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Preliminary Report  
on  
"Rain Out" from Shots Diablo and Stokes  
in the Belle Fourche - Rapid City, South Dakota Area

by  
Kermit H. Larson, Edward A. Hawthorne, Keith R. Price

Program 37  
Civil Effects Test Group

Date of Issue - August 27, 1957

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Preliminary Report on "Rain Out" from Shots Diablo and Stokes in the Belle Fourche - Rapid City, South Dakota Area

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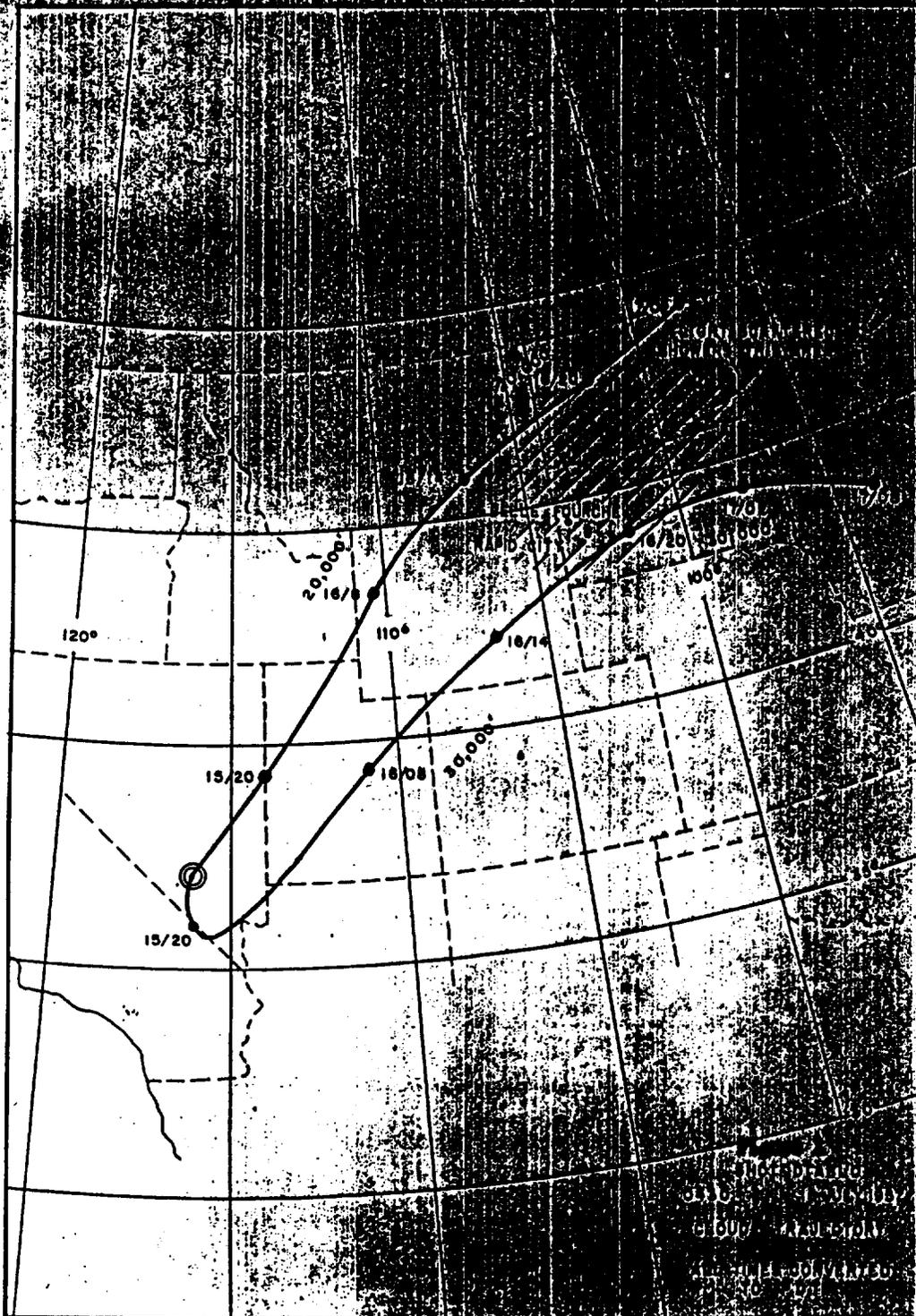
On August 13, 1957, the Division of Biology and Medicine, Atomic Energy Commission, requested that Program 37, Civil Effects Test Group, send a radiological survey team to Belle Fourche, South Dakota. Fall-out had been reported and measured by various individuals from the Rapid City area (see Appendix I). It was reported present in Belle Fourche at 1000, July 17, and radioactive rain was reported to have occurred in Rapid City, South Dakota after 1100, August 9. The objectives of the Program 37 investigators were (1) to determine to what extent fall-out had occurred, (2) to delineate the fall-out patterns, and (3) determine the levels of radioactivity existing in these areas.

