ORNL 1580
Waste Disposal

RADIOACTIVITY IN THE MUD OF WHITE OAK LAKE

H. H. Abee

OAK RIDGE NATIONAL LABORATORY
OPERATED BY
CARBIDE AND CARBON CHEMICALS COMPANY
A DIVISION OF UNION CARBIDE AND CARBON CORPORATION
UCC
POST OFFICE BOX P
OAK RIDGE, TENNESSEE

RESTRICTED
SECURITY INFORMATION

ORNL 1580

This document consists of 24 pages.
Copy 4 of 153 copies. Series A.

Contract No. W-7405-Eng-6

RADIOACTIVITY IN THE MUD OF WHITE OAK LAKE

H. H. Abee

Date Issued: OCT 26 1953

OAK RIDGE NATIONAL LABORATORY
Operated by
CARBIDE AND CARBON CHEMICALS COMPANY
A Division of Union Carbide and Carbon Corporation
Post Office Box P
Oak Ridge, Tennessee

RESTRICTED
SECURITY INFORMATION

TABLE OF CONTENTS

Radioactivity in the Mud of White Oak Lake

I. Introduction

White Oak Lake is the last step in the treatment and control of liquid radioactive waste from the Oak Ridge National Laboratory before discharge into the Clinch River and Watts Bar Reservoir. The wastes from the Laboratory are diluted with the run-off from six square miles of drainage area and are impounded in the lake which has a capacity of about fifteen million cubic feet.

Should the dam at White Oak Lake fail for any reason, it obviously would be desirable to have an approximate idea of the curie content of the mud in the lake in order to evaluate the possible hazard to the downstream users of water from the Clinch River and Watts Bar Reservoir.

It has been the practice at Oak Ridge National Laboratory to assay annually the mud of White Oak Lake for radioactive content. This report gives the results of the 1950, 1951, and 1952 assays.

II. Description of Facilities, Equipment, and Techniques

A. Preparations

In conjunction with an ecological survey being conducted of the Laboratory waste disposal system, T.V.A. engineers had placed iron markers at approximately one hundred foot intervals along the shore of the lake near the 750' elevation. These markers were used as reference points for sampling, and a grid section was set up across the lake at approximately 100 ft. intervals, beginning at the markers on the south shore (Fig. 1). This was accomplished by stretching a waxed cord, labelled at 100' intervals, across the lake. In the upper region of the lake where the water was shallow and vegetation abounded, sampling was done at points whose distances from the shore were estimated.

B. Equipment

Crew equipment consisted of protective clothing, a boat, life preservers, two sets of sampling equipment, sample bottles, paper towels, wax paper, spatulas, a small plywood board and a section of map of the White Oak Lake showing locations at which samples were to be taken.

Sampling equipment consisted of a metal pipe, two inches inside diameter and eighteen inches in length, beveled to a sharp edge on one end and slotted on the other end for attachment to the head of the sampling rod (Fig. 2). This permitted collection of adequate samples as the major activity was contained in the uppermost layers of bottom mud. The head of the sampling rod was designed so as to facilitate easy detachment of the sampler for removal of the sample. The sample rod consisted of a 12' length of 1" pipe screwed into the rod head. A small metal push rod 28" in length with a disc of approximately 2" in diameter welded onto one end was used for pushing the cores of mud from the sampler.

C. Sampling Procedure

Five 3-man crews were used, each assigned to a particular section of the lake. This enabled the sampling to be completed in a single day, minimizing errors caused by the transfer of mud from place to place.

A sample of mud was obtained by pushing the sampler through the depth of water into the mud on the bottom of the lake. Special care had to be exercised in pulling the sampler up through the water, otherwise the mud would be washed away. By pulling the sampler out of the water at an angle of approximately 45°, sample washouts were kept to a minimum. In case a sample was washed out, additional attempts to obtain a sample were made and only in a few cases was it impossible to obtain a sample.

After the sample core was pulled from the water, the sampler was dismantled from the head and the surplus water drained off. One or two paper towels were wadded and placed into the slotted end of the sampler, the push rod inserted, and the core of mud forced from the sampler. Since it had been previously determined that most of the activity was contained in the first 3" of mud, a 3" length was cut from the sample and sliced into halves lengthwise with a spatula. A small V-shaped sample was then taken from the center of one half of the 3" section (Fig. 3) and placed into a labeled sample bottle to be taken to the Laboratory for processing.

In addition to these activity samples, a stratification sample was taken at random along each line of sampling. These samples were taken in the same manner as described above. Such stratification samples provide data for applying the necessary corrections to take proper account of activity present below 3" in depth. To prevent drying, the entire length of core was wrapped in waxed paper, labeled and stored in boxes for return to the laboratory.

