74 1,100 ± 200	27
3	0.02 ± 0.01 6.5 ± 3.2	<0.01 <3.2	<3.4 <1,100	1.7 ± 0.50 530 ± 160	32
4	0.01 ± 0.01 2.5 ± 2.5	<0.01 <2.5	<4.8 <1,200	2.8 ± 0.72 690 ± 180	25
5	0.02 ± 0.01 4.8 ± 2.4	<0.01 <2.4	<6.7 <1,600	3.5 ± 0.75 830 ± 180	24
6	<0.01 <3.1	<0.01 <3.1	<7.1 <2,200	5.2 ± 0.87 1,600 ± 270	31
7	0.02 ± 0.01 6.1 ± 3.1	<0.01 <3.1	<4.3 <1,300	3.3 ± 0.77 1,000 ± 230	30
8	0.01 ± 0.01 1.9 ± 1.9	<0.01 <1.9	<5.1 <960	<0.44 <85	19
9	0.01 ± 0.01 2.7 ± 2.7	<0.01 <2.7	<6.3 <1,700	3.7 ± 0.85 990 ± 230	27
10	0.01 ± 0.01 3.4 ± 3.4	<0.01 <3.4	<7.1 <2,400	2.7 ± 0.79 920 ± 270	34
Dupl. 10	<0.01 <3.4	<0.01 <3.4	NA	NA	34
11	<0.01 <3.3	<0.01 <3.3	<3.9 <1,300	2.7 ± 0.7 890 ± 230	33
12	<0.01 <2.4	<0.01 <2.4	<4.9 <1,700	4.3 ± 0.8 1,500 ± 280	24
13	0.01 ± 0.01 3.9 ± 3.9	<0.01 <3.9	<4.4 <1,700	2.0 ± 0.64 770 ± 250	39
14	0.01 ± 0.01 2.5 ± 2.5	0.01 ± 0.01 2.5 ± 2.5	<5.2 <1,300	5.6 ± 0.96 1,400 ± 240	25
15	<0.01 <2.4	<0.01 <2.4	<5.4 <1,300	3.1 ± 0.79 740 ± 190	24
16	0.01 ± 0.01 3.1 ± 3.1	<0.02 ± 0.02 6.2 ± 6.2	<6.1 <1,900	3.5 ± 0.87 1,100 ± 270	31
17	0.02 ± 0.01 5.4 ± 2.7	<0.01 <2.7	<3.4 <930	0.93 ± 0.48 250 ± 130	27
18	<0.01 <2.6	<0.01 <2.6	<4.2 <1,100	2.8 ± 0.65 740 ± 170	26
19	<0.01 <3.3	<0.01 <3.3	<14.3 <4,800	2.9 ± 0.66 980 ± 220	33
20	<0.01 <2.7	<0.01 <2.7	<5.6 <1,500	3.7 ± 0.85 990 ± 230	27
Median	0.01 <2.9	<0.01 <2.7	<5.1 <1,400	3.1 905	27
Range	<0.01-0.02 1.9-6.5	<0.01-0.02 <1.9-6.2	<3.4-<14.3 <930-<4,800	<0.44-5.6 <85-1,600	19-39

* Wet weight
NA = Not analyzed

TABLE E-4. GAMMA-EMITTING RADIONUCLIDE AND TRITIUM CONCENTRATIONS IN SELECTED TISSUES, DESERT BIGHORN SHEEP, 1977

Animal No.	LUNGS K (g/kg*) ^{95}Zr (pCi/kg*)	LIVER K (g/kg*) ^{137}Cs (pCi/kg*)	KIDNEY K (g/kg*) ^{137}Cs (pCi/kg*) ^{3}H (pCi/l)
1	2.6 ± 0.28 <MDA	SNC	SNC
2	11 ± 0.93 <MDA	3.0 ± 0.22 <MDA	4.3 ± 0.58 <MDA <270
3	12 ± 0.91 <MDA	3.1 ± 0.28 <MDA	16 ± 1.3 <MDA 460 ± 280
4	SNC	SNC	3.7 ± 0.57 61 ± 27 510 ± 280
5	13 ± 1.0 <MDA	3.1 ± 0.25 23 ± 12	16 ± 1.3 <MDA 420 ± 280
6	3.0 ± 0.31 <MDA	SNC	2.7 ± 0.24 <MDA 390 ± 280
7	3.0 ± 0.35 <MDA	7.7 ± 0.6 <MDA	18 ± 1.6 <MDA 690 ± 280
8	7.4 ± 0.58 <MDA	8.4 ± 0.57 <MDA	8.2 ± 0.79 <MDA <270
9	14 ± 1.2 <MDA	SNC	1.8 ± 0.29 <MDA 480 ± 280
10	18 ± 1.7 <MDA	3.5 ± 0.3 26 ± 10	21 ± 1.7 <MDA 630 ± 280
11	3.6 ± 0.44 <MDA	SNC	14 ± 1.1 <MDA 510 ± 280
12	4.1 ± 0.48 150 ± 130	7.9 ± 0.68 <MDA	SNC
13	11 ± 0.98 <MDA	8.4 ± 0.64 <MDA	5.1 ± 0.62 100 ± 26 390 ± 280
14	3.2 ± 0.44 <MDA	8.6 ± 0.61 <MDA	2.6 ± 0.26 29 ± 10 440 280
15	2.2 ± 0.37 <MDA	8.7 ± 0.67 <MDA	10 ± 0.83 <MDA <270
16	3.0 ± 0.33 <MDA	9.2 ± 0.72 <MDA	17 ± 1.2 <MDA 290 ± 270
17	14 ± 1.1 <MDA	7.4 ± 0.58 <MDA	4.4 ± 0.55 62 ± 32 810 ± 280
18	2.0 ± 0.34 <MDA	SNC	7.4 ± 0.57 <MDA 300 ± 270
19	9.5 ± 0.73 <MDA	3.2 ± 0.26 17 ± 11	SNC
20	SNC	SNC	SNC
Median	5.5 <MDA	7.7 <MDA	7.8 <MDA 430
Range	2.0-18 <MDA-150	3.0-9.2 <MDA-26	1.8-21 <MDA-100 <270-810