Two nuclear devices detonated at the Nevada Test Site contributed fall-out to these areas; Diablo, detonated at 0430, July 15 and Stokes, detonated 0525, August 7.

Mr. Kenneth Nagler, U. S. Weather Bureau, and presently a member of the Test Manager's Fall-out Prediction Unit, prepared cloud trajectory maps for these shots and combined them with weather data for South Dakota. The trajectory prepared for Diablo indicated the 30,000 foot cloud level passed through the Belle Fourche region July 16. Light scattered showers occurred between 1500 and 2100. The trajectory for Stokes indicated the 20,000 foot cloud level also passed through the same area on August 8. Approximately 0.5 inches of rain fell between 1200 and 1800, August 8, (see Figure 1 and 2).

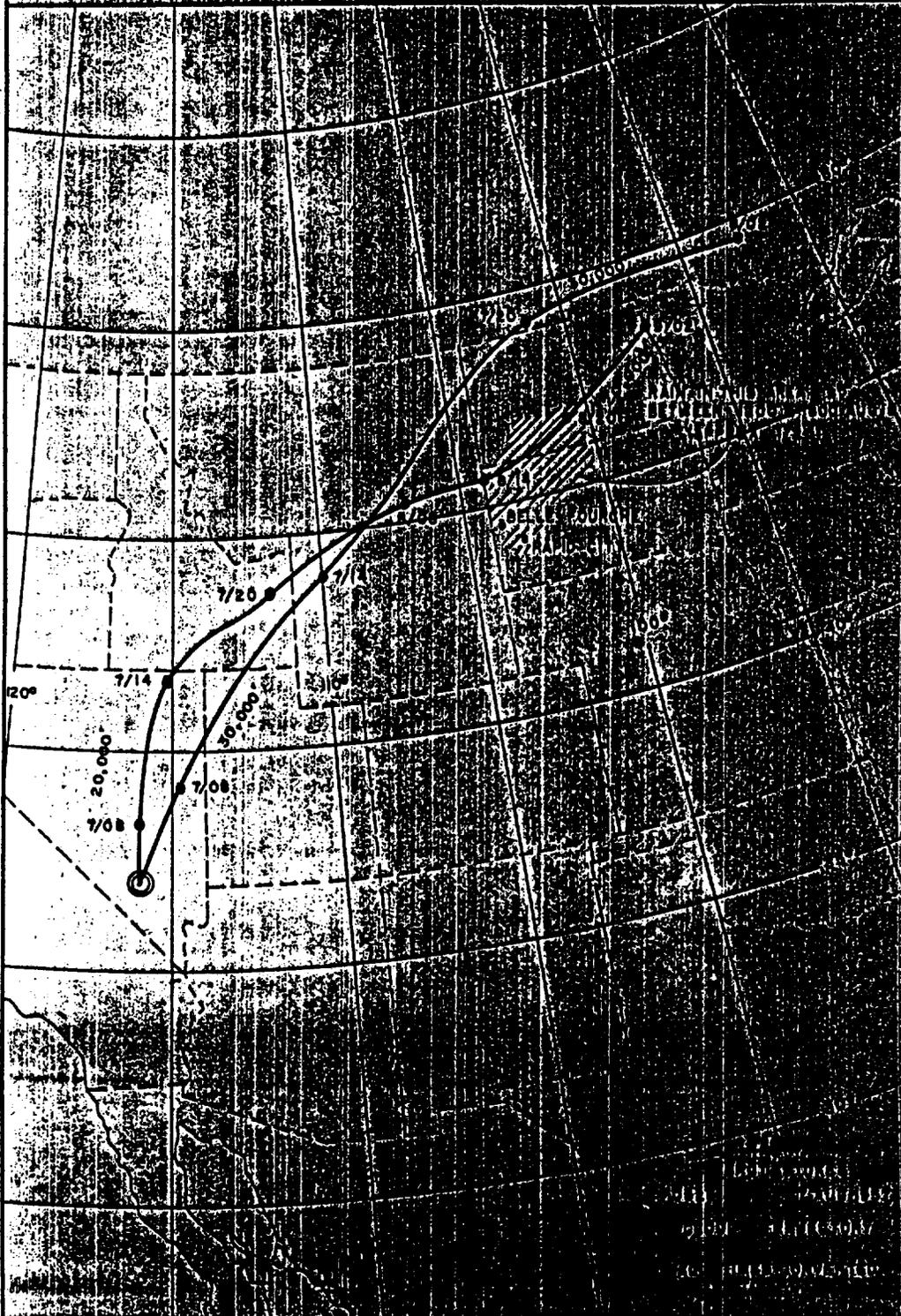
The radiological survey team dispatched August 14 consisted of a U. S. Geological Survey DC-3 aircraft and its crew of five accompanied by a ground survey party of three persons.