D. Laboratory Procedure

Each activity sample was ground to a fine consistency using a mortar and pestle and then the sample was thoroughly mixed with approximately 5 ml of distilled water. A small amount of this mixture (enough to cover the bottom) was transferred to a weighed shallow aluminum sample dish and slowly brought to dryness under a heat lamp. After cooling to room temperature the dishes containing the samples were again weighed and the net dry weight of each sample obtained. These samples were then set aside for the counting room.

An equal amount of each of the activity samples from the same section of the lake was placed in a large mortar and thoroughly mixed. From this composite sample, samples of different thicknesses were prepared in the manner described above and a self absorption curve for each section of samples was drawn from the data obtained, plotting counts/minute/gm as a function of gms/cm^2. From these self absorption curves a self absorption factor was obtained for each activity sample of that section of the lake and applied in making the final calculations.

In the processing of the stratification samples, the entire length of core was measured off and cut crosswise into one inch segments beginning from the bottom or least active end and progressing to the most active end. Each one inch segment was then split in half and a V-shaped sample taken from one of the halves and processed in the manner described for the activity samples. From the data thus obtained one can determine the per cent of the total activity in the stratification sample which is contained in the first three inches and determine the stratification activity correction factor.

E. Calculations

All samples were counted with standard end window beta counting equipment with a window thickness of $\sim 2\ mg/cm^2$ and the counts per minute thus obtained were corrected to 10% geometry. Setting N equal to the net counts per minute and W equal to the sample weight in grams we have

$$\mu c/gm\ (\text{Dry Wt.}) = \frac{N\ k}{W\ 2.22 \times 10^5}$$

where

k = absorption correction factor

2.22×10^5 = c/m/μc at 10% geometry

From this $\mu c/ft^2$ can be obtained by the following:

$$\mu c/gm \text{ (Dry Wt.)} \times R \times S \times Cw \times 45.8 = \mu c/ft^2$$

where

R = average ratio of dry wt. to wet wt. as determined empirically

S = stratification activity factor for total core

Cw = average wt/3" core

45.8 = number of cores/ft^2

Assuming that each sample is representative of the 100' x 100' section of the lake from which it was taken, one gets an estimate of the curie content of the lake by taking an average of all samples in $\mu c/ft^2$, corrected for stratification, and multiplying it by the area of the lake.

III. Results

In Table I is shown the total activity found to be contained in the mud of White Oak Lake in the 1950, 1951, and 1952 assays. These figures compare favorably with that reported in the 1948 assay which indicated a radioactive content of White Oak Lake mud of 310 curies. This represents quite an increase over the curie content reported in 1945 and 1946 where the total activity was determined to be 21 and 20 curies respectively. Higher total mud activity values reported in earlier surveys included other areas such as the spillway flats directly below the dam, upstream mud in White Oak Creek, etc.

Table I

Annual Assay	Total Mud Activity In Curies
1950	392
1951	359
1952	303

Samples of mud that were taken in previous years have been retained for decay studies. Curve 1 was obtained from a study of these samples. The effective half life of the activity is of the order of 7 to 8 years as shown by these curves. Samples taken in later years have been retained for study, but it is felt that they have not decayed for a sufficient length of time to establish a good curve. The values thus far obtained, however, appear to be in good agreement with those of the 1947 and 1948 samples.

In order to make an estimate of the probable maximum concentration of activity downstream in the Clinch River following a White Oak Dam washout, several necessarily arbitrary assumptions are required. The assumptions made are as follows:

1. Seventy-five per cent of the mud in White Oak Lake is carried away by a Dam washout.
2. Eighty per cent of that mud which is washed out is added to the Clinch River in ten minutes.
3. Flow in the Clinch River at the time of washout is taken to be 5200 c.f.s.
4. Intimate mixing is attained between Clinch River water and White Oak Lake flood water.

