SWRHL-32r

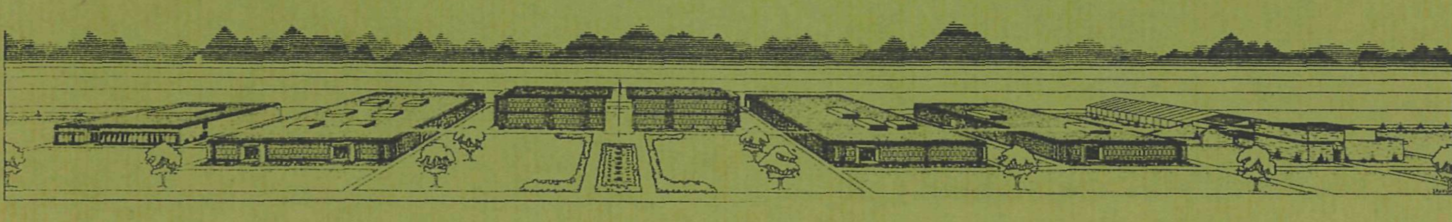
FINAL REPORT OF OFF-SITE SURVEILLANCE FOR THE NRX-A5 TEST SERIES

by the
Southwestern Radiological Health Laboratory

Department of Health, Education, and Welfare
Public Health Service
National Center for Radiological Health

October 15, 1968

This surveillance performed under a Memorandum of Understanding (No. SF 54 373) for the U. S. ATOMIC ENERGY COMMISSION



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ABSTRACT

The Southwestern Radiological Health Laboratory provided off-site radiological surveillance for the NRX-A5 Project Rover Reactor Test Series at NRDS, Test Cell A. During the period in which this series was conducted, there were four experimental plans (EP's) in the NRX-A5 series, two of which were full power runs (1100 Mw) of about 15 minutes duration which produced detectable amounts of radioactivity off-site. Radioactive effluent released by the EP-III on June 8, 1966, was detected by ground level surveillance in the southwest off-site quadrant. Effluent released by the EP-IV on June 23 was detected by ground level surveillance along an azimuth of about 30° (20° cloud width) to the Utah-Nevada border, about 190 miles from the Test Cell. Although off-site contamination occurred from the NRX-A5 test series, surveillance indicated that radioactivity levels did not exceed the radiation protection guides established by the Atomic Energy Commission (AEC Manual Chapter 0524) for the off-site population (based on the Federal Radiation Council Guidelines). The peak potential thyroid dose, for a child with a 2 gram thyroid, in the off-site area from this series was about 20 millirad or less and the external whole body exposure about 1 mR (at different locations).

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INTRODUCTION

This report presents the results of the off-site radiological surveillance program conducted by the Public Health Service (PHS) for the NRX-A5 Reactor Test Series (Experimental Plans I, II, III and IV) at the Nuclear Rocket Development Station (NRDS).

Under a memorandum of understanding with the Atomic Energy Commission (AEC), the U. S. Public Health Service conducts a program of radiological monitoring and environmental sampling in the off-site area surrounding the Nevada Test Site (NTS) and the Nellis Air Force Range (NAFR) which include the NRDS and Tonopah Test Range. For simplicity, this combined area will be termed the test range complex in this report.

The NRX-A5 was the fourth fueled reactor in the NRX series of the Rover Program. The reactor was placed so that the hydrogen coolant and escaping fission products were exhausted upwards. The primary objective of the program was to obtain accumulated operating time at design conditions. The series was conducted at Test Cell A under the auspices of the Rover Nuclear Engine for Rocket Vehicle Application (NERVA) program, which is directed by the Space Nuclear Propulsion Office (SNPO).

The reactor was operated at full power for an accumulated time of about 30 minutes, resulting in an integral power of about 2.1×10^6 Mw-sec. The peak power was 1200 Mw. The experimental plans are outlined in Table 1.

The effluent from both EP-III and EP-IV was detected in off-site environmental samples. The general hotlines and boundary of the area where fresh fission products or radioactivity above background was found at ground level are indicated in Figure 1. The EP-III effluent was spread over a relatively large arc because of considerable wind shear and shifting winds during and after the test. The effluent to the northeast of NRDS for EP-III was due to the northeasterly flow of surface level winds at test time which resulted in a small segment of the cloud going towards Control Point 1. The broken line on Figure 1 indicates the boundary where the effluent from EP-III was observed; the arrow indicates the main cloud trajectory.

Table 1. NRX-A5 experimental plans.

Experimental Plan	Date 1966	Time of Operation, PDT	Integral Power Mw-secs	Radioactivity Detected Off-Site
EP-I	May 26		Criticality and drum calibration	No
EP-II	June 8	AM	Low power test	No
EP-III	June 8	1402-1418	1.1×10^6 (Full Power)	Yes
EP-IV	June 23	1035-1050	1.0×10^6 (Full Power)	Yes

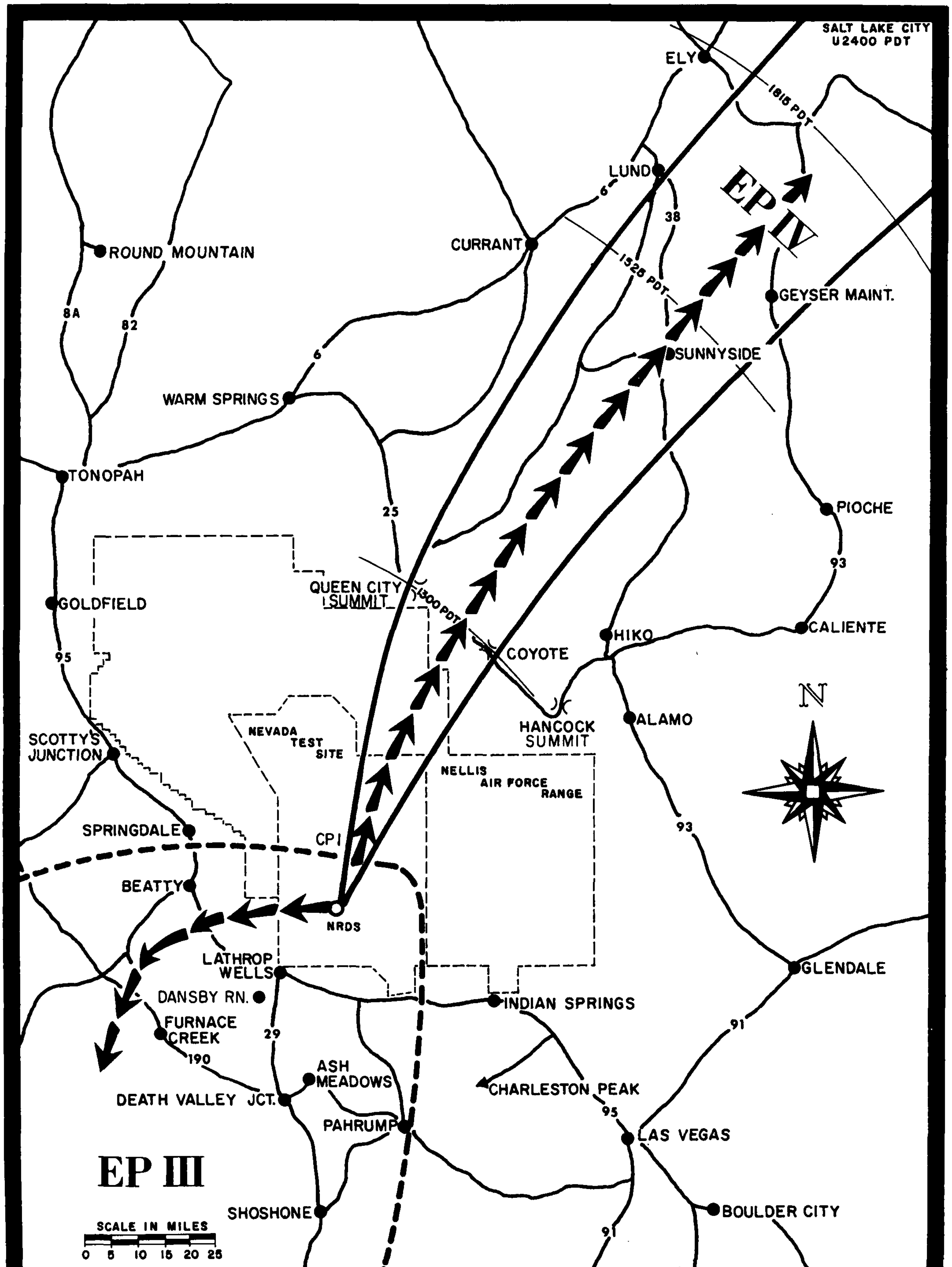

Figure 1. Hotlines for NRX-A5 EP-III, June 8, 1966, and EP-IV, June 23, 1966. (Cloud arrival times for EP-IV are based on aircraft tracking).

OPERATIONAL PROCEDURES

The Off-Site surveillance program was comprised of routine monitoring stations (includes air, milk and water) and mobile monitoring teams. The monitoring teams were initially positioned on the basis of the hot-line prediction by the Environmental Science Services Agency, Air Resources Field Research Office (ESSA, ARFRO) with final positioning and sampling based on the airplane surveillance results and the monitors' results.