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Using the available information regarding the fall-out pattern in the Rapid City - Belle Fourche area, the UEGS team flew 800 traverse miles delineating the fall-out pattern, as it existed August 15 through August 17, within an area 150 miles by 96 miles (14,400 square miles approximately). Four hundred traverse miles were flown in a detailed study surrounding Belle Fourche; an area approximately 72 miles by 20 miles in the east-west direction - each traverse being five miles apart.

Continuous radiation-intensity readings were taken by recording gamma radiation monitoring equipment. The flight patterns were a series of various straight-line bearings navigated by predetermined visual location points over as level terrain as practicable. An air speed of  $140 \pm 20$  mph was maintained at an altitude of  $500 \pm 25$  feet above ground level. A position plot was maintained by an observer, utilizing a view finder, who marked the position on a map and also actuated a marking-system switch over recognized visual reference points, which, in turn, placed fiducial marks on all record tapes and camera film. The flight pattern was recorded by a 35-mm gyrostabilized, continuous-strip-film camera.

The monitoring equipment used has been described in detail by the designers, (see Health Physics Progress Reports, ORNL-877, 1174, and 1684).

#### RESULTS

The data from the aerial survey are summarized on the map 'Aerial Radiological Survey, Belle Fourche, South Dakota Area', Figure 3. The level of radioactivity throughout the area surveyed was less than three times background. The tentative average background radiation in this area was established at 1,100 c/s. The iso-intensity lines are irregular with three areas showing more than two and a half times background levels. Based on data obtained by monitoring, it is not possible yet to separate the

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radioactivity contributions of Diablo and Stokes to the Belle Fourche region. When the analysis of the collected soil samples are completed, additional information may permit an indication as to which fall-out pattern contaminated which area.

Monitoring by the ground survey team was done along Highway # 14 from Rapid City to Sturgis continuing on Highway # 24 to Belle Fourche and northwest on Highway # 212. In addition, monitoring was done north from Sturgis along Highway # 79 to Highway # 212 continuing west to Belle Fourche. A total of 160 miles were monitored.

Survey instruments used were the Nuclear Instrument and Chemical Corporation Geiger survey meter, model 2610A and the Victoreen Instrument Company Geiger survey meter CD V-700 (Victoreen model 661). These instruments were calibrated August 14 using a 10 mgm radium source, window closed. An interval of five miles was used with readings taken at three feet and at two inches, window open and closed. Areas of special interest were monitored at 2.5 mile intervals. The aerial survey and ground monitoring were coordinated so that the ground survey route was also traversed by the DC-3. Samples of soil, vegetation and milk were collected August 17.

Mr. Robert Sandvig at the South Dakota State School of Mines and Technology, Rapid City, was consulted about the monitoring and other observations done by Dr. Willard and himself. Captain Jackson, CBR officer at Ellsworth Air Force Base, was contacted by telephone.

Monitoring by the ground survey team indicated the maximum gamma intensity was less than 0.06 mr/hr and the approximate beta plus gamma levels were less than 0.50 mr/hr measured at two inches.

The location of radiation intensities of greater than two times background determined by aerial survey along roads and by ground survey are

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listed in Table 1. Distances of the aerial survey are given in airline miles and ground monitoring in road miles.

The aerial and ground monitoring data for the area traversed by both groups are presented in Table 2. The aerial survey data are given in terms of total activity, without background corrections. The readings from <sup>ground</sup> ~~these~~ instruments are reported as gamma at three feet. The beta plus gamma data were taken with the probe window open at two inches above the ground. The distances, from reference points, given in Table 2 are road mileages.

The ground monitoring data in Table 2 were obtained from native grassland, except that in Hermann Park which was taken on mowed lawn grass. Ground monitoring indicated the soil in grain, corn, potato and alfalfa fields had from one-quarter to one-half the radiation intensity of adjacent virgin grassland. The one exception was an alfalfa field in South Belle Fourche, where the level was similar to that on adjacent native grassland.

