SWRHL-85r

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ENVIRONMENTAL PROTECTION AGENCY

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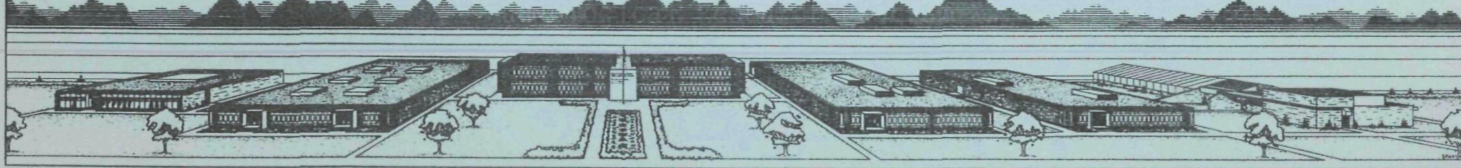

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*Formerly Southwestern Radiological Health Laboratory, part of the U.S. Department of Health, Education, and Welfare, Public Health Service, Environmental Health Service, Environmental Control Administration, Bureau of Radiological Health.

ABSTRACT

Baled hay was placed on the ground in the predicted trajectory of the effluent from the two Plowshare cratering tests, Cabriolet and Buggy. After contamination, the bales were collected and measured amounts of the hay were fed to groups of dairy cows.

As compared to similar experiments following other cratering tests, the amount of ^{131}I transferred to milk was about one-third, and the time to peak milk concentration and effective half-life in milk were longer. The ratio of peak ^{131}I concentration in milk to the peak concentration in hay was also much less than that observed in previous tests. These facts suggest that the ^{131}I in the debris from these two tests was less biologically available to the cow than it was in previous tests.

For Project Buggy, the transfer of ^{187}W to milk was also measured. Less than 0.5% of the tungsten ingested with the hay was secreted in milk and the measured half-time in milk was about 2.5 days.

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INTRODUCTION

The scheduling of two Plowshare tests, Cabriolet and Buggy, in the early months of 1968 provided an opportunity to test a hypothesis about ^{131}I transfer in the forage-cow-milk chain. Studies of this transfer during the TNT and Pin Stripe experiments[1,2] produced data which indicated certain differences in this transfer among groups of cows. Since nearly all measurable parameters among the groups of study cows were the same except for the filter/charcoal activity ratio of air samplers in the area from which forage was collected, then it was assumed that this ratio measured some factor that was responsible for the observed difference. The filter/charcoal ratio, as we interpret it, is a measure of the particulate/gaseous make-up of the radioactive cloud; that is, if most of the radioactivity in the cloud is attached to particles, then the air sample will show more activity on the filter paper than on the charcoal and the filter/charcoal ratio will be high. Therefore, the differences noted in such parameters as the milk-to-forage ratio and percent secreted in milk, among groups of cows fed forage contaminated by different portions of a radioactive cloud, have been attributed to the predominantly particulate or predominantly gaseous nature of the radioiodine in that portion of the cloud.

To resolve this assumption, the experimental plan for Project Cabriolet included stations located at various distances, both laterally and downwind of the predicted trajectory for the cloud. After the event, the cloud traveled more westerly than predicted so only one station received sufficient deposition for this study. Because of this, the plan for Project Buggy was revised. All 13 stations for Buggy were located on a single arc, approximately 10 miles from surface ground-zero (SGZ). This insured that at least one station would be on the hot-line and one station would be on the edge of the cloud.

Several objectives were set for both of these studies, but the primary ones were to obtain:

(1) Correlations between filter/charcoal measurements in the cloud and transfer of radioiodine in the forage-cow-milk system;

(2) Correlations between surveillance data and peak milk concentration that may be useful for predictive estimates;

(3) Comparisons between single and multiple ingestion of hay contaminated at the same location.

EVENT DESCRIPTIONS

Project Cabriolet was a nuclear experiment in hard, dry, rhyolite rock executed as a part of the Plowshare Program for development of nuclear excavation. Cabriolet was detonated on 26 January 1968 at approximately 0800 (PST), in Area 20, Nevada Test Site(NTS). The resultant yield was 2.3 + 0.5 kt, and emplacement depth was 170.75 feet.

Project Buggy was the first nuclear row-cratering detonation executed as part of the Plowshare Program for development of nuclear excavation techniques. Five nuclear explosives, each with a yield of 1.1 kt, were detonated simultaneously at 0904 (PST), 12 March 1968. The depths of burst were at 135 feet, and the spacing between explosives was 150 feet. The experiment took place on Chukar Mesa, Area 30, Nevada Test Site in a dry, complex basalt formation.

PROCEDURES

The procedures for each of the events were similar, and the stations were equipped in a similar manner. The station locations for Cabriolet are indicated on Figure 1. The fixed stations are indicated by triangles while the circles indicate possible locations of mobile stations which were to be moved to intercept the cloud following detonation. There were two mobile stations on both Arcs B and C. For Buggy, 13 stations were placed on a single arc approximately ten miles from SGZ, as shown in Figure 2. The items located at those stations and used for the dairy cow experiments are listed below for each event.

A. Cabriolet

Only one station had a sufficiently high deposition for use, i.e., Station A3 (2.8 miles @ 355° from SGZ). The following equipment and materials were available:

1. Baled alfalfa hay - 17 bales with one bale having an 11.4-cm planchet centered on each exposed surface;
2. A monitoring system which telemeters ion chamber and meteorological data;
3. Tempest, Staplex and special air samplers;
4. Fallout trays and planchets;
5. A precipitation collector.

B. Buggy

The cloud hot-line passed near Station 4 (10 miles @ 356° from SGZ), which was used for study. Station 2 (10 miles @ 345° from SGZ) was selected to study any edge effects. Both stations were equipped as follows:

1. Baled alfalfa hay - 18 bales with one bale having an 11.4-cm planchet on each exposed surface;
2. Fallout trays and planchets;