A. External Radiation Measurements

1. Ground Monitoring

Ground monitors tracked the reactor effluent passage and determined exposure rates at several locations with portable instruments. Each monitor was equipped with an Eberline E-500B, a Precision Model 111 Standard "Scintillator", and a Victoreen Radector Model No. AGB-50B-SR.

The Eberline E-500B is a Geiger Mueller instrument with a range of 0 to 200 milliroentgens per hour (mR/hr) beta and/or gamma on four scales with an external halogen filled GM tube and a 0 to 2000 mR/hr, gamma only, range from an internal Anton 302 6M tube.

The Precision Model 111 Standard "Scintillator" is used primarily for low level detection and an indication of cloud passage. It has a range of 0 to 5 mR/hr on six linear scales.

The Radector has a range of 0.05 to 50,000 mR/hr on two logarithmic scales. This instrument employs an inert gas ionization chamber.

The above instruments are calibrated with ^{137}Cs and are generally accurate to about $\pm 20\%$ for this energy. Exposure rate readings can be made to two significant digits.

2. Exposure Rate Recorders

Eberline RM-11 exposure rate recorders are placed at twenty-one stations around the test range complex (Figure 2) and are operational on a routine basis. These recorders utilize a Geiger Mueller tube detector to document radiation levels at specific locations. The instrument has a 0.01 to 100 mR/hr range on a 4 cycle log scale. The gamma exposure rate is recorded on a 30-hour strip chart. The RM-11 is accurate to $\pm 20\%$ as calibrated with a ^{137}Cs source.

3. Aerial Cloud Tracking

An Air Force U3-A aircraft, manned by two Public Health Service monitors equipped with portable monitoring instruments identical to those of the ground monitors (also a Radector ion chamber with a range of 0 to 1000 R/hr), tracked the reactor effluent to assist the positioning of ground monitors and to determine the general magnitude of the release. Public Health Service cloud sampling aircraft were also used as aids in cloud tracking, however their primary purpose was cloud sampling in order to determine cloud size and inventory. The results of their sampling are reported separately by the SWRHL Engineering Development Program. Long range tracking of the effluent cloud is also done by the NATS and ARMS aircraft from EG&G who also write a separate report.

4. Film Badges and TLD's

The PHS routinely maintains approximately 56 film badge stations (5 badges to a station) off the test range complex and assigns badges to approximately 120 off-site residents. DuPont type 555 film is

Figure 2. Location of air samplers and RM-11 dose rate recorders for NRX-A5. June 1966.

used in the badge. The results of exposures are accurate to ±50% in the 20 to 100 mR range and ±10% in the 100 to 2000 mR range. The lower limit of detectability is 20 mR. These sensitivities assume no heat damage, which produces interference at some locations.

As part of the external dosimetry program the PHS also has 21 stations where thermoluminescent dosimeters (TLD) are located in conjunction with the film badge stations. Three EG&G Model Tl-12 CaF TLD's are located at each station. These dosimeters have a sensitivity of 5 mR above background with an accuracy of ±10% and standard deviation at the 90% confidence level of 2.8%. They have an upper exposure limit of 5,000 R.

B. Radioactivity in Environmental Samples

1. Air Samples

During June, one-hundred and eight air samplers were routinely operated in the western United States, thirty-eight of which were located in Nevada (Figure 2). Supplementary temporary air sampler locations were established as deemed necessary to cover cloud passage. The routine samplers were the Gelman Tempest type and were equipped with Whatman 4 inch 541 prefilters. A portion of the routine samplers and all supplementary stations were equipped with MSA charcoal cartridges.

The Tempest air sampler used by SWRHL employs a Gast vacuum pump driven by a 1/2 or 3/4 horsepower motor. The pump runs at about 1400 rpm with an average flow rate of about 10 cfm. The supplementary temporary air samplers consisted of a Gast Model No. 0740 positive displacement pressure-vacuum pump coupled to a Rockwell Model No. 415 gas meter for precise measurement of air flow. The flow rate of these systems averages about 6 cfm.

All air sample prefilters and charcoal cartridges collected following the NRX-EST series were returned to the Southwestern Radiological Health Laboratory in Las Vegas for analysis. Prefilters were counted simultaneously for gross beta and alpha activity with a Beckman "Wide Beta" 4-inch low background (6 cpm beta) proportional counting system. This system has an efficiency of approximately 45% for 0.54 MeV betas. Gross beta concentrations were computed at the time of count for the purpose of screening samples and delineating the effluent trajectory. Samples which were believed to contain fresh fission products were recounted several times. Based on these counts, an individual decay constant was computed for each sample. This constant was used to extrapolate the gross beta result to the end of the collection period.

All prefilters were analyzed for the predominant biologically significant gamma emitting isotopes by using a 4" by 4" sodium iodide crystal and multi-channel analyzer. Reported values are corrected for radioactive decay to the end of the collection period. Since it was not possible to define duration of effluent passage at all locations, the reported values given as pCi/m^3 assume an average concentration over each entire sampling period. Results are also reported in $\frac{pCi\text{-}sec\ (or\ hr)}{m^3}$. This unit is obtained by multiplying pCi/m^3 by the sampling time in seconds (or hours) and results in the total cloud passage exposure.

All charcoal cartridges were analyzed for gamma isotopes using a 4"x 4" sodium iodide crystal coupled to a multi-channel pulse height analyzer set to view energies from 0 to 2 MeV. The activity on the cartridge should represent primarily the gaseous radioiodines.

The analyses of the gamma spectra were performed by an IBM 1620, utilizing a matrix technique. This method compensates for the interference between isotopes for a given spectrum by the simultaneous solution of n equations containing n unknowns, where n represents the number of isotopes for which solution is sought. Due to time and memory limitations on the 1620, the matrix is limited to eight (n=8) isotopes. The input to the computer program is variable so that a determination may be made for any eight isotopes for which standard spectra are available.

The threshold detectability for several radionuclides in air samples is presented in Table 2. These values are based on an examination of previous data collected under the following conditions and assumptions:

a. Count time in days after fissioning as indicated by footnotes.
b. Prefilters collect unfractionated fission products resulting in a complex spectrum.
c. Only the gaseous fission products (primarily iodines) are collected on the MSA charcoal cartridge.
d. An eight isotope matrix is employed for computation and isotopes other than those examined are present in amounts which are small relative to those eight.
e. Natural activity on air samples is approximately five times system background.

Table 2. Threshold detectability in picocuries (pCi)* at time of count of several radionuclides in air samples (90% confidence level).

Sample Type	^{131}I	^{132}Te-I	^{133}I	^{135}I	^{140}Ba-La	Length of Count	Notes
Whatman No. 541	500	1000	500	1000	500	10 min.	1
	200	-	200	-	200	10 min.	2
MSA Charcoal	200	400	200	400	200	10 min.	1
	100	-	100	-	100	10 min.	2

1 - counted at less than 3 days after fissioning.
2 - counted at 3 days or more after fissioning.
*1 pCi = 10^{-12} curie.

2. Milk Samples

After the release of radioactivity from NRDS, milk samples were collected from dairy farms and farms producing milk for their own consumption, which were believed to have been in the cloud path. All liquid samples are counted, with no prior preparation, in 3.5 liter inverted well aluminum beakers which are placed over a 4"x 4" sodium iodide crystal. Each milk sample is counted for 40 minutes using a multi-channel analyzer viewing an energy range from 0 to 2 MeV. The lower limit of detection for ^{131}I and ^{133}I in milk is about 20 pCi/l at time of count (if ^{137}Cs <100 pCi/l), and all results below that value are reported as non-detectable. The reported values have, at time of count, a 2 sigma error estimate of ±15 pCi/l or $\pm10\%$, whichever is greater.

Biological discrimination limits the number of radionuclides present in a milk sample. The time delay between ingestion by the cow, production of milk, and its analysis also removes short half-life isotopes such as ^{132}I and ^{135}I.

3. Vegetation Samples

Vegetation samples were collected in the suspected effluent trajectory to indicate deposition on the ground and thus the general cloud trajectory. They were also obtained at most milk sampling locations, with an effort made to make the sample representative of the cows' feed. These samples were taken as early indicators of where milk might be contaminated and the general level of contamination.

The limit of detectability for specific isotopes in vegetation samples is several hundred picocuries per kilogram and is dependent on the interference from other isotopes and sample size.

4. Water Samples

Water samples are routinely collected from about 30 locations around the test range complex. In addition special samples may be taken in the area of suspected effluent passage. The sensitivity for detection of radioiodine in water is about the same as that for milk if significant quantities of other gamma emitters are not present.

RESULTS

A. NRX-A5, EP-I and II

Experimental Plan I (EP-I) was the criticality and drum calibration test and EP-II was a low power test. There was not a significant release of radioactivity and radioactive effluent was not detected off-site. The PHS had people on standby for both ground and aerial monitoring for both tests.

B. NRX-A5, EP-III

Experimental Plan III was the first full power run on the NRX-A5 reactor. As a result of the aerial cloud tracking results, ground monitoring was performed in the southwest quadrant off-site. PHS aerial monitoring results indicated that the effluent cloud was split into two sections at about 8,000 and 9,000 feet MSL by the large wind shear which existed at test time (meteorological data from ESSA, ARFRO in Table 3). The low altitude section of the cloud went towards CP-1 at a bearing of about 40°. The main cloud went in a westerly direction with an initial bearing of about 270° for about 25 miles and later in a more southerly direction. The peak exposure reading in the airplane was 7 mR/hr at about 8 miles from the reactor, with the highest off-site reading being 3 mR/hr at the south boundary of NRDS. The ground sampling locations for air and milk are shown in Figure 3.

