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Results of Subsurface Investigation of Radionuclides in Soil in Finberg Field, Attleboro, Massachusetts

W. D. Cottrell
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Health and Safety Research Division

RESULTS OF SUBSURFACE INVESTIGATION OF RADIONUCLIDES IN SOIL IN FINBERG FIELD, ATTLEBORO, MASSACHUSETTS

W. D. Cottrell
D. A. Witt
W. H. Shinpaugh
W. A. Goldsmith
F. F. Haywood*

Work performed
as part of the
REMEDIAL ACTION SURVEY AND
CERTIFICATION ACTIVITIES

Date Published: March 1982

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ABSTRACT

A preliminary radiological survey of the Finberg Field recreation area, Attleboro, Massachusetts, conducted in late 1978, revealed the presence of radioactive materials (radium) in several wooded areas adjacent to Finberg Field. The Department of Energy (DOE) requested that a survey team from the Oak Ridge National Laboratory (ORNL) provide technical support to the Department of Public Health, Commonwealth of Massachusetts, in determining the extent of subsurface contamination in a 0.4-acre area of Finberg Field. This report describes the methods used, and presents the results of the survey performed at this site.

INTRODUCTION

Finberg Field is a recreational area and playground located in the City of Attleboro, Massachusetts (Fig. 1). It was built on a former landfill site and consists of tennis courts, basketball courts, softball fields, and open play areas.

A preliminary radiological survey of Finberg Field was first conducted during November and December 1978, by members of the Nuclear Regulatory Commission, Region I (NRC:I), and personnel from the Department of Health, Commonwealth of Massachusetts. Allegations made by a private citizen, that the site contained radioactive materials, prompted local municipal officials to request a radiological survey of the area. The survey confirmed the presence of radioactive materials in wooded and brushy areas adjacent to Finberg Field and identified the material as radium. Since the use of this material (radium) is regulated by the Commonwealth of Massachusetts, responsibility for formulating future actions was assumed by the Bureau of Radiation Control Programs, Department of Public Health, Commonwealth of Massachusetts.[1]

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*Present address: Eberline, Oak Ridge, Tennessee 37830

SURVEY METHODS

At the request of DOE, a survey team from ORNL provided technical support to the Department of Public Health, Commonwealth of Massachusetts, in determining the extent of subsurface contamination in a small area of Finberg Field. The technical support consisted of providing: (1) a drilling contractor to drill holes and take core samples in areas designated by representatives of the Massachusetts' Department of Health; (2) instrumentation and personnel to "radiolog" bore holes; (3) collection and analyses of soil and water samples from holes for radionuclide content. Characterization of the radiological conditions at the surface of the field were not included in the scope of work at this site.

Holes were drilled with a motorized rig equipped with a 6-in. diameter auger to depths ranging from 7 to 10 ft. A plan view of Finberg Field provided by the City of Attleboro, Massachusetts, including the location of holes, is shown in Fig. 2. The coordinates of these holes with respect to the "set stake" shown in Fig. 2 are given in Table 1. A plastic pipe (PVC, Schedule 40) with a 4-in. inside diameter was placed in the hole, and a NaI scintillation probe was lowered inside the pipe. The probe was encased in a lead shield with a horizontal row of collimating slits on the side. This arrangement allowed measurements of gamma radiation intensities resulting from contamination within small fractions of hole depth. The measurements were performed at 6- to 12-in. intervals in each hole.

Gamma-ray "logging" was done as a first step in determining the extent of subsurface contamination at each location. A soil sample was collected from each hole, usually at the point of maximum radiation as indicated by the gamma-ray logs. In addition, a split-spoon sampler was used to obtain soil samples at locations 22, 23, and 24. Considerable difficulty was encountered in driving the split spoon through rubble, and the sample recovery rate was extremely low. A water sample was collected from each hole where water was encountered in sufficient quantity to allow for sampling (Holes 1, 2, 4, and 5).