*Wet weight
SNC = Sample not collected
<MDA = less than minimum detectable activity

TABLE F-1. PLUTONIUM AND STRONTIUM CONCENTRATIONS IN SELECTED TISSUES, COYOTES, NTS, 1977

Animal No. and Tissue Type	^{238}Pu (pCi/g Ash) (pCi/kg*)	^{239}Pu (pCi/g Ash) (pCi/kg*)	^{89}Sr (pCi/g Ash) (pCi/kg*)	^{90}Sr (pCi/g Ash) (pCi/kg*)	Ash (%)
1 Bone	0.03 ± 0.1 8 ± 2.7	<0.01 <2.7	<7 <1,900	17 ± 2.6 4,700 ± 690	27
2 Bone	<0.003 <0.65	<0.0028 <0.62	<0.77 <170	0.77 ± 0.36 170 ± 80	22
1 Muscle	<0.02 <1.1	0.02 ± 0.01 1.1 ± 0.53	NA	NA	5.3
2 Muscle	0.004 ± 0.003 0.27 ± 0.2	<0.003 <0.2	NA	NA	6.8
1 Kidney	NA	NA	NA	NA	NA
2 Kidney	NA	NA	NA	NA	NA
1 Liver	<0.02 <2.1	0.02 ± 0.01 2.1 ± 1.1	NA	NA	10.5
2 Liver	<0.005 <0.34	<0.001 <0.069	NA	NA	6.9
1 Lung	<0.02 <1.2	0.17 ± 0.03 10 ± 1.8	NA	NA	6
2 Lung	<0.002 <0.08	0.020 ± 0.010 0.60 ± 0.48	NA	NA	4
1 Skin	<0.02 <1.9	0.74 ± 0.5 70 ± 47	NA	NA	9.4
2 Skin	0.008 ± 0.006 0.86 ± 0.65	0.03 ± 0.01 2.9 ± 1.2	NA	NA	10.7
1 Stomach C.	0.47 ± 0.08 52 ± 8.8	25 ± 3 2,700 ± 330	NA	NA	11
2 Stomach C.	0.03 ± 0.01 5.1 ± 2.2	0.65 ± 0.10 110 ± 17	NA	NA	16.9

*Wet weight
NA = Not analyzed

TABLE F-2. TRITIUM AND GAMMA-EMITTING RADIONUCLIDE CONCENTRATIONS IN SELECTED TISSUES, COYOTES, NTS, 1977

Animal No.	^{3}H (pCi/l)	K (g/kg*)	^{137}Cs (pCi/kg*)	^{95}Zr (pCi/kg*)
1 Bone	NA	NA	NA	NA
2 Bone	NA	NA	NA	NA
1 Muscle	NA	8.6 ± 0.65	150 ± 36	<MDA
2 Muscle	NA	4.1 ± 0.34	62 ± 14	<MDA
1 Kidney	18,000 ± 510	5.7 ± 0.69	210 ± 43	<MDA
2 Kidney	SL	33 ± 3.3	<MDA	<MDA
1 Liver	NA	7.7 ± 0.71	170 ± 41	<MDA
2 Liver	NA	3.1 ± 0.34	47 ± 7.1	<MDA
1 Lung	NA	2.4 ± 0.37	98 ± 24	<MDA
2 Lung	NA	16 ± 1.6	<MDA	<MDA
1 Skin	NA	<MDA	360 ± 99	<MDA
2 Skin	NA	<MDA	<MDA	<MDA
1 Stomach C.	NA	5.3 ± 1.4	480 ± 80	110 ± 65
2 Stomach C.	NA	1.7 ± 0.78	140 ± 50	150 ± 100

*Wet weight
NA = Not analyzed
<MDA = less than minimum detectable activity
SL = Sample lost
Stomach C. = Stomach contents