1. Sampling Results

a. Ground Monitoring

Ground monitors were located on U.S. 95 at the time and location of cloud passage. The monitors did not detect gamma exposure rates above background. The RM-11 recorders did not indicate any exposure rates above background.

Table 3A. Meteorological data taken by ESSA, ARFRO, for NRX-A5, EP-III.

Sky Condition: 5000' Sctd., Est. 18,000' Overcast
Clouds: 4/10 Cumulus, 6/10 Altocumulus
Visibility: Unrestricted
Upper Air Data At: Jackass Flats, Nevada, 1400 PDT, 6/8/66

	Height (Ft. MSL)	Wind (Deg/Kts)	Pressure (mb)	Temperature (°C)	Dew Point (°C)	Relative Humidity (%)
SFC	3615	210/10	887	24.9	1.1	21
	4000	220/11	876	22.3	1.9	26
	4068	210/11	871	21.5	2.2	28
	4816	210/07	850	19.3	1.3	30
	5000	210/07	841	18.8	0.9	30
	6000	180/04	814	15.4	-1.3	32
	6201	190/03	807	14.6	-1.0	34
	6955	200/01	785	13.4	-1.5	36
	7000	210/01	784	13.4	-1.5	36
	8000	120/02	757	10.8	-2.6	39
	9000	100/04	730	8.0	-4.1	42
	10000	080/09	703	5.2	-5.5	46
	10151	090/08	700	4.9	-5.8	46
	11000	M	677	2.6	-7.0	49
	11680	M	660	0.5	-8.5	51
	12000	140/04	652	-0.1	-8.9	52
	13000	130/03	627	-2.9	-11.0	53
	14000	060/03	604	-5.2	-13.0	54
	14534	060/04	593	-6.4	-13.6	56
	15000	080/04	583	-6.9	-16.9	47
	15026	100/05	582	-6.9	-16.9	47
	15420	110/06	572	-7.2	-17.4	44
	16000	120/08	558	-8.6	-18.5	45
	17000	130/15	536	-10.9	-20.2	46
	18000	130/20	516	-13.0	-21.7	47
	18806	M	500	-14.9	-23.4	48

SFC = Surface
M = Missing

Table 3B. Supplementary winds aloft: June 8, 1966.
Data (Degrees/Knots)

Observational Point	:	Jackass Flats, Nevada, Elevation 3615'						
Time of Ob. (PDT)	:	1030	1100	1130	1200	1230	1245	1300
Type of Measurement	:	Radar	Radar	Radar	Radar	Radar	Radar	Radar
H	Surface	170/04	290/02	190/06	260/05	240/08	240/05	210/07
E	4000	170/02	290/01	200/01	250/05	230/06	260/04	230/07
I	5000	110/01	280/01	160/02	220/09	190/02	250/07	220/05
G	6000	090/05	200/03	090/04	200/04	100/03	200/06	170/04
H	7000	080/10	120/06	070/06	130/04	100/06	150/08	160/06
T	8000	080/14	100/11	070/09	070/03	100/09	120/05	130/08
	9000	100/10	080/13	080/11	080/05	100/09	100/11	110/06
(Ft. MSL)	10000	110/07	090/12	080/13	090/09	100/13	090/12	090/09
	11000	120/12	110/13	090/14	100/12	100/12	----	----
	12000	130/11	130/10	100/14	100/12	120/08	----	----
	13000	150/11	150/13	150/10	140/08	160/06	----	----
	14000	160/08	170/10	170/13	170/07	180/05	----	----
	15000	180/11	180/11	170/15	150/08	----	----	----
Time of Ob. (PDT)	:	1315	1330	1345	1400	1415	1430	1500
Type of Measurement	:	Radar	Radar	Radar	Radar	Radar	Radar	Radar
H	Surface	220/06	230/10	240/05	210/10	250/07	240/06	230/08
E	4000	230/09	240/08	230/05	220/11	250/09	220/06	230/10
I	5000	220/07	220/11	240/10	210/07	250/12	230/06	220/09
G	6000	180/07	190/10	240/07	180/04	230/10	220/10	230/06
H	7000	130/07	180/07	210/03	210/01	210/05	220/11	240/05
T	8000	120/06	170/04	130/03	120/02	220/02	210/03	130/02
	9000	110/05	090/06	080/07	100/04	080/07	080/05	090/07
(Ft. MSL)	10000	100/10	090/08	080/08	080/09	080/11	060/08	080/07
	11000	----	----	----	M	----	----	080/03
	12000	----	----	----	140/04	----	----	080/02
	13000	----	----	----	130/03	----	----	080/02
	14000	----	----	----	060/03	----	----	090/04
	15000	----	----	----	080/04	----	----	110/06

M - missing

b. Film Badges and TLD's

The film badge and TLD results gave no indication of exposures above background due to the reactor effluent.

c. Air Samples

Fresh fission products were detected on air samples as shown in Figure 3 with the results given in Table 4. Gross beta results which were above background are included, if they coincide with the date and area of effluent cloud passage, even if fresh fission products weren't detected on the sample. These high gross beta results are due to several causes:

(1) Reactor effluent - even those samples with fresh fission products were near the limit of detectability. Thus, the samples marked NFFP may have contained fresh fission products, but below levels of detection.

(2) Fallout from a non-U. S. test of May 9, 1966. It was detected in environmental samples in the vicinity of the site around June 7 and 8.

(3) High natural background levels due to normal fallout and dust, etc. The general background level during June 1966 was about 0.5 pCi/m^3 and occasionally values of about 1 pCi/m^3 occurred.

The positive results found to the south and south-southeast of the site are possibly due to the release of fission products during cool down of the reactor and to the northerly flow of surface drainage winds at night. They also could have resulted from the large wind shear and changing wind direction after testing. The potential inhalation exposure from radioiodines at the sampled locations is estimated to be less than 1 millirad to an adult, assuming a breathing rate of 2.3×10^{-4} m^3/sec

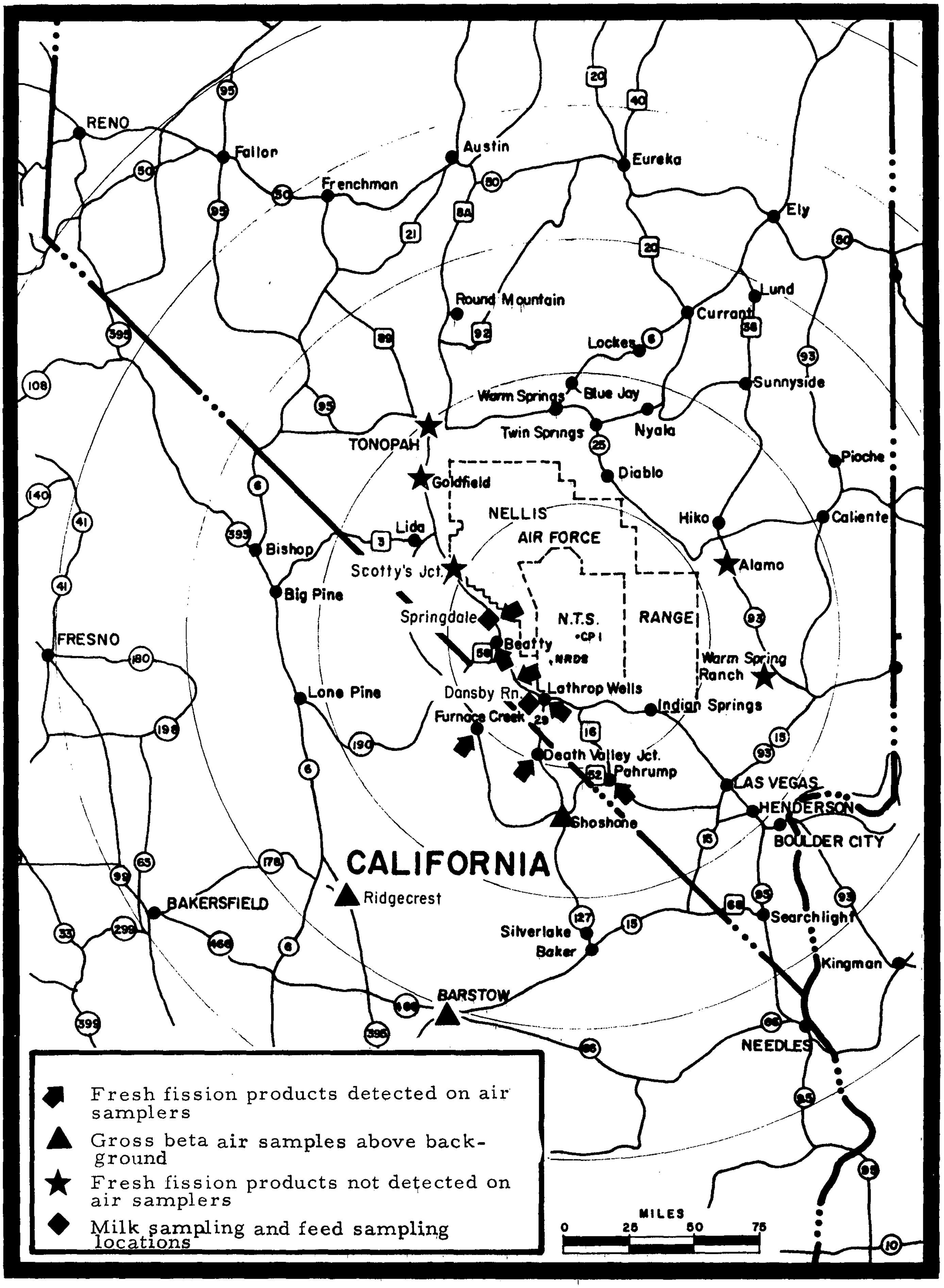

Figure 3. Milk and air sampling locations for NRX-A5, EP-III, June 8, 1966.