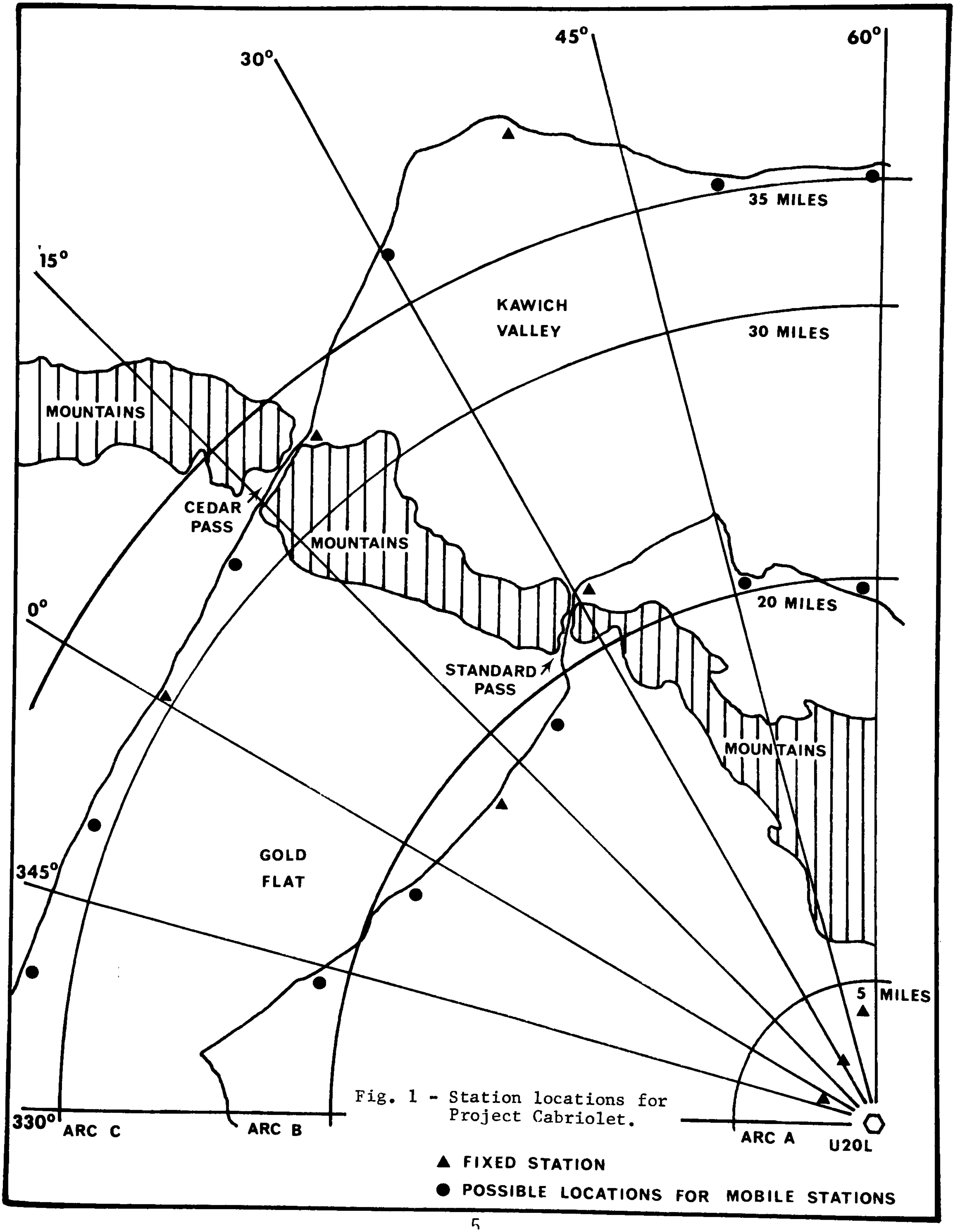

Fig. 1 - Station locations for Project Cabriolet.

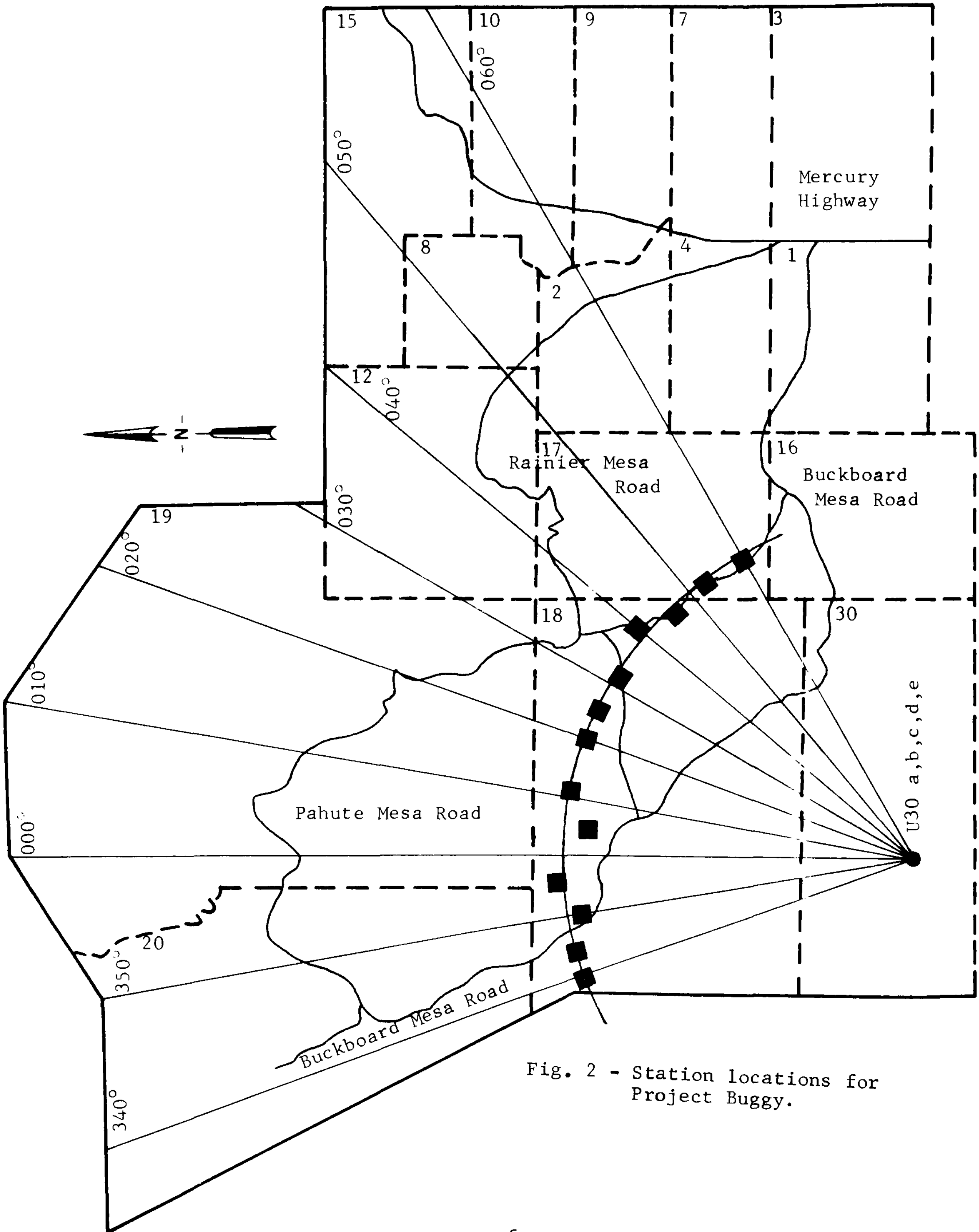

Fig. 2 - Station locations for Project Buggy.

3. Two air samplers (10 cfm, microsorban or Whatman 541 prefilter and MSA charcoal cartridge);
4. Meteorological instruments for wind direction and speed;
5. Glass microscope slides for particle size measurement.

In both studies, the individual hay bales were spaced one meter apart on the ground to maximize deposition on the hay. After cloud passage the hay was transported to the EPA dairy farm, in Area 15 of the Nevada Test Site, and fed to selected groups of cows according to the schedule shown in Table 1. For each feeding, the hay was placed in a plastic tub, weighed, counted and offered to the cow after each milking. When the cow had finished eating, the tub was removed, weighed and counted again. Counting was done by placing the tub on a turnstile and rotating it in front of a shielded 10-cm NaI(Tl) crystal with a 200-channel analyzer. Further, an aliquot of each hay bale was compressed into a standard 400-ml container and analyzed by use of a 200-channel analyzer and 10-cm NaI(Tl) crystal system as a check on the rotating tub system.

Groups II and IV, in the Buggy experiment, were given only one feeding of hay to simulate the situation where hay is in the feed bins during cloud passage but non-contaminated hay is fed thereafter. The reduction in human hazard can then be estimated by comparing the total milk secretion of the radioisotopes between the groups given single or multiple feedings of contaminated hay.

All other samples were counted on a 10-cm NaI(Tl) crystal with 200-channel analyzer and the resulting spectra resolved by a least squares method.

The hay bale at each station having an 11.4-cm planchet on each exposed surface was used to correlate planchet deposition with deposition on the bale. The deposition on each exposed surface of the bale was estimated by the pCi/m^2 measured on the appropriate planchet multiplied by the surface represented and the resulting five values summed.

Table 1. Dairy Cow Groups and Feeding Schedule

Group	Cow No.	Milk Output Liters/day	Fed Hay from Station	Feeding Schedule*
			Cabriolet	
I	13	21.8		7.5 kg given twice daily for eight days starting at 1600 hr. on 1/27/68
	18	24.1		
	71	14.0	A3	
	84	20.4		
			Buggy	
I	13	15.9		7.5 kg given twice daily for eight days starting at 1600 hr. on 3/13/68
	18	27.3		
	35	18.6	4	
	84	15.0		
II	19	15.0		7.5 kg given as single feeding at 1600 hr. on 3/13/68
	27	13.6		
	83	30.4	4	
	87	27.7		
III	11	29.5		7.5 kg given twice daily for eight days starting at 1600 hr. on 3/13/68
	44	15.0	2	
	46	13.2		
	86	12.7		
IV	21	23.2		7.5 kg given as single feeding at 1600 hr. on 3/13/68
	26	13.2		
	43	20.4	2	
	85	26.4		

*The nominal weight was 7.5 kg/feeding but the actual weight varied among the cows.

