Subsurface Investigation of the Energy Systems Research Laboratory Site at Oak Ridge National Laboratory

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OAK RIDGE NATIONAL LABORATORY

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SUBSURFACE INVESTIGATION OF THE ENERGY SYSTEMS RESEARCH
LABORATORY SITE AT OAK RIDGE NATIONAL LABORATORY

T. W. Oakes and K. E. Shank

Environmental Surveillance and Evaluation Section
INDUSTRIAL SAFETY AND APPLIED HEALTH PHYSICS DIVISION

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SUBSURFACE INVESTIGATION OF THE ENERGY SYSTEMS RESEARCH
LABORATORY SITE AT OAK RIDGE NATIONAL LABORATORY

T. W. Oakes and K. E. Shank

ABSTRACT

Subsurface soil from the site of the proposed Energy Systems Research Laboratory was examined to determine radioactive concentration levels. This study was undertaken because the proposed site is in close proximity to the former Solid Waste Storage Area-2. A total of 25 cores were taken, ranging in depth from 4 to 9 feet, and the soil samples were analyzed for gamma-, beta-, and alpha-emitting isotopes. Water taken from 13 of the core holes was analyzed to determine tritium, gross beta, and gross alpha levels. None of the samples analyzed were found to be significantly higher than background samples collected throughout eastern and central Tennessee. No special health physics precautions are expected to be needed for the excavation at the site, other than using the excavated soil as backfill at burial sites on the reservation.

INTRODUCTION

During April, 1976, the Plant and Equipment Division at Oak Ridge National Laboratory (ORNL) undertook an initial coring operation to determine the nature of subsurface materials for foundation of the proposed Energy Systems Research Laboratory (ESRL) and to examine subsurface soils for radioactive contamination. An additional coring operation was conducted in August, 1976, to further examine subsurface soil for radionuclide concentration levels. The site for the ESRL, northeastern quadrant of ORNL at the intersection of Fifth Street and Central Avenue (Fig. 1), is in close proximity to the former Solid Waste Storage Area-2 (SWSA-2). An aerial photograph indicating the location of the SWSA-2 site is shown in Fig. 2. The proposed ESRL site as seen from various viewpoints is shown in Fig. 3.

Fig. 1. Map of proposed ESRL site.

Fig. 2. Aerial photograph of the existing ORNL site.

Fig. 3. The ESRL site as seen from various viewpoints; (a) view of Substation Drive; (b) view from Substation Drive looking towards Bldg. 4500 North; (c and d) views of site from Central Avenue looking north towards Substation Drive.

Solid Waste Storage Area-2 was operated between 1943-1946, and it covered a total area of about four acres. Figure 4 is an aerial photograph of the SWSA-2 site as it appeared during operation; Fig. 5 is a diagram showing the location of SWSA-2 relative to present features. A comparison of Figs. 1 and 5 demonstrates the closeness of the ESRL proposed site to the area used for SWSA-2. During the operation of SWSA-2, wastes were dumped into open trenches which were then backfilled. There are no available records documenting the quantity or kind of solid waste disposed of in this area.¹ It has been ascertained that solid waste contaminated by beta or gamma activity was placed in black iron drums and buried in the trenches.² Liquid waste contaminated by plutonium was put in stainless steel drums and either buried in trenches or stored without burial in a "natural ravine" eroded in the denuded slope. Also, waste from an off-site source was buried and covered with concrete (suggestive of alpha contamination) near the present location of a transformer station.²

The use of the SWSA-2 site was later found to be incompatible with the long-range land-use planning at the Laboratory, and the operation was terminated in 1946. After closure, all the waste is said to have been exhumed and reburied in Burial Ground 3 (see Fig. 2). The stainless steel drums containing liquid plutonium waste were removed intact, but the black iron drums containing beta-gamma solid waste had deteriorated. Thus, the surrounding earth was also removed and reburied at Burial Ground 3. The hillside of the SWSA-2 site was then bulldozed to smooth out the irregularities, and it was seeded.²

Because of the possibility of encountering radioactive contamination during coring operations in the area of the proposed

Fig. 4. Aerial photograph of SWSA-2 site as it appeared in 1944.

—x—x— FORMER FENCE AROUND BURIAL GROUND
 ROADS IN AND NEAR BURIAL GROUND AT TIME OF USE

Fig. 5. Diagram of SWSA-2 site relative to present features. Position of trees shown is approximate. Location of former fence and roads at the site was taken from Oak Ridge National Laboratory Engineering Drawing No. E-559, dated February 1, 1947.

building, the Radiation and Safety Survey Section of the Health Physics Division (now the Industrial Safety and Applied Health Physics Division) was requested to monitor the operations. The Environmental Monitoring Group (now the Environmental Surveillance and Evaluation Section) was given the responsibility for determining the radioactive concentration levels in soil and water samples removed from each core hole.

CORING OPERATION

During the initial coring operations, 13 core samples were collected at the points indicated by the number notations in Drawing X-20038-EA-005-E (pocket). Soil samples were collected and composited from each core, and taken to the laboratory for preparation. Sump pits were dug at each hole location for the collection of the water used during the drilling operations. At the completion of each drilling operation, a grab sample of water from the sump pit was collected, prepared, and analyzed.