Soil samples were returned to ORNL and dried at 110°C for 24 hours, then pulverized to a particle size of -35 mesh (500 μ). Aliquots of each sample were counted on a Ge(Li) detector and the photon spectra analyzed by computer techniques. Neutron absorption methods were used to determine the concentration of ^{238}U in each sample. Water samples were analyzed using sequential separation techniques to determine concentrations of ^{226}Ra, ^{238}U, ^{230}Th, and ^{210}Pb.

SURVEY RESULTS

Concentrations of ^{226}Ra and ^{238}U in subsurface soil are listed in Table 2. Results of ground water sample analyses are given in Table 3. Plots of gamma radiation intensity versus hole depth along with a characterization by depth of the subsurface material at each hole location are presented in Figs. 3 through 26.

The logging technique used here is not radionuclide-specific. However, this technique can be used to estimate the concentration of ^{226}Ra when that nuclide is distributed evenly in soil, such as in the case of uranium mill tailings. Unless this latter condition exists, radionuclides in soil cannot be estimated reliably from these data. Normally a reading of 1000 cpm or greater on the shielded gamma scintillator (hole logger) indicates the presence of radionuclides in concentrations above normal terrestrial levels. Gamma-ray logs of holes on this site indicate elevated concentrations of radionuclides in 19 holes out of 24. Concentrations of ^{226}Ra and ^{238}U in subsurface soil are not consistent with gamma radiation levels observed in holes at corresponding depths. In the majority of cases, the gamma logs suggest concentrations much higher than was actually found from assays of soil samples. The apparent lack of correlation of soil concentrations with gamma-ray profile information is probably due to the spotty and uneven distribution of radioactive materials in the area samples. Radium-bearing items in the form of small rings (~ 1 cm in diameter) and hemispherical glass beads were found on this and other dump sites in the Attleboro, Massachusetts, area. Two types of these objects are shown in Fig. 27. These items are suggestive of wastes from industries engaged in the manufacture of

instruments with luminous markers and/or dials of the type found in cockpits of airplanes of 1940's and 1950's vintage. If these objects are distributed throughout the landfill and are not crushed or otherwise dispersed in the soil adjacent to an elevated gamma-ray reading at a specific depth, soil from that depth may not exhibit an elevated radionuclide concentration. Many of the peaks which appear in the gamma profiles, Figs. 3-26, may be caused by the presence of these objects.

With the exception of one sample from Hole 11, concentrations of ^{226}Ra in soil ranged from 0.68 pCi/g to 6.9 pCi/g, average 2.9 ± 1.6 pCi/g. The sample collected from Hole 11 showed 280 pCi of ^{226}Ra per gram of soil. Again this illustrates the uneven distribution of radionuclides in soil on this site, and could result from the crushing of one or more objects of the type shown in Fig. 27. Concentrations of ^{238}U in soil ranged from 0.52 pCi/g to 2.8 pCi/g with an average of 1.6 ± 0.70 pCi/g.

Concentrations of ^{226}Ra, ^{238}U, ^{230}Th, and ^{210}Pb in water collected from drill holes (Table 2) are well below the concentration guides as stated in 10 CFR 20. However, it should be noted that the concentration of ^{226}Ra in water collected in holes 1 and 2 exceeds the EPA guideline of 5 pCi/L for ^{226}Ra and ^{228}Ra together.[2]

It should be emphasized that the data generated as a result of this study, applies only to that area of Finberg Field investigated, and in no way is it intended as a complete subsurface characterization of Finberg Field.

REFERENCES

1. U.S. Nuclear Regulatory Commission, Office of Inspection and Enforcement, Region I, Report 078-154, February 12, 1979.

2. Environmental Protection Agency, Interim Primary Drinking Water Regulations, 40 CFR 141.15, *Federal Register*, 41, No. 133, July 9, 1976.