TABLE G-1. PLUTONIUM CONCENTRATIONS IN SELECTED TISSUES, RABBITS, AREA 18, NTS, 1977

Animal No.	MUSCLES			INTERNAL ORGANS			G. I. TRACT			SKIN		
	^{238}Pu (pCi/g Ash) (pCi/kg*)	^{239}Pu (pCi/g Ash) (pCi/kg*)	Ash (%)	^{238}Pu (pCi/g Ash) (pCi/kg*)	^{239}Pu (pCi/g Ash) (pCi/kg*)	Ash (%)	^{238}Pu (pCi/g Ash) (pCi/kg*)	^{239}Pu (pCi/g Ash) (pCi/kg*)	Ash (%)	^{238}Pu (pCi/g Ash) (pCi/kg*)	^{239}Pu (pCi/g Ash) (pCi/kg*)	Ash (%)
1	0.012 ± 0.006 0.68 ± 0.32	<0.002 <0.11	5.7	<0.005 <0.48	0.03 ± 0.02 2.4 ± 2.2	9.2	<0.02 <0.98	0.13 ± 0.03 6.4 ± 1.5	4.9	0.05 ± 0.01 6.5 ± 1.7	0.18 ± 0.03 23 ± 3.6	13
2	0.004 ± 0.003 0.29 ± 0.23	0.004 ± 0.003 0.29 ± 0.23	7.8	<0.001 <0.12	<0.003 <0.22	8.3	0.09 ± 0.02 5.2 ± 1.2	0.45 ± 0.05 26 ± 3	5.8	0.03 ± 0.02 2.9 ± 1.9	0.37 ± 0.11 36 ± 1	9.7
3	<0.001 <0.09	<0.004 <0.37	9.3	0.03 ± 0.01 2.4 ± 0.84	0.02 ± 0.01 1.8 ± 0.72	9.2	0.011 ± 0.007 0.87 ± 0.53	0.04 ± 0.01 2.7 ± 0.98	7.8	0.04 ± 0.02 3 ± 1.5	0.29 ± 0.06 22 ± 5	7.6
4	<0.001 <0.039	0.006 ± 0.004 0.43 ± 0.26	6.6	0.013 ± 0.007 0.73 ± 0.38	0.03 ± 0.01 1.7 ± 0.6	5.6	<0.01 <0.56	0.03 ± 0.01 1.7 ± 0.6	5.6	0.06 ± 0.02 7.1 ± 2.5	0.42 ± 0.07 49 ± 8.1	12
5	<0.007 <0.51	<0.006 <0.38	6.8	0.02 ± 0.01 1.3 ± 0.61	0.06 ± 0.02 4.4 ± 1.2	7.6	0.07 ± 0.03 13 ± 4.4	0.3 ± 0.07 51 ± 11	17	<0.02 <2	0.15 ± 0.4 15 ± 4	10
Median	0.004 0.29	0.004 <0.37	6.8	0.013 0.73	0.03 1.8	8.3	<0.02 <0.98	0.13 6.4	5.8	0.04 3	0.29 23	10
Range	<0.001-0.012 <0.039-0.68	<0.002-0.006 <0.11-0.43	5.7-9.3	<0.001-0.03 <0.12-2.4	<0.003-0.06 <0.22-4.4	5.6-9.2	<0.01-0.09 <0.56-13	0.03-0.45 1.7-51	4.9-17	<0.02-0.06 <2-7.1	0.15-0.42 15-49	7.6-13

Wet weight

TABLE G-2. PLUTONIUM AND STRONTIUM CONCENTRATIONS IN BONES, RABBITS, AREA 18, NTS, 1977

Animal No.	^{238}Pu (pCi/g Ash) (pCi/kg*)	^{239}Pu (pCi/g Ash) (pCi/kg*)	^{89}Sr (pCi/g Ash) (pCi/kg*)	^{90}Sr (pCi/g Ash) (pCi/kg*)	Ash (%)
1	<0.01 <1.4	<0.01 <1.4	<2.7 <380	3.6 ± 0.79 500 ± 110	14
2	<0.01 <1.7	<0.01 <1.7	<7.6 <1,300	10 ± 1.3 1,700 ± 220	17
3	<0.01 <0.8	<0.01 <0.8	<9.2 <730	15 ± 2.7 1,200 ± 210	7.9
4	<0.01 <2	<0.02 <4	<2.3 <480	3 ± 0.67 640 ± 140	21
5	<0.01 <1.4	<0.01 <1.4	<4.7 <660	2.8 ± 0.79 390 ± 110	14
Median	<0.01 <1.4	<0.01 <1.4	<4.7 <660	3.6 640	14
Range	<0.01-<0.01 <0.80-<1.7	<0.01-<0.02 <0.8-<4	<2.3-<9.2 <380-<1,300	2.8-15 390-1,700	7.9-21

*Wet weight

TABLE G-3. GAMMA-EMITTING RADIONUCLIDE AND TRITIUM CONCENTRATIONS IN SELECTED TISSUES, RABBITS, AREA 18, NTS, 1977

Animal No.	MUSCLE K (g/kg*) ^{137}Cs (pCi/kg*) ^{3}H (pCi/l)	INTERNAL ORGANS K (g/kg*) ^{137}Cs (pCi/kg*)	SKIN K (g/kg*) ^{137}Cs (pCi/kg*) ^{95}Zr (pCi/kg*)	G. I. TRACT K (g/kg*) ^{137}Cs (pCi/kg*) ^{95}Zr (pCi/kg*)
1	8.6 ± 0.59 <MDA <330	3.9 ± 0.35 <MDA	6.2 ± 0.63 68 ± 31 150 ± 57	4.2 ± 0.39 82 ± 28 240 ± 55
2	4.1 ± 0.37 28 ± 6.6 750 ± 450	3.9 ± 0.42 35 ± 7.3	6 ± 1.4 150 75 <MDA	5.9 ± 0.31 60 ± 15 310 ± 29
3	4.6 ± 0.33 <MDA 480 ± 270	13 ± 1.4 <MDA	<MDA <MDA <MDA	4.4 ± 0.46 56 ± 33 300 ± 94
4	4.3 ± 0.3 18 ± 6.6 430 ± 270	8.9 ± 0.72 <MDA	5.6 ± 1.3 360 ± 97 <MDA	7.1 ± 0.52 <MDA 350 ± 53
5	3.9 ± 0.27 12 ± 4.4 320 ± 270	8.8 ± 0.68 <MDA	5.6 ± 1.2 <MDA <MDA	10 ± 0.62 27 ± 3.1 <MDA
Median	4.3 12 430	8.8 <MDA	5.6 68 <MDA	5.9 56 300
Range	3.9-8.6 <MDA-28 320-750	3.9-13 <MDA-35	<MDA-6.2 <MDA-360 <MDA-150	4.2-10 <MDA-82 <MDA-350

