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Environmental Monitoring and Support Laboratory

U.S. ENVIRONMENTAL PROTECTION AGENCY
Las Vegas, Nevada 89114

November 1975

This research was performed as a part of the Animal Investigation Program under a Memorandum of Understanding No. AT(26-1)-539
for the
U.S. ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION

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Effective June 29, 1975, the National Environmental Research Center-Las Vegas (NERC-LV) was designated the Environmental Monitoring and Support Laboratory-Las Vegas (EMSL-LV). This Laboratory is one of three Environmental Monitoring and Support Laboratories of the Office of Monitoring and Technical Support in the U.S. Environmental Protection Agency's Office of Research and Development.

ABSTRACT

On December 18, 1970, an underground nuclear test, conducted at the Nevada Test Site, released radioactive materials into the atmosphere with resultant on-site and off-site contamination. The Animal Investigation Program of the National Environmental Research Center-Las Vegas developed studies to document the distribution of fission and activation products in the tissue of domestic and wild animals residing within contaminated areas on and surrounding the Nevada Test Site. A study of radioiodine secretion in milk from cows at the experimental dairy farm, including urine and fecal excretion from four of them, was started about 24 hours after the venting. A grazing intake study, which utilized fistulated steers, was also carried out. The analytical data collected from these studies are presented in this report.

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INTRODUCTION

The Baneberry Event was an underground nuclear test conducted in Area 8 of the Nevada Test Site. Shortly after detonation at 0730 hours PST on December 18, 1970, radioactive materials escaped into the atmosphere from a fissure near ground zero. Winds carried the effluent beyond the boundaries of the Nevada Test Site.

During the next several weeks, the radiological monitoring program conducted by the National Environmental Research Center, Las Vegas (NERC-LV) indicated the presence of radioactivity in environmental media collected over a widespread area throughout the Western United States. Data collected indicated that the deposition pattern encompassed about 270 degrees, from southwest through north to southeast of ground zero, with the line of maximum deposition initially extending almost due north.(1)

Following notification of the venting, ad hoc studies were initiated to document the distribution of fission and activation products in the tissues of domestic and wild animals residing within areas on and surrounding the Nevada Test Site. This report presents the analytical data collected during these studies.

The ad hoc studies were designed to provide data on the tissue distribution of radionuclides inhaled and/or ingested by animals at varying distances and azimuths from ground zero. These animals were sacrificed at different time intervals following their original exposure.

The initial portion of the study was conducted immediately following the event using animals from the Area 15 dairy farm which was located approximately four miles from ground zero.

For the second portion of the studies, tissue samples were collected from domestic and wild animals that lived in the fallout zone at varying distances from ground zero. These animals were sampled from 12 through 62 days following the detonation. The vital statistics and geographic location of each sampled animal are shown in Table 1 and Figure 1.

The third phase of the studies utilized fistulated steers that grazed contaminated range within three miles of ground zero. Rumen samples were collected from the animals during the 5th, 6th, 7th, and 8th months following detonation.

An investigation of injury and death in grazing sheep allegedly resulting from the Baneberry Event was reported previously.(2) Also investigated was alleged radiation sickness in domestic animals residing on a farmstead near Ursine, Nevada.

Table 1. Vital Statistics of Animals Collected Subsequent to Baneberry Event

Species and No.	Date Mo./Day	Sex	Age Yrs.	Wt. kg.	Azimuth and Distance (miles) from GZ	Remarks
Cotton-tail-1	12/20	F	Adult	0.72	60° 4	Live trapped near Area 15 Farm haystack, NTS.
Cotton-tail-2	12/20	F	Adult	0.80	60° 4	Live trapped near Area 15 Farm haystack, NTS.
Cotton-tail-3	12/21	F	Adult	0.76	60° 4	Live trapped near Area 15 Farm haystack, NTS.
Calf No. 1	12/22	F	0.25	160	60° 4	Holstein maintained at Area 15 Farm, NTS until day of death.
Calf No. 2	12/22	F	0.20	95	60° 4	Holstein maintained at Area 15 Farm, NTS until day of death.
Rabbit-1-L	12/30	M	Adult	Unk	34° 110	Hunter kill at Sunnyside, Nevada.
Rabbit-2-L	12/30	M	Adult	Unk	37° 100	Hunter kill 10 miles south of Sunnyside, Nevada.
Duck-1-L	12/30	F	Adult	Unk	34° 110	Hunter kill at Sunnyside, Nevada. Ruddy duck.
Bovine-3-N	12/30	F	1.5	Unk	242° 50	Animal died from malnutrition, 15 miles south of Beatty, Nevada.
Bovine-26	1/4	F	11	735	175° 15	Dairy cow maintained at Well 3, NTS until death.
Bovine-1-N	1/5	M	0.8	200	326° 72	Purchased 1.5 miles east of main gate, Tonopah Test Range.
Bovine-2-N	1/5	F	3.5	330	326° 72	Purchased 1.5 miles east of main gate, Tonopah Test Range. Uterus contained a fetus.

Table 1. Vital Statistics of Animals Collected Subsequent to Baneberry Event (contd)

Species and No.	Date Mo./Day	Sex	Age Yrs.	Wt. kg.	Azimuth and Distance (miles) from GZ	Remarks
Coyote-1-N	1/4	M	Adult	16	326° 72	Hunter kill. Animal in poor flesh. One and one-half miles west of main gate, Tonopah Test Range.
Bovine-1-L	1/8	M	1.5	290	332° 20	Purchased from north end of dry lake bed, Kawich Valley, Originated from Del Rio, Texas and had been on range 3-6 months.
Bovine-2-L	1/8	M	2.0	290	332° 20	Purchased from north end of dry lake bed, Kawich Valley. Originated from Del Rio, Texas and had been on range 3-6 months.
Sheep-1	1/22	F	Adult	Unk	47° 200	Columbia ewe died from eating halogeton, 18 miles southeast of Garrison, Utah.
Sheep 1-L	2/2	F	5-6	69	30° 90	Purchased from east side of Coal Valley, 30 miles east of Adaven, Nevada. Aged ewe in good condition. Rabouillet-Columbia cross.
Sheep-2-L	2/2	F	5-6	65	30° 90	Purchased from east side of Coal Valley, 30 miles east of Adaven, Nevada. Aged ewe in poor condition. Rabouillet-Columbia cross.
Chicken-1-L	2/18	F	Adult	1.5	63° 125	Mature chicken. Ten miles northeast of Ursine, Nevada.
Chicken-2-L	2/18	M	Adult	2.0	63° 125	Mature chicken. Ten miles northeast of Ursine, Nevada. Sent to Nevada Animal Disease Laboratory.

Table 1. Vital Statistics of Animals Collected Subsequent to Baneberry Event (contd)

Species and No.	Date Mo./Day	Sex	Age Yrs.	Wt. kg.	Azimuth and Distance (miles) from GZ	Remarks
Rabbit-3-L	2/18	M	Adult	5.4	63^{0} 125	Domestic rabbit. Ten miles northeast of Ursine, Nevada.

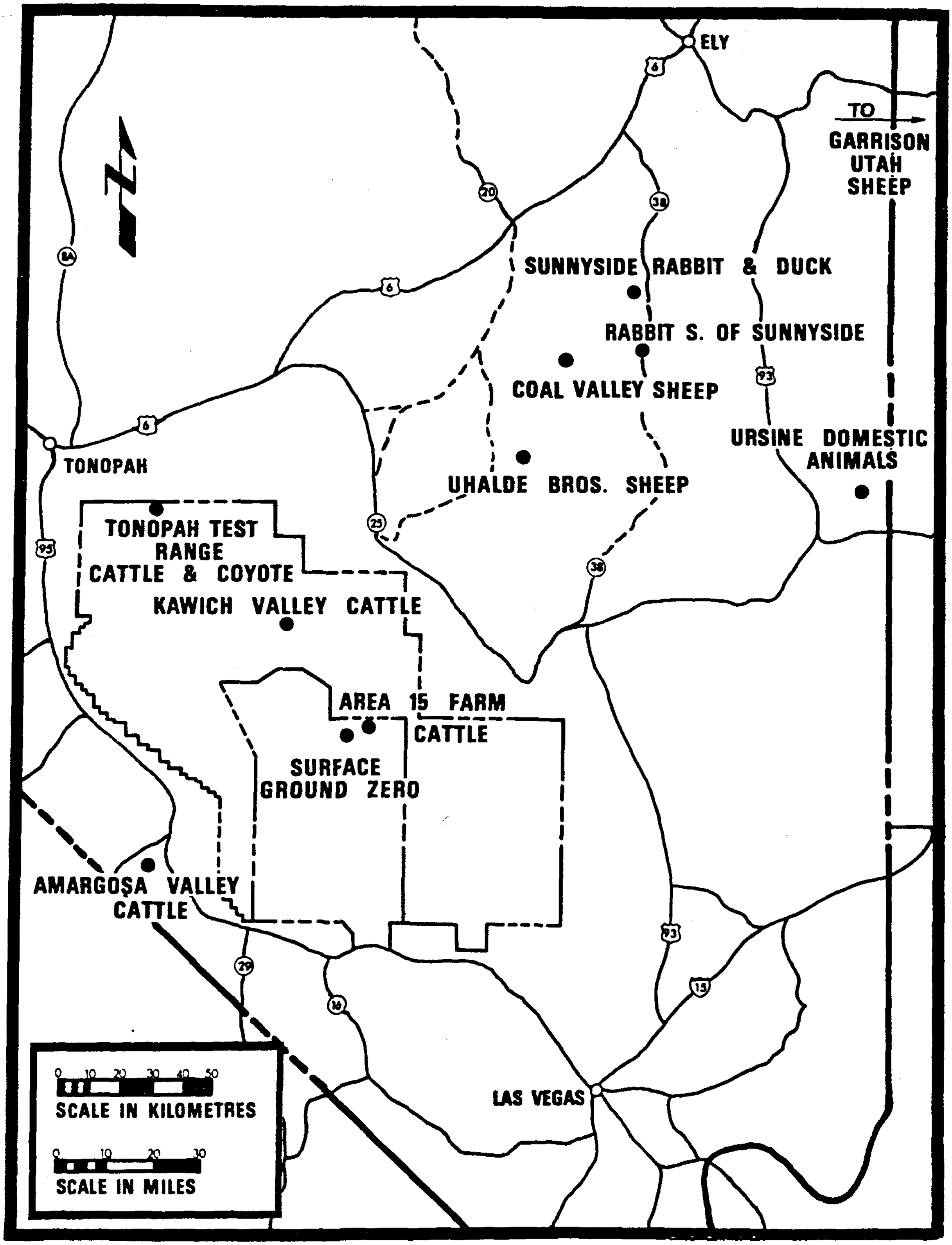

Figure 1. Biological Sampling Locations - Baneberry Event

AREA 15 DAIRY FARM STUDY

As mentioned previously, the Environmental Protection Agency experimental dairy farm at Area 15 was located approximately four miles northeast of the ground zero. The eastern edge of the effluent cloud passed over the farm immediately after detonation. At reentry, 36 hours post-event, three-foot beta-gamma readings, taken with a portable survey instrument (35 mg/cm^2 window), exceeded 5 mR/h. Among the dairy animals exposed to the effluent cloud were mature lactating Holstein cows and replacement Holstein heifer calves.