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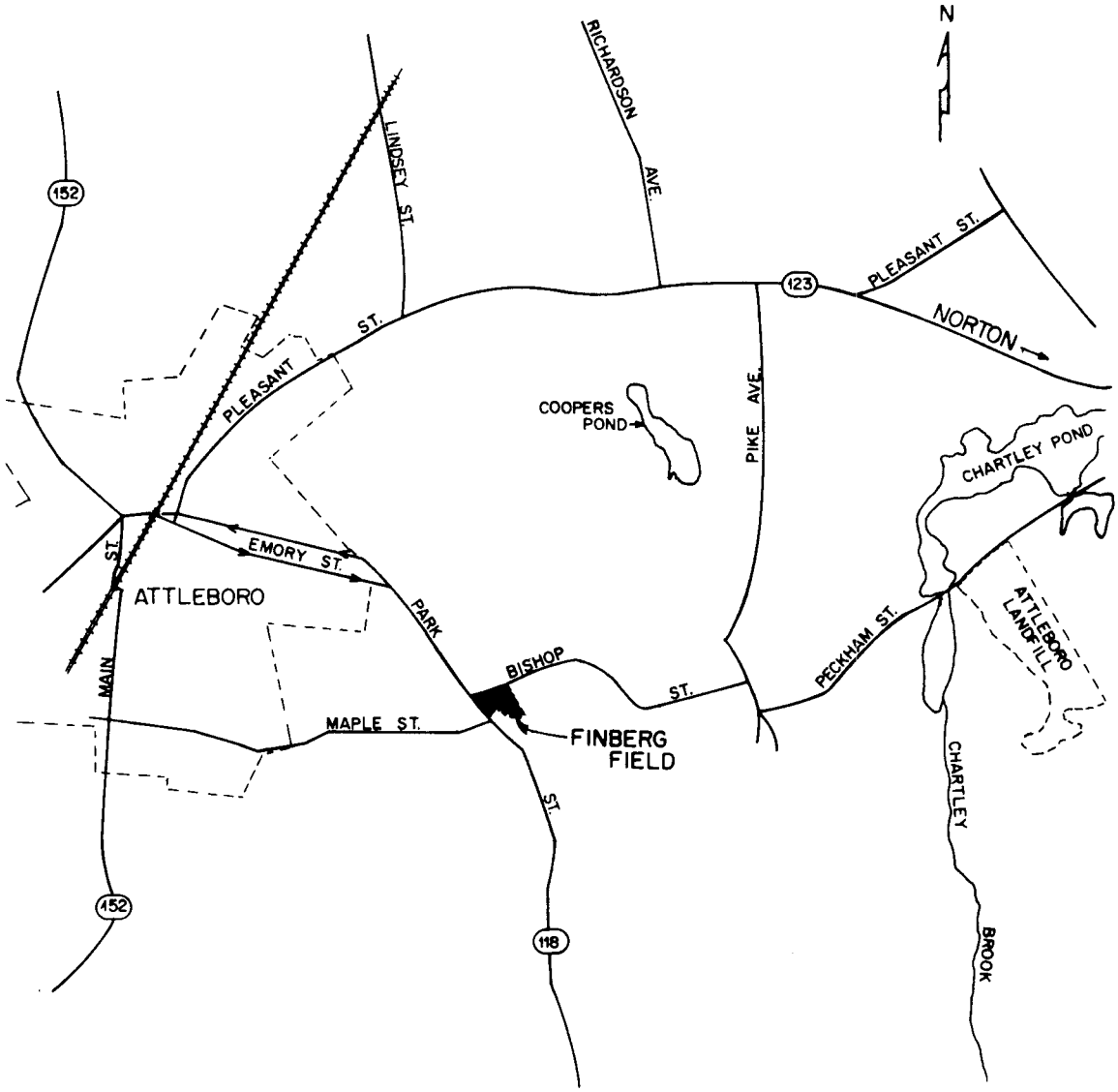

Fig. 1. Attleboro - Norton, Massachusetts, area showing location of Finberg Field.

