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Project Rulison Off-Site
Surveillance Operation for the
Flaring Period - October 26 -
November 3, 1970

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PROJECT RULISON OFF-SITE SURVEILLANCE
FOR THE
FLARING OPERATION OF OCTOBER 26 - November 3, 1970

Southwestern Radiological Health Laboratory
U. S. Public Health Service*

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Introduction

During the period of October 26 through November 3, 1970, natural gas from the Project Rulison test well was flared for the high-rate production flaring test. The flaring operation was started at 1430 MST on October 26, 1970. The gas flow rate was increased over a six-hour period to 20 MMCFD. At this high flow rate, the flame at the top of the flare stack could not be sustained due to the high gas velocity. Because of this flame-out problem, the flow rate was reduced to 17 MMCFD at about 2100 MST.

During the remainder of the flaring period, the flow rate continually decreased to 11.4 MMCFD at the time the flaring operation was shut down at 1417 MST on November 3, 1970. A total volume of approximately 109 million standard cubic feet of gas was flared. The Public Health Service (PHS), Southwestern Radiological Health Laboratory (SWRHL), continued its off-site environmental surveillance program in the area during the flaring period in accordance with an AEC/PHS Memorandum of Understanding. Surveillance activities and results relating to this specific flaring operation are reported herein.

Continuous off-site radiological surveillance was conducted by the SWRHL throughout the flaring period through the operation of fixed atmospheric moisture sampling stations at populated locations near the project site and the collection of a daily water sample from Battlement Creek. In addition, an intensive program of special aerial and ground sampling was conducted on October 27-28, 1970, to monitor radiological parameters for both "drainage" and "up-slope" wind conditions. Natural gas samples from the Project Rulison test well were collected on the first four full days of flaring. After the flaring operation was completed, samples of milk, water, vegetation, soil, and urine were collected from the Project Rulison area, and the thermoluminescent dosimeters at off-site dosimetry stations were exchanged.

*On December 2, 1970, the Southwestern Radiological Health Laboratory was transferred from the Public Health Service to the newly formed Environmental Protection Agency.

October 27, 1970, Special Survey

On the first morning of the intensive monitoring period, no "drainage wind" samples were collected because the very light drainage winds broke up into up-slope winds before a sample could be collected. During the morning, a cloud cover on top of Battlement Mesa made aerial tracking and sampling impossible. By noon, the cloud cover had dispersed enough for aircraft operations. At noon, the upper level winds were blowing from the north, but during the afternoon they turned counter-clockwise until they were from the west southwest at about 1400 MST. The air crew collected two "grab" samples in the plume, but due to very low absolute humidity, there was insufficient moisture in the samples for tritium analysis. The results of krypton-85 analysis for these samples are listed below. The background level for krypton-85 in the area is 12 ± 2 pCi/m³. Both aerial samples collected contained levels of krypton-85 above background levels, but these levels were very low compared to the general population RPG, which is 100,000 pCi/m³ of air.

Location	Collected		⁸⁵ Kr (pCi/m ³)
	Date	Time	
40°, 1.0 mi.	10/27/70	- 1432	150
80°, 7.5 mi.	10/27/70	- 1554	31

After the wind direction stabilized, three ground monitors collected four molecular sieve samples and a compressed air sample in the downwind direction based on aircraft plume tracking information. The background levels for tritium in air in the Rulison area have ranged from <400 to 2,600 pCi/l of water, with an average of 960 pCi/l. This corresponds to a range of 0.4 to 13 pCi/m³ of air, with an average of 4.2 pCi/m³. The general population RPG for tritium is 67,000 pCi/m³. The results of the analyses of the molecular sieve samples are listed below. The samples from Special Stations D-31 and D-33 contained levels of tritium above background.

Location (Azimuth, Dist.)	Sampling Period			^3H	$^3\text{H}_3$
	Date	Time On	Time Off	(pCi/l H_2O)	(pCi/m ³ air)
Spec. Sta. D-27 (67°, 18 mi.)	10/27/70	1520	1650	980	1.8
Spec. Sta. D-29 (76°, 16 mi.)	10/27/70	1540	1710	930	1.8
Spec. Sta. D-31 (87°, 17 mi.)	10/27/70	1530	1700	7,300	20
Spec. Sta. D-33 (97°, 16 mi.)	10/27/70	1547	1717	8,900	26

The results of the analysis of the compressed air sample are listed below. The levels of both the tritium and krypton-85 were above background.