Ten of the lactating cows were selected for radioiodine studies. They were divided into three groups as shown in Table 2 to document the relative importance of inhalation vis-a-vis ingestion in the transfer of radioiodine to milk.

Table 2. Dairy Cow Groups for Radioiodine Studies

Group	Cow Nos.	Exposure	Treatment
1	16, 45, 46, 126	Inhalation plus ingestion	Placed in metabolism stalls. Fed contaminated hay twice daily for 11 feedings. Milk, urine, and feces collected.
2	13, 87, 127, 134	Inhalation	Kept at dairy farm. Fed hay from the Well 3 facility. Milk collected.
3	11, 119	Inhalation plus ingestion	Kept at dairy farm. Fed contaminated hay. Milk collected.

The Group 1 cows were moved to the metabolism stalls at Well 3 after the a.m. milking on December 19 and returned to individual pens at the Area 15 farm after the a.m. milking on December 24. The cows of the other two groups were placed in individual pens at the farm for the duration of the study.

The Group 1 cows were fed contaminated hay from the Area 15 farm twice daily. An attempt was made to feed that hay which gave the highest reading on a survey mater, but the overall contamination at the farm negated that procedure. The hay was chopped, placed in plastic feeding tubs, weighed, sampled, and fed. The residue after feeding was weighed to estimate the total amount ingested by each animal. The Group 2 cows were fed hay obtained from the Well 3 facility using the same procedure as for Group 1 cows except that the hay was not chopped. This hay was assumed to be uncontaminated, however, analytical results showed otherwise. In this report, hay fed to the Group 2 cows is referred to as "uncontaminated." The Group 3 cows were fed contaminated hay from the farm using the same procedure as for the Group 2 animals. Approximately 10 kg of hay was offered to each animal twice daily.

SAMPLING AND ANALYTICAL PROCEDURES

For the dairy farm study, milk was collected from each cow at each milking in individual milk buckets and the total volume measured. Three and one-half liters from each milking was transferred to Marinelli beakers for gamma spectroscopy. For the four metabolism cows, urine was collected in 20-liter plastic jugs by use of an indwelling bladder catheter, and feces were collected in plastic-lined pans appropriately placed in the metabolism stalls. The total amount of urine and feces was measured at the time of milking and formaldehyde added as a preservative. The fecal collection from each cow was mixed thoroughly and three aliquots, 400 ml each, were taken for counting. The urine samples were also thoroughly mixed and 400-ml aliquots taken from each sample for counting. After the Group 1 cows were returned to individual pens at the dairy farm, aliquots of freshly voided urine and feces were collected at each morning milking until January 2, 1971.

Hay samples from each cow or cow group were placed in small plastic bags which were then compressed into 400-ml containers for gamma spectroscopy. These samples varied in weight from 65 to approximately 100 grams.

Unless otherwise noted, each animal sampled for tissue distribution studies was sacrificed by shooting. Immediately after death each animal was necropsied and all pathological conditions were noted. The adrenals, eyes, heart, kidneys, liver, lungs, muscle, spleen, thyroid, and gonads of each animal were sampled and tissue sections were prepared for pathological evaluation.

Tissues collected for radioanalysis included rumen contents, liver, lungs, muscle, thyroid, blood or urine, kidney, fetus, if present, and bone. The soft tissue and rumen contents were analyzed by gamma spectroscopy. Urine or blood samples were analyzed for tritium. Bone was analyzed for ^{89}Sr, ^{90}Sr, and ^{239}Pu. Selected soft tissues were also analyzed for ^{239}Pu content.

The soft tissues of sufficient volume and rumen contents were prepared for gamma analysis by grinding and placing in 1000-ml polyethylene Marinelli beakers. Those of smaller volume, i.e., thyroid, kidneys, etc., were prepared for analysis by macerating in a blender and then suspended in agar in a 400-ml container. The samples were then counted either 40 or 100 minutes on a 4-inch by 4-inch NaI(Tl) crystal connected to a 400-channel pulse height analyzer calibrated at 10 keV/channel.

Tissues for ^{89}Sr, ^{90}Sr, and ^{239}Pu were prepared by low temperature ashing. An aliquot of animal tissue was dissolved and the plutonium was separated by adsorbtion and selective elution from an anion exchange resin.(3) The plutonium was then electroplated(4) and counted on a solid state alpha spectrometer. The recovery efficiency was determined by use of ^{236}Pu as an internal standard. Other radionuclide analytical procedures used at the National Environmental Research Center-Las Vegas were described previously.(5) In general, the counting errors associated with tritium analyses were approximately 10%.

Three mature Hereford steers with permanent rumen fistulas were used as biological samplers for the grazing study. At three-week intervals between May 14 and July 27, 1971, the animals were placed on the contaminated range. Prior to placement on the range, each animal's rumen was emptied of all ingesta[6] and a blood sample was drawn from the jugular vein for background radionuclide analysis. After a 72-hour grazing period, the animals were removed from the range and rumen samples collected for radionuclide analysis and for botanical analysis. Drinking water and post-grazing blood samples were also collected for radionuclide analysis.

Following collection, the botanical samples were frozen until analyzed. Samples were prepared for botanical analysis by washing and screening a random aliquot, which was then examined under a binocular microscope. Individual species of browse, forbs, and grasses were identified by procedures described elsewhere.[7,8] After the species in the sample were identified, a visual estimate was made of the fraction of each species in the sample. All data reported are at the 95% confidence level and are corrected to time of collection.

RESULTS AND DISCUSSION

Nevada Test Site Studies

Inhalation was the major route of exposure for the calves during the first 36 hours post-event. During the next 60 hours, ingestion was the major route of exposure as the calves ate contaminated hay and drank milk produced by cows that were also exposed to the cloud. Two calves were sacrificed on December 22, 1970, and sampled extensively. These samples were analyzed for short-lived fission products on December 23, and after allowing time for decay, were recounted on January 28, 1971. Analytical results are reported in Table 3.

The highest levels of gamma-emitting radionuclides were detected on the hair of the animals, indicating an exposure to direct particulate fallout. The thyroids contained significant levels of ^{133}I and ^{131}I. The next highest levels were found in the intestinal contents. The activity in the lungs was relatively low, with no detectable gamma-emitting radionuclides reported on the January 28 recount. Tritium concentrations in the urine of both calves were found to be 1.9 pCi/ml.

The results of plutonium and strontium analyses of lung and bone samples from these calves are shown in Table 4.

It is of particular interest to compare the data of Tables 3 and 4. It can be seen that levels of short-lived fission products in the two calves are comparable. The ^{131}I content in thyroids of the two animals was 0.73 and 0.78 nCi/g, respectively. Similar blood levels were also found for this

Table 3. Analytical Data - Area 15 Farm Calves (pCi/kg)

Tissue	Calf No.	^{132}Te	^{133}I	^{131}I	^{103}Ru	^{140}Ba	^{141}Ce
Rumen contents	1	$7x10^4$	$4.8x10^4$	$1.8x10^4$	$7.7x10^3$	680	<200
	2	$1.7x10^5$	$9.6x10^4$	$4.3x10^4$	$2.1x10^4$	$3.7x10^3$	<200
Omasal contents	1	$3x10^5$	$2x10^5$	$8.5x10^3$	$2.5x10^4$	<40	<200
	2	$2.4x10^5$	<40	$1.1x10^5$	$5.4x10^4$	$2.3x10^4$	$1.2x10^4$
Abomasal contents	1	$7.1x10^4$	$7.4x10^4$	$3.6x10^4$	$8.8x10^3$	$6.7x10^3$	$2.5x10^3$
	2	$1.4x10^5$	$1.5x10^5$	$8.8x10^4$	$2.1x10^4$	$1.3x10^4$	$4.3x10^3$
Small intestine contents	1	$5.2x10^3$	$7.2x10^3$	$6.9x10^3$	280	<40	<200
	2	$2.6x10^4$	$2.2x10^4$	$1.3x10^4$	$3.1x10^3$	<40	<200
Large intestine contents	1	$5x10^5$	$2x10^5$	$1x10^5$	$3.8x10^4$	$4x10^4$	$1.4x10^4$
	2	$6.5x10^5$	$4x10^5$	$1.8x10^5$	$8x10^4$	$2.7x10^4$	$1.1x10^4$
Urine	1	$5x10^3$	$1.1x10^4$	$9.5x10^3$	<40	<40	<200
	2	$4x10^3$	$6.7x10^3$	$5x10^3$	<40	<40	<200
Parotid salivary gland	1	$2.3x10^3$	$5.4x10^3$	$1.9x10^3$	<40	<40	<200
	2	$2.4x10^3$	$2.4x10^3$	$1.6x10^3$	<40	<40	<200
Rumen tissue	1	$5.6x10^3$	<40	$2x10^3$	410	<40	<200
	2	$1.1x10^4$	$6.1x10^3$	$2.9x10^3$	660	<40	<200
Omasal tissue	1	$8.4x10^3$	$6.3x10^3$	$2.9x10^3$	970	<40	<200
	2	$8x10^3$	$5.5x10^3$	$3x10^3$	670	<40	<200
Abomasal tissue	1	$3x10^3$	$8x10^3$	$5.1x10^3$	<40	<40	<200
	2	$7.3x10^3$	$1.1x10^4$	$1x10^4$	$1.2x10^3$	<40	$3.1x10^2$