ORNL-DWG 82-8489

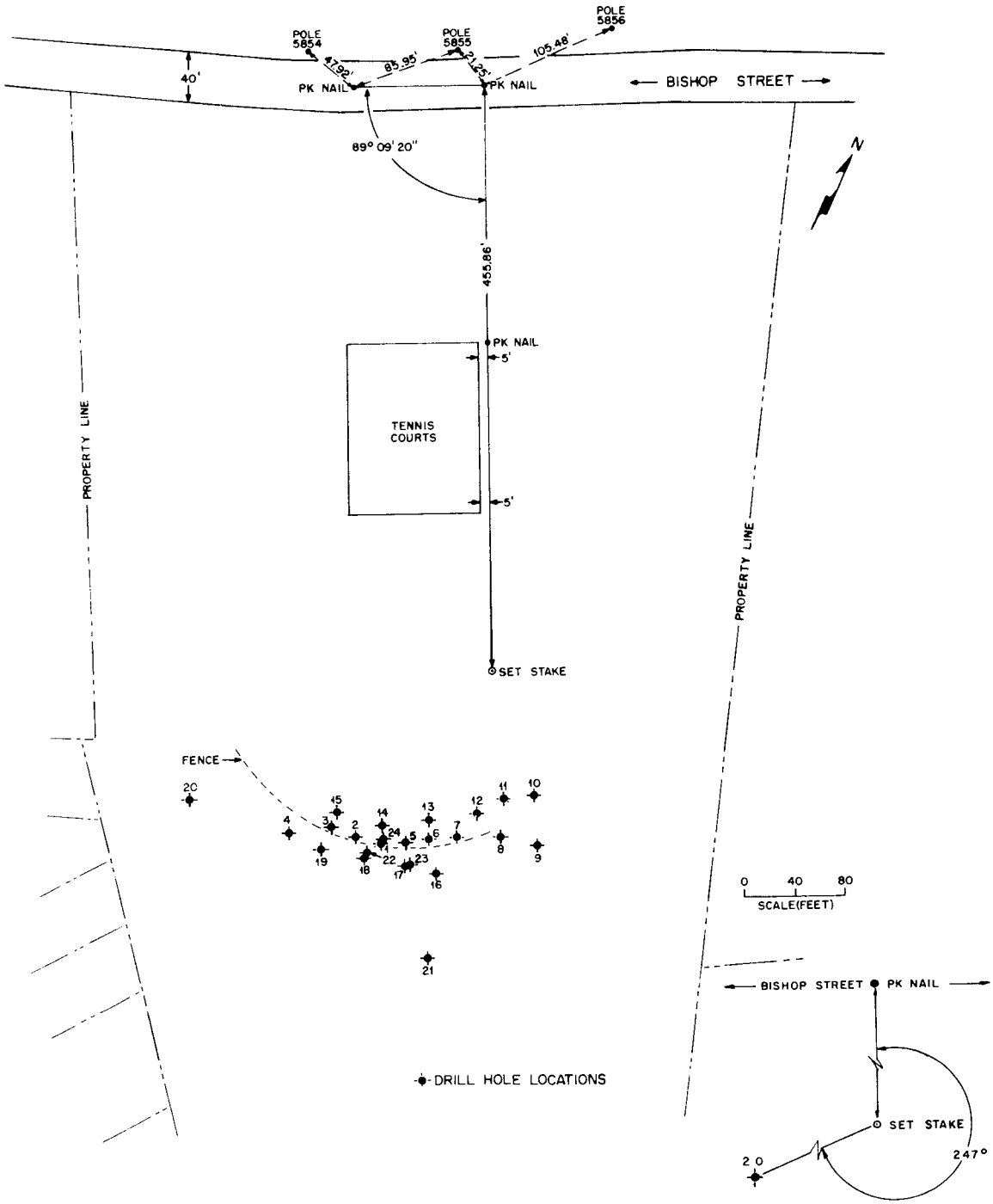

Fig. 2. Finberg Field drill hole locations.