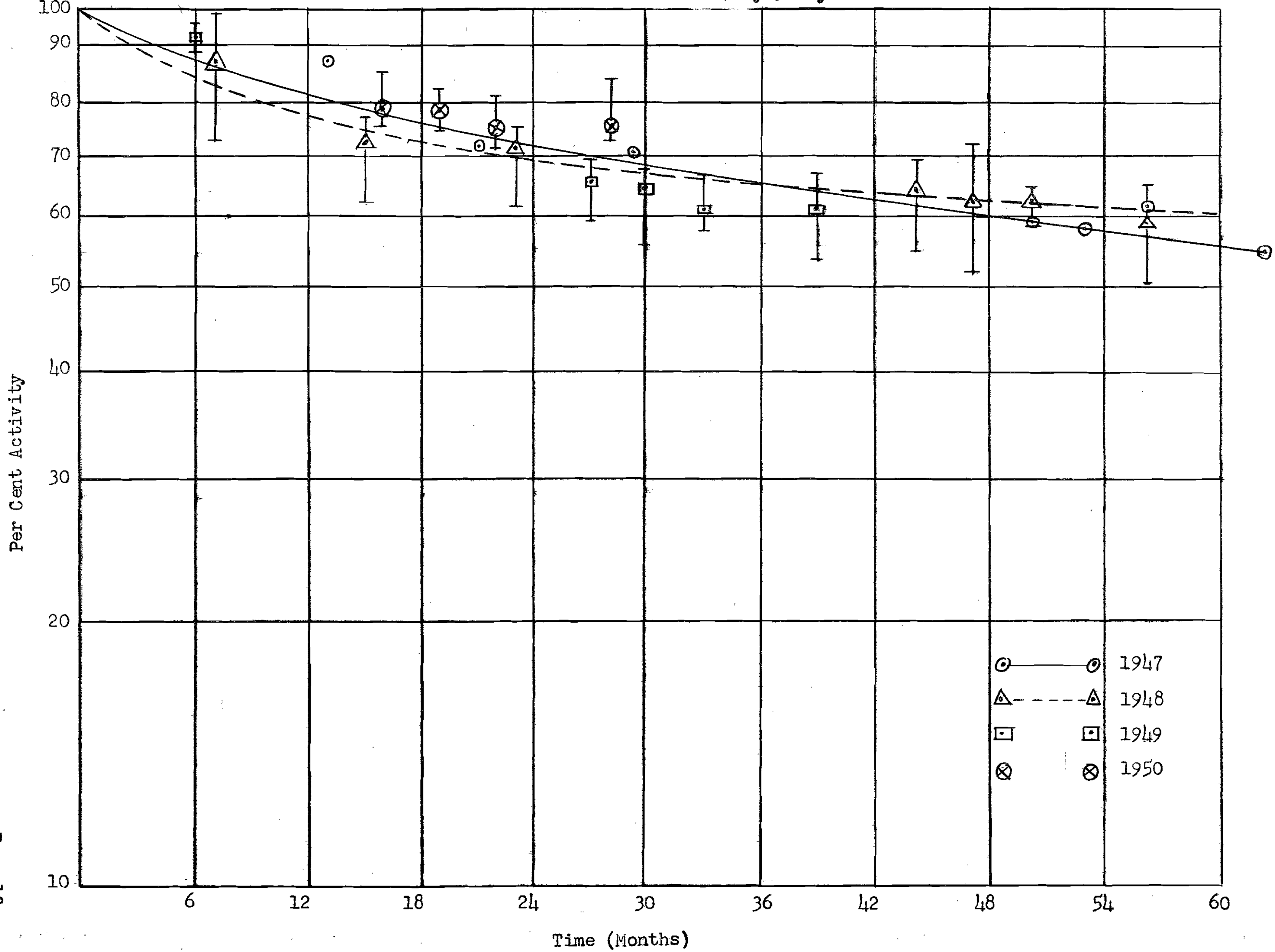
Taking the value for radioactive mud content found in 1952, we have 182 curies being added to *8.84×10^{10} cc to give a probable maximum concentration in the Clinch River of 2×10^{-3} μc/cc. This is less than the proposed AEC emergency levels for activity in drinking water where the time of water consumption is taken to be as long as one month. It is estimated that further dilution as the activity progresses downstream would reduce this probable maximum by a factor of 10 to 100 by the time the activity reaches Chattanooga. Should flows in the Clinch River and Watts Bar Reservoir be greater than that assumed, the condition would be improved by a compensating greater dilution volume. It is felt unreasonable to assume lower than average flow in the Clinch River during a condition of flood weather sufficient to wash out White Oak Dam.

Acknowledgement is given to T. H. J. Burnett for his helpful discussion and review of this paper.