Table 3. Analytical Data - Area 15 Farm Calves (pCi/kg) (contd)

Tissue	Calf No.	^{132}Te	^{133}I	^{131}I	^{103}Ru	^{140}Ba	^{141}Ce
Small intestine tissue	1	$1.1x10^3$	$5.6x10^2$	$1x10^3$	<40	<40	<200
	2	$2.8x10^3$	$2.1x10^3$	$1.6x10^3$	<40	<40	<200
Pancreas	1	<40	<40	$1.1x10^3$	<40	<40	<200
	2	$6x10^3$	$2.7x10^3$	$2.2x10^3$	<40	<40	<200
Large intestine tissue	1	$1.3x10^4$	$5.6x10^3$	$2.5x10^3$	850	<40	<200
	2	$8.3x10^3$	$4.8x10^3$	$2.2x10^3$	$4.8x10^3$	<40	<200
Kidney	1	$1.9x10^4$	$2.6x10^3$	$1.3x10^3$	<40	<40	<200
	2	$1.7x10^4$	$3.2x10^3$	$1.8x10^3$	<40	<40	<200
Liver	1	$7.6x10^3$	$1.5x10^3$	800	<40	<40	<200
	2	$8.3x10^3$	$1.9x10^3$	$1x10^3$	<40	<40	<200
Gall bladder with bile	1	<40	<40	$1.4x10^3$	<40	<40	<200
	2	<40	<40	$1.3x10^3$	<40	<40	<200
Lung	1	$1.9x10^3$	$1.6x10^3$	$1.2x10^3$	<40	<40	<200
	2	$2.4x10^3$	$1.9x10^3$	$1.4x10^3$	<40	<40	<200
Heart	1	$2.9x10^3$	500	800	<40	<40	<200
	2	$2.6x10^3$	$1.2x10^3$	800	<40	<40	<200
Blood	1	300	600	$1.4x10^3$	<40	<40	<200
	2	500	400	$1.5x10^3$	<40	<40	<200
Spleen	1	$1.2x10^3$	800	800	<40	<40	<200
	2	$1x10^3$	<40	$1.1x10^3$	<40	<40	<200
Tracheo-bronchial lymph nodes	1	$1.5x10^3$	<40	700	<40	<40	<200
	2	<40	<40	<40	<40	<40	<200

Table 3. Analytical Data - Area 15 Farm Calves (pCi/kg) (contd)

Tissue	Calf No.	^{132}Te	^{133}I	^{131}I	^{103}Ru	^{140}Ba	^{141}Ce
Thyroid	1	<40	$1.3x10^6$	$1.8x10^6$	S A M P L E		L O S T
	2	<40	$9.6x10^5$	$1.6x10^6$	S A M P L E		L O S T
Adrenal	1	<40	<40	<40	<40	<40	<200
	2	<40	<40	<40	<40	<40	<200
Gonads	1	<40	<40	<40	<40	<40	<200
	2	<40	<40	<40	<40	<40	<200
Muscle	1	700	$5x10^2$	$3x10^2$	<40	<40	<200
	2	600	500	300	<40	<40	<200
Fat	1	700	400	160	<40	<40	<200
	2	$1.4x10^3$	<40	<40	<40	<40	<200
Bone shaft	1	900	$1.1x10^3$	800	<40	<40	<200
	2	$1.1x10^3$	800	$9.9x10^3$	<40	<40	<200
Bone marrow	1	<40	<40	800	<40	<40	<200
	2	$1.7x10^3$	800	$1x10^3$	<40	<40	<200
Hair	1	$2.4x10^6$	$2.1x10^6$	$8.9x10^5$	$3.1x10^5$	$9.7x10^4$	$6.7x10^3$
	2	$1.6x10^6$	$1.3x10^6$	$5.8x10^5$	$2.2x10^5$	$6.3x10^4$	$4x10^3$
Skin, no hair	1	$2.6x10^3$	$5.6x10^3$	$2.6x10^3$	<40	<40	<200
	2	$3.8x10^4$	$2.6x10^4$	$1.4x10^4$	$3.6x10^3$	990	340

Table 4. Plutonium and Radiostrontium Data - Area 15 Calves

Calf No.	Tissue	Ash (%)	Ca mg/g ash	^{90}Sr pCi/kg wet pCi/g ash	^{238}Pu pCi/kg wet pCi/g ash	^{239}Pu pCi/kg wet pCi/g ash
1	Bone	36	130	2100±500 6.0±1.0	<1.0 <0.003	<0.6 <0.002
	Lung	NA	NA	NA	<0.5 <0.003	<0.1 <0.01
2	Bone	28	100	560±220 2.0±0.8	<0.7 <0.003	1.9±0.7 0.007±0.003
	Lung	NA	NA	NA	0.6±0.5 0.05±0.04	<0.1 <0.01

NA = Not analyzed.

radionuclide, i.e., 1.4 and 1.5 nCi/kg. Using the concentration data from Table 3, except for intestinal contents, and estimates of total organ weights, it is estimated that the smaller Calf-2 had a body burden of 342 nCi of ^{131}I while the larger one had a burden of 293 nCi. Although occasional differences are found between these two animals, the concentration of radionuclides described in Table 3 seldom deviates by more than a factor of 2. The ^{90}Sr content of the bone ash between these two animals deviates, however, by a factor of 3. The ^{239}Pu levels indicate a reverse relationship. Levels of ^{239}Pu in bone from Calf-1 were below the detectable limits, while measurable levels of ^{239}Pu were found in Calf-2. As the bone concentration of ^{239}Pu is significantly higher than the lung concentration, it can be presumed that ^{239}Pu in this animal originated from a long-term exposure or possibly as a result of placental transfer as this animal was only two months old.

The reason for these latter anomalies remains unknown. Both animals were born and raised under presumably identical conditions. The exposure histories of their dams are similar. Their exposure to Baneberry fallout must have been similar, yet they indicate significant differences in their ^{90}Sr and ^{239}Pu body burden. These facts demonstrate the necessity of multi-animal experiments if generally applicable results are to be expected.

During the nights of December 19 and 20, three desert cottontail rabbits, (Sylvilagus audubonii), were live-trapped at the Area 15 dairy farm near the haystack which furnished feed for both them and the dairy calves described above. Vital statistics of the rabbits are reported in Table 1.

Rabbits Nos. 1 and 2 were sacrificed on December 20, 1970, and rabbit No. 3 was sacrificed on December 21. Measurement with a portable survey instrument (35 mg/cm^2 window), set for beta-plus-gamma radiation, gave a relative reading of 0.6 mR/h for rabbit No. 3 and 1.0 mR/h for rabbits Nos. 1 and 2.

The analytical data from tissues of these rabbits are presented in Table 5. Again the pelts and thyroids contained the highest burdens of fresh fission products. The tritium levels in the free water of the tissues from the three rabbits averaged 6.9±0.3 pCi/ml, 9.7±0.3 pCi/ml, and 9.3±3.0 pCi/ml, respectively. It is of interest to compare these values with the tritium concentration of 1.9 pCi/ml in the body water of the calves. The rabbits and calves were presumably in the same vicinity of the Area 15 farm during and subsequent to the venting. The four-fold difference in the tritium

Table 5. Analytical Data - Area 15 Farm Cottontails (pCi/g)

	Rabbit No. 1			Rabbit No. 2			Rabbit No. 3		
Tissue	^{132}Te	^{133}I	^{131}I	^{132}Te	^{133}I	^{131}I	^{132}Te	^{133}I	^{131}I
Stomach*	2.4×10^3	3.0×10^3	700	1.7×10^3	2.3×10^3	700	900	700	200
Intestines*	460	<40	10	4.8×10^3	2.3×10^3	<40	5.2×10^3	1.7×10^3	<40
Kidney	650	67	10	1.6×10^3	<40	70	3.1×10^3	<40	<40
Liver	460	30	10	1.0×10^3	<40	<40	1.1×10^3	50	17
Lung	90	100	30	1.3×10^3	100	30	90	140	<40
Thyroid	<40	2.2×10^6	4.0×10^5	<40	4.0×10^6	7.2×10^5	<40	1.8×10^6	5.3×10^5
Muscle	20	20	5	30	30	7	50	20	6
Pelt	1.8×10^5	2.5×10^5	4.2×10^4	3.2×10^3	4.1×10^3	800	1.3×10^3	1.5×10^3	300

*Includes tissue and contents.

concentrations may be attributed to the calves' consumption of uncontaminated deep well water, while the rabbits' source of water was from feed that had been exposed to cloud passage.

On January 3, 1971, a mature, pregnant, Holstein cow was found dead at Well 3 which is located 15 miles south of the ground zero. Cause of death was determined to be blood loss from a self-amputated teat. Tissue samples were collected from this animal for radionuclide analysis. The rumen contents contained 200 pCi of ^{103}Ru per kg, the thyroid contained 5 pCi of ^{131}I per g, the lungs 1.5±0.6 pCi of ^{239}Pu per kg, and the femur 1.6±0.7 pCi of ^{90}Sr per g of bone ash. The short-lived radionuclides detected in this animal may have originated from a small leakage from a test conducted December 16 as hay from this facility was contaminated.

The results of sample measurements for each of the cows involved in the dairy herd studies are displayed individually in Appendix II. Weighted average values for each group are shown in Tables 6 and 7 and are displayed graphically in Figures 2 and 3. The weighting is based on the volume or mass produced by each animal. The effective half-lives, indicated in Figure 2, were calculated from logarithmic least-squares fits to the measured data.

The results of this experiment were unexpected. Group 2, fed hay from Well 3, was expected to show the least peak activity in milk instead of the most activity. Another anomaly is evident in Figure 2. Starting about 60 hours after detonation, the milk secretion of ^{131}I decreased with an effective half-life of about 30 hours which approximates the effect observed in previous experiments when cows were given uncontaminated forage. However, as indicated in Figure 3, the hay for the Group 1 cows contained nearly 2 nCi/kg in the feed consumed at 129 hours post-detonation, enough activity to keep the milk levels higher than those measured. Water and grain samples contained negligible amounts of radioiodine.