Table 4. NRX-A5, EP-III air sample results, June 8, 1966.*

Location	Sampling Period Start Day Hr	Sampling Period Stop Day Hr	Total Time (Hr)	Sample Volume (m^3)	Collector	Beta Activity (pCi/m^3)	Beta Exposure ($pCi\text{-}hr/m^3$)	Notes	^{131}I pCi/m^3	^{131}I $pCi\text{-}sec/m^3$	^{133}I pCi/m^3	^{133}I $pCi\text{-}sec/m^3$
Beatty, Nevada	08 0742	09 0826	24.6	467	P	1.1	28		ND		< 0.1	
					C				ND		< 0.1	
Death Valley Jct., Calif.	08 0645	09 0645	24.0	485	P	1.1	26		ND		1.4	1.2×10^5
					C				ND		5.2	4.3×10^5
Death Valley Jct., Calif.	09 0645	10 0645	23.9	495	P	1.1	26	NFFP				
Furnace Creek, Calif.	08 1130	09 1020	22.8	472	P	1.8	40		0.7	5.7×10^4	0.8	6.7×10^4
					C				ND		ND	
Furnace Creek, Calif.	09 1030	10 1125	25.0	518	P	1.0	25	NFFP				
Furnace Creek, Calif.	10 1125	11 1155	24.6	497	P	1.5	36	NGS				
Lathrop Wells, Nevada	08 0755	09 0620	22.3	450	P	1.1	24		0.5	4.3×10^4	1.8	1.4×10^5
					C				1.7	1.4×10^5	8.0	6.4×10^5
Pahrump, Nevada	07 1200	08 1200	24.0	435	P	1.3	31	NGS				
Pahrump, Nevada	08 1200	09 1200	24.0	448	P	1.7	40		ND		1.1	9.5×10^4
Pahrump, Nevada	09 1200	10 1200	24.0	435	P	1.3	31	NFFP				
Shoshone, Calif.	09 1435	10 1843	28.2	468	P	1.1	31	NFFP				
Barstow, Calif.	09 0700	10 0700	24.0	460	P	1.1	27	NGS				
Ridgecrest, Calif.	08 1308	09 1422	25.3	485	P	2.3	59	NGS				
Ridgecrest, Calif.	09 1425	10 1315	22.9	415	P	2.1	48	NGS				
10 mi. S. of Beatty, Nev. (Hwy. 95)	08 1545	09 0930	17.3	193	P	1.9	33		0.7	4.4×10^4	1.8	1.1×10^5
					C				1.0	6.2×10^4	2.4	1.5×10^5
Springdale, Nev. (Hwy. 95)	08 1540	09 1156	20.3	410	P	0.7	14		ND		0.4	3.0×10^4
					C				ND		ND	

*Results extrapolated to end of collection.
Notes: NFFP - No fresh fission products detected. NGS - Not gamma scanned. ND - Not detected.
P = Prefilter C = Charcoal cartridge

($20\ m^3/day$), and using the values for the ICRP standard man(2) and assuming equal uptake of iodine associated with both vapor and particles (see Appendix A for calculations).

d. Milk Samples

Milk and feed samples were obtained from the locations indicated in Figure 3. The only milk samples with a detectable level of radioiodine were from Dansby's Ranch, southwest of Lathrop Wells, which had 40 pCi/l of ^{131}I on June 13 and 50 pCi/l of ^{131}I on June 17. Two samples prior to this (June 9 and 10) did not have detectable levels of radioiodine, although vegetation from the pasture did show the presence of radioiodine (Table 5). Peak levels do not usually occur in milk until 2 to 6 days after deposition on the pasture. There are two potential sources of the ^{131}I: fallout from a non-U. S. nuclear detonation of May 9, 1966, which was observed in air samples about this time and/or the reactor effluent.

e. Vegetation Samples

Vegetation samples were taken at five mile intervals on U.S.95 between Springdale and Lathrop Wells, Nevada on June 9. No fresh fission products were detected in these samples except for those collected 10 miles south of Springdale and 5 miles south of Beatty (see Table 5). Vegetation samples were also taken at Peacock Ranch near Springdale and at Dansby's Ranch. The results for samples containing fresh fission products are given in Table 5.

f. Water Samples

Fresh fission products were not detected in water samples collected from Dansby's Ranch and near Springdale, Nevada.

Table 5. Vegetation results, NRX-A5, EP-III, June 8, 1966.*

Location	Date	^{131}I pCi/kg	^{133}I pCi/kg
10 miles south of Springdale	6/09/66	ND	600
5 miles south of Beatty	6/09/66	ND	1500
Dansby Ranch, near Lathrop Wells	6/09/66	ND	800
Dansby Ranch, near Lathrop Wells	6/10/66	230	600
Dansby Ranch, near Lathrop Wells	6/13/66	560	ND
Dansby Ranch, near Lathrop Wells	6/17/66	420	ND

*Results extrapolated to end of collection time.

C. NRX-A5, EP-IV

The EP-IV was the second and final full power run on the NRX-A5 reactor. The EP-V which had been tentatively scheduled was canceled.

Ground monitoring and environmental surveillance was performed in the northeast quadrant of the off-site area based on aerial monitoring results and initial ground monitoring. A reading of about 2 mR/hr in the airplane near Coyote Summit (60 miles from the reactor) was detected. An initial hotline of about 25° changing to about 30° beyond 60 miles was indicated. The effluent was tracked to the area around Rapid City, South Dakota. Cloud effluent levels had decreased to the point where further tracking could not be accomplished and the aircraft returned to Las Vegas. The transport speed for distances greater than 60 miles was about 26 mph. Fresh fission products were detected in off-site samples of air, vegetation, and milk; gamma exposure rates were recorded by portable survey meters and the RM-11 recorders. The air and milk sampling locations are indicated in Figure 4. Meteorological data for the time of reactor run, taken by ESSA, ARFRO, is given in Table 6.

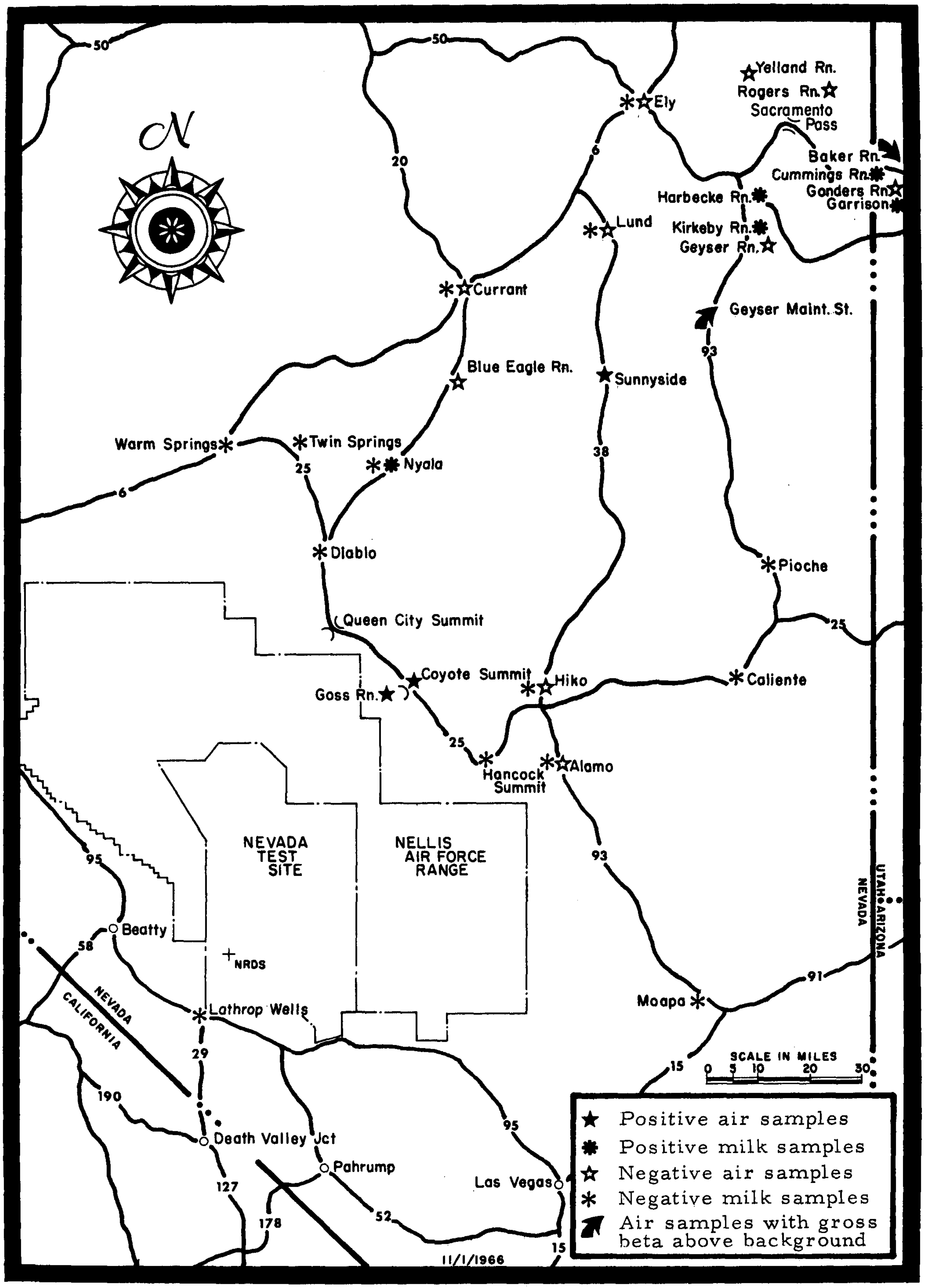

Figure 4. Milk and air sampling locations for NRX-A5, EP-IV, June 23, 1966.