Location (Azimuth, Dist.)	Sampling Period			^3H	$^3\text{H}_3$	$^{85}\text{Kr}_3$
	Date	Time On	Time Off	(pCi/l H_2O)	(pCi/m ³ air)	(pCi/m ³ air)
Spec. Sta. D-29	10/27/70	1720	1750	5,600	15	14

October 28, 1970, Special Survey

On the morning of October 28, two molecular sieve samples and one compressed air sample were collected on the ground in the "drainage" wind. The analytical results of the molecular sieve samples are listed below. Both samples contained levels of tritium above background.

Location (Azimuth, Dist.)	Sampling Period			^3H	$^3\text{H}_3$
	Date	Time On	Time Off	(pCi/l H_2O)	(pCi/m ³ air)
John C. Clem Ranch (325°, 3 mi.)	10/28/70	0600	0800	5,100	9.4
Old Control Point Pad (325°, 2 mi.)	10/28/70	0615	0815	19,000	29

The results of the analyses of the compressed air sample are listed below. Due to low absolute humidity, there was insufficient moisture collected with this sample for tritium analysis. The level of krypton-85 was above background.

Location (Azimuth, Dist.)	Sampling Period			⁸⁵ Kr (pCi/m ³ air)
	Date	Time On	Time Off	
Old Control Point Pad (325°, 2 mi.)	10/28/70	0645	0710	47

Later that morning, the air crew flew a sampling mission in the plume and collected a cryogenic sample. The results of the analysis of this sample are listed below. The level of tritium in the sample was above background levels.

Location	Sampling Period			³ H (pCi/l H ₂ O)	³ H (pCi/m ³)	⁸⁵ Kr (pCi/m ³)
	Date	Time On	Time Off			
135°, 3.5 mi.	10/28/70	1003	1042	28,000	75	<5

Natural Gas Sampling

Natural gas samples were collected from the test well once a day for the first four full days of flaring. These samples were collected from the low pressure side of the separator, so some of the water had been removed from the gas. Therefore, the tritium concentrations in these samples were lower than those reported by other project participants collecting gas samples. The levels of tritium and krypton-85 in the SWRHL natural gas samples are listed below.

Collected		³ H (pCi/l gas)	⁸⁵ Kr (pCi/l gas)
Date	Time		
10/27/70	1700	1.2 x 10 ⁵	1.4 x 10 ⁵
10/28/70	1700	7.8 x 10 ⁴	1.6 x 10 ⁵
10/29/70	1630	1.1 x 10 ⁵	1.6 x 10 ⁵
10/30/70	1615	5.1 x 10 ⁴	1.5 x 10 ⁵

Since the gas samples were saturated with water and the gas temperature was high as the gas came from the separator, some of the water condensed in the sampling bottle when the gas cooled. For the gas sample collected on October 29, this "free" water was driven from the sampling bottle and analyzed. It contained a tritium concentration of 2.7 x 10⁴ pCi/ml of H₂O. The water formed by the combustion of the gas from this sample contained a tritium concentration of 2.2 x 10⁵ pCi/ml of H₂O. The water collected from the separator contained a tritium concentration of 4.8 x 10⁵ pCi/ml of H₂O.

Atmospheric Moisture Sampling

The seven permanent atmospheric moisture sampling stations were started before flaring began and continued to collect 48-hour atmospheric moisture samples until flaring was completed. The results of the analyses of these samples are listed below. The sample collected at Clem's Ranch from October 27 to October 29 contained a tritium concentration slightly above background. This level was still very small compared to the off-site RPG for tritium. The locations of the sampling stations are shown in Figure 1.

Location (Azimuth, Dist.)	Sampling Period		^3H (pCi/l H_2O)	$^3\text{H}_3$ (pCi/m ³ air)
	Date-Time On	Date-Time Off		
Russ Latham Ranch (243°, 17 mi.)	10/25-1355	10/27-1135	500	2.2
Grand Valley, Colo. (300°, 7 mi.)	10/25-1315	10/27-1005	870	1.8
Dan Duplice Ranch (305°, 5 mi.)	10/25-1250	10/27-0850	<400	<1.0
John C. Clem Ranch (325°, 3 mi.)	10/25-1230	10/27-0755	790	2.3
Rifle, Colo. (43°, 16 mi.)	10/25-1115	10/27-1100	540	1.2
Don Jackett Ranch (86°, 17 mi.)	10/25-1030	10/27-1040	450	1.1
Bert Griffith Ranch (150°, 11 mi.)	10/25-0845	10/27-0820	540	0.9
Russ Latham Ranch (243°, 17 mi.)	10/27-1140	10/29-1310	680	2.1
Grand Valley, Colo. (300°, 7 mi.)	10/27-1010	10/29-1225	1,800	0.4
Dan Duplice Ranch (305°, 5 mi.)	10/27-0830	10/29-1115	930	2.0
John C. Clem Ranch (325°, 3 mi.)	10/27-0800	10/29-1040	2,700	3.6
Rifle, Colo. (43°, 16 mi.)	10/27-1140	10/29-0950	1,400	2.6
Don Jackett Ranch (86°, 17 mi.)	10/27-1020	10/29-0840	1,700	2.6
Bert Griffith Ranch (150°, 11 mi.)	10/27-0830	10/29-0730	1,200	2.4