The high level of ^{131}I in the milk of Group 2 cows represents continued exposure due to keeping them at the contaminated farm and to the levels of ^{131}I measured in the "uncontaminated" hay from Well 3. This latter may be ascribed to a small leakage from a test conducted on December 16 as an air sampler at the farm measured 2.3 μCi-sec/m^3 of ^{131}I on that date, or to redistribution of Baneberry debris as indicated by the air sampler data for Well 3 shown in Table 8.

Table 6. Weighted Average Radioiodine Concentrations, Intake, and Output for Group 1 "Metabolism" Cows - nCi/liter or kilogram

Year 1970 Date & Time		Hours from Venting	^{131}I				^{133}I			
			Hay	Milk	Urine	Feces	Hay	Milk	Urine	Feces
12/19	a.m.	24	0.8	0.60	NC	NC	NC	11.5	NC	NC
	p.m.	32	5.87	0.75	5.7	13.6	9.7	9.3	57.0	69.0
12/20	a.m.	47	1.38	0.60	2.1	23.3	32.7	2.8	9.2	54.5
	p.m.	56	6.65	0.69	2.0	14.2	13.7	0.80	3.3	18.4
12/21	a.m.	72	4.09	0.33	1.16	7.2	10.3	0.43	1.8	10.7
	p.m.	81	3.16	0.28	0.85	4.0	3.1	0.16	0.95	5.3
12/22	a.m.	96	1.82	0.18	0.60	2.3	1.2	0.06	ND	ND
	p.m.	105	3.66	0.12	0.5	1.2	ND	ND	ND	ND
12/23	a.m.	120	4.16	0.10	0.43	1.97				
	p.m.	129	1.75	0.10	0.31	0.76				
12/24	a.m.	145	NC	0.06	ND	0.83				
	p.m.	153		0.06	NC	NC				
12/25	a.m.	169		0.07						
	p.m.	177		0.08						
12/26	a.m.	193		0.08						
	p.m.	201		0.08						
12/27	a.m.	217		0.05						
	p.m.	225		0.03						
12/28	a.m.	241		0.03						
	p.m.	249		0.05						
12/29	a.m.	265		0.02						
	p.m.	273		0.02						

NC = Not collected
ND = Not detectable

Table 7. Weighted Average ^{131}I Concentrations in Milk and Hay Groups 2 and 3 - nCi/liter or kilogram

Date & Time		Hours from Venting	Group 2 Hay	Group 2 Milk	Group 3 Hay	Group 3 Milk
12/19	a.m.	24	0.80	1.10	0.80	1.20
	p.m.	32	4.60	1.10	2.10	1.10
12/20	a.m.	47	0.50	1.50	2.50	1.10
	p.m.	56	0.50	1.80	2.50	1.10
12/21	a.m.	72	9.40	1.10	0.80	0.66
	p.m.	81	1.30	0.83	1.40	0.50
12/22	a.m.	96	ND	0.46	ND	0.37
	p.m.	105	ND	0.48	ND	0.32
12/23	a.m.	120	1.40	0.37	1.50	0.20
	p.m.	129	1.40	0.35	ND	0.21
12/24	a.m.	145	ND	0.28	ND	0.14
	p.m.	153	ND	0.36	ND	0.14
12/25	a.m.	169	ND	0.32	0.93	0.09
	p.m.	177	ND	0.24	ND	0.14
12/26	a.m.	193	ND	0.20	ND	0.14
	p.m.	201	ND	0.18	ND	0.12
12/27	a.m.	217	ND	0.14	ND	0.08
	p.m.	225	ND	0.15	ND	0.07
12/28	a.m.	241	ND	0.14	ND	0.07
	p.m.	249	ND	0.14	ND	0.06
12/29	a.m.	265	ND	0.10	1.30	0.04
	p.m.	273	1.30	0.10	1.30	0.03

Table 7. Weighted Average ^{131}I Concentrations in Milk and Hay Groups 2 and 3 - nCi/liter or kilogram (contd)

Date & Time		Hours from Venting	Group 2		Group 3	
			Hay	Milk	Hay	Milk
12/30	a.m.	289	0.84	0.22	0.84	0.07
	p.m.	297	ND	0.15	ND	0.05
12/31	a.m.	313	ND	0.11	ND	0.04
	p.m.	321	ND	0.11	ND	0.05

ND = Not detectable

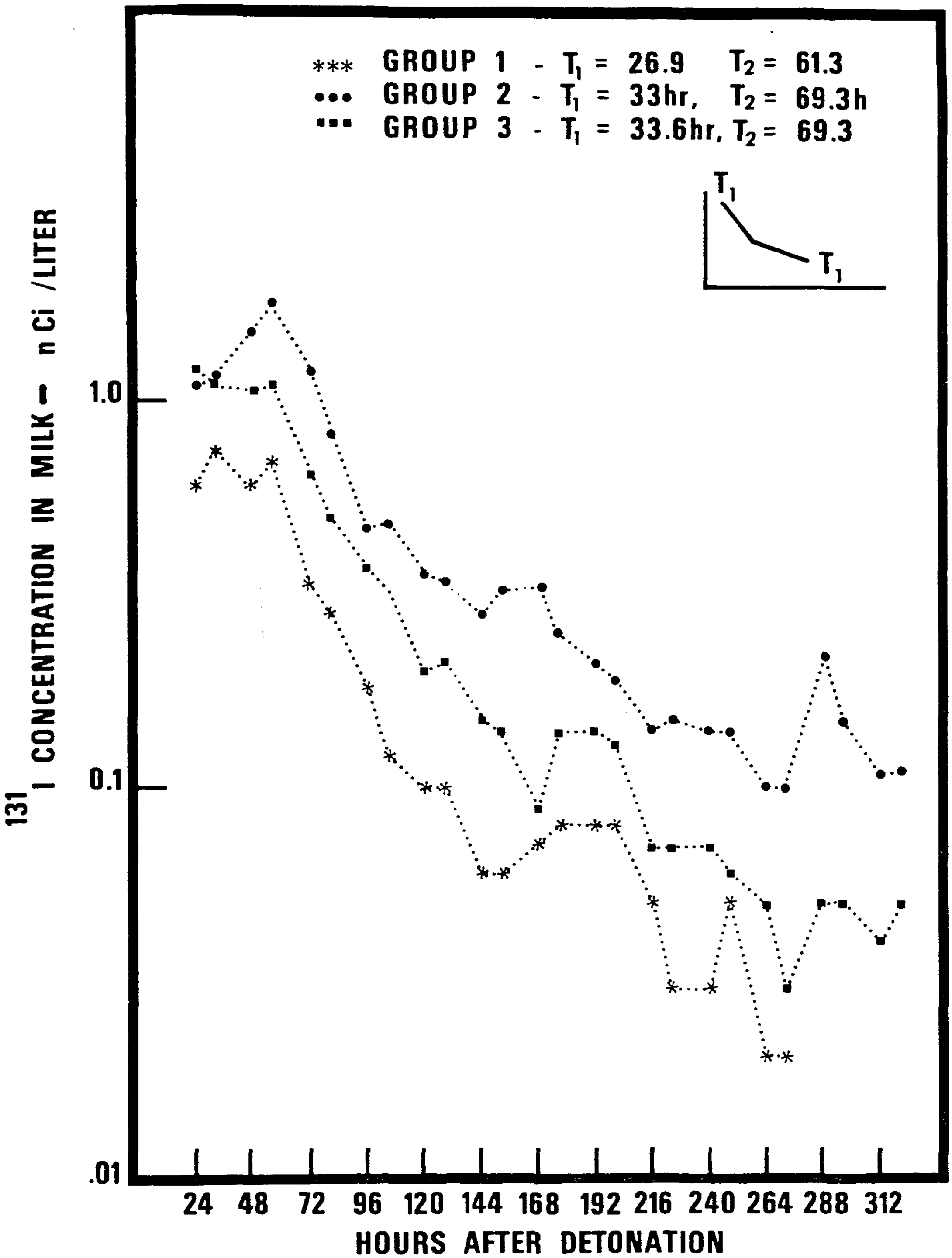

Figure 2. Weighted Average Milk Concentrations of ^{131}I from the Three Groups of Cows