Table 6. Meteorological data taken by ESSA, ARFRO, for NRX-A5, EP-IV.

Sky Condition: Clear
Clouds: None
Visibility: Unrestricted
UPPER AIR DATA AT: Jackass Flats, Nevada 1035 PDT, 6/23/66.

	Height (Ft. MSL)	Wind (Deg/Kts)	Pressure (mb)	Temperature (°C)	Dew Point (°C)	Rel. Humidity (%)
SFC	3615	220/04	884	25.0	-6.3	12
	4000	220/04	874	22.6	-2.9	18
	4400	210/04	860	22.6	-2.9	18
	4728	200/03	850	21.7	-3.7	18
	5000	200/02	841	21.0	-4.2	18
	6000	210/03	812	18.4	-6.3	18
	7000	190/05	784	15.4	-8.8	18
	8000	190/11	755	14.1	-9.9	18
	9000	200/17	729	12.1	-11.5	18
	10000	210/21	703	9.9	-13.3	18
	10125	210/21	700	9.4	-13.8	18
	11000	200/22	676	7.2	-15.5	18
	12000	220/21	651	4.6	-17.7	18
	13000	230/18	627	2.1	-19.8	18
	13040	220/18	626	1.9	-19.9	18
	14000	240/19	604	0.7	-21.6	17
	15000	260/24	582	-0.7	-21.6	17
	16000	250/34	560	-2.6	-24.3	17
	17000	250/34	538	-4.4	-25.2	18
	18000	250/34	518	-7.0	-26.8	19
	18957	260/42	500	-9.1	-28.0	20

1. Sampling Results

a. Ground Monitoring

Monitors on Highway 25 between Queen City Summit and Coyote Summit detected the cloud passage with portable survey instruments. The highest off-site ground level external gamma exposure* detected was at Goss' Ranch (60 miles from the reactor at an azimuth of 25^{G}). Cloud passage was also indicated by RM-11 recorders at Sunnyside and Lund, Nevada. The results are given in Table 7.

Air monitoring results did not show fresh fission products at Lund. Thus, it is assumed that the cloud did pass over Lund (confirmed by aerial surveillance results), but remained aloft.

b. Film Badges and TLD's

Film badge and TLD results gave no indication of the reactor effluent passage.

c. Air Samples

Air samplers were operated at the locations indicated in Figure 4. In addition, air samples (including charcoal cartridges) were also taken throughout Utah. The positive air sample results are given in Tables 8 and 9. The results from Utah, except Garrison, indicated the absence of fresh fission products. The gross beta results from Garrison and Geyser Maintenance Station were above background, but specific isotope analysis is not available.

The potential inhalation exposure to an adult's thyroid, based on air sampling results and the method of calculation outlined

*For purposes of this report, exposure in mR will be considered equivalent to dose in millirad. Also a dose in rads is assumed to be equal to rems (i.e., RBE of 1) for the doses in this report.

Table 7. External gamma exposures, NRX-A5, EP-IV (above background).

Location	Distance From NRDS	Arrival Time (PDT)	Instrument for Measurement	Peak Exposure Rate mR/hr	Integrated* Exposure mR
Goss' Ranch	60	1300	E-500B	1.2	1
Coyote Summit	60	1300	E-500B	0.1	0.06
Sunnyside	130	1540	RM-11	0.02	0.05
Lund	150	1600	RM-11	above bkgd.	<0.01

*This exposure is based on an integration of instrument readings over time and is thus representing primarily cloud passage. Residual activity was not noted and, therefore, is not included (the sensitivity of the instruments was not sufficient to determine fallout at these low levels).

Table 8. NRX-A5, EP-IV gross beta air sample results.*

Location	Sampling Period Start Day Hr	Stop Day Hr	Total Time** (Hr)	Sample Volume (m^3)	Beta Activity (pCi/m^3)	Beta Exposure (pCi-hr/m^3)	Notes
Goss' Ranch (NW of Coyote Summit)	23 1314	23 1500	01.8	17	14,400	26,000	
Coyote Summit, Hwy. 25	23 1135	23 1540	04.1	40	527	2,160	
Sunnyside, Nev.	23 0730	24 0726	23.9	470	138	3,320	
Geyser Maint. Station, Nev.	23 1602	24 1610	24.6	446	10.1	247	NGS
Garrison, Utah	23 0800	24 0800	22.7	458	3.1	71	NGS

*Results extrapolated to end of collection time.
**Based on running time indicator rather than time on and off.
NGS = Not gamma scanned.

Table 9. NRX-A5, EP-IV air sample results.*

Location	Time		Collector	^{131}I pCi/m^3	^{131}I pCi-sec/m^3	^{132}I pCi/m^3	^{132}I pCi-sec/m^3	^{133}I pCi/m^3	^{133}I pCi-sec/m^3	^{135}I pCi/m^3	^{135}I pCi-sec/m^3	Potential adult Inhalation Dose (mrad)
Goss' Ranch	6/23	1314	P	9.1×10^{2}	5.8×10^{6}	ND	ND	1.6×10^{3}	1.0×10^{7}	1.6×10^{3}	1.0×10^{7}	5.3
	6/23	1500	C	6.2×10^{2}	3.9×10^{6}	1.2×10^{3}	7.6×10^{6}	1.7×10^{3}	1.1×10^{7}	1.1×10^{3}	7.0×10^{6}	
Coyote Summit	6/23	1135	P	ND	ND	ND	ND	70	1.0×10^{6}	80	1.2×10^{6}	< 1
	6/23	1540	C	40	5.9×10^{5}	50	7.4×10^{5}	80	1.2×10^{6}	100	1.5×10^{6}	
Sunny-side	6/23	0730	P	9.9	8.6×10^{5}	ND	ND	23	2.0×10^{6}	ND	ND	1
	6/24	0726	C	4.7	4.1×10^{5}	5.1	4.4×10^{5}	17	1.5×10^{6}	4.8	4.2×10^{5}	

*Results extrapolated to end of collection time.

P - Prefilter. C - Charcoal cartridge. ND - Not detectable.

^{132}I is not reported on the prefilter because of interference from ^{97}Zr.

in Appendix A was about 5 millirad at Goss' Ranch, which was near the hotline at a distance of 60 miles from the reactor. An evaluation of this exposure on the basis of the new ICRP model[4] gives very similar results (assume 90% of vapor deposited in respiratory system and a mass median diameter of 1 micron for the particulate radioactivity). A similar analysis gives a thyroid inhalation dose of about 1 millirad at Sunnyside, Nevada.

The air sampler at Goss' Ranch was not started until after cloud arrival. By estimating the total integrated air concentration based on ground monitored results of exposure rates versus time, the total potential adult thyroid inhalation dose at Goss' Ranch would be about 7 millirad.

d. Milk Samples

Milk and feed samples were obtained as indicated in Figure 4. Samples were also obtained from the standby network in Utah. A complete list of milk samples is given in Appendix B. The results of milk samples containing fresh fission products are given in Table 10. The samples from Utah did not have detectable levels of fresh fission products.