HHAbee:cs

*5200 cfs x 2.83×10^{4} cc/cf x 6×10^{2} s = 8.84×10^{10} cc

Curve 1: Mud Activity Decay



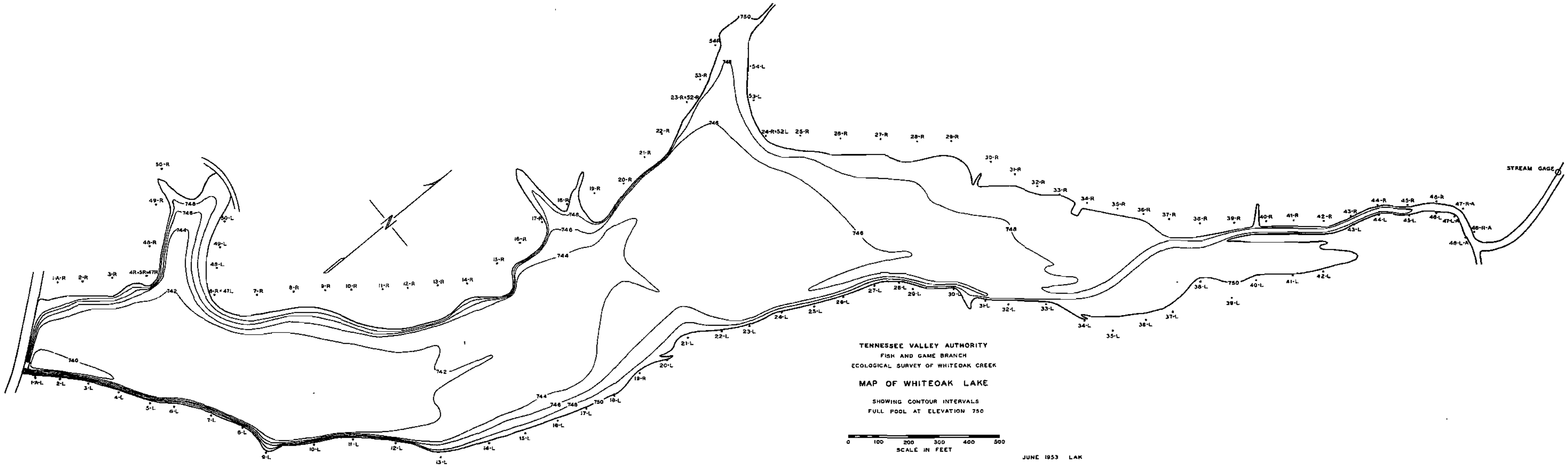

TENNESSEE VALLEY AUTHORITY
FISH AND GAME BRANCH
ECOLOGICAL SURVEY OF WHITEOAK CREEK
MAP OF WHITEOAK LAKE
SHOWING CONTOUR INTERVALS
FULL POOL AT ELEVATION 750
0 100 200 300 400 500
SCALE IN FEET
JUNE 1953 LAK
STREAM GAGE