The samples of soil and bulk vegetation collected will be assayed. An attempt will be made to determine the predominate particle size at this distance of 850 miles from Yucca Flat, NTS. Certain soil fractions are to be assayed radiochemically. Specific activity per particle will be further studied. These particles are being isolated from the leaf material collected.

The milk sample from the Belle Fourche market will be assayed radiochemically for Sr and Cs.

In an attempt to investigate the validity of the suggestion that Bremsstrahlung could effect electroscope dosimeters, certain information was obtained from personal communications and available literature (see Appendix II).

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TABLE 1

SITES OF MAXIMUM RADIOACTIVITY DETERMINED BY AERIAL OR GROUND MONITORING

I. Greater than two and one-half times background

A. Northwest from Junction of Highways # 85 and # 212, on # 212.

1. Aerial: 9 - 12 miles
2. Ground: 12.9 miles

B. North of Junction of Highways # 85 and # 212, on # 85.

1. Aerial: 9 miles (no ground data).

C. Junction of Highways # 85 and # 24.

1. Aerial: At Junction (no ground data).

II. Greater than two times background

A. West of Junction of Highways # 85 and # 24, on # 24.

1. Aerial: 0 - 8 miles
2. Ground: 5.0 miles

B. Northwest from Junction of Highways # 85 and # 212, on # 212

1. Aerial: 4 - 5, 6.5 - 13 miles
2. Ground: 12.9 miles

C. Rapid City northwest to Junction Highway # 24 and # 85, on # 24

1. Aerial: 15.5 miles, 21.5 - 24 miles north of Sturgis
2. Ground: 16.1 miles north of Sturgis
3. Ground: 3.5 miles south of Sturgis

(Aerial: Peak of 1.8 times background here. Also a peak of same intensity at 4 miles north of Sturgis.)

D. Rapid City, South Dakota to Gillette, Wyoming via Route # 16

1. Aerial: 1½ miles northwest of Upton, Wyoming (No ground data).

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TABLE 2

RADIOMETRIC SURVEY OF BELLE FOURCHE, SOUTH DAKOTA AREA, AUGUST 15 - 17, 1957  
(AERIAL SURVEY DISCRECUND 1,100 c/s)

1. West of Junction of Highways # 85 and # 24, on Highway # 24

Distance in miles	Aerial Survey Counts/second	Ground Survey Average Intensity	
		Gamma, 3 ft	Beta + gamma, 2 in.
nr/hr			
22.4	1200	0.015	0.108
25.6	1200	0.015	0.10
20.2	1400	0.025	0.115
15.0	2000	0.03	0.169
9.7	2000	0.04	0.193
5.0	1900	0.045	0.435

2. Northwest of Belle Fourche from Junction of Highways #85 and # 212, on # 212.

20.3	1500	0.015	0.10
23.0	1200	0.015	0.118
20.5	1300	0.02	0.08
17.9	1700	0.02	0.14
15.4	1800	0.01	0.129
12.9	2700	0.055	0.275
10.3	2800	0.03	0.172
7.7	2300	0.01	0.13
4.9	1900	0.03	0.117
2.2	1500	0.035	0.138

3. In Belle Fourche

Location - two blocks  
east of Highway # 85,  
1.0 mi. north of Jct.  
Rwy # 24 & # 85  
Raymond Park  
East of city limit

0.04	0.40
-	0.175
0.035	0.328

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Table 2 (Continued)

Distance in miles	Aerial Survey Counts/second	Ground Survey Average Intensity	
		Gamma, 3 ft	Beta + gamma, 2 in.
mr/hr			
4. East of Belle Fourche City Limit on Highway # 212, Towards Junction of Highway # 79 and # 212.			
0	1800	0.035	0.328
1.0	1900	0.03	0.183
2.0	2000	0.03	0.266
4.9	2000	0.02	0.15
5.8	1900	0.03	0.16
7.8	1700	0.02	0.154
9.8	1600	0.015	0.123
15.7	1300	<0.01	0.10
5. Rapid City Northwest to Junction Highways # 24 and # 85, on Hwy # 24 and # 14.			
0	800	0.025	0.125
5.1	1400	0.03	0.125
11.7	1500	0.025	0.124
16.8	1300	0.015	0.09
22.1	2000	0.055	0.235
25.6	Sturgis	-	-
26.9	1900	0.04	0.445
31.9	1300	0.025	0.445
35.8	1400	0.03	0.113
41.7	1800	0.048	0.123
45.9	2000	0.015	0.145
50.9	Jet.	-	-
6. Sturgis to Junction Highways # 212 and # 79, on Highway # 79			
2.3	"	0.02	0.118
6.0	"	0.025	0.13
12.5	"	0.02	0.12
17.5	1500	0.01	0.092
21.5	1300	<0.01	0.078