When divided by the weight of the bale, the sum gives the concentration in that bale which can then be compared to the concentrations measured in the other 16 bales. If the correlation is satisfactory, this procedure would replace forage sampling with its attendant inaccuracies.

The particles deposited on the microscope slides were sized by using an optical microscope with an eyepiece reticule. The size was expressed as the count-median-diameter (CMD) based on the Feret diameter measurements.

The cows in each group were milked on the normal twice-daily schedule (approximately 0600 and 1500). The individual milk samples were counted in a 3.5-liter Marinelli beaker. Analysis of other cow feed and water as well as milk from control cows indicated that the contaminated hay was the only significant source of radioactivity for the cows in these studies.

RESULTS

Of the hay collected from the four selected stations following Cabriolet, only that collected from station A3 produced detectable amounts of ^{131}I in milk when fed to cows. The ^{131}I activity in the hay actually consumed by the cows is shown in Table 2. These data are the average for four cows. The least squares line through the plotted hay data indicates that the effective half-life (T_{eff}) of radioiodine on this hay was 6.2 days.

The average ^{131}I data on the milk from these cows are shown in Table 3 and plotted in Figure 3. The least squares lines in Figure 3 indicate that the measured half-time in milk during feeding of the contaminated hay was 11.1 days which changed to 1.1 days after cessation of intake.

The average data for the ^{131}I in hay contaminated during Project Buggy are shown in Table 4. Groups I and II cows were fed hay from Station 4 and Groups III and IV cows were fed hay from Station 2. The effective half-life for deposited ^{131}I was 6.67 days for Station 4 hay and 6.79 days for Station 2 hay.

The group average data for ^{131}I in milk are shown in Tables 5-7 and are plotted in Figs. 4 and 5. The levels in milk during feeding of contaminated hay continued to rise so a half-time was not calculated. Possible reasons for this effect are discussed later. The T_{eff} in milk after feeding ceased is indicated in the figures and, in both cases, the T_{eff} following a single feeding was shorter than that after multiple feeding of hay from the same station.

The group-average data for ^{133}I and ^{187}W concentrations in milk are also shown in Tables 5-7 and are plotted in Figs. 6-8. The T_{eff} in milk, as derived by least squares analysis, is also shown in the figures for each group of cows. The data for ^{187}W concentration in hay are plotted in Figure 9.

Table 2. Average hay data, Group 1 cows, Project Cabriolet

Date 1968	Time	Hay Ingested kg	Total nCi Ingested	^{131}I Conc. nCi/kg
1/27	1600	6.93	417	60.2
1/28	0830	5.18	284	54.8
	1600	5.66	207	36.6
1/29	0830	5.27	270	51.2
	1600	4.66	202	43.3
1/30	0830	4.99	167	33.5
	1600	6.46	298	46.1
1/31	0830	5.10	164	32.2
	1600	6.28	66	10.5
2/1	0830	5.19	156	30.0
	1600	6.38	185	29.0
2/2	0830	4.31	77	17.9
	1600	7.33	300	40.9
2/3	0830	5.08	257	50.6
	1600	6.03	143	23.7
2/4	0830	4.62	127	27.5

Table 3. Average milk data for Group I cows, Project Cabriolet

Date 1968	Time	Collection Time days*	^{131}I in Milk pCi/liter	Production liters	Total in Milk nCi
1/28	0732	0.65	301	11.8	3.55
	1557	1.00	455	6.1	2.78
1/29	0734	1.65	547	12.0	6.56
	1619	2.01	561	5.9	3.31
1/30	0724	2.64	519	11.0	5.71
	1549	2.99	513	6.3	3.23
1/31	0942	3.73	466	13.5	6.29
	1549	3.99	536	5.6	3.00
2/1	0734	4.65	467	11.5	5.37
	1557	5.00	457	7.9	3.61
2/2	0734	5.65	427	12.5	5.34
	1557	6.00	424	6.3	2.67
2/3	0749	6.66	438	11.9	5.21
	1630	7.02	455	6.9	3.14
2/4	0749	7.66	377	11.9	4.49
	1619	8.01	436	6.4	2.79
2/5	0708	8.63	286	10.4	2.97
	1704	9.04	238	7.3	1.74
2/6	0700	9.62	158	11.2	1.77

*in days following initial feeding (1.33 days or 32 h. after event).

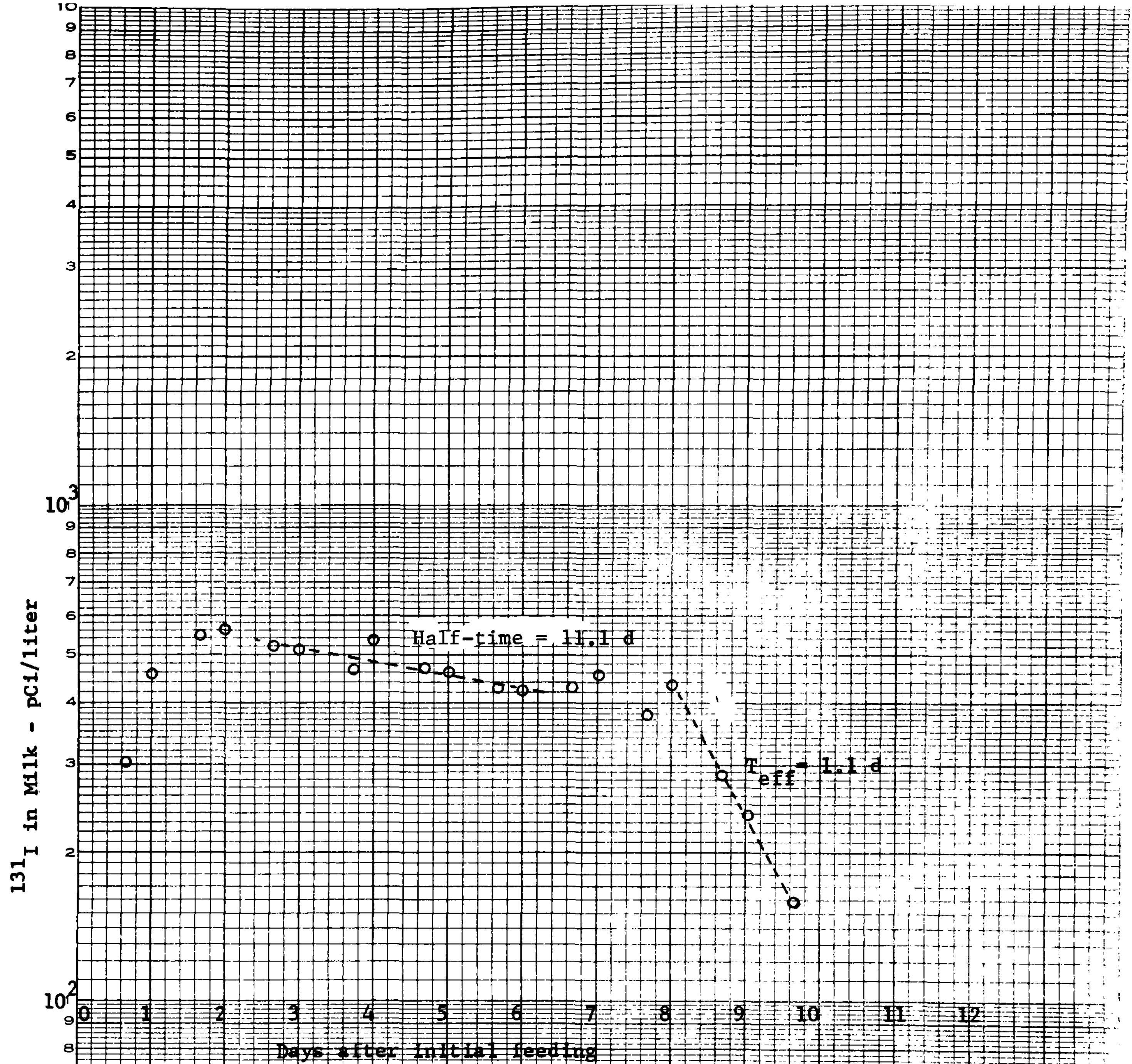

Fig. 3 - ^{131}I concentration in milk for cows fed hay from Cabriolet Station A3.