Figure 1

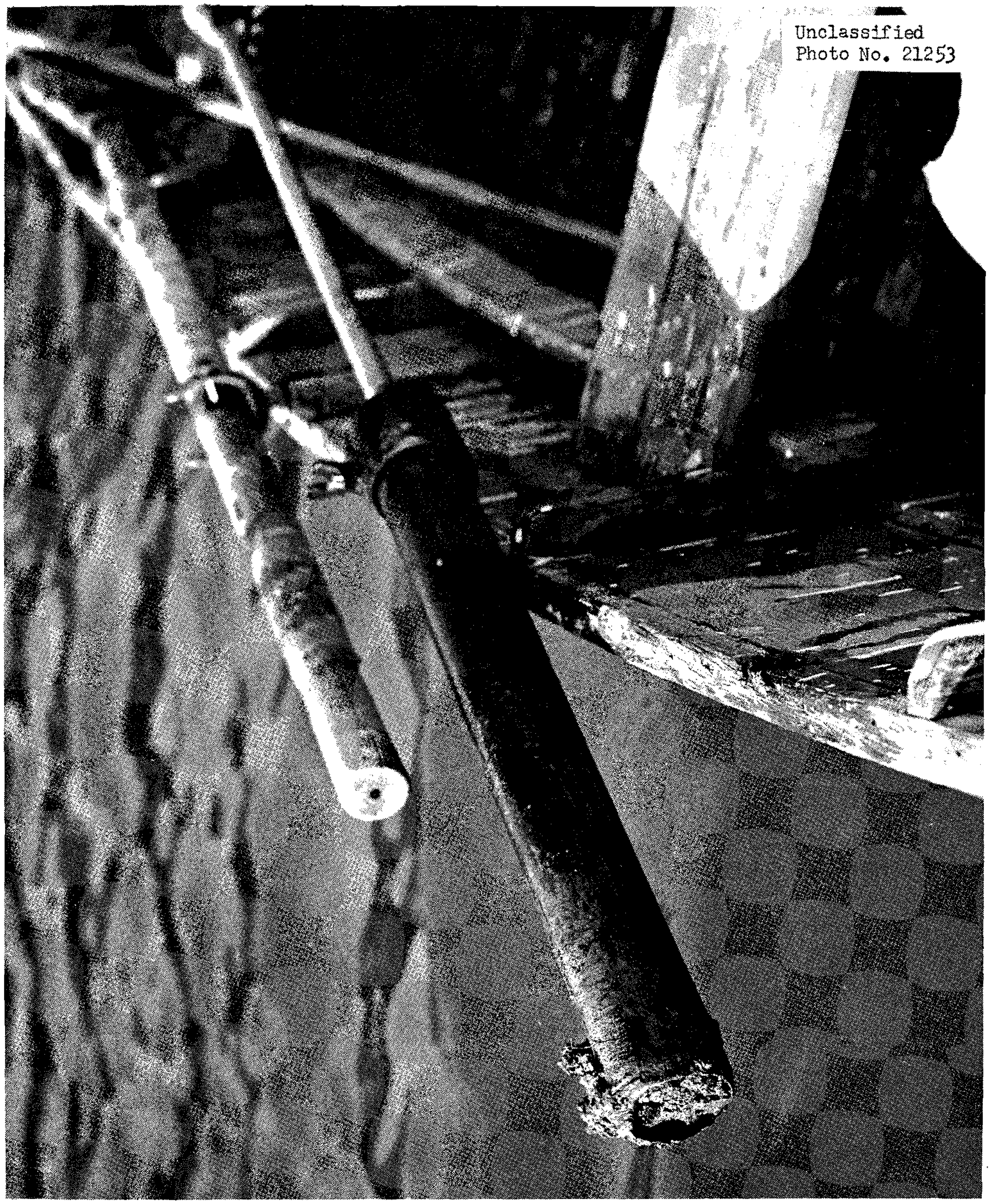


Figure 2

UNCLASSIFIED
DWG. 21510

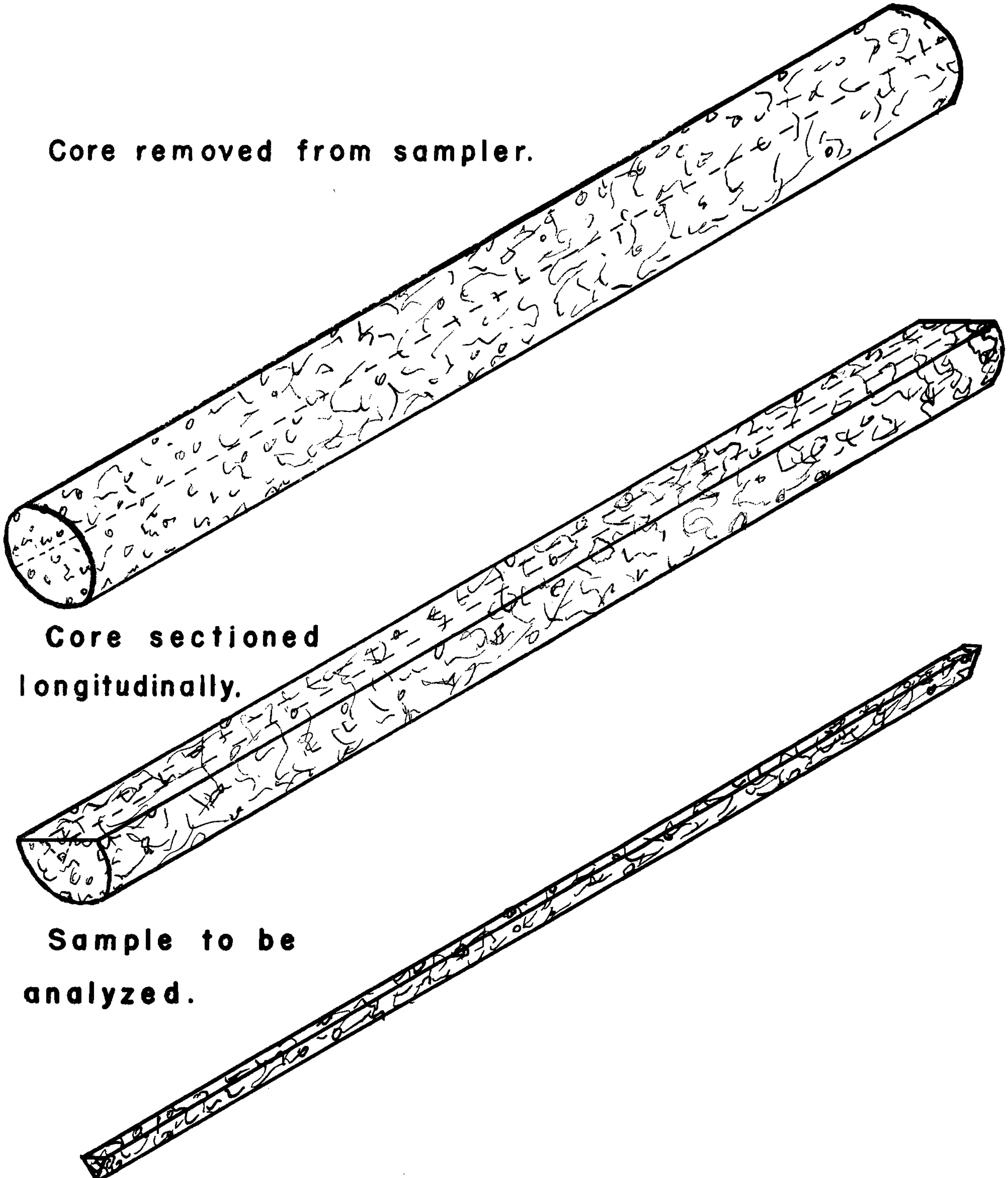


Figure 3

pom.