*Wet weight
<MDA = less than minimum detectable activity

TABLE H-1. PLUTONIUM CONCENTRATIONS IN SELECTED TISSUES, RABBITS, AREA 15, NTS, 1977

Animal No.	MUSCLES			INTERNAL ORGANS			G. I. TRACT			SKIN		
	^{238}Pu (pCi/g Ash) (pCi/kg*)	^{239}Pu (pCi/g Ash) (pCi/kg*)	Ash (%)	^{238}Pu (pCi/g Ash) (pCi/kg*)	^{239}Pu (pCi/g Ash) (pCi/kg*)	Ash (%)	^{238}Pu (pCi/g Ash) (pCi/kg*)	^{239}Pu (pCi/g Ash) (pCi/kg*)	Ash (%)	^{238}Pu (pCi/g Ash) (pCi/kg*)	^{239}Pu (pCi/g Ash) (pCi/kg*)	Ash (%)
1	← Sample Lost →			<0.004 <0.2	0.16 ± 0.03 7.9 ± 1.5	4.8	0.06 ± 0.02 1.1 ± 0.1	2.7 ± 0.9 50 ± 5	4.5	0.52 ± 0.08 56 ± 8.5	27 ± 2.5 2,900 ± 270	10.7
2	<0.003 <0.18	0.008 ± 0.005 0.47 ± 0.3	5.9	<0.003 <0.14	0.04 ± 0.01 1.8 ± 0.58	4.8	0.07 ± 0.02 2.9 ± 0.8	1.9 ± 0.3 80 ± 10	4.2	0.29 ± 0.09 28 ± 9	12 ± 2 1,200 ± 200	9.7
3	0.006 ± 0.004 0.31 ± 0.21	0.02 ± 0.01 1.3 ± 0.4	5.2	<0.002 <0.11	0.07 ± 0.02 4 ± 1.1	5.6	0.06 ± 0.02 1.9 ± 0.6	0.79 ± 0.1 25 ± 3	3.2	0.07 ± 0.02 6.6 ± 2.2	1.3 ± 0.14 130 ± 14	10
4	0.006 ± 0.004 0.33 ± 0.22	0.04 ± 0.01 2.4 ± 0.66	5.5	0.009 ± 0.006 0.56 0.37	0.07 ± 0.02 4.5 ± 1.1	6.2	0.08 ± 0.04 4.1 ± 2	3.1 ± 0.7 160 ± 40	5.2	0.34 ± 0.08 35 ± 8	15 ± 2 1,500 ± 200	10.2
5	0.011 ± 0.006 0.6 ± 0.33	0.02 ± 0.01 1.1 ± 0.43	5.4	0.005 ± 0.004 0.26 ± 0.21	0.07 ± 0.02 3.6 ± 0.8	5.3	0.14 ± 0.03 5.6 ± 1.2	3 ± 0.4 120 ± 20	4	0.37 ± 0.06 32 ± 6	12 ± 1 1,300 ± 100	10.5
6	0.007 ± 0.004 0.38 ± 0.22	0.02 ± 0.01 0.92 ± 0.38	5.4	0.01 ± 0.007 0.51 ± 0.36	0.09 ± 0.02 4.7 ± 1.2	5.1	1.7 ± 0.03 9.1 ± 1.7	6.5 ± 0.8 370 ± 50	5.7	0.23 ± 0.04 23 ± 4	5.9 ± 0.5 580 ± 50	10
Median	0.006 0.33	0.02 1.1	5.4	<0.005 <2.3	0.07 4.3	5.2	0:075 3.5	2.9 100	4.4	0.3 30	12 1,300	10.1
Range	<0.003-0.011 <0.18-0.6	0.008-0.04 0.47-2.4	5.2-5.9	<0.002-0.01 <0.11-0.56	0.04-0.16 1.8-7.9	4.8-6.2	0.06-1.7 1.1-9.1	0.79-6.5 25-370	3.2-5.7	0.07-0.52 6.6-56	1.3-27 130-2,900	9.7-10.7

*Wet weight

TABLE H-2. PLUTONIUM AND STRONTIUM CONCENTRATIONS IN BONES, RABBITS, AREA 15, NTS, 1977

Animal No.	^{238}Pu (pCi/g Ash) (pCi/kg*)	^{239}Pu (pCi/g Ash) (pCi/kg*)	^{89}Sr (pCi/g Ash) (pCi/kg*)	^{90}Sr (pCi/g Ash) (pCi/kg*)	Ash (%)
1	<0.01 <2	<0.01 <2	<3.1 <650	<0.67 <140	21
2	<0.01 <1.6	<0.01 <1.6	<6.9 <1,100	11 ± 1.3 1,700 ± 200	16
3	<0.01 <2	<0.01 <2	<6.5 <1,300	8 ± 1.1 1,600 ± 230	20
4	<0.02 <2.8	<0.02 <2.8	<3 <420	4 ± 0.86 560 ± 120	14
5	<0.01 <1.7	<0.01 <1.7	<6.9 <1,100	5.6 ± 1.1 890 ± 170	16
6	<0.01 <1.9	<0.02 <3.8	<6.3 <1,200	6.3 ± 1.1 1,200 ± 200	19
Median	<0.01 <2	<0.01 <2	<6.4 <1,100	6 1,100	17.5
Range	<0.01-<0.02 <1.6-<2.8	<0.01-<0.02 <1.6-<3.8	<3-<6.9 <420-<1,300	<0.67-11 <140-1,700	14-21