ORNL-DWG 82-8490

FINBERG FIELD SOIL CODE GROUPS

A. Topsoil - brown silty sand with some organics.

B. Fill material - abundant rubble; glass, metal, plastics, and slag.

C. Inorganic subsoil - silty sand with quartz, shale, and rock fragments.

D. Inorganic subsoil - silty sand, fine-grained with some clay.

E. Peat - decomposed organic material.

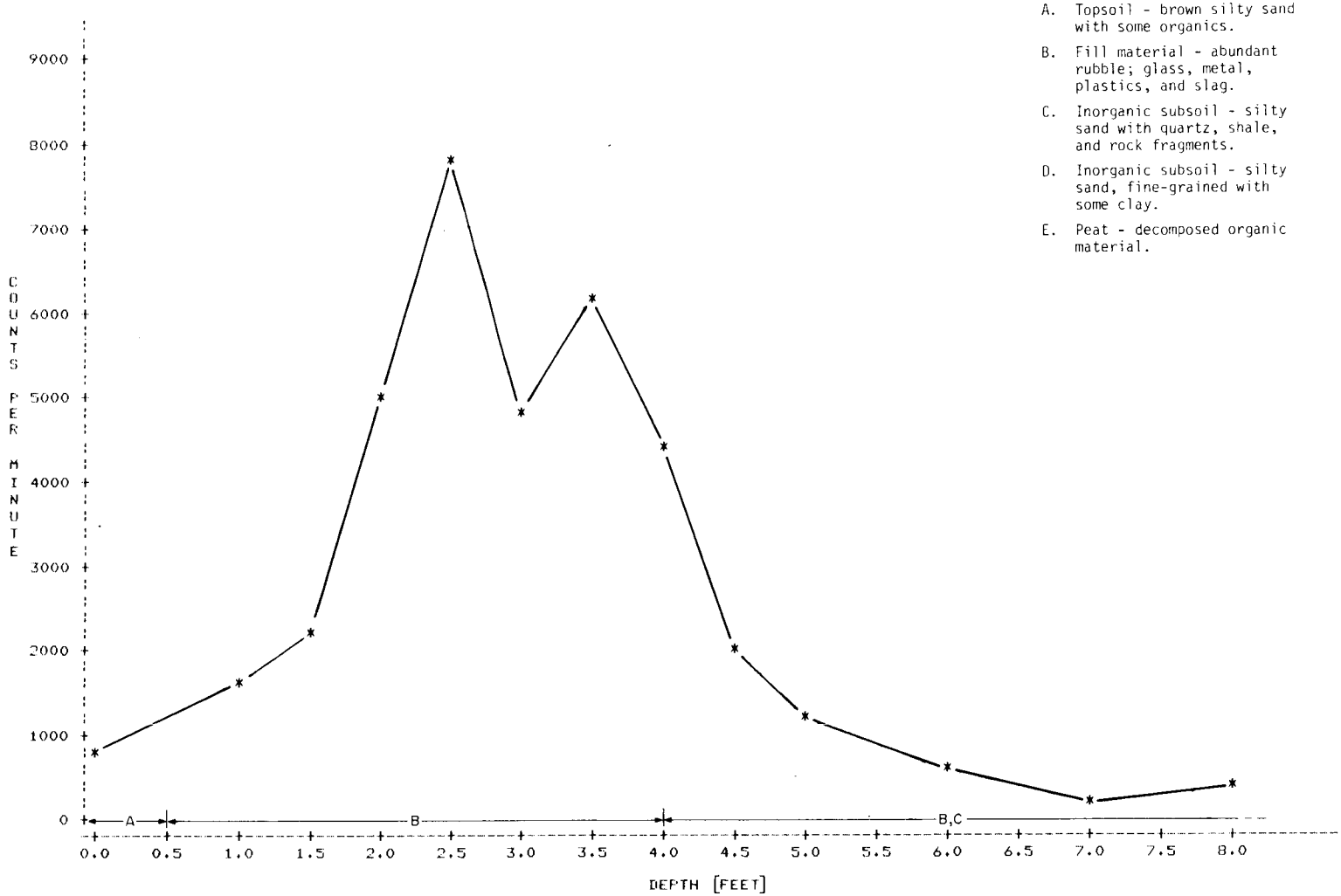

Fig. 3. Gamma-ray profile of Drill Hole 1.