Table 4. Group average data for ^{131}I in hay, Project Buggy.

Date	Time	Group I Hay Ingested kg	Group I Total Intake μCi	Group III Hay Ingested kg	Group III Total Intake μCi
3/13	1600	8.48	1.45	8.87	0.13
3/14	0715	7.37	1.07	8.08	0.09
3/14	1600	9.28	3.98	7.17	0.31
3/15	0730	6.93	1.55	6.30	0.29
3/15	1600	6.92	1.75	6.88	0.38
3/16	0800	5.51	1.07	5.50	0.24
3/16	1600	7.94	1.88	6.98	0.37
3/17	0830	6.71	1.47	7.04	0.33
3/17	1600	8.91	2.12	8.63	0.21
3/18	0730	7.14	2.01	7.37	0.25
3/18	1600	7.94	1.37	7.54	0.23
3/19	0830	7.31	1.66	7.14	0.17
3/19	1600	8.64	1.96	8.38	0.32
3/20	0800	6.47	1.14	7.08	0.21
3/20	1600	8.91	0.84	10.06	0.22
3/21	0800	6.77	0.12	7.01	0.19
		Group II		Group IV	
3/13	1600	7.17	0.09	7.19	0.14

Table 5. Milk data for Group I cows, Project Buggy

Date 1968	Collection Time days*	Avg. Milk Production liters	^{131}I nCi/liter	^{133}I nCi/liter	^{187}W nCi/liter
3/14	0.66	10.9	0.73	5.06	1.30
	0.99	6.0	0.88	4.52	1.84
3/15	1.66	11.4	1.58	3.79	2.42
	1.99	4.6	1.99	3.51	2.20
3/16	2.66	13.0	1.83	1.89	1.73
	2.99	5.9	2.15	1.62	1.78
3/17	3.66	12.0	1.79	0.97	1.07
	3.99	4.7	2.27	0.96	1.12
3/18	4.67	12.1	2.03	0.53	0.91
	4.99	6.5	2.54	0.60	1.15
3/19	5.67	10.3	2.76	0.37	0.80
	6.02	5.0	2.40	0.30	0.82
3/20	6.67	10.8	2.18	0.17	0.43
	6.89	7.5	2.38		0.67
3/21	7.65	11.4	2.02		0.35
	8.01	6.9	2.43		1.50
3/22	8.64	10.6	1.45		0.87
	9.01	6.7	1.11		0.57
3/23	9.65	10.8	0.66		0.31
	10.01	7.9	0.39		0.18
3/24	10.65	11.2	0.22		0.12
	11.01	6.1	0.16		0.13
3/25	11.65	11.1	0.10		0.07
	12.01	6.3	0.08		0.07
3/26	12.64	12.0	0.05		0.04
	13.02	7.1	0.05		0.06
3/27	13.65	11.6	0.04		0.06

*Days after initial feeding which was given 31 hr. or 1.27 days after detonation.

Table 6. Milk data for Groups II and IV, Project Buggy

Date 1968	Collection Time days*	Avg. Milk Production liters	^{131}I pCi/liter	^{133}I nCi/liter	^{187}W nCi/liter
		Group II Cows			
3/14	0.64	12.9	745	4.76	1.86
	0.97	6.4	853	3.42	2.77
3/15	1.64	11.8	382	0.81	1.01
	1.97	6.8	277	0.43	0.69
3/16	2.64	13.2	122	0.20	0.21
	2.97	7.6	81	0.090	0.18
3/17	3.64	12.5	42	0.024	0.17
	4.01	5.8	29	0.016	0.10
3/18	4.64	12.5	13		0.051
	5.01	7.0	13		0.058
3/19	5.64	12.1	13		0.026
	5.98	6.5	14		
3/20		ND	ND		
		ND	ND		
		Group IV Cows			
3/14	0.63	11.8	92	0.644	0.227
	0.96	6.4	115	0.455	0.367
3/15	1.63	13.1	63	0.129	0.150
	1.96	5.6	45	0.053	0.150
3/16	2.63	12.3	21	0.018	0.035
	2.96	7.2	16	0.027	0.058
3/17	3.64	11.5	14		0.032
	4.01	5.9	13		0.048
3/18	4.64	13.0	10		0.017
	5.01	7.3	11		0.100
3/19	5.64	11.8	23		0.039
	5.98	6.2	7.2		

*Days after initial feeding which was given 31 hr. or 1.27 days after detonation.

Table 7. Milk data for Group III cows, Project Buggy

Date 1968	Collection Time days*	Avg. Milk Production liters	^{131}I pCi/liter	^{133}I pCi/liter	^{187}W pCi/liter
3/14	0.65	10.0	80	585	205
	0.98	6.0	182	771	352
3/15	1.65	10.6	248	602	400
	1.98	6.2	293	525	336
3/16	2.65	10.8	326	351	322
	2.98	5.0	399	317	338
3/17	3.65	10.2	315	211	217
	3.98	4.7	428	165	262
3/18	4.65	10.8	392	98	165
	4.98	5.8	456	100	166
3/19	5.65	10.1	491	41	149
	6.00	4.7	517		
3/20	6.65	9.1	482	30	127
	7.01	5.6	538		105
3/21	7.64	10.3	483		70
	8.00	6.0	548		306
3/22	8.63	9.3	327		232
	9.00	6.1	278		224
3/23	9.64	9.5	132		70
	10.00	5.7	93		91
3/24	10.64	9.3	53		84
	11.00	4.5	41		44
3/25	11.64	9.4	32		27
	12.00	5.4	26		19
3/26	12.63	7.3	16		33
	13.01	3.9	11		46

*Days after initial feeding which was given 31 hr. or 1.27 days after detonation.