*Wet weight

TABLE H-3. GAMMA-EMITTING RADIONUCLIDE AND TRITIUM CONCENTRATIONS IN SELECTED TISSUES, RABBITS, AREA 15, NTS, 1977

Animal No.	MUSCLE K (g/kg*) ^{137}Cs (pCi/kg*) ^{3}H (pCi/l)	INTERNAL ORGANS K (g/kg*) ^{137}Cs (pCi/kg*)	SKIN K (g/kg*) ^{137}Cs (pCi/kg*)	G. I. TRACT K (g/kg*) ^{137}Cs (pCi/kg*) ^{95}Zr (pCi/kg*)
1	8.4 ± 0.59 53 ± 24 2,700 ± 310	7.6 ± 0.64 <MDA	2.4 ± 2 640 ± 150	2.6 ± 0.34 100 ± 22 270 ± 47
2	8.4 ± 0.53 44 ± 12 3,800 ± 320	3.1 ± 0.3 30 ± 5.3	3.6 ± 1.4 480 ± 100	3.5 ± 0.3 120 ± 20 320 ± 41
3	9.5 ± 0.76 <MDA 3,400 ± 320	3.8 ± 0.3 54 ± 7.5	<MDA 600 ± 140	4.4 ± 0.5 73 ± 25 110 ± 51
4	3.9 ± 0.28 30 ± 6.8 4,600 ± 330	9.1 ± 0.73 <MDA	2.3 ± 1.5 800 110	4.8 ± 0.43 75 ± 21 260 ± 41
5	7.5 ± 0.57 28 ± 13 16,000 ± 900	8.3 ± 0.65 21 ± 14	4.4 ± 2.9 760 160	4.5 ± 0.49 97 ± 24 230 ± 48
6	9.4 ± 0.69 <MDA 690 ± 270	3.9 ± 0.44 51 ± 9.8	3.1 ± 2.4 280 ± 140	5.5 ± 0.44 180 ± 22 300 ± 45
Median	8.4 29 3,600	5.8 26	2.8 620	4.5 99 265
Range	3.9-9.4 <MDA-53 690-16,000	3.1-9.1 <MDA-54	<MDA-4.4 280-800	2.6-5.5 73-180 110-300

*Wet weight
<MDA = less than minimum detectable activity

APPENDIX I. PLUTONIUM, STRONTIUM, TRITIUM, AND GAMMA-EMITTING RADIONUCLIDE CONCENTRATIONS IN SELECTED TISSUES, OTHER NTS WILDLIFE, 1977

Animal and Tissue Type	^{238}Pu (pCi/g Ash) (pCi/kg*)	^{239}Pu (pCi/g Ash) (pCi/kg*)	^{89}Sr (pCi/g Ash) (pCi/kg*)	^{90}Sr (pCi/g Ash) (pCi/kg*)	Ash (%)	K (g/kg*) ^{137}Cs (pCi/kg*)	^{3}H (pCi/l)
Horse Muscle	<0.01 <0.37	<0.02 <0.74	NA	NA	3.7	2.6 ± 0.18 <MDA	<300
Horse Dupl. Muscle	<0.01 <0.37	<0.01 <0.37	NA	NA	3.7	NA	NA
Horse Bone	0.0025 ± 0.0022 0.81 ± 0.074	0.0067 ± 0.0028 2.2 ± 0.91	<2.3 <760	21 ± 1.2 6,800 ± 410	33	NA	NA
Eagle 1 Bone	<0.01 <1.5	<0.01 <1.5	<1.3 <190	2 ± 0.55 300 ± 83	15	NA	NA
Eagle 2 Muscle	<0.02 <0.79	<0.02 <0.79	NA	NA	4	3.7 ± 0.28 26 ± 8.6	2,400 ± 310
Eagle 2 Bone	0.01 ± 0.01 1.4 ± 1.4	<0.01 <1.4	2.1 ± 2.1 300 ± 290	0.79 ± 0.58 110 ± 81	14	NA	NA
Mt. Lion Bone	<0.01 <5.9	<1.0 <5.9	<2.9 <1,700	3.4 ± 0.58 2,000 ± 340	59	NA	NA
Mt. Lion Dupl. Bone	<0.02 <12	<0.02 <12	NA	NA	59	NA	NA

*Wet weight
NA = Not analyzed
<MDA = less than minimum detectable activity

APPENDIX J. GROSS* AND MICROSCOPIC PATHOLOGIES† FOUND IN NECROPSIED ANIMALS

AREA 18 CATTLE, MAY

1

Necropsy findings: Beginning squamous cell carcinoma on medial canthus of left eye.

Histopathological findings: Moderate hemosiderosis of spleen, cystic follicle in ovary, squamous papilloma of skin.

Hematological findings:‡ RBC/cmm 8.5×10^6, WBC/cmm 4.5×10^3, MCV/cu.μ 61, Hb g % 18.5, Hematocrit % 52.

Clinical diagnosis: Normal, aged, barren cow with small squamous cell carcinoma of the eye.

2

Necropsy findings: No gross lesions noted.

Histopathological findings: Cardiac muscle contained sarcocysts.

Hematological findings: RBC/cmm 7.7×10^6, WBC/cmm 6.3×10^3, MCV/cu.μ 48, Hb g % 13.8, Hematocrit % 39.

Clinical diagnosis: Normal 3-year-old steer.