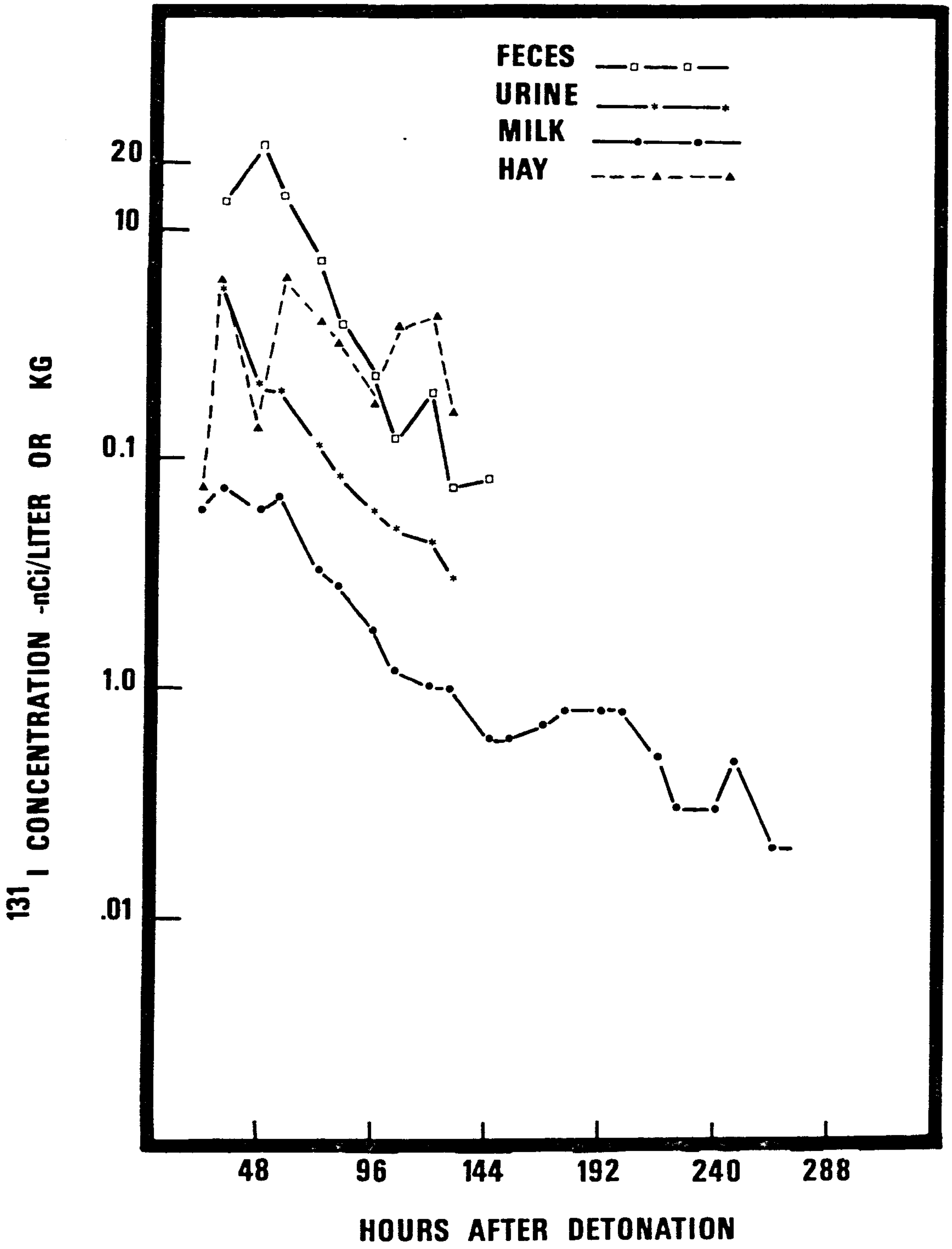

Figure 3. Weighted Average Values for Group 1 "Metabolism" Cows

The ratio of peak concentration in milk to peak concentration in feed (0.11 for Group 1, 0.19 for Group 2, and 0.48 for Group 3) was higher for this study than for previous experiments. This may have been caused by inhalation exposure. Air sampler data for the farm showed measurable ^{131}I activity for several days after Baneberry (Table 8). Unfortunately, the sampler was inoperative from 1240 hr on December 17 until 0815 hr on December 19 so the maximum inhalation exposure for all the cows cannot be determined. The inhalation exposure for the period December 20 to January 3 can be calculated by assuming a breathing rate of 100 liters/min (0.0017 m^3/sec) and multiplying the integrated air concentrations in Table 8 by this amount. The exposure thus calculated is only 10.5 nCi ^{131}I for that period or about the amount ingested in the first hay feeding.

Another factor affecting the milk secretion of the cows, and possibly affecting the results of this study, was that they were not milked for many hours (1500 hr December 17 to 0730 hr December 19) because of test activities. This depressed milk production of all cows by 40% on December 20. However, milk production returned to normal levels by December 23.

The ^{131}I concentration in the first milking, approximately 24 hours after venting, was high in all three groups. A supply of hay was put in the feed bunkers after the afternoon milking on December 17 but was probably mostly consumed by the time of venting on December 18. Therefore, the radioiodine in the first milking was probably due to ingestion of normally ignored residue of the feed plus inhalation during cloud passage. Based on intake measurements for the Group 1 cows, they secreted 13.8% of their

Table 8. Integrated ^{131}I Concentration in Air ($\mu Ci\text{-}sec/m^3$)

Air Sampler Date and Time ON	OFF	Area 15	Well 3
12/16, 1000	12/17, 1240	2.31	---
12/19, 0815	12/20, 1045	0.69	1.04
12/20, 1045	12/21, 0945	0.23	0.04
12/21, 0945	12/23, 1300	0.77	0.76
12/23, 1300	12/24, 0940	0.44	
12/24, 0940	12/25, 1000	0.22	
12/25, 1000	12/26, 1220	0.88	
12/26, 1220	12/27, 1045	0.19	
12/27, 1045	12/28, 1450	0.21	
12/28, 1450	12/30, 1200	0.23	
12/30, 1200	12/31, 1500	0.04	
12/31, 1500	01/02/71, 0830	0.50	
01/02, 0830	01/03, 0900	0.12	

intake into their milk. This is little higher than the 9% average of all previous experiments, the excess possibly reflecting inhalation intake, or errors in estimating the contamination of the hay.

The peak concentration of 1.8 nCi/liter measured in the milk from Group 2 cows, located only 4 miles from surface ground zero, was only about twice the peak ^{131}I concentration of 0.81 nCi/liter measured in the cows at the McCurdy ranch[1] which was more than 40 miles away.

An estimate of total intake can be made using the calf thyroid data from Table 3 and the thyroid weights. The average ^{131}I in those thyroids was 28 nCi. An earlier study[10] indicated calf thyroids had a peak activity at four days with continued intake and the total in the thyroids represented 8.4 to 13.2% of intake. Dividing 28 nCi by these percentages gives an estimate of 212 to 333 nCi as the total intake. This is not inconsistent with the weighted average intake in hay of 243 nCi ^{131}I for the Group 1 cows. However, the Group 2 cows secreted about three times as much ^{131}I in their milk as Group 1 cows so their intake must have been much greater.

Off-Site Studies

On December 30, 1970, a beef animal was sacrificed from a herd grazing 15 miles south of Beatty, Nevada. Samples collected included the thyroid, kidney, liver, and sternum. The thyroid was the only sample containing detectable levels of gamma-emitting radionuclides. The ^{131}I content was 2.4 nCi/g. Selenium and molybdenum analyses were performed as requested by the owner and was found to be less than 10 parts per million.

On December 30, 1970, two jackrabbits (Lepus californicus) and one male ruddy duck (Oxyura jamaicensis), a bottom feeder, were collected in the vicinity of Sunnyside, Nevada.

Table 9 presents the analytical data of the rabbit tissues that contained detectable levels of radionuclides. Significant levels of ^{131}I were found in the kidneys and ingesta of the rabbits, but were not found in other tissues collected. All tissues collected from the duck were below detectable limits. This might have been the result of the duck having

Table 9. Analytical Data - Sunnyside Rabbits (pCi/kg)

Tissue	Rabbit No. 1			Rabbit No. 2	
	^{131}I	^{103}Ru	^{137}Cs	^{131}I	^{137}Cs
Stomach contents	3.3×10^4	<25	<25	2.1×10^4	<25
Intestinal contents	3.7×10^4	1.4×10^4	<25	<25	<25
Kidney	2.5×10^4	<25	<25	3.6×10^4	<25
Muscle	<25	<25	1.9×10^2	<40	1.9×10^2

just migrated into the area prior to the time of sampling, whereas the rabbits were residents of the area.

A cow and a steer that ranged the Tonopah Test Range were purchased in Goldfield, Nevada. They were sacrificed, necropsied, and sampled on January 5, 1971. The uterus of the cow contained a 5½-month-old fetus. The analytical data are presented in Table 10. The thyroids contained significant levels of ^{131}I. The bones of the fetus contained ^{239}Pu and the muscle tissue contained ^{131}I, indicating placental transfer of these radionuclides. Tritium levels in the blood were 1 pCi/ml of free water. The botanical analysis of the rumen contents is presented in Appendix III.

Also collected on this date was a young female coyote that was shot approximately 1½ miles west of the main gate of the Tonopah Test Range. The thyroid was not collected as it was destroyed by the .243 caliber bullet. No detectable gamma-emitting radionuclides were found in the muscle. The femur bone contained 0.5±0.3 pCi of ^{239}Pu/kg and 4.0±0.9 pCi of ^{90}Sr/g of ash.

Table 10. Analytical Data - Tonopah Test Range Cattle

Tissue	Bovine No.	^{131}I pCi/kg	^{103}Ru pCi/kg	^{140}Ba pCi/kg	^{137}Cs pCi/kg	^{239}Pu pCi/kg wet pCi/g ash	^{90}Sr pCi/kg wet pCi/g ash
Rumen contents	1	7.6×10^{3}	6.6×10^{3}	870	<25	NA	NA
	2	4.4×10^{3}	3.8×10^{3}	790	<25	NA	NA
Liver	1	1.8×10^{3}	70	<25	<25	NA	NA
	2	1.3×10^{3}	160	<25	<25	NA	NA
Lung	1	4.6×10^{3}	<25	<25	<25	<0.1 <0.001	NA
	2	2.5×10^{3}	720	<25	<25	0.9±0.2 0.09±0.03	NA
Thyroid	1	5.8×10^{7}	<25	<25	<25	NA	NA
	2	1.7×10^{7}	<25	<25	<25	NA	NA
Muscle	1	640	<25	<25	<25	NA	NA
	2	400	160	<25	70	NA	NA
Bone	1	NA	NA	NA	NA	0.3±0.2 0.02±0.01	450±100 3.0±0.9
	2	NA	NA	NA	NA	4.0±0.6 0.04±0.006	350±100 3.5±0.9
Fetal bone	1	-----	-----	-----	-----	-----	-----
	2	NA	NA	NA	NA	0.5±0.2 0.008±0.002	150±50 2.1±0.8
Fetal muscle	1	-----	-----	-----	-----	-----	-----
	2	550	<25	<25	<25	NA	NA

NA = Not analyzed.

On January 8, 1971, samples were collected from two beef steers of mixed breeding that had been grazing on the Kawich Valley range for several months preceding the event.

One animal was suffering from a liver abscess. No other lesions were noted during the necropsies. The analytical data are presented in Table 11. Again, the highest levels of ^{131}I were found in the thyroids and the greatest variety of gamma-emitting nuclides were present on the skin and hair. Tritium levels in the blood of these two steers were 1.2 and 1.4 pCi/ml of free water, respectively. See Appendix III for botanical analysis of the rumen contents.

During December of 1970, a band of sheep from Adaven, Nevada, was grazing in the Timber Pass area on the east side of Coal Valley. A portion of the Baneberry cloud passed over this area.(1)

On February 2, 1971, two aged ewe sheep were purchased from this band for sacrifice. Necropsy showed that the first sheep was pregnant and had an abscessed mammary gland. The second sheep was dying from extensive liver abscesses. Vital statistics of these sheep are presented in Table 1 and the analytical data are presented in Table 12. The thyroids, six weeks after exposure, still contained significant levels of ^{131}I. No other short-lived fission products were detected in the other tissues.