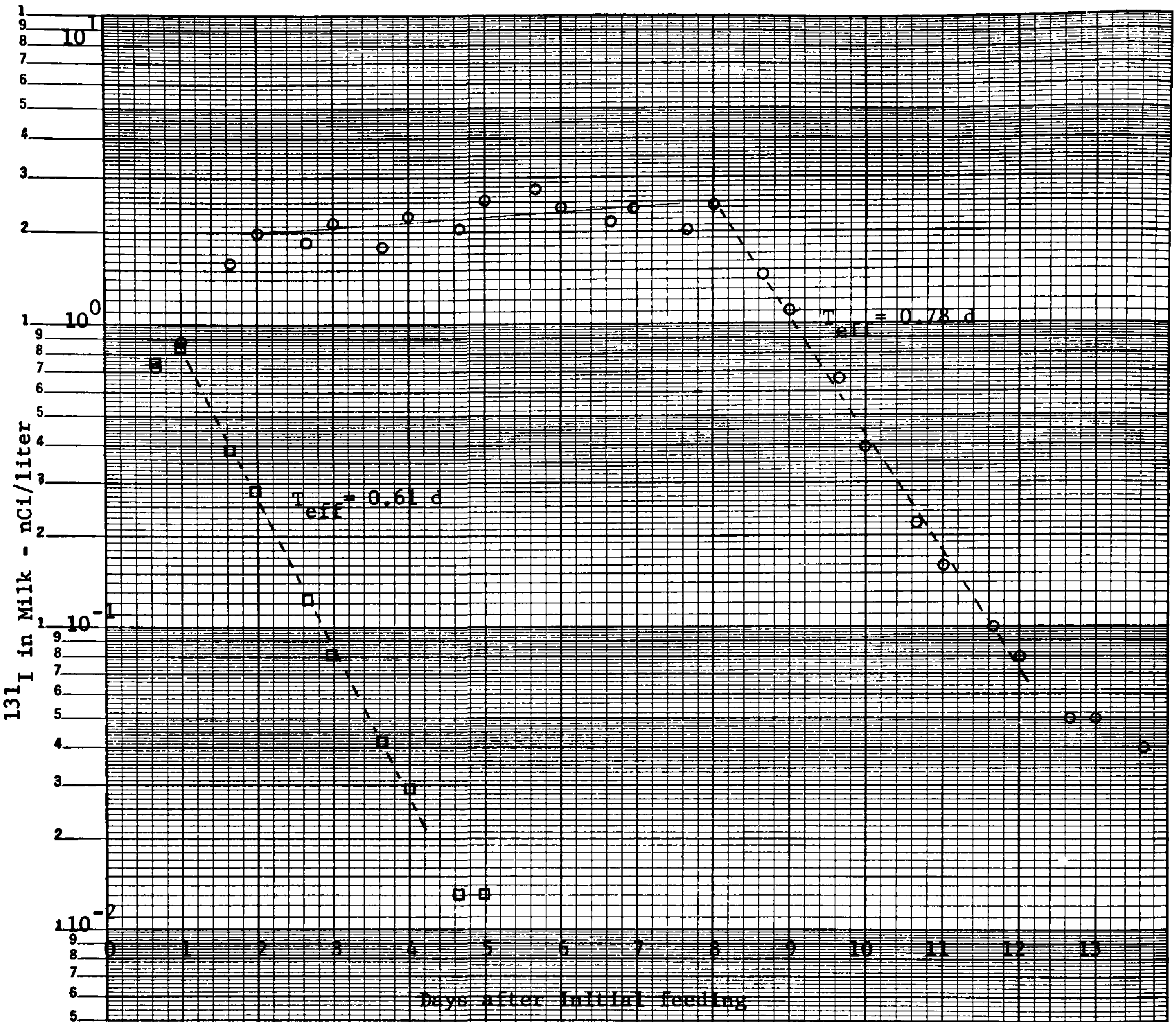

Fig. 4 - ^{131}I concentration in milk from Group I (o) and Group II (□) cows fed hay from Station 4.

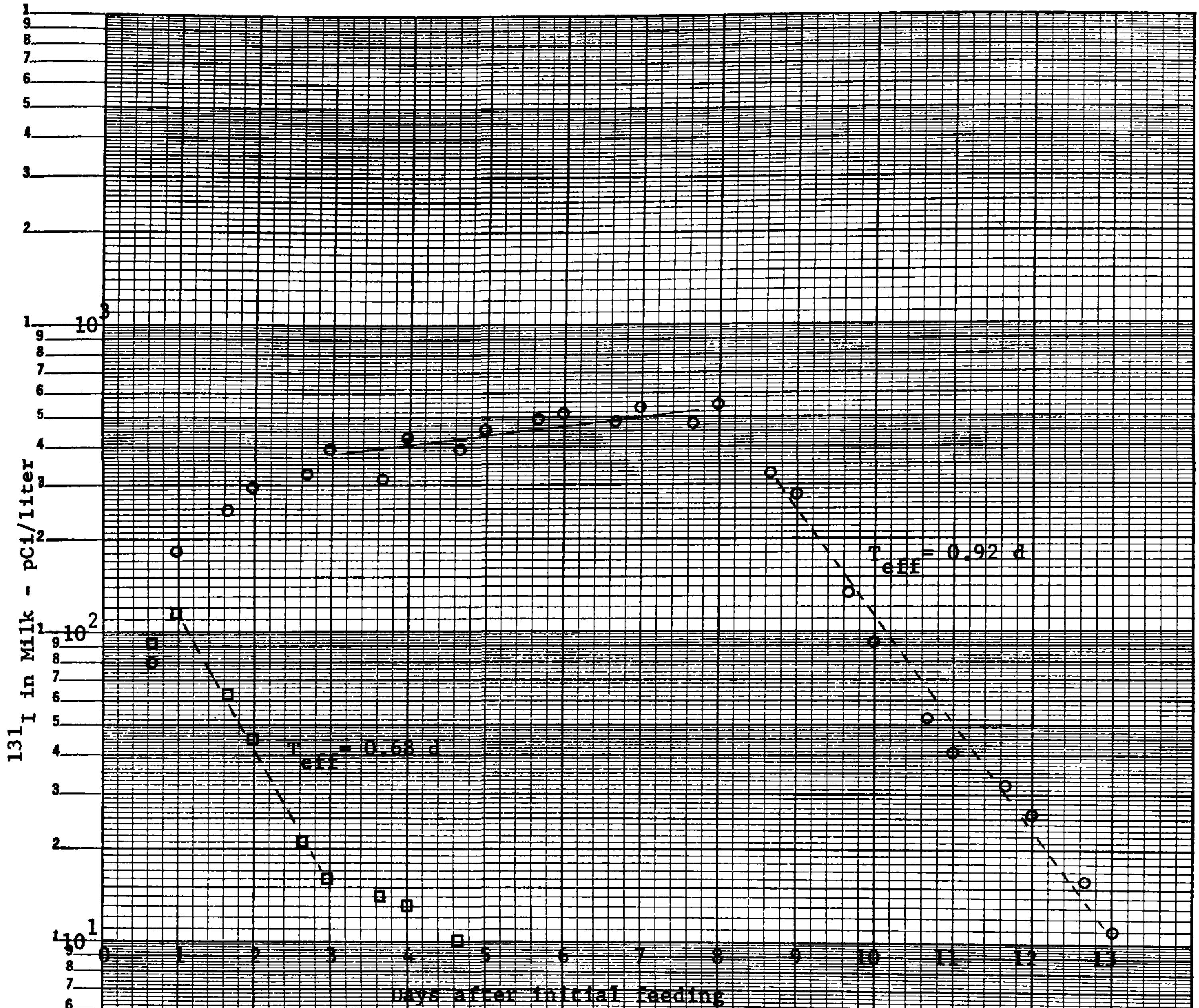

Fig. 5 - ^{131}I concentration in milk from Group III (○) and Group IV (□) cows fed hay from Station 2.