3

Necropsy findings: Fibrinous adhesions between liver and diaphragm, uterus contains 7-month-old fetus.

Histopathological findings: Cardiac muscle contained sarcocysts.

Hematological findings: RBC/cmm 7.5×10^6, WBC/cmm 9.5×10^3, MCV/cu.μ 55, Hb g % 15.3, Hematocrit % 43.

Clinical diagnosis: Normal, pregnant, mature cow.

Fetus-3

Necropsy findings: No gross lesions noted.

Histopathological findings: Hematopoiesis of liver (normal for fetus).

Hematological findings: Blood samples not collected.

APPENDIX J. GROSS* AND MICROSCOPIC PATHOLOGIES† FOUND IN NECROPSIED ANIMALS (continued)

AREA 18 CATTLE, MAY (continued)

Fetus-3 (continued)

Clinical diagnosis: Normal 7-month-old fetus.

4

Necropsy findings: No gross lesions noted.

Histopathological findings: No lesions noted.

Hematological findings: RBC/cmm 7.5 × 10^6, WBC/cmm 9.1 × 10^3, MCV/cu.μ 49, Hb g % 12.7, Hematocrit % 38.

Clinical diagnosis: Normal 1-year-old steer.

5

Necropsy findings: No gross lesions noted.

Histopathological findings: No lesions noted.

Hematological findings: RBC/cmm 8.6 × 10^6, WBC/cmm 7.1 × 10^3, MCV/cu.μ 44, Hb g % 13.3, Hematocrit % 39.

Clinical diagnosis: Normal 1-year-old steer.

6

Necropsy findings: No gross lesions noted.

Histopathological findings: Mild fatty changes in liver.

Hematological findings: RBC/cmm 8.6 × 10^6, WBC 7.1 × 10^3, MCV/cu.μ 44, Hb g % 13.3, Hematocrit % 39.

Clinical diagnosis: Normal 1-year-old steer.

AREA 18 CATTLE, OCTOBER

7

Necropsy findings: No gross lesions noted. Was an extremely fat animal. Two meters of nylon rope present in rumen.

Histopathological findings: Some mineralization of tubules near the collecting ducts and cortico-medullary junction of the kidney. The liver hepatocytes are slightly swollen and contain finely granular cytoplasm.

APPENDIX J. GROSS* AND MICROSCOPIC PATHOLOGIES† FOUND IN NECROPSIED ANIMALS (continued)

AREA 18 CATTLE, OCTOBER (continued)

7 (continued)

Hematological findings: RBC/cmm 10.4 × 10^6, WBC/cmm 5.2 × 10^3, MCV/cu.μ 46, Hb g % 16.1, Hematocrit % 48.

Clinical diagnosis: Normal, mature cow. Comment--no remarkable findings in this case.

8

Necropsy findings: Small abscess (actinobacillosis) on left mandible, uterus contained 4-month-old female fetus.

Histopathological findings: Cardiac muscle contained sarcocysts. Excessive amount of hemosiderosis in macrophages of the white pulp of the spleen.

Hematological findings: RBC/cmm 8.4 × 10^6, WBC/cmm 2.8 × 10^3, MCV/cu.μ 49, Hb g % 14.7, Hematocrit % 41.

Clinical diagnosis: Pregnant, mature cow with beginning actinobacillosis (lumpy-jaw). Comment--no remarkable findings in this case.

9

Necropsy findings: Uterus contained 3-month-old female fetus, rumen contained three meters of nylon rope. An edematous circumscribed lesion (5 cm in diameter) was present on right diaphragmatic lobe of lung.

Histopathological findings: Small lymphocytic foci were noted in the interstitial tissues of the kidney. Some melanin deposits were noted in the adrenal capsule, moderate hemosiderosis of the spleen. There was an area of inflammation in the lung characterized by fibrin exudation into alveoli and the immigration of leukocytes through the alveolar septa.

Hematological findings: RBC/cmm 7.4 × 10^6, WBC/cmm 3.6 × 10^3, MCV/cu.μ 49, Hb g % 13.1, Hematocrit % 36.

Clinical diagnosis: Normal, pregnant, mature cow with localized pneumonia. Comment--the most remarkable finding in this case was the presence of a localized acute fibrinous area of pneumonia in the lungs. The specific localization and type of reaction seen in this lung is suggestive of the response to aspiration of an irritating substance such as ingesta. However, it could also have been caused by an infectious agent such as pasteurella.

10

Necropsy findings: No gross lesions noted.

APPENDIX J. GROSS* AND MICROSCOPIC PATHOLOGIES† FOUND IN NECROPSIED ANIMALS (continued)

AREA 18 CATTLE, OCTOBER (continued)

10 (continued)

Histopathological findings: Some localized mineralization at the tubules near the cortico-medullary junction of the kidney.

Hematological findings: RBC/cmm 9 × 10^6, WBC/cmm 5 × 10^3, MCV/cu.μ 54, Hb g % 18.3, Hematocrit % 49.

Clinical diagnosis: Normal 1.5-year-old bull. Comment--the tissues from this animal were unremarkable.

11

Necropsy findings: No gross lesions noted.

Histopathological findings: Accumulation of lymphocytes in a nodular pattern were noted around some of the major airways of the lungs. Lesions of testicular hypoplasia or atrophy were found. Probably related to immaturity.

Hematological findings: RBC/cmm 11.1 × 10^6, WBC/cmm 6.6 × 10^3, MCV/cu.μ 41, Hb g % 16.1, Hematocrit % 45.

Clinical diagnosis: Normal 6-month-old bull calf.

12

Necropsy findings: No gross lesions noted.