ORNL-DWG 82-8491

FINBERG FIELD SOIL CODE GROUPS

A. Topsoil - brown silty sand with some organics.

B. Fill material - abundant rubble; glass, metal, plastics, and slag.

C. Inorganic subsoil - silty sand with quartz, shale, and rock fragments.

D. Inorganic subsoil - silty sand, fine-grained with some clay.

E. Peat - decomposed organic material.

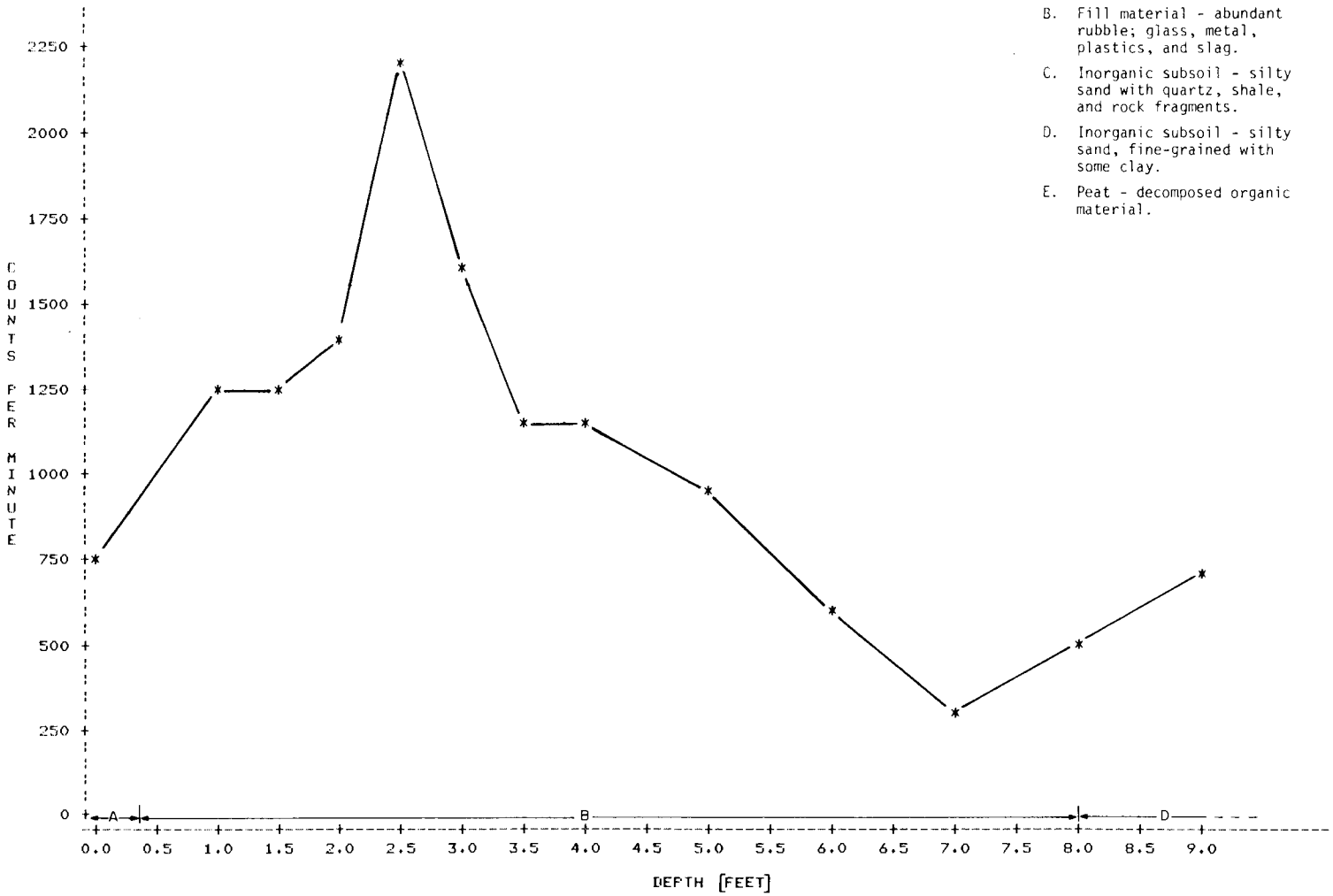

Fig. 4. Gamma-ray profile of Drill Hole 2.