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APPENDIX I

Summary of Notes on  
Discussion of Rain Out with  
Dr. John W. Willard, Professor of Chemistry  
and  
Dr. Robert Sandvig, Instructor, Chemical Engineering Department  
South Dakota School of Mines  
and  
Bernit H. Larson, Director, Program 37, CERG

August 12 - August 17

1957

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#### Appendix I

Summary of notes on discussion with Dr. John W. Willard in presence of Mr. George Anton on morning of 8/12/57, warehouse 6, ETS.

Dr. J. Willard is a physical chemist, Professor at South Dakota School of Mines, Rapid City, South Dakota.

Dr. Robert Sandvig, Instructor, Chemical Engineering Department, South Dakota School of Mines, on the morning of 8/17/57, at Rapid City, South Dakota.

According to Dr. Willard, Diablo fall-out was first detected by prospectors in the general area of Belle Fourche. On July 17, 6 p.m., Belle Fourche apparently received its first fall-out. (It was not noted if it was raining at the time; however, scattered showers were in the general area).

Dr. Davis, county health officer was a contact. Readings were obtained as high as 20 mr/hr at 3 ft supposedly.

According to Willard, General Arnt (?), State Civil Defense Director and Captain Jackson, the CBR officer at Ellsworth AF Base 'were in the picture'.

At Rapid City, the background on the one CD Geiger survey meter (model GS-3CD) that Dr. Willard and Mr. Sandvig have is 0.025 to 0.030 mr/hr window closed.

On July 17, 8 p.m., reading at Rapid City was 0.3 - 0.5 mr/hr window closed. At the Air Force Base, using survey meter model PDR 27 the same readings were obtained.

At Belle Fourche, 6 to 10 mr/hr, probably window open. A 5 mile diameter area was reading between 3 to 4 mr/hr window closed (?) at July 18, 4 a.m.

The Spearfish Valley was lower.

On July 19, the Deputy Sheriff of Belle Fourche area called in the 'hot' readings based on prospectors' reports according to Willard.

On July 19, afternoon, readings by Willard were 0.5 to 1.0 mr/hr at 3 ft. 10 mr/hr near surface of alfalfa plants (probably window open).

Soil measured at 2 to 3 inches above surface was reported by Willard to be 0.5 - 1.0 mr/hr with window open. (Confirmed by Sandvig, who recorded at the 5 mile Steak House, east of Belle Fourche on Highway # 212, on July 22, 1 mr/hr beta - gamma and on July 25, 0.5 mr/hr beta - gamma.) 'Hot spots' were also reported by Willard up to 5.0 mr/hr on lawn of Dr. Davis in Belle Fourche.

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Appendix I

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From lawn (and perhaps other locations) soil samples were collected - 6" x 6" and  $\frac{1}{2}$ " -  $\frac{1}{2}$ " deep. Using a Bendix dosimeter (range 0 - 20 r) mounted 8" above in lab, soil sample having been spread on the lab bench approximately 6" square on Friday (July 19): by Saturday a.m., after 14 hr exposure, reading was 0.18 r and 24 hr exposure was 0.3 r according to Willard. Other dosimeters (0 - 20 r range) in the room had not changed, at least one was used for 'control'.

Willard did chemical separations on the soil, using a Keleket model 90 lab demonstrator as the detector. Reads in counts per minute. He reported finding:

Ca	} Radioactive These fractions were further identified by spectrographic analysis.
Sr	
Pb	
Mn	

A magnetic fraction was also obtained by Willard and was found to be radioactive. After removing SiO<sub>2</sub> from the remaining residue, it was found to be radioactive.

Note: No values were given by Willard.

Readings from mounted dosimeter over soil were 0.9 to 1 r per 72 hours (equivalent to one division of the total scale of the dosimeter). By holding the probe (GM tube) of the Keleket instrument over the soil sample in the lab bench, a reading of 600 c/m was reported by Willard. (Using a Co60 standard, the keleket gives 450 c/m equivalent to 1 mr/hr by survey meter.)

July 24, Willard and others returned to same previously monitored area around Belle Fourche. It was noted that the decay was not as rapid as supposed to be.

July 26, Captain Jackson collected milk from a farmer. Willard evaporated one liter and ashed the residue. Using Keleket instrument obtained 200 to 300 c/m on ashed material.