Location (Azimuth, Dist.)	Sampling Period		^3H (pCi/l H_2O)	^3H (pCi/m ³ air)
	Date-Time On	Date-Time Off		
Russ Latham Ranch (243°, 17 mi.)	10/29-1330	10/31-1405	520	1.7
Grand Valley, Colo. (300°, 7 mi.)	10/29-1245	10/31-1240	1,600	2.1
Dan Duplice Ranch (305°, 5 mi.)	10/29-1140	10/31-1050	640	1.7
John C. Clem Ranch (325°, 3 mi.)	10/29-1100	10/31-1130	1,200	1.8
Rifle, Colo. (43°, 16 mi.)	10/29-1005	10/31-0935	840	2.2
Don Jackett Ranch (86°, 17 mi.)	10/29-0855	10/31-0835	1,100	2.1
Bert Griffith Ranch (150°, 11 mi.)	10/29-0745	10/31-0720	810	1.9
Russ Latham Ranch (243°, 17 mi.)	10/31-1430	11/2-1340	<400	<0.2
Grand Valley, Colo. (300°, 7 mi.)	10/31-1305	11/2-1005	700	1.1
Dan Duplice Ranch (305°, 5 mi.)	10/31-1105	11/2-1035	640	1.9
John C. Clem Ranch (325°, 3 mi.)	10/31-1150	11/2-1105	800	1.9
Rifle, Colo. (43°, 16 mi.)	10/31-1000	11/2-0925	700	1.8
Don Jackett Ranch (86°, 17 mi.)	10/31-0855	11/2-0815	860	1.8
Bert Griffith Ranch (150°, 11 mi.)	10/31-0745	11/2-0710	1,400	3.6
Russ Latham Ranch (243°, 17 mi.)	11/2-1350	11/4-1415	550	1.5
Grand Valley, Colo. (300°, 7 mi.)	11/2-1015	11/4-1040	650	0.7
Dan Duplice Ranch (305°, 5 mi.)	11/2-1045	11/4-1145	1,500	3.2
John C. Clem Ranch (325°, 3 mi.)	11/2-1120	11/4-1215	2,000	3.2
Rifle, Colo. (43°, 16 mi.)	11/2-0940	11/4-0920	460	0.8
Don Jackett Ranch (86°, 17 mi.)	11/2-0830	11/4-0810	1,100	1.5
Bert Griffith Ranch (150°, 11 mi.)	11/2-0725	11/4-0705	890	1.3

Precipitation Sampling

Six precipitation samples were collected during the high-rate flaring period. The tritium levels in samples collected prior to flaring ranged from <400 to 2,100 pCi/l of water. The results of the analyses of the samples are listed below. The levels of tritium are within the range of background levels.

Location (Azimuth, Dist.)	Date Collected	Type	³ H (pCi/l H ₂ O)
Rifle, Colo. (43°, 16 mi.)	10/26	Snow	<400
Grand Valley, Colo. (300°, 7 mi.)	10/27	Rain	<400
Russ Latham Ranch (243°, 17 mi.)	10/28	Snow	<400
John C. Clem Ranch (325°, 3 mi.)	10/28	Snow	630
Dan Duplice Ranch (305°, 5 mi.)	10/28	Snow	<400
Bert Griffith Ranch (150°, 11 mi.)	11/1	Snow	960

Water Sampling

Daily water samples were collected from Battlement Creek prior to and during the high-rate flaring operation. The background levels of tritium in surface water ranged from <400 to 1,600 pCi/l with an average of 920 pCi/l. The results of the analyses of the daily Battlement Creek water samples are listed below. These results show that the tritium levels in Battlement Creek were at background levels.