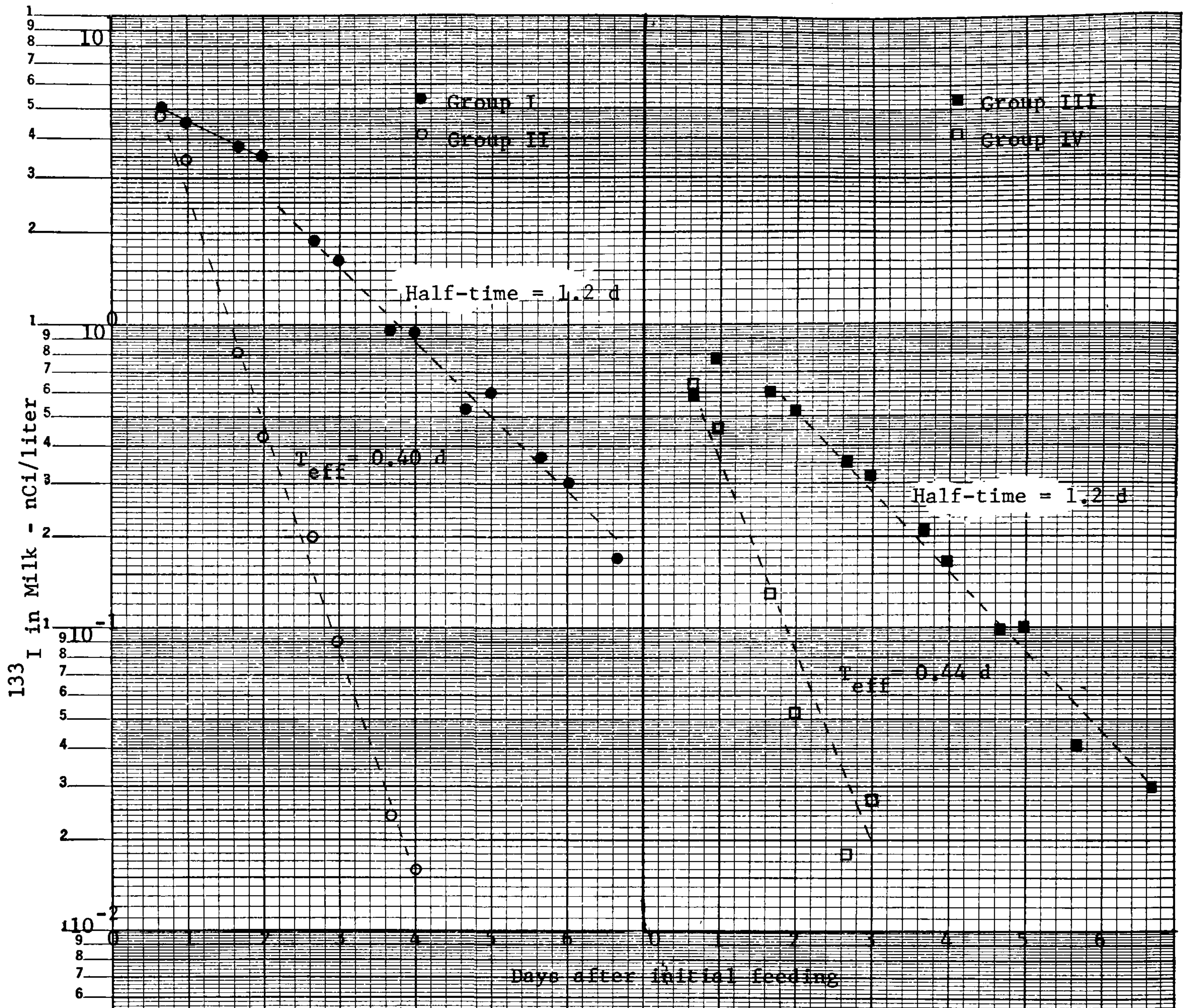

Fig. 6 - ^{133}I concentration in cow's milk following single or multiple ingestion of contaminated hay.

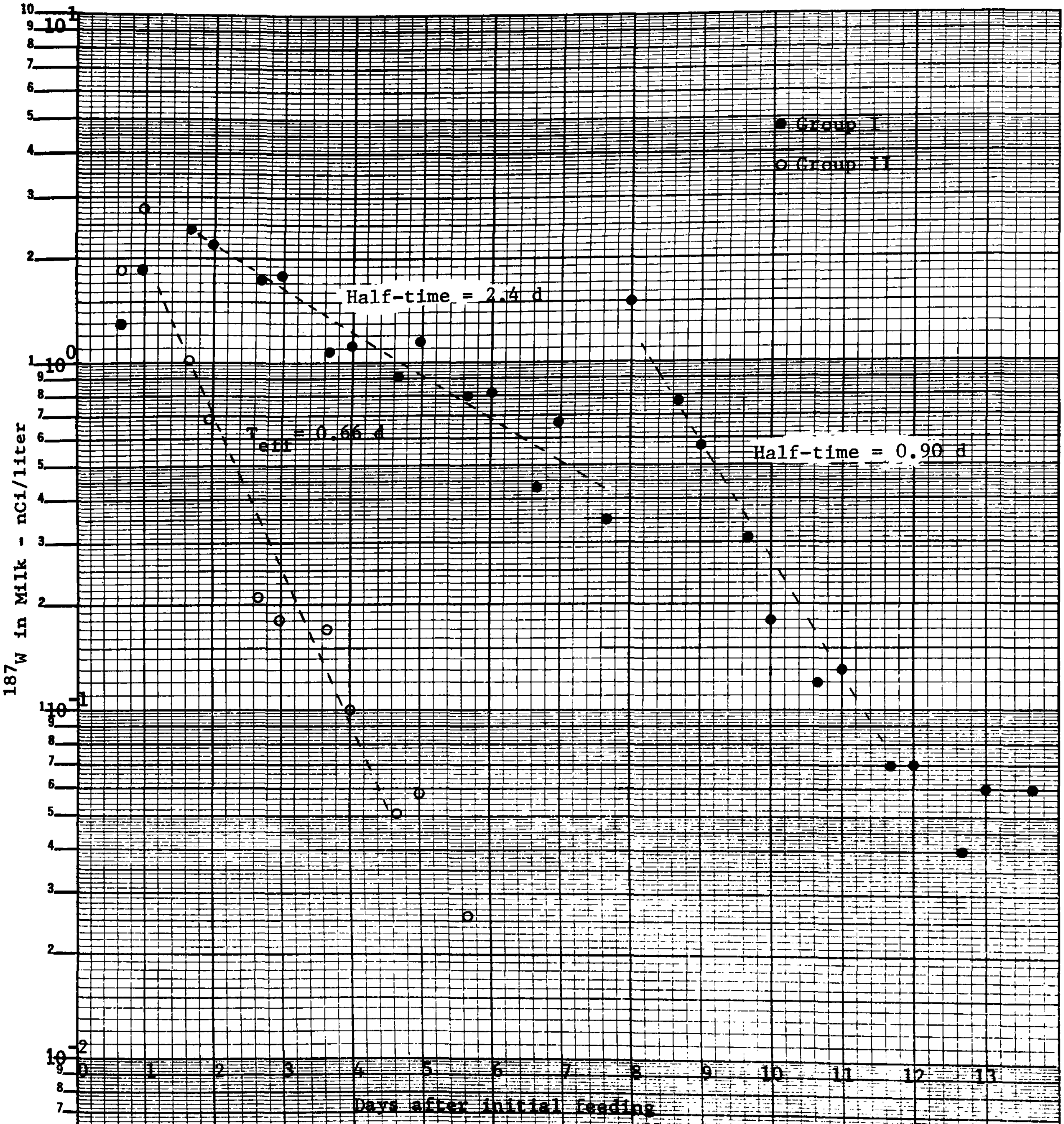

Fig. 7 - ^{187}W in milk after single (Group II) or multiple (Group I) ingestion of contaminated hay.