Mr. Nelson from Public Health, Rapid City, collected milk samples and sent these to USPHS at Cincinnati. Also alfalfa and water samples.

(According to Dr. Dunning telecon on August 13, the results obtained by USPHS on water from reservoir at Belle Fourche collected on July 27 and assayed on July 31, gave 1,180  $\mu$ c/l. at time of collection or  $1.4 \times 10^{-7}$   $\mu$ c/ml. Soil at Reservoir slightly above background.)

General information by Willard. Captain Jackson separated black active spheres from soil samples. Checking with Captain Jackson (telecon Jackson and Larson, August 17) Jackson says he was not able to positively identify spheres and he did not make that statement as given by Willard at NBS.

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Appendix I

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According to Willard, Jackson obtained a model PDR-10B alpha survey meter and obtained an alpha indication (weak) on soil sample on Willard's lab bench.

According to Willard, on August 8, approximately 11:00 a.m., the kellogg instrument indicated an increase of activity of approximately 1,000 c/m about 2 ft from his office window. It was raining. According to Sandvig on August 17, it started raining at 9:15 a.m. on August 8.) Willard reported the activity as measured by survey meter with probe adjacent to drain spout from chemistry building roof to be 10 to 20 mr/hr.

Willard called Captain Jackson at this time to check around the AF Base, Jackson reported 0.3 mr/hr.

Willard and others went to Belle Fourche starting from Rapid City about 1:00 p.m. Enroute Willard held probe of survey meter out the window of vehicle (Chevrolet sedan) behind the 'no-draft' window and obtained approximately 10 mr/hr at 4 ft above ground surface. Willard's party approached Belle Fourche from the east (Highway # 212), measured at previously located areas (Disble pattern), 0.3 mr/hr was one value Willard remembered.

In Haroun Park, Belle Fourche, leaves of shrubs - 10 mr/hr. A sample of rain puddles in park on August 9, 8:00 a.m. gave 0.2 - 0.3 mr/hr.

Enroute to Spearfish. Localized areas were found of 5 mr/hr.

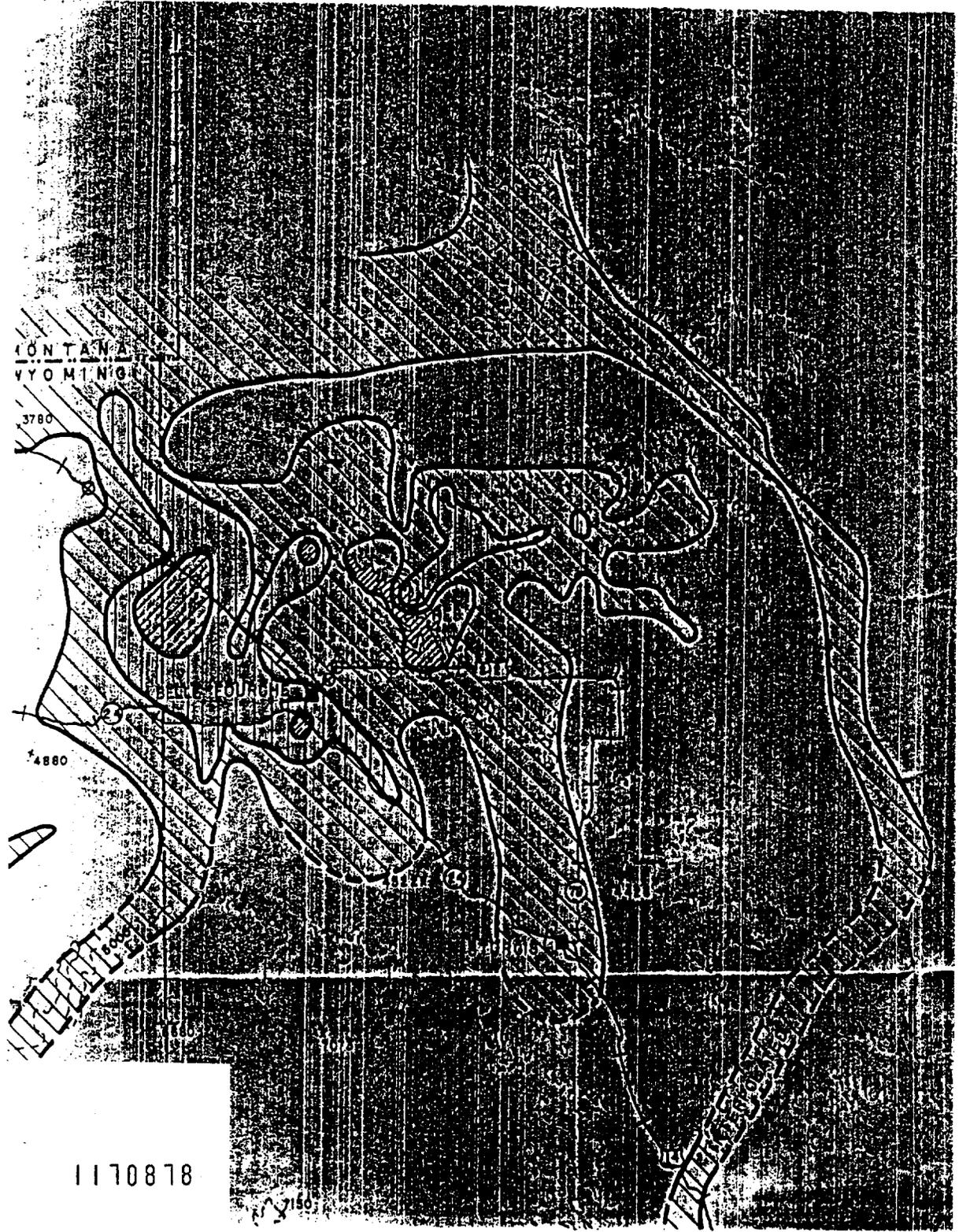
Willard left Rapid City late afternoon, August 9 to attend training project 36.5, CTRG.