MUD ACTIVITY DATA - 1950

Sample	x 10^{-2} μc/gm Dry Wt.	μc/sq.ft.	Sample	x 10^{-2} μc/gm Dry Wt.	μc/sq.ft.
1-A	0.021	5.7	8-A	0.357	34.5
1-B	0.971	257.7	8-B	0.025	2.5
2-A	7.141	912.4	8-C	0.049	4.8
2-B	3.928	501.9	8-D	0.465	44.9
3-A	0.179	31.9	9-A	0.215	27.0
3-B	0.423	75.1	9-B	0.046	5.7
4-A	10.700	1033.8	9-C	0.191	24.0
4-B	2.545	245.9	9-D	0.250	31.3
4-C	0.044	4.3	9-E	0.806	101.3
5-A	7.887	764.9	10-A	8.832	860.0
5-B	0.174	16.9	10-B	0.720	70.1
5-C	0.625	60.5	10-C	3.832	373.2
5-D	0.125	12.0	10-D	0.028	2.7
5-E	0.017	1.7	11-A	2.142	207.3
5-F	0.045	4.4	11-B	9.099	880.8
6-A	0.008	0.8	11-C	4.495	435.1
6-B	0.047	4.7	12-A	0.190	18.3
6-C	0.028	2.8	12-B	2.281	220.5
7-A	0.041	4.4	12-C	0.369	35.6
7-B	0.009	1.0	13-A	5.763	560.1
7-C	0.217	23.2	13-B	3.397	330.1

Sample	x 10^{-2} μc/gm Dry Wt.	μc/sq.ft.	Sample	x 10^{-2} μc/gm Dry Wt.	μc/sq.ft.
13-C	2.319	225.4	18-E	0.049	5.6
13-D	4.164	404.7	18-F	0.382	43.3
14-A	1.310	126.8	19-A	0.018	3.9
14-B	5.462	528.8	19-B	0.032	7.2
14-C	3.255	315.1	19-C	0.149	33.2
14-D	3.157	305.5	19-D	0.051	11.4
15-A	0.283	29.2	19-E	0.021	4.9
15-B	0.114	11.7	20-A	18.407	2854.2
15-C	1.365	140.8	20-B	0.114	17.6
15-D	2.871	295.9	20-C	1.086	168.4
16-A	0.386	37.3	20-D	8.300	1286.9
16-B	0.158	15.3	20-E	0.893	138.5
16-C	0.009	0.9	21-A	0.070	7.1
16-D	0.694	67.1	21-B	0.017	1.9
16-E	0.323	31.2	21-C	0.009	1.0
17-A	0.175	16.9	21-D	0.496	55.1
17-B	0.192	18.6	21-E	0.311	34.6
17-C	0.037	3.6	22-A	0.129	14.8
17-D	0.512	49.5	22-B	2.352	271.1
17-E	0.013	1.3	22-C	1.409	162.4
18-A	0.059	6.7	22-D	0.045	5.3
18-B	0.148	16.7	22-E	0.014	1.5
18-C	0.121	13.6	22-F	0.000	0.0
18-D	0.131	14.7	23-A	2.447	311.0

Sample	x 10^{-2} μc/gm Dry Wt.	μc/sq.ft.	Sample	x 10^{-2} μc/gm Dry Wt.	μc/sq.ft.
23-C	0.098	12.3	28-C	1.320	128.8
23-D	0.100	12.7	29-A	3.118	301.8
23-E	2.556	325.0	29-B	2.685	259.9
23-F	0.356	45.5	29-C	1.368	132.4
23-G	0.034	4.3	30-A	6.019	583.8
24-B	2.545	245.9	30-B	3.989	386.9
24-C	0.888	85.7	31-A	2.289	245.1
24-D	0.064	6.2	31-B	11.750	1258.5
24-E	0.906	87.6	32-A	1.830	180.4
25-A	10.467	1011.2	32-B	17.216	1697.2
25-B	1.074	103.7	33-A	5.974	614.0
25-C	1.304	125.9	33-B	12.087	1242.2
25-D	0.158	15.3	34-A	4.441	432.9
26-A	16.707	1618.9	34-B	4.915	479.1
26-B	6.266	607.1			
26-C	0.112	10.9			
26-D	0.164	15.9			
27-A	12.909	1266.0			
27-B	6.290	616.9			
27-C	0.621	60.8			
27-D	0.077	7.6			
28-A	18.516	1806.8			
28-B	14.028	1368.8			