The maximum milk concentration found was at the Kirkeby Ranch, about 3 miles north of Shoshone, Nevada. The potential dose to a child's thyroid (2 gram) was estimated from this concentration to be 40 millirad based on the assumptions in FRC-5[4] (38 millirad from ^{131}I and some contribution from ^{133}I) which assumes an effective half-life of ^{131}I in milk of about 5 days. However, the milk results from Kirkeby Ranch did not fit the expected decay curve of an effective half-life

Table 10. NRX-A5, EP-IV milk results.*

Location	Date	Milk pCi/l		Pasturage pCi/kg	
		^{131}I	^{133}I	^{131}I	^{133}I
3 mi. N. of Shoshone (Kirkeby Ranch)	6/24	20	1.3×10^3		
3 mi. N. of Shoshone (Kirkeby Ranch)	6/25	80	20		
3 mi. N. of Shoshone (Kirkeby Ranch)	6/26	240	310	830	2.7×10^3
3 mi. N. of Shoshone (Kirkeby Ranch)	6/27	90	60	640	1×10^3
3 mi. N. of Shoshone (Kirkeby Ranch)	6/30	ND	ND		
3 mi. N. of Shoshone (Kirkeby Ranch)	7/01	ND	ND	ND	ND
3 mi. S. of Baker, Nev. (Baker Ranch)	6/30	50	ND		
3 mi. S. of Baker, Nev. (Baker Ranch)	7/01	20	ND	ND	ND
13 mi. N. of Shoshone (Harbecke Ranch)	6/26	50	50	680	1.5×10^3
13 mi. N. of Shoshone (Harbecke Ranch)	6/27	60	ND	420	ND
5 mi. S. of Baker (E.J. Cummings Ranch)	6/26	not available		770	2×10^3
5 mi. S. of Baker** (E.J. Cummings Ranch)	6/27	110	30	ND	ND
Nyala	6/24	30	ND	ND	ND

*Activity extrapolated to end of collection time.
**Samples were not available after this date.
ND - Not detectable.

in milk.[4,5,6] Rather the effective half-life was about one day or less (Figure 5). Thus, the estimated potential dose based upon integration of the daily concentrations was calculated to be 12 millirad for a child with a 2 gram thyroid.

There are several possible reasons for the rapid decay:
(1) These results are based on individual samples from only 1 or 2 cows. Theoretical values are based on average results from several cows where the results from individual cows may vary by several factors.[6,7]

(2) The deposition of effluent was very spotty due to the rough terrain. The cow grazed in a large pasture and varying amounts of deposition in different areas of the pasture could have been analogous to changing the feed to uncontaminated feed (this results in a half-life for ^{131}I in the milk of about 1 day[6]). The cow was given some supplemental feed which could also have influenced the results.

(3) Part of the cow's intake of radioiodine may have been due to inhalation of radioiodine in the particulate, elemental, and/or methyl iodine form (shows a much shorter half-life in milk). It has been reported[10] that the deposition of methyl iodine on pasturage is very minimal and that inhalation by the cow may be important. The fraction of methyl iodine present in the reactor effluent is not known at this time.

The other milk results given in Table 10 generally represent only 1 cow. If the milk from these cows was used for human consumption, the potential dose for a child with a two gram thyroid, based on the FRC-5[4] assumptions would be about 20 millirad or less (100 pCi/liter peak milk concentration is

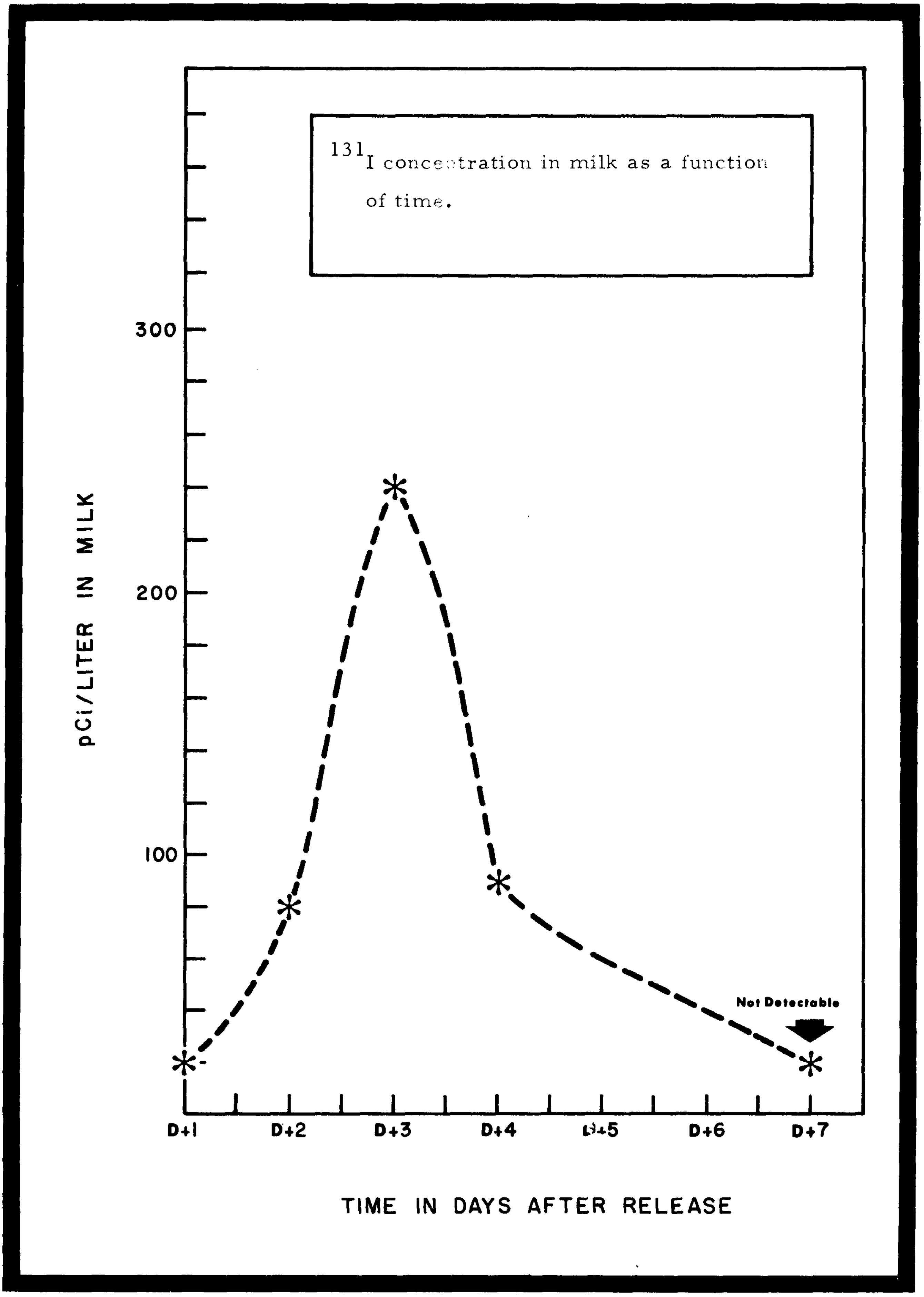

Figure 5. Concentration of ^{131}I in milk vs. time after release at the Kirkeby Ranch, three miles north of Shoshone, Nevada, NRX-A5, EP-IV, June 23, 1966.

equivalent to about 16 millirad). This dose estimate assumes that the peak ^{131}I concentration in milk occurs at about three to four days when the cow is exposed via ingestion. If the exposure to the cow is by inhalation, the effective half-life of ^{131}I in milk is much less than five days and thus the integrated dose is less.

e. Vegetation Samples

Natural vegetation samples were taken on Highway 25 between Hancock Summit and Queen City Summit on June 23, to help delineate the hotline. The vegetation samples south of Coyote Summit did not show the presence of fresh fission products. The results of the samples between Queen City Summit and Coyote Summit are given graphically in Figure 6. The high results near Queen City Summit are possibly due to the increased elevation in this area. The hotline was considered to be 5 to 10 miles from Coyote Summit on the basis of aerial monitoring and other surveillance results.

Vegetation samples were taken from Sacramento Pass, Nevada to Garrison, Utah (Figure 4) on July 1 to detect the area of cloud passage. Fresh fission products were not detected on any of the samples. The time delay between possible deposition and collection of samples would have allowed a factor of about four decay which may explain the absence of fresh fission products.

Natural vegetation and pasturage samples were taken at the same locations where milk samples were collected and are reported along with the milk results in Table 10.