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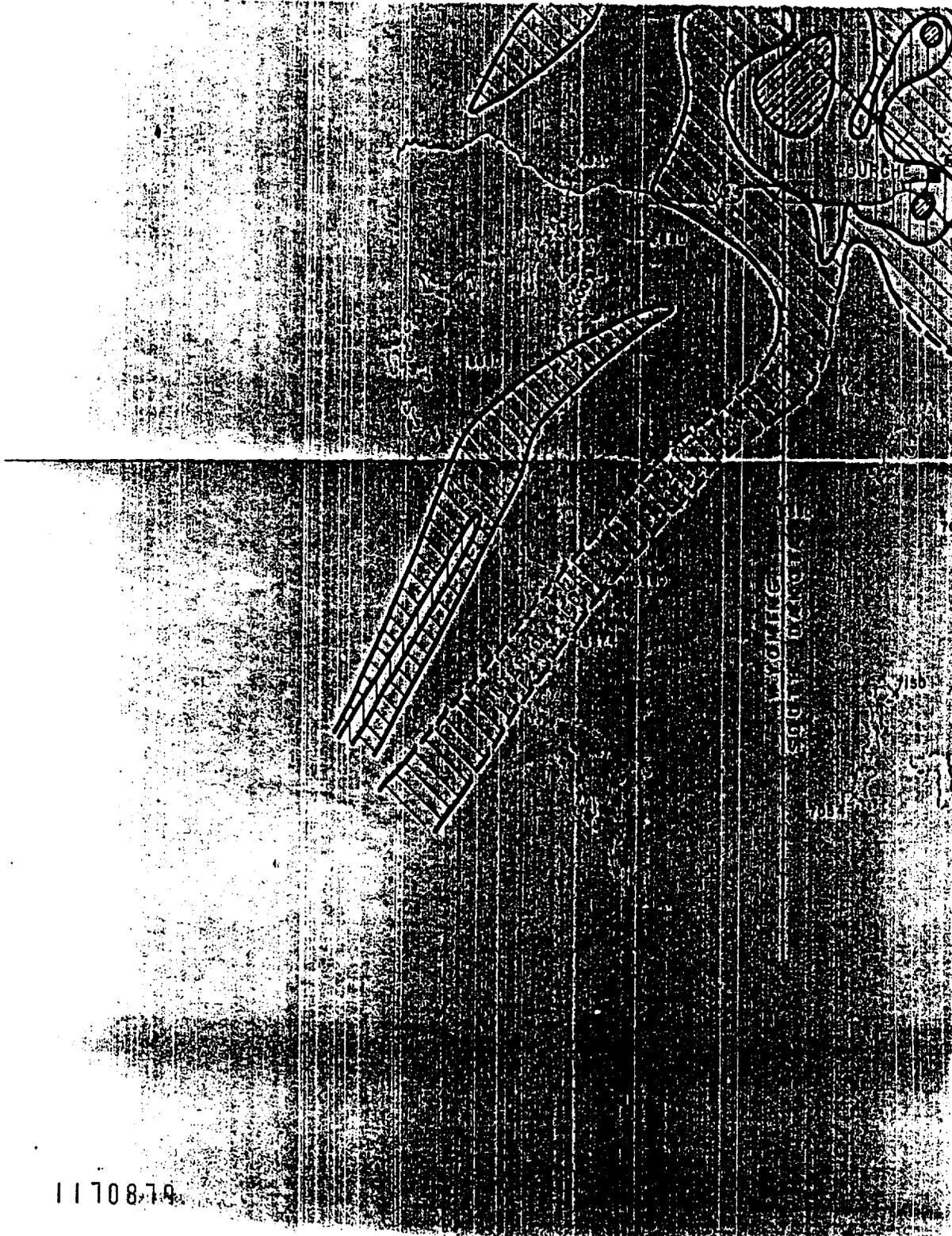
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