Average μc/ft^2 = 265.8

MUD ACTIVITY DATA - 1951

Sample	x 10^{-2} µc/gm Dry Wt.	µc/sq.ft.	Sample	x 10^{-2} µc/gm Dry Wt.	µc/sq.ft.
1-A	0.049	4.9	8-B	4.437	445.3
1-B	0.606	60.0	8-C	0.915	91.8
2-A	3.708	367.6	8-D	0.116	11.6
2-B	0.561	55.6	9-A	0.652	65.7
3-A	4.435	447.9	9-B	0.189	19.1
3-B	0.902	91.1	9-C	0.646	65.1
4-A	6.189	648.0	9-D	4.167	465.4
4-B	0.243	25.4	10-A	0.379	39.1
4-C	0.252	26.3	10-B	3.195	330.3
5-A	7.564	110.4	10-C	0.417	43.2
5-B	1.268	185.1	10-D	0.167	17.2
5-C	3.229	471.9	11-A	1.128	110.9
5-D	2.527	369.3	11-B	2.521	247.9
5-E	1.129	164.9	11-C	1.093	107.5
5-F	0.973	142.3	12-A	5.725	564.0
6-A	6.247	613.7	12-B	0.024	2.3
6-B	5.867	576.3	12-C	0.281	27.7
6-C	1.473	144.7	13-A	0.166	16.7
7-A	5.932	595.9	13-B	2.021	202.6
7-B	0.021	2.2	13-C	0.047	4.7
7-C	0.277	27.8	13-D	0.016	1.7
8-A	0.337	33.8	14-A	0.337	32.8

Sample	x 10^{-2} µc/gm Dry Wt.	µc/sq.ft.	Sample	x 10^{-2} µc/gm Dry Wt.	µc/sq.ft.
14-B	0.014	1.3	19-A	0.331	32.5
14-C	0.014	1.3	19-B	0.074	7.2
14-D	0.827	80.6	19-C	0.007	0.6
15-A	0.402	40.0	19-D	0.005	0.5
15-B	0.050	4.9	19-E	0.014	1.3
15-C	0.195	19.4	20-A	0.023	2.5
15-D	0.012	1.2	20-B	0.067	7.4
16-A	0.358	35.1	20-C	0.045	5.0
16-B	0.014	1.3	20-D	8.112	894.9
16-C	0.735	72.0	20-E	0.000	0.0
16-D	0.625	61.1	21-A	0.007	0.6
16-E	1.255	122.9	21-B	0.000	0.0
17-A	0.285	69.2	21-C	0.000	0.0
17-B	0.729	176.7	21-D	0.000	0.0
17-C	0.235	56.9	21-E	7.359	712.1
17-D	6.247	1515.0	22-A	9.623	1278.9
17-E	0.482	117.0	22-B	0.318	42.3
18-A	0.053	5.2	22-C	1.608	213.7
18-B	0.049	4.8	22-D	0.452	60.0
18-C	0.303	29.4	22-E	0.302	40.1
18-D	0.000	0.0	22-F	0.000	0.0
18-E	0.193	18.6	23-A	0.076	7.4
18-F	0.000	0.0	23-B	0.488	47.4

Sample	x 10^{-2} µc/gm Dry Wt.	µc/sq.ft.	Sample	x 10^{-2} µc/gm Dry Wt.	µc/sq.ft.
23-C	4.037	392.1	27-C	0.064	6.3
23-D	0.244	23.8	27-D	0.338	33.4
23-E	6.119	594.3	28-A	7.175	713.5
24-A	3.713	395.5	28-B	5.019	499.1
24-B	0.588	62.7	28-C	0.011	1.1
24-C	1.322	140.8	28-D	0.025	2.6
24-D	0.105	11.2	29-A	25.423	2533.0
24-E	0.220	23.5	29-B	1.491	148.2
25-A	0.179	31.2	29-C	0.000	0.0
25-B	0.214	37.4	30-A	2.647	406.5
25-C	4.083	826.8	30-B	3.262	500.9
25-D	0.582	101.6	30-C	0.012	1.7
25-E	0.114	19.8	31-A	14.573	1452.2
26-A	2.722	282.0	31-B	3.765	375.2
26-B	0.119	12.3	32-A	4.005	1947.7
26-C	1.421	147.2	32-B	0.141	68.3
26-D	0.104	10.8	33-A	13.065	2879.7
27-A	15.590	1540.7	33-B	0.806	177.7
27-B	6.545	646.9			