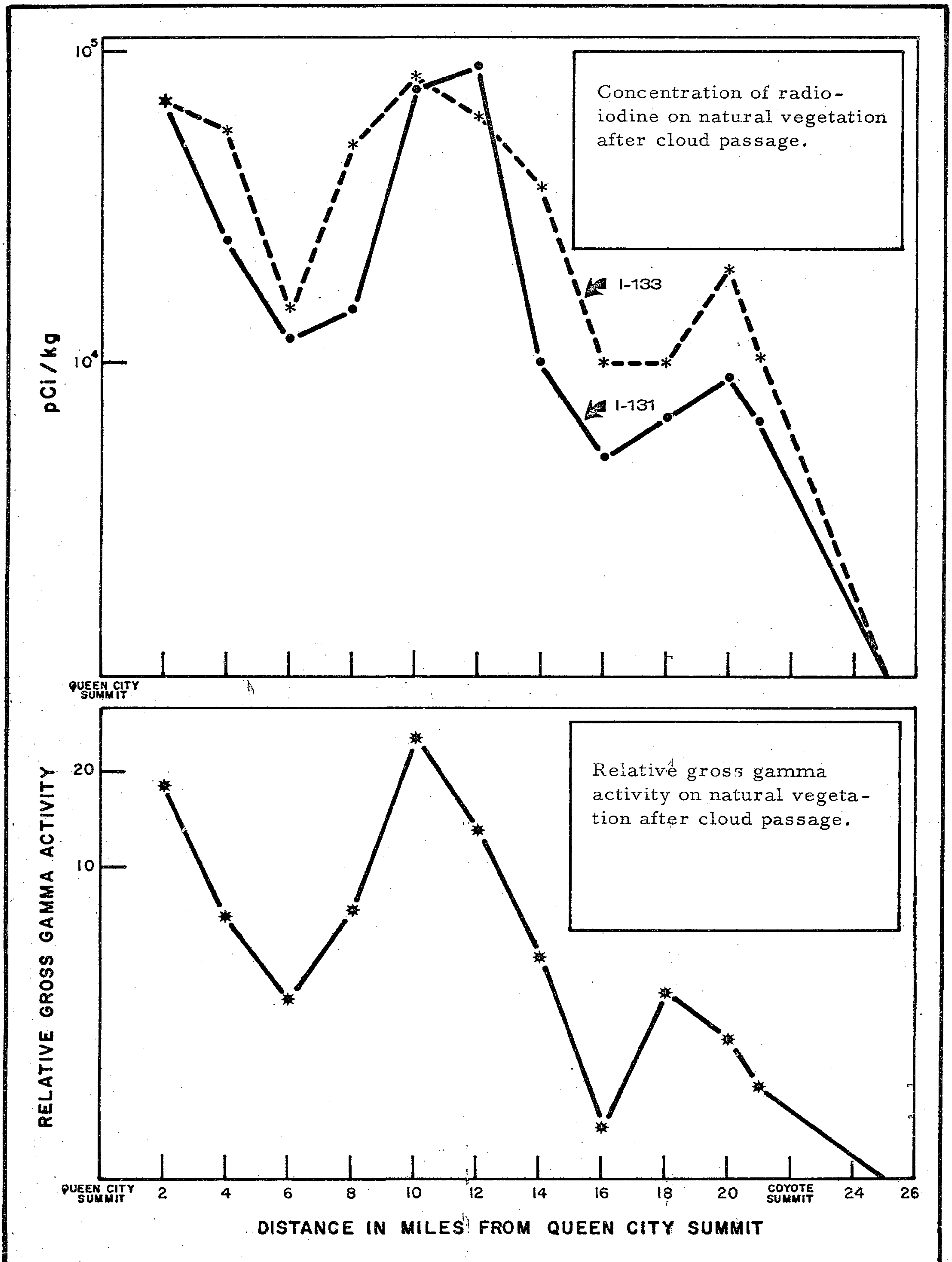

Figure 6. Results of vegetation samples taken on Highway 25 following NRX-A5, EP-IV, June 23, 1966.

f. Water Samples

Water samples from near Alamo, Hiko, Warm Springs, and Shoshone, Nevada area did not show detectable levels of fresh fission products.

CONCLUSIONS

The effluent from two of the tests (EP-III and IV) in the NRX-A5 series was detected off-site. The potential dose to the off-site population was below the standards listed in the AEC Manual Chapter 0524, which generally follows the FRC guidelines.

The AEC radiation protection standards (RPS) for the average dose to a suitable sample of the population are:

Average for Suitable Sample	Average for Individual
Whole Body - 170 millirem/year	500 millirem/year
Thyroid - 500 millirem/year	1500 millirem/year

The standards for radioiodine concentrations in air in an uncontrolled area for the principal soluble radioiodines are given in Table 11.

The principal air exposures from EP-III and EP-IV are given in Table 12. Comparison of these results with the radiation standards in Table 11 gives the conclusions listed below. For comparing areas with significant population--Ridgecrest, Lathrop Wells, Sunnyside--1/3 of the values listed in Table 11 should be used.

(1) Based on the instantaneous values, i.e., not averaged for a year as intended by AEC Manual Chapter 0524, three of the results are above the RPS for gross unidentified isotopes, but are not above the RPS for specific isotopes (except Goss' Ranch). The intent is not to show that the RPS was exceeded, but rather to show the advantage of specific isotope analysis.

Table 11. Radiation protection standards.

Isotope	Air Conc.[1] pCi/m³	Integrated Air Conc.[1,2] pCi-sec/m³ / Day	Integrated Air Conc.[1,2] pCi-sec/m³ / Year
^{131}I[3]	10^2	8.64×10^6	3.16×10^9
^{133}I[4]	10^3	8.64×10^7	3.16×10^{10}
Unknown[5]	10^2	8.64×10^6	3.16×10^9

NOTES: (1) Derived from AEC Manual Chapter 0524 by converting units of μCi/ml to pCi/m³. The values are based on exposures to individuals and should be reduced by a factor of three if applied to an average exposure to a sample of the population. When more than one isotope is present, the summation of ratios of quantity of isotope present to respective RPS should be less than one.

(2) Derived from the Radiation Protection Standard air concentration by integrating it over a period of one (1) day, i.e., multiply pCi/m³ times seconds in a day. The column on the right is integrated for a year.

(3) The standard for ^{131}I is based on a child with a two gram thyroid breathing 3 m³/day.

(4) The standard for ^{133}I is based on the standard adult (ICRP).

(5) Based on Sr-90, I-129, Pb-210, Ac-227, Ra-228, Pa-230, Pu-241, Bk-249 and alpha emitters not being present as defined in reference 8. Strontium-90 is assumed not present because of reactor operating history; if it were present, the value would be 10.

Table 12. Principal air concentrations resulting from NRX-A5.*

EP	Location	Gross Beta		^{131}I**		^{133}I**	
		pCi/m^3	$pCi\text{-}sec/m^3$	pCi/m^3	$pCi\text{-}sec/m^3$	pCi/m^3	$pCi\text{-}sec/m^3$
III	Ridgecrest, California***	2.3	$2.1x10^5$	NGS		NGS	
	10 mi. S. of Beatty (Hwy. 95) (unpopulated)	1.9	$1.2x10^5$	1.7	$1.1x10^5$	4.2	$2.6x10^5$
	Lathrop Wells	1.1	$8.8x10^4$	2.2	$1.8x10^5$	9.8	$7.8x10^5$
IV	Goss' Ranch	14,400	$9.4x10^7$	$1.5x10^3$	$9.7x10^6$	$3.3x10^3$	$2.1x10^7$
	Coyote Summit (unpopulated)	527	$7.8x10^6$	40	$5.9x10^5$	$1.5x10^2$	$2.2x10^6$
	Sunnyside	138	$1.2x10^7$	15	$1.3x10^6$	40	$3.5x10^6$
	Geyser Maint. Station***	10	$8.9x10^5$	NGS		NGS	

*Results extrapolated to end of collection time.

**The iodine activities for both the prefilter and charcoal cartridge have been added.

***Cloud passage at this location was not noted until after the fact; therefore, gamma spectrum analysis was not performed on these two samples because the gross beta count did not fall above the control limit set for determining whether this analysis should be performed.

NGS - Not gamma scanned.

(2) Further, if the integrated concentrations are used, the result from Goss' Ranch is equivalent to less than two days exposure at the RPS level (2nd column from right indicates 1 day of exposure to RPS). AEC Manual Chapter 0524 specifies that concentrations may be averaged over a period of a year (column on right in Table 11). The RPS concentrations are based on continuous exposure and thus are not strictly applicable to short term air concentrations. The concept of integrated concentration guides allows comparison of short term concentrations to the guides.

The peak external gamma dose from the NRX-A5 series was about 1 millirad at Goss' Ranch (based on E-500B survey meter). The highest dose at a reasonably dense populated area was about 0.05 millirad at Sunnyside, Nevada based on the RM-11 results. Both of these exposures were from the EP-IV.

The milk samples in this report all come from ranches where the milk is used locally. The age of individuals using the various milk supplies varies. The term potential dose has been used when it is not actually known if someone received the dose. Doses varying from the potential dose could result from variation in individuals milk consumption, biological variability of individuals from the "critical receptor" used in calculations (child with 2 gram thyroid and ICRP assumptions on uptake), etc. This frame of "potential dose" also applies to the other doses or exposures reported in this report.

The summation of doses for several locations are given in Table 13. This summation includes the dose from cloud passage, inhalation and ingestion.

Table 13. Summary of results and doses from NRX-A5.

Location (Nevada)	EP	Date	Air: Gross Beta pCi/m^3	Air: Gross Beta pCi-sec/m^3	Air: ^{131}I pCi/m^3	Air: ^{131}I pCi-sec/m^3	Air: ^{133}I pCi/m^3	Air: ^{133}I pCi-sec/m^3	Thyroid Dose Inhalation Child mR	Thyroid Dose Inhalation Adult mR	External Exposure Rate mR/hr	External Exposure Total mR	Milk Peak pCi/l ^{131}I	Milk Peak pCi/l ^{133}I	Potential Ingestion Dose millirad Peak(7)	Potential Ingestion Dose millirad Actual(6)	Total Thyroid Dose millirad (6)
Lathrop Wells	III	6-8	1.1	8.8×10^4	2.2	1.8×10^5	9.8	7.8×10^5	0.40	0.13	ND		No milk				< 1
Dansby's Ranch, Lathrop Wells	III	6-8	---	---	---	---	---	---	---	---	---	---	50	ND	8	8 (1)	8
Goss' Ranch (2)	IV	6-23	14,400	9.4×10^7	1.5×10^3	9.7×10^6	3.3×10^3	2.1×10^7	---	7	1.2	1	---	---	---	---	8
Sunnyside	IV	6-23	138	1.2×10^7	15	1.3×10^6	40	3.5×10^6	2.3	0.8	0.02	0.05	---	---	---	---	2
Kirkeby Ranch, (3) Shoshone	IV	6-23	---	---	---	---	---	---	---	---	---	.02	240	1300	17 (8)	9 (4, 8)	9
E. J. Cummings, (3) Baker	IV	6-23	---	---	---	---	---	---	---	---	---	.02	110	30	18	5 (5)	5

Notes:

(1) A child of about one year old was present.