Tungsten-181 was detected in the liver from both sheep. Tritium levels in the free water from blood were less than 0.4 pCi/ml. Gamma-emitting radionuclides were below detectable limits in the tissues of the fetus collected from the pregnant ewe. See Appendix III for botanical analysis of rumen contents.

Table 11. Analytical Data - Kawich Valley Cattle

Tissue	Bovine No.	^{131}I pCi/kg	^{103}Ru pCi/kg	^{140}Ba pCi/kg	^{141}Ce pCi/kg	^{239}Pu pCi/kg wet pCi/g ash	^{90}Sr pCi/kg wet pCi/g ash
Rumen contents	1	7.9×10^4	1.2×10^5	1.4×10^3	<125	NA	NA
	2	1.1×10^5	1.5×10^5	2.0×10^4	<125	NA	NA
Kidney	1	4.1×10^4	<25	<25	<125	NA	NA
	2	3.8×10^4	<25	<25	<125	NA	NA
Liver	1	2.7×10^4	4.2×10^4	<25	<125	0.10±0.06 0.03±0.01	NA
	2	1.1×10^4	590	<25	<125	NA	NA
Lung	1	2.7×10^5	9.6×10^3	250	<125	0.6±0.3 0.05±0.02	NA
	2	3.2×10^4	1.6×10^3	240	<125	0.3±0.2 0.04±0.02	NA
Thyroid	1	4.1×10^8	<25	<25	<125	NA	NA
	2	6.4×10^8	<25	<25	<125	NA	NA
Muscle	1	4.6×10^3	210	<25	<125	NA	NA
	2	4.7×10^3	300	<25	<125	NA	NA
Bone	1	NA	NA	NA	NA	<0.003	800±300 3.0±1.1
	2	NA	NA	NA	NA	<0.003	250±200 0.9±0.7
Skin	1	8.9×10^4	2.6×10^4	2.2×10^3	7.0×10^3	NA	NA
	2	4.8×10^4	2.5×10^4	6.1×10^3	3.4×10^3	NA	NA

NA = Not analyzed.

Table 12. Analytical Data - Coal Valley Sheep

Tissue	Sheep No.	^{131}I pCi/kg	^{103}Ru pCi/kg	^{144}Ce pCi/kg	^{137}Cs pCi/kg	^{181}W pCi/kg	^{239}Pu pCi/kg wet pCi/g ash	^{90}Sr pCi/kg wet pCi/g ash
Rumen contents	1	<25	<25	<250	<25	<300	NA	NA
	2	<25	400	700	<25	<300	NA	NA
Kidney	1	<25	<25	<250	<25	<300	NA	NA
	2	<25	<25	<250	<25	<300	NA	NA
Liver	1	<25	50	<250	40	2.0×10^3	NA	NA
	2	<25	<25	<250	70	1.2×10^3	3.0±0.1 0.3±0.05	NA
Lung	1	<25	<25	<250	<25	<300	<0.001	NA
	2	<25	<25	<250	<25	<300	<0.001	NA
Thyroid	1	1.3×10^5	<25	<250	<25	<300	NA	NA
	2	1.1×10^5	<25	<250	<25	<300	NA	NA
Muscle	1	<25	<25	<250	<25	<300	NA	NA
	2	<25	<25	<250	<30	<300	NA	NA
Bone	1	NA	NA	NA	NA	NA	1.2±0.4 0.05±0.02	900±200 4.3±1.0
	2	NA	NA	NA	NA	NA	<0.001	1700±300 9.9±1.6
Skin and wool	1	<25	<25	<250	<25	<300	NA	NA
	2	<25	<25	<250	<25	<300	NA	NA
Fetus	1	<25	<25	<250	<25	<300	NA	NA
	2	-----	-----	-----	-----	-----	-----	-----

NA = Not analyzed.

HISTOPATHOLOGY

Tissue slides were prepared from tissues collected from all sacrificed animals and were submitted for interpretation by the pathologist, J. M. Ward, DVM, Ph. D., Veterinary Pathologist, Radiation Office, EPA, Rockville, Maryland. No unexpected pathological lesions were found. The individual reports on each specimen examined are on file at the National Environmental Research Center-Las Vegas.

FISTULATED STEER STUDY ON THE NEVADA TEST SITE

This study was designed to determine the oral intake of fresh fission products by cattle grazing natural vegetation contaminated by fallout from the Baneberry Event. The study also provided information as to the food habits of grazing cattle.

The study area was centered on White Rock Springs which is located approx - mately two miles northwest of the ground zero. The spring supplied drinking water for the three rumen-fistulated mature Hereford steers which served as the biological samplers for the study.

Between April 14, 1971 and July 27, 1971, the three steers were placed on the study area every three weeks. The steers were maintained in the Area 15 corrals between sampling periods. Prior to placement on the range, the steers' rumens were emptied of all ingesta and a blood sample was collected. The steers were then transported from Area 15 to the White Rock Springs area where they were allowed to graze freely for 72 hours. They were then returned to Area 15 where the rumen contents were sampled for radionuclide and botanical analysis and a post-grazing blood sample was collected for tritium analysis. Drinking water samples from Area 15 and White Rock Springs were collected prior to grazing.

Table 13 presents the data on tritium levels in rumen contents, drinking water and in blood collected prior to and subsequent to grazing the study area. In general, the tritium levels in the blood were higher following grazing and were slightly higher than that found in the rumen

Table 13. Tritium Levels - Fistulated Steers (pCi/ml of Free Water)

Animal No.	Date	Blood Pre-grazing	Blood Post-grazing	Rumen Contents	Drinking Water Area 15	Drinking Water White Rock
901	4/14/71	<0.4	<0.4	0.4	<0.4	<0.4
902	4/14/71	<0.4	1.0	0.5		
905	4/14/71	0.5	0.6	<0.4		
901	5/12/71	0.9	3.8	2.1	<0.4	<0.4
902	5/12/71	2.1	3.9	2.4		
905	5/12/71	0.9	2.3	1.0		
901	6/2/71	1.9	3.2	2.9	<0.4	<0.4
902	6/2/71	2.5	3.3	2.6		
905	6/2/71	2.9	2.6	2.5		
901	6/30/71	1.5	2.1	1.5	<0.4	<0.4
902	6/30/71	2.0	2.2	1.7		
905	6/30/71	1.9	1.5	1.7		
901	7/27/71	2.2±0.3	1.8±0.3	1.6±0.3	0.6±0.3	<0.4
902	7/27/71	2.7±0.4	2.2±0.3	1.8±0.3		
905	7/27/71	2.2±0.4	1.8±0.3	1.9±0.4		

contents. The tritium content of the drinking water was usually below detectable levels. No gamma-emitting radionuclides were detected in the water samples.

Data on the gamma-emitting radionuclides and plutonium levels detected in the rumen contents are presented in Table 14. Short-lived radionuclides detected included ^{103}Ru, ^{95}Zr, and ^{124}Sb. The latter was not detected in any samples collected off the Nevada Test Site.

Results of the botanical analysis are presented in Table 15. Grasses made up the bulk of the diet of the animals while on the range. Favored grasses were Stipa speciosa (desert needlegrass) during April and May, Orhyzopsis hymenoides (Indian rice grass) during June and July and Elymus cinereus (giant rye grass) during late July.

Table 14. Gamma-Emitting Radionuclides and Plutonium Levels in Rumen Contents

Animal No.	Date	^{144}Ce pCi/kg	^{103}Ru pCi/kg	^{95}Zr pCi/kg	^{60}Co pCi/kg	^{124}Sb pCi/kg	^{54}Mn pCi/kg	^{238}Pu pCi/kg wet pCi/g ash	^{239}Pu pCi/kg wet pCi/g ash
901	4/14/71	7.8×10^3	1.1×10^5	2.4×10^3	2.3×10^3	8.9×10^3	2.0×10^3	3.5±0.9 0.2±0.04	21.0±2.0 1.0±0.09
902	4/14/71	1.4×10^3	2.0×10^5	1.1×10^4	300	1.4×10^4	9.3×10^3	3.0±1.0 0.1±0.04	26.0±2.0 1.1±0.09
905	4/14/71	1.2×10^4	2.3×10^5	4.4×10^3	1.7×10^3	1.1×10^3	<25	3.0±0.8 0.1±0.04	24.0±2.0 1.0±0.09
901	5/12/71	4.5×10^3	4.4×10^4	200	300	3.5×10^3	2.6×10^3	1.1±0.7 0.1±0.04	10.0±1.0 0.6±0.07
902	5/12/71	2.1×10^3	3.0×10^3	300	700	1.4×10^3	2.4×10^3	1.7±0.6 0.1±0.04	11.0±1.0 0.7±0.08
905	5/12/71	1.2×10^3	1.8×10^3	450	300	1.2×10^3	300	0.7±0.3 0.1±0.03	4.5±0.6 0.4±0.06
901	6/2/71	500	8.4×10^3	400	200	1.1×10^3	<25	0.9±0.6 0.1±0.03	7.0±1.0 0.3±0.05
902	6/2/71	450	1.0×10^3	500	300	1.0×10^3	<25	1.5±0.7 0.1±0.03	9.0±1.0 0.4±0.05
905	6/2/71	1.0×10^3	1.3×10^4	500	600	1.4×10^3	1.4×10^3	3.0±1.0 0.1±0.03	20.0±2.0 0.6±0.07
901	6/30/71	300	200	100	400	1.1×10^3	900	2.1±0.8 0.05±0.06	70.0±5.0 5.0±0.4
902	6/30/71	250	2.4×10^3	100	150	400	900	0.9±0.5 0.5±0.03	5.0±0.8 0.3±0.05
905	6/30/71	400	7.8×10^3	200	400	950	1.2×10^3	1.7±0.7 0.1±0.04	10.0±1.0 0.6±0.07
901	7/27/71	500	1.0×10^4	200	1.1×10^3	1.4×10^3	2.1×10^3	4.0±1.0 0.1±0.04	22.0±2.0 0.9±0.09

Table 14. Gamma-Emitting Radionuclides and Plutonium Levels in Rumen Contents (contd)