Histopathological findings: There was considerable pigmentation beneath the retina; however, all elements appeared well-formed. The interstitial elements of the testicles are quite prominent with well-formed semeniferous tubules. Spermatogenesis was not evident which is normal for a 4-month-old calf.

Hematological findings: RBC/cmm 11.1 × 10^6, WBC/cmm 9.6 × 10^6, MCV/cu.μ 40, Hb g % 14.7, Hematocrit % 44.

Clinical diagnosis: Normal 4-month-old bull calf.

OTHER NEVADA TEST SITE CATTLE

251

Necropsy findings: No gross lesions noted.

(Samples were not collected for histopathological or hematological examinations.)

APPENDIX J. GROSS* AND MICROSCOPIC PATHOLOGIES† FOUND IN NECROPSIED ANIMALS (continued)

OTHER NEVADA TEST SITE CATTLE (continued)

251 (continued)

Clinical diagnosis: Normal 5-year-old Holstein cow that was surplus to needs of the dairy farm.

761

This animal was not necropsied. Clinical diagnosis was death due to tympanites.

NEVADA TEST SITE MULE DEER

1

Necropsy findings: No gross lesions noted, except the trauma associated with the passage of a bullet through the lungs and cervical areas. Samples not collected for histopathological and hematological examinations.

Clinical diagnosis: Normal buck deer.

2

Necropsy findings: Not necropsied, was pregnant.

Clinical diagnosis: Normal doe deer that died in collision with motor vehicle.

3

Necropsy findings: Extensive trauma including broken right front leg, penetrating laceration of abdominal cavity with evisceration, herniated diaphragm, ruptured rumen. All ribs on right side were fractured. Samples not collected for histopathological and hematological examinations.

Clinical diagnosis: Normal 1-year-old buck that died in collision with motor vehicle.

4

Necropsy findings: Not necropsied, samples not collected for histopathological and hematological examinations.

Clinical diagnosis: Mature buck that was killed in collision with motor vehicle.

5

Necropsy findings: No gross lesions noted, except trauma associated with bullet passage.

APPENDIX J. GROSS* AND MICROSCOPIC PATHOLOGIES† FOUND IN NECROPSIED ANIMALS (continued)

NEVADA TEST SITE MULE DEER (continued)

5 (continued)

Histopathological findings: No significant changes noted.

Clinical diagnosis: Normal 2-year-old buck.

6

Necropsy findings: Not necropsied, samples not collected for histopathological or hematological examinations.

Clinical diagnosis: Mature buck that was killed in collision with motor vehicle.

7

Necropsy findings: Not necropsied, samples not collected for histopathological or hematological examinations.

Clinical diagnosis: Mature doe that was killed in collison with motor vehicle.

8

Necropsy findings: Extensive trauma of right side including fractured ribs, legs, and rupture of the liver. Animal was blind in right eye. Samples not collected for histopathological or hematological examinations.

Clinical diagnosis: Immature buck that was killed in collision with motor vehicle.

DESERT BIGHORN SHEEP

All of these animals were mature males that were killed by licensed hunters. No necropsies were performed but all were apparently normal at time of death. No samples were collected for histopathological or hematological examinations.

FERAL NEVADA TEST SITE HORSE

Animal died as result of collison with motor vehicle. Was an aged mare in poor condition. Left rib cage and rear leg fractured. Abdominal contents were exposed by scavangers. No samples collected for histopathological or hematological examinations.

APPENDIX J. GROSS* AND MICROSCOPIC PATHOLOGIES† FOUND IN NECROPSIED ANIMALS (continued)

NEVADA TEST SITE RABBITS

All of these animals were collected by shotgun fire. All were placed in freezer until necropsied. No gross lesions were noted. All were apparently normal at time of death. Samples for histopathological or hematological examinations were not collected.

NEVADA TEST SITE COYOTES

Necropsies revealed no gross lesions. All were apparently normal at time of death. Samples not collected for histopathological or hematological examinations.

NEVADA TEST SITE EAGLES AND MOUNTAIN LION

These animals were found dead and were thought to be accident victims. Advanced postmortem changes precluded a necropsy or collection of samples for histopathological or hematological examinations.