(2) Sampler not started till after cloud arrival; dose based on extrapolation to estimated arrival time.

(3) Gamma exposure based on extrapolation from Sunnyside(distance to the minus three power). Total thyroid dose includes contribution from gamma exposure and inhalation(inhalation extrapolated from Sunnyside results using distance to the minus two power).

(4) Youngest child present four years old - assume 4 gram thyroid.

(5) Youngest child present eight years old - assume 8 gram thyroid.

(6) Based on age of child present.

(7) The peak value is based on a child with a 2 gram thyroid drinking 1 liter of milk per day. It is assumed a peak value of 100 pCi per liter in milk results in an integrated dose of 16 millirads (reference 4).

(8) The dose calculation is based on the observed half-life in milk, about 1 day, rather than the value of 5 days from FRC No. 5 (reference 4).

Although the peak milk concentration, 240 pCi/liter was detected at Kirkeby's Ranch, it is noted that it might not have resulted in the peak dose because of the short effective half-life of the ^{131}I in the milk. Thus the result from the E. J. Cummings Ranch is included in Table 13. Insufficient data are available to determine the effective half-life in the Cummings sample, thus a value of about 5 days is used.

Two sets of results are given in Table 13 for Kirkeby's and Cummings'. One set gives the potential dose for a 1 year old child, the second for the youngest child known to be present.

A comparison of the two graphs in Figure 6 shows that the ^{131}I, ^{133}I, and gross gamma results for vegetation follow the same trend. If future results also demonstrate this trend, analysis of vegetation samples to determine trajectories may be limited to gross gamma. Specific analysis should still be performed on selected samples to demonstrate the presence of fresh fission products and indicate the levels of various isotopes.

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APPENDICES

APPENDIX A

Thyroid Inhalation Exposure from Radioiodine

Absorbed dose is the quotient of the energy imparted by ionizing radiation to the matter in an "element of volume."

Dose rate is the rate at which the energy is absorbed. For tissue containing a beta emitter the amount of energy absorbed per unit volume is equal to the energy emitted per unit volume. This assumes the radioisotope is essentially uniformly distributed in tissue of uniform composition with dimensions large compared to the range of the beta particles. These assumptions can be applied to the calculation of thyroid dose from radioiodines, if an effective energy based on the thyroid dimensions is used. Thus, for the dose rate (DR):

$$DR_t = KEA \exp - \lambda_{eff} t \qquad \text{Eq. 1}$$

Where: DR_t - The dose rate at time t

K - Conversion parameter

E - Effective energy (Mev) per disentegration (d)

A - Activity at time deposited in organ (Ci/gan)

λ_{eff} - Effective decay constant for radioisotope of interest

t - Time after deposition in organ

To obtain the infinite or total dose, equation 1 must be integrated with respect to time between zero and infinity(∞).

$$\text{Dose} = KEA \int_0^{\infty} \exp -\lambda_{eff} t \, dt$$

$$\text{Dose} = KEA \left(-1/\lambda_{eff} \exp -\lambda_{eff} t\right)_0^{\infty}$$

Thus, $$\text{Dose} = KEA \left(-1/\lambda_{eff} (0-1)\right)$$

$$\text{Dose} = KEA/\lambda_{eff} \qquad \text{Eq. 2}$$

The numerical values for the parameters are:

$$K = \frac{3.7\times10^{10}\ d}{Ci\text{-}sec} \times \frac{8.64\times10^{4}\ sec}{day} \times \frac{1.602\ ergs}{10^{6}\ Mev} \times \frac{rad}{100\ erg/gm}$$

$K = 5.12\times10^{7}$ (gram-rad-d/Ci-day-Mev

E = 0.23 Mev for ^{131}I (ICRP-2)

A = X (Ci-sec/M^3) x R(M^3/sec) x f x 1/m(gm) (Assumes no decay during uptake)

Where: X - integrated air concentration for isotope of interest

R - 2.32×10^{-4} M^3/sec - breathing rate for average adult (ICRP)

f - 0.23 (for iodine) - fraction of inhaled activity reaching thyroid (ICRP)

m - 20 grams - mass of adult thyroid

A = XRf/m (Ci/gm)

$\lambda_{eff} = .693/t_{eff}$ - t_{eff} is the effective half-life in days - 7.6 days for ^{131}I (ICRP)

Substituting these parameters into equation 2:

Dose = 5.12×10^{7} (gm-rad-d/Ci-day-Mev) x E (Mev/d) x XRf/m) x t_{eff}/.693(day)

Dose = 7.39×10^{7} XERf t_{eff}/m (rad) Eq. 3

Substituting the ICRP parameters for ^{131}I and standard man:

$$D = \frac{7.39\times10^{7} \times 0.23 \times 2.32\times10^{-4} \times 0.23 \times 7.6 \times X}{20}$$

Dose (rads) = 3.44×10^{2} (Ci-sec/M^3)*

Converting this to pCi and mrad:

Dose (mrad) = 3.44×10^{-7} (pCi-sec/M^3)* for ^{131}I

This same calculation can be performed for other isotopes using the appropriate parameters (ICRP2)[2]. It should also be noted that if more than one radioiodine isotope is present, the doses should be summed to obtain total dose. The general equation for this would be (using equation 3):

$$\text{Total dose from radioiodines} = 7.39\times10^{7} \frac{Rf}{m} \sum_{\text{iodines}} E\, t_{eff}\, X$$

*If the dose conversion constant K is rounded to 5.1×10^{7} the significant digits are 3.42

APPENDIX B

Milk and Associated Feed Results
NRX-A5, EP-IV, June 23, 1966

Location	Date	Milk pCi/l		Vegetation pCi/kg		
		^{131}I	^{133}I	^{131}I	^{133}I	
3 mi. N. Shoshone, Nev. (Kirkeby Ranch)	6/24	20	1.3×10^3			
	6/25	80	20			
	6/26	240	310	830	2.7×10^3	
	6/27	90	60	640	1.0×10^3	past.
	6/30	ND	ND			
	7/01	ND	ND	ND	ND	
13 mi. N. Shoshone, Nev. (Harbecke Ranch)	6/26	50	50	680	1.5×10^3	
	6/27	60	ND	420	ND	past.
15 mi. SW Shoshone, Nev. (Geyser Rch)	6/26			ND	ND	
	6/27	ND	ND	890	ND	
5 mi. S. Baker, Nev. (E. J. Cummings)	6/26	not avail.		7.7×10^2	2×10^3	grass
	6/27	110	30	ND	ND	past.
	7/01	not avail.		ND	ND	past.
	7/05	ND	ND	ND	ND	past.
3 mi. S. Baker, Nev. (Baker Ranch)	6/30	50	ND			
	7/01	20	ND	ND	ND	hay
Baker, Nevada	7/01			ND	ND	
20 mi. NNW Baker, Nev. (H. T. Rogers)	6/26			ND	ND	nat.
	6/27	ND	ND	ND	ND	nat.
Caliente, Nevada (Young Ranch)	6/24	ND	ND	ND	ND	

Location	Date	Milk pCi/l		Vegetation pCi/kg		
		^{131}I	^{133}I	^{131}I	^{133}I	
Nyala, Nevada (Sharp)	6/24	30	ND	ND	ND	
	6/25			ND	ND	nat. & past.
Lund, Nevada (McKenzie)	6/24	ND	ND	ND	ND	
	6/25	ND	ND	ND	ND	
Moapa, Nevada (Searles Dairy)	6/24			ND	ND	
Hiko,Nevada (Schofield Dairy)	6/23	ND	ND	ND	ND	
	6/24	ND	ND	ND	ND	
Currant, Nevada (Manzonie Ranch)	6/24	ND	ND	ND	ND	
Lockes, Nevada (Blue Eagle Ranch)	6/24	ND	ND			
	6/25			ND	ND	
Pioche, Nevada (Horlacher Ranch)	6/24	ND	ND	ND	ND	
15 mi. E. Ely, Nev. (Yelland Ranch)	6/26	ND	ND	ND	ND	
	6/27	ND	ND	ND	ND	past.
Garrison, Utah (Gonders Ranch)	6/30	ND	ND			
	7/01			ND	ND	hay & past.
Ogden, Utah (Maple Leaf Dairy)	6/30	ND	ND			
	7/01	ND	ND			
	7/02	ND	ND			
	7/05	ND	ND			

Location	Date	Milk pCi/l		Vegetation pCi/kg	
		^{131}I	^{133}I	^{131}I	^{133}I
Mt. Pleasant, Utah					
(Brooktown Creamery)	6/29	ND	ND		
	6/30	ND	ND		
	7/01	ND	ND		
	7/02	ND	ND		
	7/03	ND	ND		
Springfield, Utah					
(Cache Valley Dairy)	7/01	ND	ND		
	7/02	ND	ND		
	7/05	ND	ND		

Notes: ND - not detected

Blanks indicate no sample.

Results extrapolated to time of collection.

Past. = Pasture

Nat. = Natural vegetation

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