Collected		³ H
Date	Time	(pCi/l)
10/16	1330	580
10/17	0650	490
10/18	0650	520
10/19	0730	<400
10/20	0730	<400
10/21	0745	<400

Collected		³ H
Date	Time	(pCi/l)
10/22	0745	880
10/23	0745	540
10/24	--	560
10/25	0820	700
10/26	0745	510
10/27	1700	810
10/28	1730	870
10/29	1700	840
10/30	--	920
10/31	1200	440
11/1	1200	890
11/2	1130	580
11/3	1130	520
11/4	1300	500
11/5	1400	960

The levels of tritium in the twenty water samples collected within sixteen miles of the flare stack, other than those collected from Battlement Creek, ranged from <400 to 1,400 pCi/l with an average of 830 pCi/l. The background samples collected prior to flaring operations had tritium concentrations ranging from <400 to 1,600 pCi/l with an average of 930 pCi/l. There was no increase in concentrations of tritium in water supplies due to high-rate flaring.

Milk Sampling

The levels of tritium in the eight milk samples collected within eighteen miles of the flare stack following high-rate flaring ranged from 550 to 1,300 pCi/l with an average of 930 pCi/l. The background samples collected prior to flaring operations had tritium concentrations ranging from <400 to 2,100 pCi/l with an average of 1,000 pCi/l. There was no increase in tritium levels in milk due to high-rate flaring.

Vegetation Sampling

The levels of tritium in the moisture taken from fourteen natural vegetation samples collected within nineteen miles of the flare stack following high-rate flaring ranged from 570 to 2,900 pCi/l of water, with an average of 1,300 pCi/l of water. This corresponds to a range of 280 to 1,600 pCi/kg of vegetation (wet weight) with an average of 640 pCi/kg. The background tritium concentrations for vegetation samples collected prior to flaring operations ranged from <400 to 5,800 pCi/l of water with an average of 1,100 pCi/l of water. The 5,800 pCi/l of water is very high compared to the second highest background value of 1,700 pCi/l of water. If it is assumed that 1,700 pCi/l is actually the upper limit for background tritium in vegetation, then the vegetation from one-quarter and one-half mile northwest of the test well contained elevated concentrations of tritium. The results of the analyses of these samples are listed below.

Location	Collected		^3H	^3H
	Date	Time	(pCi/l H_2O)	(pCi/kg) ^a
1/4 mi. NW of Test Well	10/4	1400	2,900	1,600
1/2 mi. NW of Test Well	10/4	1430	2,000	930
1/4 mi. NW of Test Well	10/5	1600	2,500	1,000

Soil Sampling

The levels of tritium in the moisture from fourteen soil samples collected within nineteen miles of the flare stack after high-rate flaring ranged from 560 to 1,600 pCi/l of water with an average of 850 pCi/l of water. This corresponds to a range of 25-480 pCi/kg of wet soil with an average of 150 pCi/kg. The background tritium concentrations in the moisture from soil samples collected before the flaring operations began ranged from <400 to 1,300 pCi/l of water with an average of 940 pCi/l of water. The level of tritium in the soil moisture samples was greater than background levels only at one quarter of a mile northwest of the test well. The results of the analyses of the samples from that location are listed below.

^a Wet Weight

Location	Collected		^3H (pCi/l H_2O)	^3H (pCi/kg) ^a
	Date	Time		
1/4 mi. NW of Test Well	11/4	1400	1,500	460
1/4 mi. NW of Test Well	11/5	1545	1,600	480

Urine Sampling

The levels of tritium in the urine samples donated by 20 residents living within nineteen miles of the Project Rulison site ranged from 610 to 5,500 pCi/l with an average of 1,300 pCi/l. Samples collected prior to flaring operations contained background tritium concentrations ranging from <400 to 9,500 pCi/l with an average of 2,300 pCi/l. All the samples collected after high-rate flaring were within background levels of tritium.

Animal Sampling

Several animal tissue and blood samples were collected during and following the high-rate flaring operation. The animal samples consisted of kidney and muscle samples from various types of animals, both domestic and wild. The background tritium levels for animal samples collected prior to flaring operations ranged from 620 to 1,200 pCi/l of water with an average of 920 pCi/l of water. This corresponds to a range of 450-840 pCi/kg of tissue with an average of 660 pCi/kg. The results of the analyses of the animal samples collected for high-rate flaring are listed below. The levels of tritium are all within background levels.

Location	Type	Date Collected	^3H (pCi/l H_2O)	^3H (pCi/kg) ^a
Battlement Mesa	Deer	11/4	580	390
Battlement Mesa	Deer	11/4	660	460
Battlement Mesa	Deer	11/4	880	640
Vega Reservoir	Elk	11/2	780	630
Battlement Mesa	Elk	11/6	910	670
Battlement Mesa	Elk	11/7	950	690

^aWet Weight

The results of the analyses of the blood samples are listed below. No background samples of blood were collected, but it can be assumed that tritium would be about the same concentration in all tissues. Using this assumption, the tritium levels in the blood samples are at background levels.