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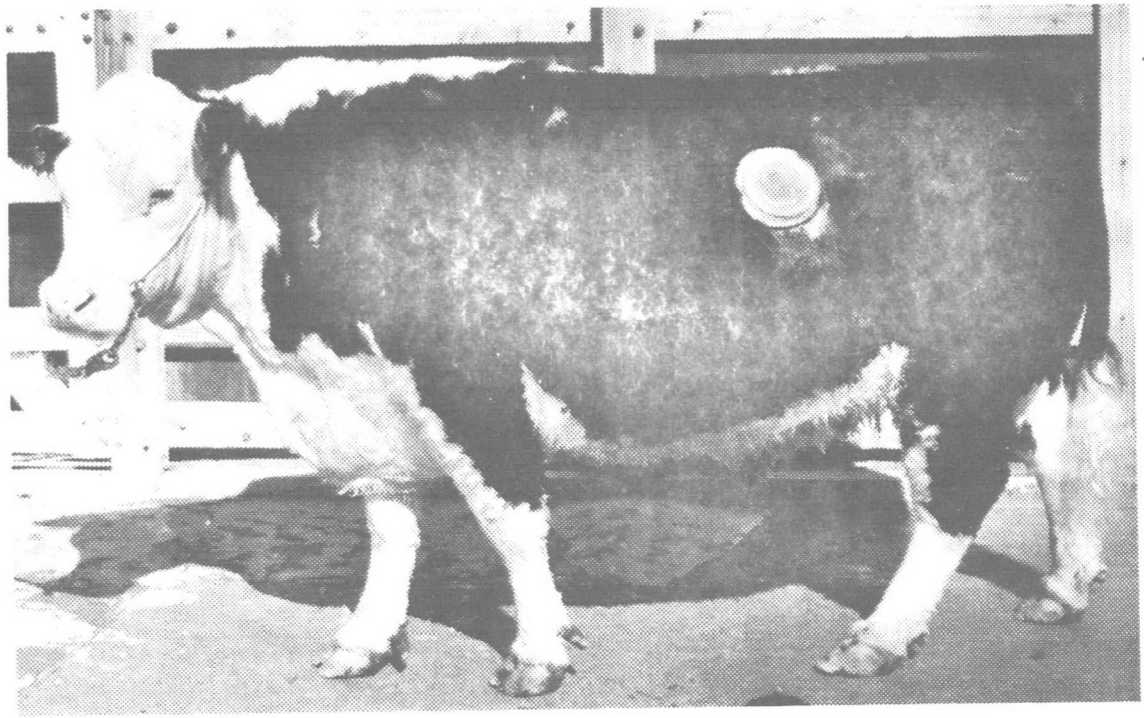
*As reported by senior author.
†As reported by Dr. Billy C. Ward, College of Veterinary Medicine, Drawer V. Mississippi State University, Starkville, Mississippi.
‡RBC/cmm = number of red blood cells per cubic millimeter of blood.
WBC/cmm = number of white blood cells per cubic millimeter of blood.
MCV/cu.μ = mean corpuscular volume per cubic micron.
Hb g % = hemoglobin expressed in gram percent.

big sam



Big Sam is one of four fistulated steers in a herd of about 100 Hereford beef cattle the U.S. Environmental Protection Agency (EPA) maintains on the Nevada Test Site where the U.S. Department of Energy (DOE)* has conducted hundreds of nuclear tests since 1951.

He and the other fistulated steers (animals with a surgical opening in their sides) are part of a special research project conducted by the EPA's Environmental Monitoring and Support Laboratory in Las Vegas, Nevada, which has been managing the DOE's beef herd since 1964. The fistulated animals serve as biological samplers of the food (forage) consumed by the rest of the herd as it ranges over part of the Test Site, which has a total area of 1,350 square miles.

* *Formerly the Atomic Energy Commission and the Energy Research & Development Administration*

U.S. ENVIRONMENTAL PROTECTION AGENCY
ENVIRONMENTAL MONITORING AND SUPPORT LABORATORY, P.O. BOX 15027, LAS VEGAS, NEVADA 89114

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When the four steers, including Big Sam, were a year old, they underwent operations in which a capped tube (cannula) was installed into the forestomach (rumen) of each animal through a surgical opening (fistula) on the left side of each. The tube and opening cause no apparent discomfort to Sam or his similarly fitted corral mates. They seem unaware of the 'hardware' which sets them apart from the rest of the herd.

Periodically, one of the Laboratory workers removes the cap from the tube as he would a jar lid, reaches into the opening, and removes the forestomach contents from each animal. The four steers, with forestomachs empty, are then placed back on the range and allowed to resume grazing, after which samples of the forestomach contents are removed for analysis.

It is assumed that the diet of the fistulated steers matches that of the herd as a whole; and scientists have noted that botanical and radiochemical composition of the diet may be affected by season, year-to-year variations in climate, and any nuclear tests which may have been conducted in or near the grazing area.

The EPA Laboratory in Las Vegas and the DOE's Nevada Operations Office in Las Vegas have sponsored the exhibit of Big Sam at special events where he was displayed in his own special portable pen. He has been a featured presentation at a number of fairs, expositions, and other public events.

Twice a year, the entire beef herd is rounded up and six animals are selected at random and sacrificed. Tissue and organ samples are taken and analyzed at the Las Vegas Laboratory to see if they contain radioactive materials (radionuclides). The samples are also checked thoroughly with the microscope.

Thus far, scientists have found no disease or tissue damage which can be blamed on radiation exposure, and radiation levels in the tissue samples have been well below levels which are considered dangerous. Not only would the meat have been safe to eat but the health of the herd is above average. It is not unusual for over 90 percent of the cows in the herd to produce calves, a yield which is considered exceptional.

The beef herd is only part of the agricultural complex operated by the EPA at the Nevada Test Site. There is also an experimental farm and dairy herd which were developed and are managed by the Laboratory in Las Vegas as a field research facility for studying the movement of radioactive materials through the environment to man.

In some studies, dairy cows or growing crops are exposed to aerosol sprays of radioactive capsules. Scientists measure the concentrations of radioactive materials, or radionuclides, in the forage, milk, certain tissues, and animal wastes to determine the influence of radioactive particle size and chemical form on the animals' body functions and feeding habits. This information is used to develop 'models' for predicting the effects of exposure on man and to evaluate methods for protecting the public against certain situations which might result in the radioactive contamination of their food.

The beef herd can also be used to study environmental contaminants other than radionuclides. Sodium chloride, or salt, was the subject of one such study.

Besides managing the beef herd and dairy farm, the Las Vegas Laboratory collects samples from several wild species living in or near the Test Site as biological indicators of fallout. It cooperates with State and Federal conservation agencies in observation of bighorn sheep, mule deer, and other native species.

From these and other continuing and cooperative programs carried out over the years comes a better understanding of the complex behavior of radioactive materials in the environment and their effects on living things.

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