Animal No.	Date	^{144}Ce pCi/kg	^{103}Ru pCi/kg	^{95}Zr pCi/kg	^{60}Co pCi/kg	^{124}Sb pCi/kg	^{54}Mn pCi/kg	^{238}Pu pCi/kg wet pCi/g ash	^{239}Pu pCi/kg wet pCi/g ash
902	7/27/71	700	$1.4x10^4$	300	$1.1x10^3$	$1.6x10^3$	$2.5x10^3$	3.0±1.0 0.1±0.05	10.0±1.0 0.4±0.06
905	7/27/71	500	$8.3x10^3$	600	500	800	40	2.0±1.0 0.1±0.05	15.0±2.0 0.7±0.1

Table 15. Botanical Analysis of Rumen Contents of Bovines Grazing White Rock Spring Area

Date Collected	Animal Identification	Botanical Analysis
4/14/71	901	*Stipa speciosa* - 54% *Orhyzopsis hymenoides* - 46% *Ephedra nevadensis* - Trace
4/14/71	902	*Stipa speciosa* - 58% *Orhyzopsis hymenoides* - 37% *Sitanion hystrix* - 5%
4/14/71	905	*Stipa speciosa* - 87% *Orhyzopsis hymenoides* - 11% *Sitanion hystrix* - 2%
5/12/71	901	*Stipa speciosa* - 36% *Orhyzopsis hymenoides* - 34% *Sitanion hystrix* - 29% *Ephedra nevadensis* - 1% *Atriplex canescens* - Trace
5/12/71	902	*Orhyzopsis hymenoides* - 63% *Stipa speciosa* - 30% *Sitanion hystrix* - 4% *Ephedra nevadensis* - 3% *Forb spp.* - Trace
5/12/71	905	*Orhyzopsis hymenoides* - 35% *Stipa speciosa* - 33% *Sitanion hystrix* - 32% *Ephedra nevadensis* - Trace *Forb spp.* - Trace
6/2/71	901	*Stipa speciosa* - 63% *Orhyzopsis hymenoides* - 37% *Chenopodium spp.* - Trace *Salsola kali* - Trace
6/2/71	902	*Orhyzopsis hymenoides* - 63% *Stipa speciosa* - 34% *Sitanion hystrix* - 3%

Table 15. Botanical Analysis of Rumen Contents of Bovines Grazing White Rock Spring Area (contd)

Date Collected	Animal Identification	Botanical Analysis
6/2/71	905	*Orhyzopsis hymenoides* - 90% *Stipa speciosa* - 9% *Eriogonum spp.* - 1% *Salsola kali* - Trace
6/30/71	905	*Orhyzopsis hymenoides* - 53% *Sitanion hystrix* - 7% *Stipa speciosa* - 39% *Salsola kali* - 1%
6/30/71	902	*Orhyzopsis hymenoides* - 58% *Sitanion hystrix* - 39% *Salsola kali* - 3% *Elymus cinereus* - Trace *Bromus spp.* - Trace
6/30/71	901	*Orhyzopsis hymenoides* - 63% *Stipa speciosa* - 10% *Sitanion hystrix* - 17% *Salsola kali* - 10%
7/27/71	901	*Elymus cinereus* - 78% *Stipa speciosa* - 12% *Hilaria jamesii* - 4% *Sitanion hystrix* - 2% *Herbaceous* fragments - 4% *Orhyzopsis hymenoides* - Trace
7/27/71	902	*Elymus cinereus* - 58% *Orhyzopsis hymenoides* - 28% *Sitanion hystrix* - 6% *Herbaceous* fragments - 4% *Stipa speciosa* - 4% *Atriplex canescens* - Trace *Purshia glandulosa* - Trace
7/27/71	905	*Orhyzopsis hymenoides* - 47% *Elymus cinereus* - 39% *Stipa speciosa* - 6% *Herbaceous* fragments - 4% *Hilaria jamesii* - 4% *Atriplex canescens* - Trace *Purshia glandulosa* - Trace

INVESTIGATIONS

Garrison, Utah, Sheep Investigation

On January 21, 1971, it was reported that more than a thousand sheep had died suddenly near the small town of Garrison which is located in Western Utah. A comprehensive investigation of the cause of the losses was initiated by the State of Utah. Because speculation by the press implied radiation was a possible etiological agent, the National Environmental Research Center-Las Vegas was permitted to observe the incident and to conduct an independent investigation on a non-interference basis. The final report(2) concluded that the cause of death was halogeton poisoning.

A thyroid collected on January 22 from an aged Columbia ewe contained 350 pCi ^{131}I per gram. The calculated peak concentration(9) on January 1, 1971, would have been about 3.5 nCi/g. Tissues were not collected for tritium analysis.

Investigation of Alleged Radiation Sicknesses - Ursine, Nevada

On February 18, 1971, an investigation was made of sickness and deaths in domestic animals belonging to a family living near Ursine, Nevada.

The family (man, wife, and three-year-old son) had previously been examined for "radiation sickness" by the local physician and by public health physicians and their illnesses had been diagnosed as a viral enteritis of non-specific etiological origin. The family felt that their animals (chickens, rabbit, cats, dogs, cockateels, and canaries) were suffering from the same condition as themselves.

One rabbit, two chickens, canary eggs, alfalfa hay, and water were collected for radionuclide analyses. The animals were necropsied by the Animal Investigation Program veterinarian and by the Nevada Animal Disease Laboratory. Histological specimens were examined by an independent histopathologist, Dr. J. W. Ward. No definite diagnosis was made on the basis of the necropsy, hematologic, or histopathologic examinations. Detectable levels of fresh fission radionuclides were not found in any of the samples. This investigation was closed on April 3, 1971.

The exact etiological agent will probably remain unidentified but it was postulated that the stresses of severe cold, high winds, and heavy snows during this time, lowered the resistance of the animals and allowed a viral or bacterial agent to overcome their natural defenses and resulted in the illnesses reported.

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APPENDIX I. Minimum Detectable Activities by Gamma Spectroscopy, Technical Support Laboratory, National Environmental Research Center-Las Vegas, Environmental Protection Agency

The minimum detectable activities (MDA's) 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 MDA has been defined as that activity which produced a ±100% deviation at the 95% confidence level. On the basis of experience the MDA is defined as that activity which can be positively identified on a net spectrum plot. These values are applicable to ideal conditions and simple complexes of nuclides. Complex spectra or spectra showing natural contamination can raise the MDA's considerably.

Minimum Detectable Activities in pCi for Total Sample

	10 Min Count	40 Min Count			100 Min Count		
Isotope	Planchet	Planchet	400 ml	3.5 l	400 ml	1000 ml	3.5 l
^{54}Mn	50	25	40	35	25	25	22
^{65}Zn	500	250	400	350	250	250	220
^{60}Co	50	25	40	35	25	25	22
^{95}Zr	50	25	40	35	25	25	22
^{103}Ru	50	25	40	35	25	25	22
^{106}Ru	500	250	400	350	250	250	220
^{124}Sb	50	25	40	35	25	25	22
^{125}Sb	250	125	200	175	125	125	110
^{132}Te	50	25	40	35	25	25	22
^{131}I	50	25	40	35	25	25	22
^{133}I	50	25	40	35	25	25	22
^{137}Cs	50	25	40	35	25	25	22
^{140}Ba	50	25	40	35	25	25	22
^{141}Ce	250	125	200	175	125	125	110

APPENDIX I. Minimum Detectable Activities in pCi for Total Sample (contd)

Isotope	10 Min Count Planchet	40 Min Count Planchet	40 Min Count 400 ml	40 Min Count 3.5 l	100 Min Count 400 ml	100 Min Count 1000 ml	100 Min Count 3.5 l
^{144}Ce	500	250	400	350	250	250	220
^{181}W	600	300	475	425	300	300	260
^{3}H	0.4 pCi per ml of H_2O						
^{89}Sr	5.0 pCi total sample of ash						
^{90}Sr	2.0 pCi total sample of ash						
^{238}Pu	0.01 pCi per gram of ash						
^{239}Pu	0.01 pCi per gram of ash						
K*	0.5	0.3	0.4	0.4	0.3	0.3	0.25

*Grams of stable potassium per kilogram of sample (wet weight) as determined from ^{40}K activity.

Appendix II-1. ^{131}I Concentration in Hay and Milk Samples from Group 1 "Metabolism" Cows - nCi/liter or kilogram

Date & Time		Cow 16 Hay	Cow 16 Milk	Cow 45 Hay	Cow 45 Milk	Cow 46 Hay	Cow 46 Milk	Cow 123 Hay	Cow 123 Milk
12/19	a.m.	0.80	0.28	0.80	0.36	0.80	0.56	0.80	1.20
	p.m.	8.10	0.34	2.80	0.42	6.60	0.80	6.00	2.00
12/20	a.m.	1.50	0.51	1.00	0.66	NC	0.38	2.80	1.30
	p.m.	2.30	0.42	8.30	0.62	9.80	0.67	4.20	1.20
12/21	a.m.	3.10	0.24	1.90	0.26	7.70	0.37	4.20	0.52
	p.m.	0.40	0.24	2.40	0.23	6.50	0.31	3.20	0.34
12/22	a.m.	1.90	0.16	1.70	0.14	1.70	0.22	2.00	0.17
	p.m.	7.60	0.09	1.80	0.09	2.10	0.16	NS	0.13
12/23	a.m.	4.40	0.09	5.70	0.05	3.60	0.14	1.90	0.01
	p.m.	2.80	0.10	0.90	0.09	0.99	0.12	2.50	0.07
12/24*	a.m.	ND	0.10		0.05		0.07		0.04
	p.m.	ND	0.09		0.05		0.03		0.06
12/25	a.m.	0.93	0.12		0.05		0.04		0.08
	p.m.	ND	0.13		0.06		0.07		0.07
12/26	a.m.	ND	0.12		0.06		0.08		0.06
	p.m.	ND	0.12		0.07		0.07		0.06
12/27	a.m.	ND	0.08		0.03		0.05		0.04
	p.m.	ND	0.09		0.03		0.05		0.04
12/28	a.m.	ND	0.06		0.02		0.04		0.04
	p.m.	ND	0.06		0.02		0.05		0.05
12/29	a.m.	ND	0.04		<0.01		<0.01		0.02
	p.m.	1.30	0.03		0.02		0.03		0.20
12/30	a.m.	0.84	0.02		<0.01		0.03		0.02
	p.m.	ND	0.03		<0.01		0.02		0.02