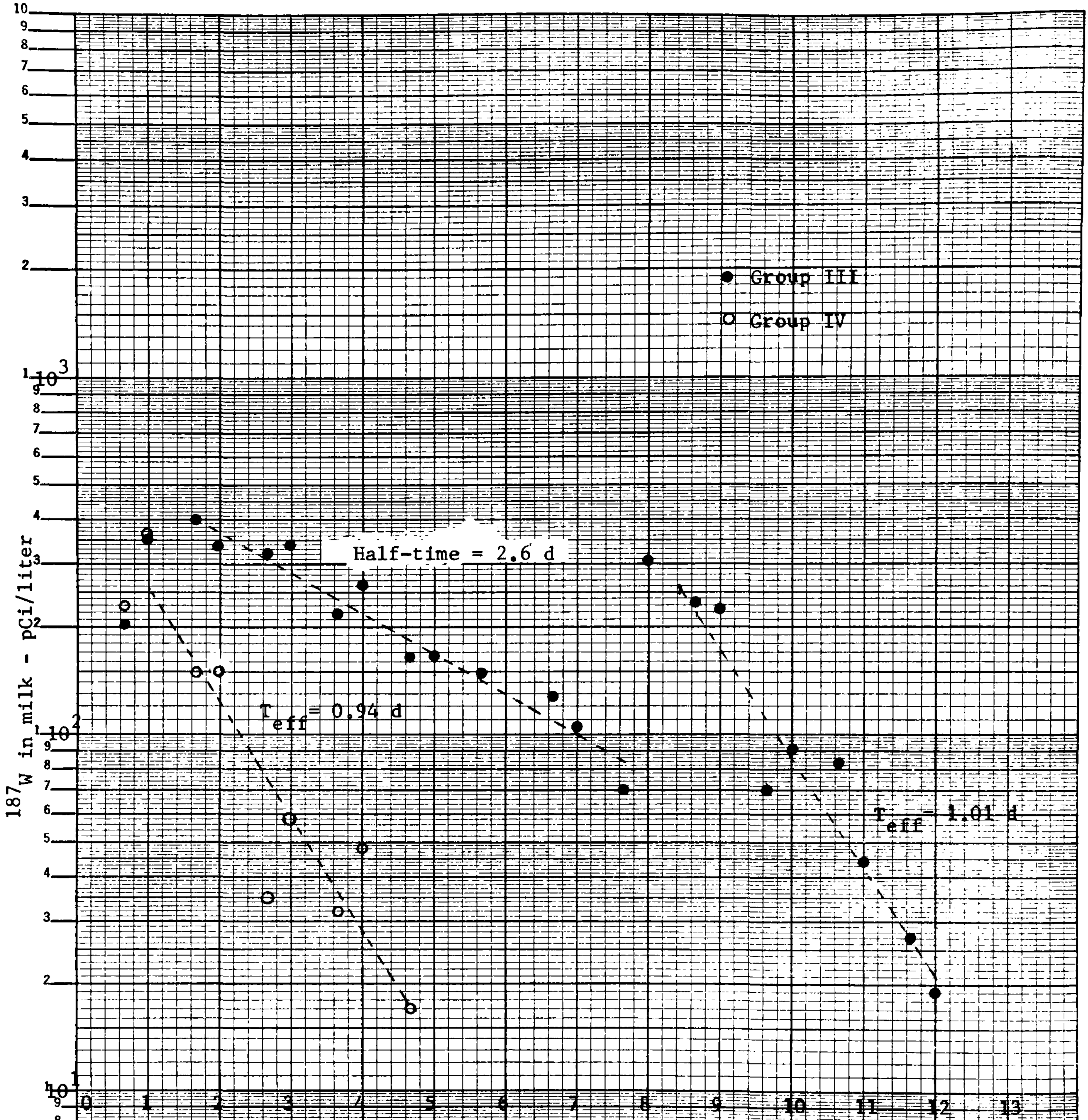

Fig. 8 - ^{187}W in milk following single (Group IV) or multiple (Group III) ingestion of contaminated hay.

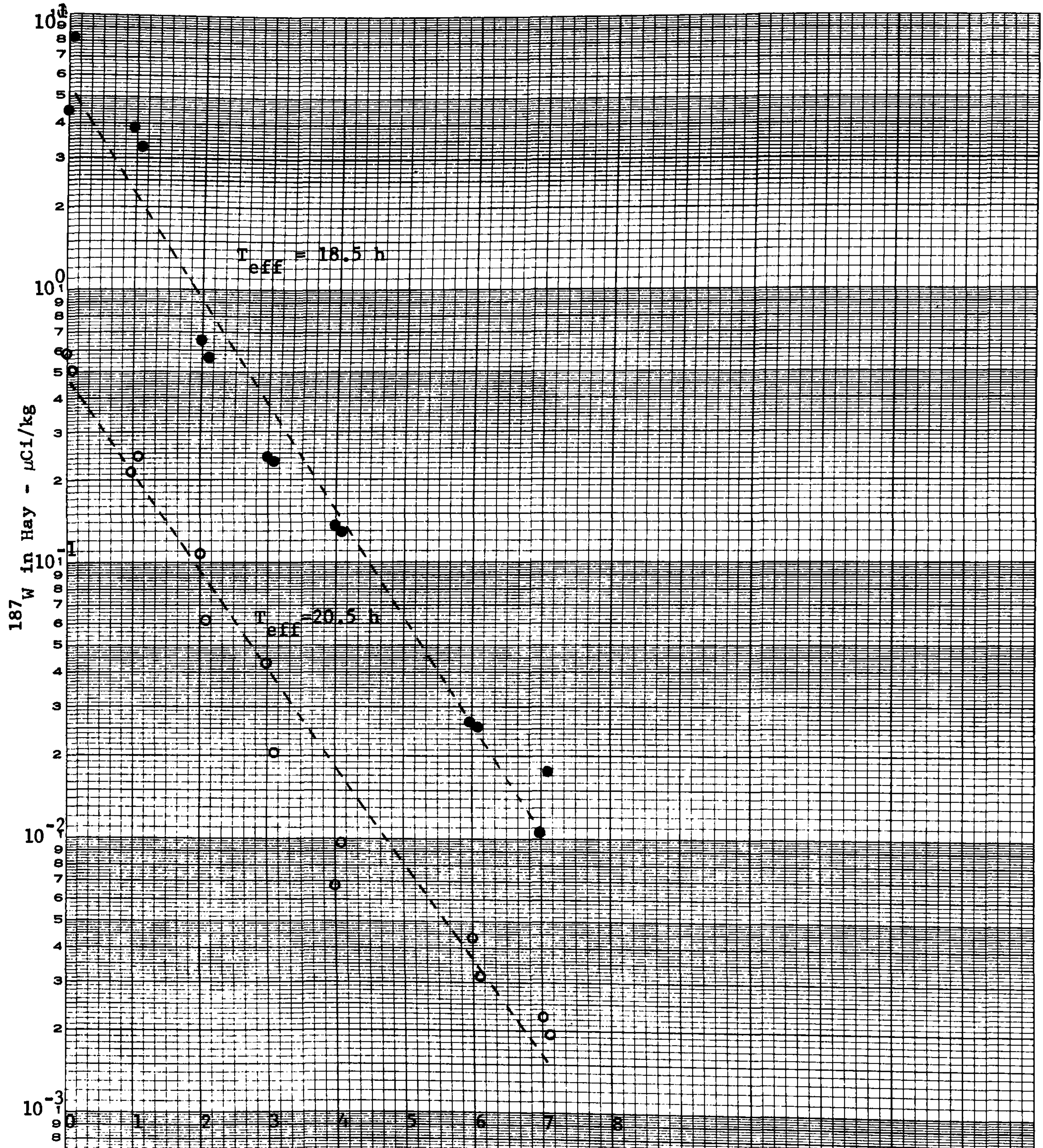

Fig. 9 - ^{187}W in hay from Station 2 (○) and Station 4 (●), Buggy

The data collected by the use of air samplers, fallout planchets, and GM type survey meters following each event are shown in Table 8. The deposition velocity data indicate a higher particulate content for the Buggy cloud at the experimental stations than for the Cabriolet cloud. This is supported by the filter/charcoal ratio of the air samplers. The filter/charcoal ratio is obtained by dividing the prefilter activity by the charcoal cartridge activity and is an estimate of the ratio of particulate to gaseous material in the effluent cloud. The small particle size measured on the Buggy stations suggests a large fraction of the cloud was composed of very fine particulate material.

The hay ^{131}I concentration as estimated by the planchets placed on each exposed face of one bale is also shown in Table 8.

Table 8. ^{131}I and other data from the Cabriolet and Buggy stations.

Station No.	Peak γ@1m mR/h*	Planchet Deposition μCi/m²	Hay† nCi/kg	Integrated Air Concentration μCi-s/m³	Deposition Velocity cm/s	Filter to Charcoal Ratio	CMD** μm
				CABRIOLET			
A3	31	1.04	34	4.96	0.21	1.43	
				BUGGY			
1	20	0.66		11.1	5.93	34.8	<0.6
2	64	3.08	62	7.9	38.8	6.6	<0.6
3	280	19.4		31.4	61.8	7.6	<0.6
4	252	18.2	315	52.0	35.0	14.6	<0.6
5	3	0.17					0.6

*Extrapolated from survey-meter readings
†Hay concentration from planchets placed on the bale.
**Count median diameter.

DISCUSSION

Some of the radioiodine results from these studies vary significantly from the results of other similar studies we have conducted.[1-5] Of particular note are the long time until peak milk activity in the Buggy study, the long T_{eff} in milk in the Cabriolet study and the low percent of ingested iodine which appears in milk in both studies. These as well as other data derived from the experimental results are shown in Table 9.