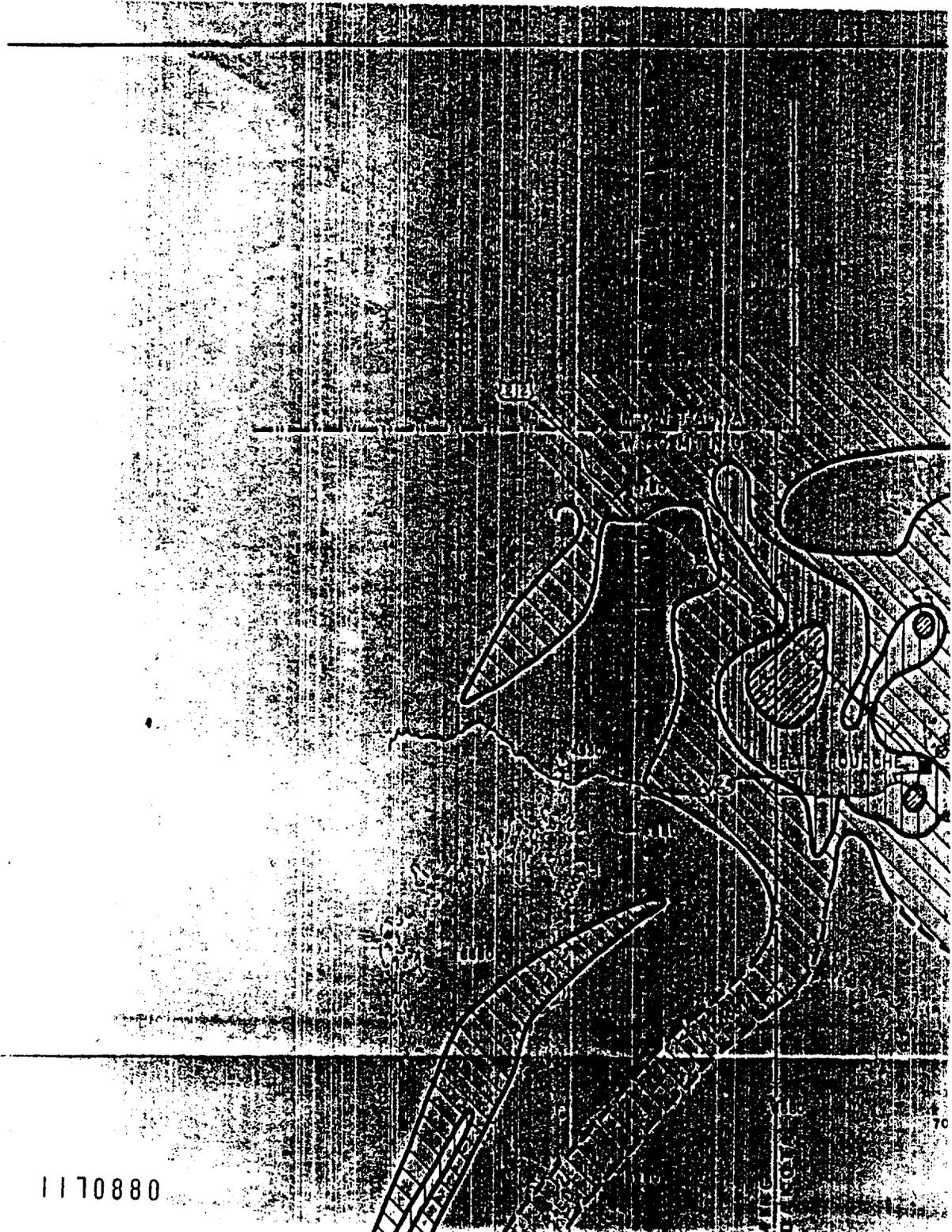


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