Appendix II-1. ^{131}I Concentration in Hay and Milk Samples from Group 1 "Metabolism" Cows - nCi/liter or kilogram (contd)

Date & Time		Cow 16 Hay	Cow 16 Milk	Cow 45 Hay	Cow 45 Milk	Cow 46 Hay	Cow 46 Milk	Cow 123 Hay	Cow 123 Milk
12/31	a.m.		0.03		0.02		0.04		0.03
	p.m.		0.04		0.02		0.03		0.02
01/01/71	a.m.		0.03		<0.01		0.02		<0.01
	p.m.		0.03		0.02		0.03		0.02
01/02	a.m.		0.04		0.02		0.04		<0.01
	p.m.		0.04		0.02		0.04		0.03

NC = Not collected
*Moved to Area 15 after a.m. milking 12/24 and composite hay samples taken.
ND = Not detectable

Appendix II-2. Radioiodine Concentration in Urine and Feces Samples from Group 1 Cows - nCi/liter or kilogram

Date & Time		Cow 16 Urine	Cow 16 Feces	Cow 45 Urine	Cow 45 Feces	Cow 46 Urine	Cow 46 Feces	Cow 123 Urine	Cow 123 Feces
					^{131}I				
12/19	p.m.	1.0	5.8	3.9	18.0	2.8	17.0	15.0	NC
12/20	a.m.	0.9	8.1	1.9	22.0	1.9	16.0	4.1	59.0
	p.m.	0.7	4.8	1.6	15.0	2.1	12.0	3.8	27.0
12/21	a.m.	0.47	2.7	0.96	11.0	1.2	5.4	2.4	10.6
	p.m.	0.4	2.2	0.7	3.5	0.99	3.2	1.5	7.2
12/22	a.m.	0.34	1.9	0.51	2.3	0.81	2.2	0.88	3.0
	p.m.	0.35	0.96	0.48	0.99	0.51	1.3	0.70	1.8
12/23	a.m.	0.16	1.8	0.27	1.6	0.57	0.86	0.63	3.9
	p.m.	0.26	0.73	0.26	0.73	0.33	0.70	0.41	0.91
12/24	a.m.	NC	0.85	NC	0.72	NC	0.88	NC	0.90
					^{133}I				
12/19	p.m.	12.0	29.0	45.0	90.0	32.0	89.0	140	NC
12/20	a.m.	7.6	31.0	13.0	110	14.0	81.7	25.0	350
	p.m.	3.4	14.0	7.3	55.0	9.4	45.0	18.0	110
12/21	a.m.	1.5	8.3	2.5	20.0	3.2	15.7	7.4	31.7
	p.m.	0.9	6.0	1.8	9.6	ND	9.1	3.3	18.3
12/22	a.m.	0.68	3.8	0.81	6.8	1.1	5.3	1.4	5.3
	p.m.	ND	ND	ND	ND	ND	ND	ND	ND

NC = Not collected
ND = Not detectable

Appendix II-3. ^{131}I Concentration in Hay and Milk Samples from Group 3 Cows - Milk-nCi/liter - Hay-nCi/kilogram

Date & Time		Hay	Cow 11 Milk	Cow 119 Milk
12/19	a.m.	0.80	NC	1.20
	p.m.	2.10	1.10	1.20
12/20	a.m.	2.50	1.00	1.20
	p.m.	2.50	1.20	0.89
12/21	a.m.	0.80	0.66	0.64
	p.m.	1.40	0.52	0.43
12/22	a.m.	ND	0.40	0.32
	p.m.	ND	0.35	0.24
12/23	a.m.	1.50	0.22	0.15
	p.m.	ND	0.21	0.21
12/24	a.m.	ND	0.17	0.10
	p.m.	ND	0.17	0.10
12/25	a.m.	0.93	0.10	0.08
	p.m.	ND	0.15	0.12
12/26	a.m.	ND	0.15	0.11
	p.m.	ND	0.14	0.10
12/27	a.m.	ND	0.08	0.06
	p.m.	ND	0.08	0.06
12/28	a.m.	ND	0.07	0.08
	p.m.	ND	0.06	0.05
12/29	a.m.	ND	0.05	0.04
	p.m.	1.30	0.03	0.04
12/30	a.m.	0.84	0.05	0.04
	p.m.	ND	0.05	0.05

Appendix II-3. ^{131}I Concentration in Hay and Milk Samples from Group 3 Cows - Milk-nCi/liter - Hay-nCi/kilogram (contd)

Date & Time		Hay	Cow 11 Milk	Cow 119 Milk
12/31	a.m.	ND	0.04	0.05
	p.m.	ND	0.05	0.04
01/01/71	a.m.	ND	0.05	0.05
	p.m.	ND	0.05	0.06
01/02	a.m.	0.9	0.05	0.07
	p.m.	ND	0.04	0.07
01/03	a.m.	4.70	0.04	0.08
	p.m.	ND	0.05	0.06

NC = Not collected
ND = Not detectable

Appendix II-4. ^{131}I Concentration in Hay and Milk Samples from Group 2 "Inhalation" Cows - Milk-nCi/liter - Hay-nCi/kilogram

Date & Time		Hay	Cow 13 Milk	Cow 87 Milk	Cow 127 Milk	Cow 134 Milk
12/19	a.m.	0.80	0.39	1.60	1.30	1.10
	p.m.	4.60	0.38	0.66	2.10	1.70
12/20	a.m.	0.50	0.55	3.40	1.40	1.30
	p.m.	0.50	0.52	3.20	1.50	1.40
12/21	a.m.	9.40	0.35	2.00	1.40	0.72
	p.m.	1.30	0.26	1.20	1.00	0.50
12/22	a.m.	ND	0.15	0.75	0.77	0.29
	p.m.	ND	0.20	0.77	0.59	0.25
12/23	a.m.	1.40	0.19	0.57	0.50	0.21
	p.m.	1.40	0.24	0.40	0.61	0.18
12/24	a.m.	ND	0.22	0.36	0.43	0.14
	p.m.	ND	0.21	0.41	0.45	0.17
12/25	a.m.	ND	0.22	0.43	0.39	0.23
	p.m.	ND	0.21	0.32	0.32	0.14
12/26	a.m.	ND	0.14	0.25	0.29	0.15
	p.m.	ND	0.14	0.25	0.34	0.12
12/27	a.m.	ND	0.06	0.16	0.32	0.16
	p.m.	ND	0.07	0.12	0.36	0.16
12/28	a.m.	ND	0.04	0.17	0.30	0.16
	p.m.	ND	0.06	0.16	0.27	0.14
12/29	a.m.	ND	0.04	0.10	0.20	0.10
	p.m.	ND	0.06	0.11	0.15	0.09
12/30	a.m.	0.84	0.03	0.50	0.11	0.08
	p.m.	ND	0.02	0.31	0.09	0.10

Appendix II-4. ^{131}I Concentration in Hay and Milk Samples from Group 2 "Inhalation" Cows - Milk-nCi/liter - Hay-nCi/kilogram (contd)

Date & Time		Hay	Cow 13 Milk	Cow 87 Milk	Cow 127 Milk	Cow 134 Milk
12/31	a.m.	ND	0.11	0.10	0.06	0.17
	p.m.	ND	0.15	0.09	0.09	0.09
01/01/71	a.m.	ND	0.04	0.15	0.09	0.07
	p.m.	ND	0.05	0.14	0.08	0.07
01/02	a.m.	ND	0.04	0.15	0.12	0.07
	p.m.	ND	0.03	0.15	0.11	0.07
01/03	a.m.	ND	0.03	0.10	0.10	0.07
	p.m.	ND	0.03	0.10	0.10	0.07
01/04	a.m.	ND	<0.01	0.05	0.07	0.04
	p.m.	ND	<0.01	0.10	0.06	0.06

ND = Not detectable

APPENDIX III. Botanical Analysis of Rumen Contents from Off-Site Cattle and Sheep

BOV-1-Nye Co

Scientific Name	Common Name	Plant Parts	% Composition
Orhyzopsis hymenoides	Indian rice grass	Stems-leaves	83
Eurotia lanata	Winter fat	Stems-leaves	17
Malacothrix	Sunflower	Leaves	Trace
Unidentified forb		Fragments	Trace
Herbaceous fragments		Fragments	Trace

BOV-2-Nye Co

Scientific Name	Common Name	Plant Parts	% Composition
Orhyzopsis hymenoides	Indian rice grass	Stems-leaves	89
Eurotia lanata	Winter fat	Stems-leaves	11
Atriplex canescens	Four-winged saltbush	Leaves	Trace
Hilaria jamesii	Galleta grass	Leaves	Trace
Eriogonum spp.	Wild buckwheat	Stems	Trace

BOV-1-Lin Co

Scientific Name	Common Name	Plant Parts	% Composition
Atriplex canescens	Four-winged saltbush	Stems-leaves	76
Orhyzopsis hymenoides	Indian rice grass	Stems-leaves	18
Unidentified shrub		Woody fragments	3
Unidentified grass		Leaves	1
Unidentified forb		Fragments	1
Hilaria jamesii	Galleta grass	Leaves	1

APPENDIX III. Botanical Analysis of Rumen Contents from Off-Site Cattle and Sheep (contd)

BOV-2-Lin Co

Scientific Name	Common Name	Plant Parts	% Composition
Atriplex canescens	Four-winged saltbush	Stems-leaves	69
Orhyzopsis hymenoides	Indian rice grass	Stems-leaves	25
Hilaria jamesii	Galleta grass	Stems-leaves	3
Unidentified grass		Leaves	2
Salsola kali	Russian thistle	Stems-leaves	1
Eriogonum spp.	Wild buckwheat	Stems	Trace

SHEEP-2-Lin Co

Scientific Name	Common Name	Plant Parts	% Composition
Grass		Stems-leaves	78
Forbs		Stems-leaves	4
Shrubs		Stems-leaves	18

NOTE: 10% of shrub composition was *Atriplex canescens*; other species unidentified.

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58 - 59 Floyd L. Galpin, Director, Field Operations Division, ORP, EPA, Washington, DC

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