Average µc/ft^2 = 243.4

MUD ACTIVITY DATA - 1952

Sample	x 10^{-2} µc/gm Dry Wt.	µc/sq.ft.	Sample	x 10^{-2} µc/gm Dry Wt.	µc/sq.ft.
1-A	2.127	230.7	9-A	0.197	19.2
1-B	0.051	5.5	9-B	6.635	642.6
2-A	3.817	369.3	9-C	0.059	5.7
2-B	0.017	1.7	9-D	0.026	2.5
3-A	0.024	2.3	9-E	0.017	1.7
3-B	0.172	16.7	10-A	7.953	776.5
4-A	6.647	671.3	10-B	0.020	1.9
4-B	0.036	3.6	10-C	0.618	60.3
4-C	0.199	20.5	10-D	0.050	4.8
5-A	0.814	79.5	11-A	0.005	0.6
5-B	1.480	144.5	11-B	0.100	11.1
5-C	0.016	1.6	11-C	0.006	0.6
5-D	0.020	1.9	12-A	0.004	0.4
5-E	0.022	2.1	12-B	0.010	1.0
5-F	0.026	2.5	12-C	0.099	10.1
6-A	2.045	215.1	13-A	0.164	16.4
6-B	0.259	27.3	13-B	0.008	0.8
6-C	0.017	1.8	13-C	0.019	1.8
7-A	0.013	1.3	13-D	0.005	0.5
7-B	0.014	1.3	14-A	0.732	141.2
7-C	0.020	1.9	14-B	1.112	214.4
8-A	0.565	58.9	14-C	0.932	179.6
8-B	0.030	3.1	14-D	0.092	17.8
8-C	0.083	8.6	15-A	0.456	49.6
8-D	0.025	2.7	15-B	0.008	0.9

Sample	x 10^{-2} µc/gm Dry Wt.	µc/sq.ft.	Sample	x 10^{-2} µc/gm Dry Wt.	µc/sq.ft.
15-C	0.247	26.9	20-C	0.577	55.9
15-D	5.529	601.8	20-D	11.834	1145.1
16-A	0.252	26.3	20-E	3.388	327.8
16-B	2.055	214.9	21-A	0.180	18.5
16-C	5.346	559.2	21-B	4.170	427.9
16-D	0.232	24.3	21-C	4.021	412.6
16-E	6.059	633.8	21-D	9.114	935.1
17-A	0.136	107.4	21-E	0.613	62.9
17-B	0.155	120.8	22-A	0.056	5.5
17-C	0.051	40.6	22-B	1.349	132.4
17-D	6.256	4920.8	22-C	1.129	110.7
17-E	0.420	330.0	22-D	0.237	23.2
18-A	0.251	26.6	22-E	1.955	191.8
18-B	0.379	40.0	22-F	0.193	18.9
18-C	0.446	47.3	23-A	0.068	6.7
18-D	1.095	115.9	23-B	0.064	6.3
18-E	1.346	142.5	23-C	0.017	1.7
18-F	0.223	23.6	23-D	0.115	11.4
19-A	0.025	2.8	23-E	0.060	5.9
19-B	0.151	16.5	23-F	0.076	7.5
19-C	6.393	696.6	23-G	0.058	5.7
19-D	1.252	136.4	24-A	0.025	2.6
19-E	2.002	218.1	24-B	0.030	3.0
20-A	0.078	7.5	24-C	0.602	61.4
20-B	0.119	11.5	24-D	0.186	19.0

Sample	x 10^{-2} µc/gm Dry Wt.	µc/sq.ft.	Sample	x 10^{-2} µc/gm Dry Wt.	µc/sq.ft.
24-E	0.290	29.6	32-A	4.306	434.4
25-A	1.204	126.8	32-B	2.753	277.7
25-B	1.894	199.5	33-A	5.800	1382.1
25-C	0.216	22.8	33-B	15.099	3598.3
25-D	0.146	15.3	34-A	10.406	1075.7
25-E	0.049	5.2	34-B	2.805	289.9
26-A	10.026	1016.8			
26-B	0.321	32.6			
26-C	0.039	3.9			
26-D	0.030	3.0			
27-A	7.343	845.9			
27-B	0.131	15.1			
27-C	0.130	15.0			
27-D	0.058	6.6			
28-A	0.006	0.5			
28-B	0.696	73.1			
28-C	0.031	3.2			
29-A	0.377	36.6			
29-B	0.174	16.9			
29-C	0.017	1.7			
30-A	0.016	1.6			
30-B	0.004	0.4			
31-A	0.135	14.3			
31-B	0.624	66.0			

Average µc/ft^2 = 205.7