<u>Location</u>	<u>Type</u>	<u>Date Collected</u>	<u>³H (pCi/l)</u>
Dan Duplice Ranch	Sheep	11/6	750
Don Burtard Ranch	Cow	11/6	1,200

Dosimetry

During high-rate flaring, thermoluminescent dosimeters (TLD's) were located at seventeen stations within forty miles of the test well. The exposure rates measured by these TLD's ranged from 0.38 to 0.59 mR/day with an average of 0.47 mR/day. TLD's were placed around the test well before flaring to measure the background radiation which ranged from 0.10 to 0.68 mR/day with an average of 0.38 mR/day. The exposure rate measured by the TLD's during high-rate flaring was within the range of background.

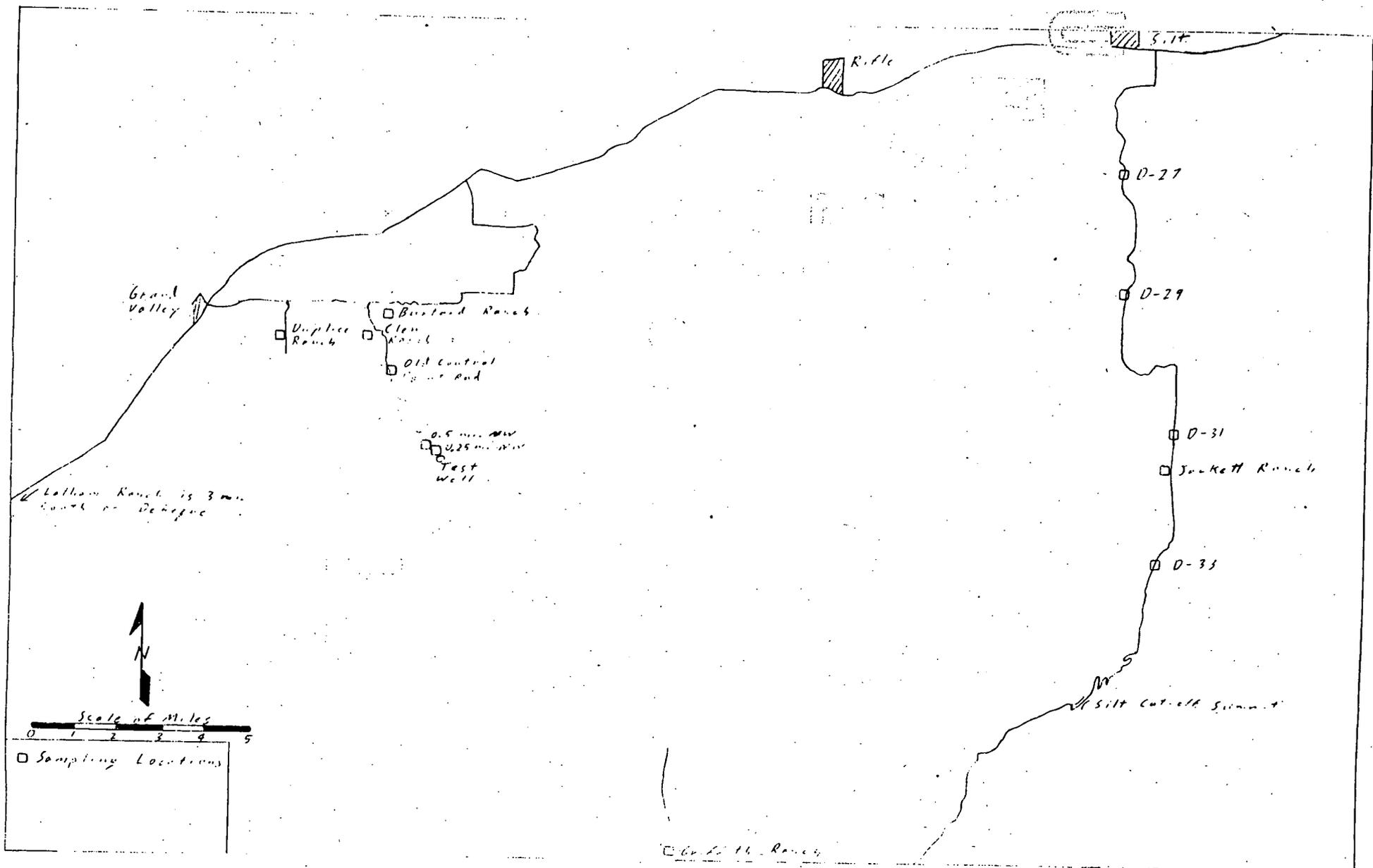


Figure 1. Sampling Locations