A suggested cause for these results is the lower biological availability of radioiodine in the debris from the two events. This may have been due to a stronger binding of the radioiodine to the particulate material in the debris as compared to other events. The reasoning behind these suggestions is rather straightforward. Note that in both groups from Buggy receiving a single feeding of contaminated hay, the peak activity in milk occurred in the second milking. In other single-feeding experiments,[5] the peak milk activity occurred in the first milking after ingestion - when the first milking was at least 3-4 hours after ingestion. This implies that the radioiodine was released very slowly from the debris and was not immediately available as had been true in the previous studies. The slow release of radioiodine and the long residence time in the cow's G.I. tract (approximately 72 hours) also explain the low percent transfer to milk and the longer effective half-life in milk. Further, the relatively normal T_{eff} on hay (6.2 - 6.8 days) suggests that the hay was not a major factor in these effects.

The ^{133}I and ^{187}W results from Project Buggy are somewhat similar in indicating a lower biological availability for those radionuclides, also. In a metabolism study,[6] a solution of Na_2WO_4 was given to four

Table 9. Forage and milk summary data

Measured Parameter	Cabriolet	Buggy Station 2			Buggy Station 4		
	^{131}I	^{131}I	^{133}I	^{187}W	^{131}I	^{133}I	^{187}W
$\mu Ci/m^2$	1.04	3.08	-	-	18.2	-	-
$\mu Ci\text{-}s/m^3$	4.96	7.9	-	-	52.0	-	-
Peak mR/h	31	64	-	-	252	-	-
Hay T_{eff}-days	6.2	6.8	-	0.85	6.7	-	0.77
Single ingestion data							
Milk T_{eff}-days		0.68	0.44	0.94	0.61	0.40	0.66
Time to Peak days		1.0	0.66	1.0	1.0	0.66	1.0
% in milk		2.8	-	0.26	2.8	-	0.16
Milk/forage*		0.0056	-	-	0.0068	-	-
Multiple ingestion data							
Peak nCi/liter	0.56	0.55	0.77	0.40	2.76	5.1	2.4
Milk half-time-days	11.1	-	1.2	2.6	-	1.2	2.4
Time to Peak-days	2.01	7.0	1.0	1.7	5.7	0.66	1.7
% in milk	2.2	1.4	-	0.34	1.2	-	0.12
Milk/forage*	0.0093	0.01	-	0.0007	0.0064	-	0.0003
Milk T_{eff} after feeding-days	1.13	0.92	-	1.01	0.78	-	0.90

*Peak concentration in milk divided by peak concentration in hay.

cows (as a single oral dose) and the secretion of tungsten in milk and excreta measured. The results from that study indicate that the biological half-time (in milk and blood) for ^{187}W is 0.75 days - T_{eff} of 0.42 days - and that the percent transferred to milk is 0.4. These values are different from those in Table 9. Later, another group of four cows was given twice-daily doses of ^{181}W, as the tungstate, for seven days. The percent in milk in the latter experiment was 0.64 and the peak milk concentration was 0.0005 times the activity in the first dose. The higher percent in milk, compared to that in Table 9, also suggests a lower biological availability of the tungsten in the debris from Project Buggy.

Another possible reason for the long T_{eff} in milk during ingestion of the contaminated hay was the variation in intake. The data in Table 4 indicate only a small variation in total μCi intake during the 8 days of feeding the hay. This was due to a combination of the amount consumed and the activity concentration in the hay. The cows consumed varying amounts at each feeding which would influence the activity secreted in the milk. Also, the bales of hay were used in a pre-assigned sequence and since the deposition on the bales was not uniform, it was possible to feed a bale with a higher deposition at a later time than one with a lower deposition.

An important prediction to be made after a release of radioactive material is the peak ^{131}I concentration to be expected in milk. This prediction can be made rather promptly if surveillance data can be correlated with the peak milk concentration. For Project Buggy, a useful procedure is to take the ratio of the various parameters at Station 4 to those at Station 2 and compare the ratios. The peak milk ratio (Table 9) is 5.1 while the other ratios are: mR/h = 3.9, $\mu Ci/m^2$ = 5.9, and $\mu Ci\text{-}s/m^3$ = 6.6. These three ratios would give good estimates of the relative peak milk concentrations at different locations contaminated by the same event. The absolute concentrations, though, could not be predicted with any confidence as can be seen if the Buggy surveillance data are used to estimate the peak milk concentration obtained during the Cabriolet experiment. The extrapolation from the mR/h data would estimate a peak milk concentration for Cabriolet of 300 pCi/liter, from the air data would also estimate 300 pCi/liter, while from the $\mu Ci/m^2$ data would estimate only 160 pCi/liter. Thus the best estimate is about 1/2 the observed value.

There was no obvious difference in the milk transfer of radioiodine between the two groups of cows in the Buggy experiment which could be attributed to the difference in the filter/charcoal ratio at the two stations. This may have been due to the large ratio at each station as in one case 87% of the air sampler activity was on the prefilter and in the other case 94% was on the prefilter. Such a small difference in the filter/charcoal ratio may not be detectable in biological sampling.

The planchets placed on each exposed surface of a hay bale, when properly corrected, should yield data for estimating the concentration in the hay. This was not necessarily true for any particular bale from the 16 contaminated at each station, though the average for all 16 bales was reasonably close. The planchet estimate when divided by the average concentration in all bales resulted in ratios which were 0.58, 1.0, and 1.2 for the Cabriolet and two Buggy stations, respectively. The planchet on top of the bale, however, when used as the sole means of estimation, seriously under-estimates the hay concentration so it is useful merely in establishing the relative contamination of forage. This effect may have been due to the close-in location of the experimental stations where the major portion of the deposition was probably not on top of the bales.

SUMMARY

Hay, contaminated by the effluent from the Cabriolet and Buggy cratering events, was fed to groups of dairy cows in controlled ingestion experiments. Air sampling, survey meter, and deposition data were also collected at the locations where the hay was contaminated. The principal objectives of the experiments were to detect any differences in the forage-cow-milk transfer of ^{131}I which might be due to the varying particulate/gaseous mix in the effluent clouds and to search for correlations between surveillance data and milk levels.

Of the ten possible stations set out for Cabriolet, only one received sufficient activity for useful study, but Project Buggy contaminated several stations of which two were used for ingestion studies. For Project Cabriolet, the hay was fed twice daily for eight days to a group of four cows. For Project Buggy, one feeding of hay was given to one group of cows while twice-daily feeding of hay from the same station was offered to another group of cows for eight days. This was also done with the hay from a second station.

The particulate/gaseous ratio was sufficiently large at both stations, for Buggy, that no detectable difference occurred in the forage-cow-milk transfer of ^{131}I. The best surveillance data for predicting peak milk concentrations were the integrated air concentration (μCi-s/m^3) and the peak gamma mR/h measured at 1 m above ground. However, both parameters predicted only 50% of the observed peak milk value in the Cabriolet experiment.

In both experiments, the biological availability of ^{131}I apparently was less than had been observed in previous experiments. Less than 3% of the ingested ^{131}I appeared in milk, and both the T_{eff} and time to

reach the peak milk concentration were longer than was observed in other similar studies. Furthermore, the peak milk/peak forage ratios were less than 0.01, much less than those found previously.

In the Buggy experiment, it was also possible to obtain some forage-milk transfer data for ^{187}W. Though the ^{187}W in hay was 10 times that of ^{131}I, less than 0.5% appeared in the milk and the half-time in milk was only about 2.5 days.

The single feeding experiments for Buggy, when compared to the multiple intake experiments, indicate that multiple ingestion yielded peak milk concentrations that were 3.2 and 4.8 times those from single ingestion and the total ^{131}I in milk was 13 and 15 times that following single ingestion. Thus the hazard to humans drinking milk would be markedly reduced if the cows consumed only the hay contaminated in their bunkers during cloud passage and were then fed hay that had been covered at that time.

The low percentage of ingested radioiodine which was secreted in milk in these two Plowshare tests has an important bearing on the potential human hazard which may result from events of this type. Since the reduced peak concentration and reduced total content in milk will result in a lower thyroid concentration in humans drinking the milk, the thyroid dose will be proportionately reduced. This will be offset, to some extent, by the longer measured half-time in milk.

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