Twelve additional soil-sampling holes were drilled during the second coring operation at the points indicated by the letter notations on Drawing No. X-20038-EA-005-E (pocket). Core samples were collected, using a split-spoon sampler to the depth of bedrock. These core samples were separated into three sections for the determination of the radioactive concentration at different depths.

LABORATORY ANALYSIS

Each soil sample was dried for 24 hours at 110°C and then pulverized to a particle size of 500 µm. Aliquotes from each sample were transferred into twelve 30-cc polyethylene bottles and weighed. A specific gamma-emitting isotope analysis was performed on each sample.

Counting of the samples was accomplished using a 50-cc Ge(Li) detector system. The output of the detector was amplified and then analyzed using a Nuclear Data Model 3300 multichannel analyzer.

A 50-g aliquot from each soil sample was also taken for radiochemical analyses. Radiochemical separations were performed for ^{90}Sr , thorium, uranium, and plutonium assay. Alpha pulse-height analyses were used for identification and assay of the thorium, uranium, and plutonium isotopes with ^{234}Th , ^{232}U , and ^{242}Pu , respectively, being used as tracers for yield corrections. These samples were counted using ORTEC and Princeton Gamma-Tech solid-state detectors. Concentrations of ^{90}Sr were determined with a Tracerlab low-background proportional counter.

RESULTS AND DISCUSSION

Activity levels in water samples were found not to be significantly different from baseline samples when analyzed for ^3H , gross alpha and beta activity. Analytical results of the soil samples from the initial coring operations are presented in Table 1. A representative portion of the homogenized whole core was used for this analysis. The average uranium and plutonium concentrations were measured to be 0.47 pCi/g and 0.06 pCi/g, respectively. The average radioisotope concentration for soil samples near the perimeter air monitoring stations at ORNL have been measured to contain 0.66 pCi/g of uranium and 0.04 pCi/g of plutonium.³ Because the average plutonium value for the cores was higher than those values of soil from perimeter locations and also since selected samples, such as core numbers 12 and 15 (see Table 1), indicated significantly higher than normal levels, additional coring was requested. These additional cores were divided into thirds for indications of changes in activity

levels with depth. The results of these analyses are presented in Tables 2 and 3.

The average ^{137}Cs concentration for the upper third and the entire core was measured to be 0.7 and 0.3 pCi/g, respectively (Table 2). Both of these values are substantially lower than the value of 1.0 pCi/g, the average value of samples collected in 1976 from 16 sites throughout eastern and central Tennessee.⁴ It should be noted, however, that the soil samples for the coring operation extend several feet into the ground, whereas the results used in the comparisons were from soil samples of the first centimeter of topsoil.

For ^{90}Sr (Table 3), the average value for the cores from the site was found to be ≤ 0.57 and ≤ 0.53 pCi/g for the upper third and the entire core, respectively. Further, the ^{238}Pu and ^{239}Pu (Table 3) content of the entire core samples were found to be ≤ 0.0015 and ≤ 0.014 pCi/g, respectively, whereas the average values for other sites in eastern and central Tennessee have been reported⁴ to be ≤ 0.0021 and 0.014 pCi/g. Results of the analysis of air filters from local monitoring stations near the site indicated an average ^{239}Pu air concentration of 1.4×10^{-17} $\mu\text{Ci/ml}$, which is equivalent to fall-out levels detected at perimeter and remote stations.³

CONCLUSIONS

The results of the analyses of the soil, water, and air filter samples on and near the proposed ESRL site do not indicate higher radioactive concentrations than baseline samples in the same geographical location. However, since it is possible that the coring operations may have missed some "hot spots" on the site, it is recommended that the

excavated soil be contained on the control area of the ORNL Reservation and used as backfill in burial-ground operations. It is also recommended that the excavation activities be overseen by a qualified health physicist and other ORNL staff as deemed necessary. The excavation operations at this site should not pose any significant radioactive hazard to personnel working at the site, to other ORNL personnel, or to members of the general public.

Table 1. Results of radiochemical analyses of soil samples
from initial coring operation.
(pCi/Dry g)

Sample I.D. No.	U	Th	⁹⁰ Sr	Pu
1	0.68	0.82	0.63	0.030
2	0.57	0.75	0.68	0.030
3	No sample			
4	0.29	0.84	0.68	0.059
5	0.064	0.79	0.63	0.020
6	No sample			
7	0.62	0.81	1.1	0.11
8	0.51	0.37	1.0	0.050
9	0.51	0.75	0.63	0.023
10	0.63	0.49	0.36	0.030
11	0.62	0.093	0.68	0.020
12	1.1	0.75	1.7	0.14
13	ND*	0.88	0.68	0.049
14	0.018	0.26	0.27	0.017
15	0.053	0.27	0.50	0.21
Average	0.47	0.61	0.73	0.06

* Not detectable.

Table 2. Results of gamma-spectrometric analyses of soil samples
from second coring operation
(pCi/Dry g)

Sample I.D. No.*	^{137}Cs	^{40}K	^{226}Ra	^{232}Th
A-1	0.4	3.4	0.6	1.0
A-2	ND**	5.5	0.7	1.0
A-3	ND	1.1	0.7	1.3
B-1	0.1	ND	0.4	0.6
B-2	ND	12	0.8	1.4
B-3	ND	9.9	0.9	0.9
C-1	0.6	11	0.9	1.2
C-2	ND	15	1.0	1.5
C-3	ND	16	1.0	1.5
D-1	1.9	9.9	0.9	1.2
D-2	ND	12	0.8	1.3
D-3	0.04	13	0.9	1.5
E-1	0.04	5.1	0.7	0.9
E-2	0.3	8.3	1.0	1.2
E-3	0.2	9.5	1.0	1.2
F-1	0.4	ND	0.7	1.3
F-2	ND	11	0.7	1.0
F-3	ND	12	0.8	1.4
G-1	0.3	15	0.9	1.4
G-2	0.1	15	0.8	1.2
G-3	ND	12	0.5	0.9
H-1	0.8	10	0.5	0.8
H-2	ND	13	0.6	0.8
H-3	ND	15	0.6	1.2
J-1	0.5	5.0	0.5	0.7
J-2	ND	9.6	0.9	1.3
J-3	ND	12	0.8	1.2
K-1	0.5	8.2	0.8	0.9
K-2	0.2	8.5	0.9	1.1
K-3	0.8	6.6	0.8	1.2
L-1	1.7	9.8	0.8	1.0
L-2	0.1	3.8	0.6	0.7
L-3	ND	4.3	0.6	0.9
M-1	0.7	6.2	0.7	0.9
M-2	ND	4.6	0.7	0.9
M-3	ND	9.1	1.1	1.3
Av. three levels	0.3	9.0	0.8	1.1
Av. top only	0.7	7.0	0.7	1.0

* Each core was divided into thirds for analysis (1 is uppermost section; 3 is lowest).

** Not detectable.

Table 3. Results of radiochemical analyses of soil samples from second coring operation

(pCi/Dry g)

Sample I.D. No. *	⁹⁰ Sr	²³⁹ Pu	²³⁸ Pu
A-1	0.34 ± 0.16**	0.011 ± 0.0027	≤0.00045
A-2	≤0.17	0.0014 0.00091	≤0.00045
A-3	≤0.20	≤0.00045	≤0.00045
B-1	≤0.41	0.0039 ± 0.0018	≤0.00091
B-2	≤0.21	≤0.00091	≤0.00091
B-3	≤0.21	0.0014 ± 0.00046	≤0.00091
C-1	1.0 ± 0.24	0.022 ± 0.0036	≤0.0018
C-2	1.3 ± 0.36	0.0036 ± 0.0018	≤0.00091
C-3	0.64 ± 0.37	≤0.0023	≤0.0023
D-1	0.77 ± 0.21	0.0021 ± 0.00045	≤0.00091
D-2	≤0.37	0.0027 ± 0.0018	≤0.00091
D-3	≤0.20	≤0.00091	≤0.00091
E-1	≤0.37	0.016 ± 0.0036	≤0.00091
E-2	0.68 ± 0.21	0.029 ± 0.0050	≤0.0014
E-3	3.4 ± 0.40	0.015 ± 0.0045	≤0.0014
F-1	≤0.36	≤0.0045	≤0.00045
F-2	≤0.30	≤0.0018	≤0.0018
F-3	≤0.32	≤0.0046	≤0.00045
G-1	≤0.27	0.014 ± 0.0018	0.0014 ± 0.00045
G-2	≤0.25	0.0046 ± 0.00091	0.0032 ± 0.00091
G-3	≤0.14	≤0.0014	≤0.0014
H-1	0.59 ± 0.31	0.039 ± 0.0090	0.0041 ± 0.0022
H-2	0.45 ± 0.18	≤0.0018	≤0.0018
H-3	0.45 ± 0.18	≤0.00091	≤0.00091
J-1	0.73 ± 0.23	0.014 ± 0.0027	NA***
J-2	≤0.46	≤0.0018	≤0.0018
J-3	0.50 ± 0.20	≤0.00091	≤0.00091
K-1	0.46 ± 0.19	0.019 ± 0.0018	0.0027 ± 0.00091
K-2	≤0.17	0.025 ± 0.0023	≤0.00091
K-3	≤0.32	0.0045 ± 0.00045	≤0.00045
L-1	1.0 ± 0.22	0.22 ± 0.014	0.0059 ± 0.0018
L-2	0.50 ± 0.17	0.0073 ± 0.0027	≤0.0036
L-3	0.50 ± 0.33	≤0.00091	≤0.0018
M-1	0.55 ± 0.16	0.022 ± 0.0036	≤0.00091
M-2	0.30 ± 0.13	≤0.00091	≤0.00091
M-3	≤0.25	≤0.00091	≤0.00091
Av. three levels	≤0.53	≤0.014	≤0.0015
Av. top only	≤0.57	≤0.032	≤0.0019

* Each core was divided into thirds for analysis (1 is uppermost section; 3 is lowest).

** Values at the 95% confidence level.

*** No analysis.

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