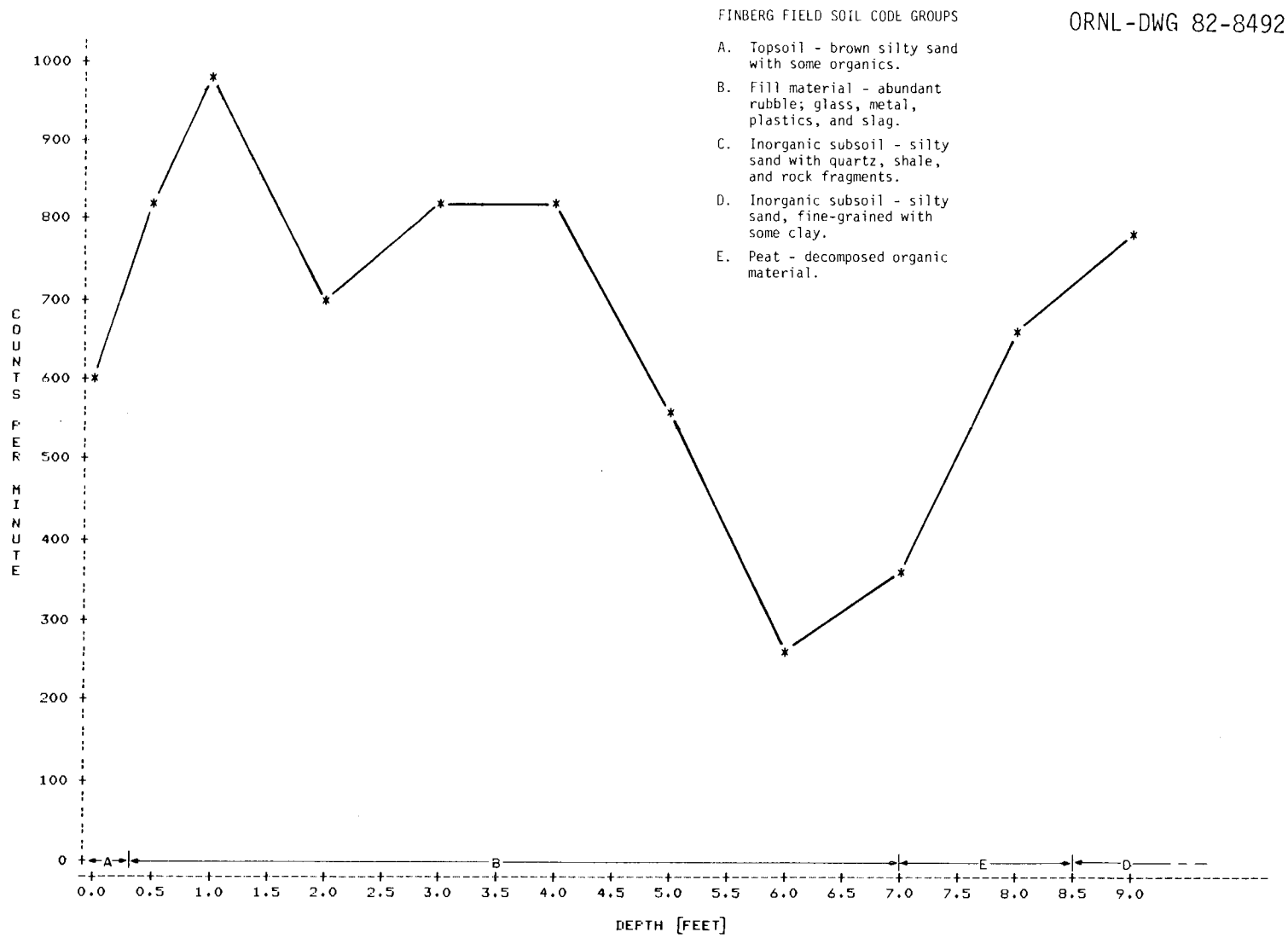

Fig. 5. Gamma-ray profile of Drill Hole 3.

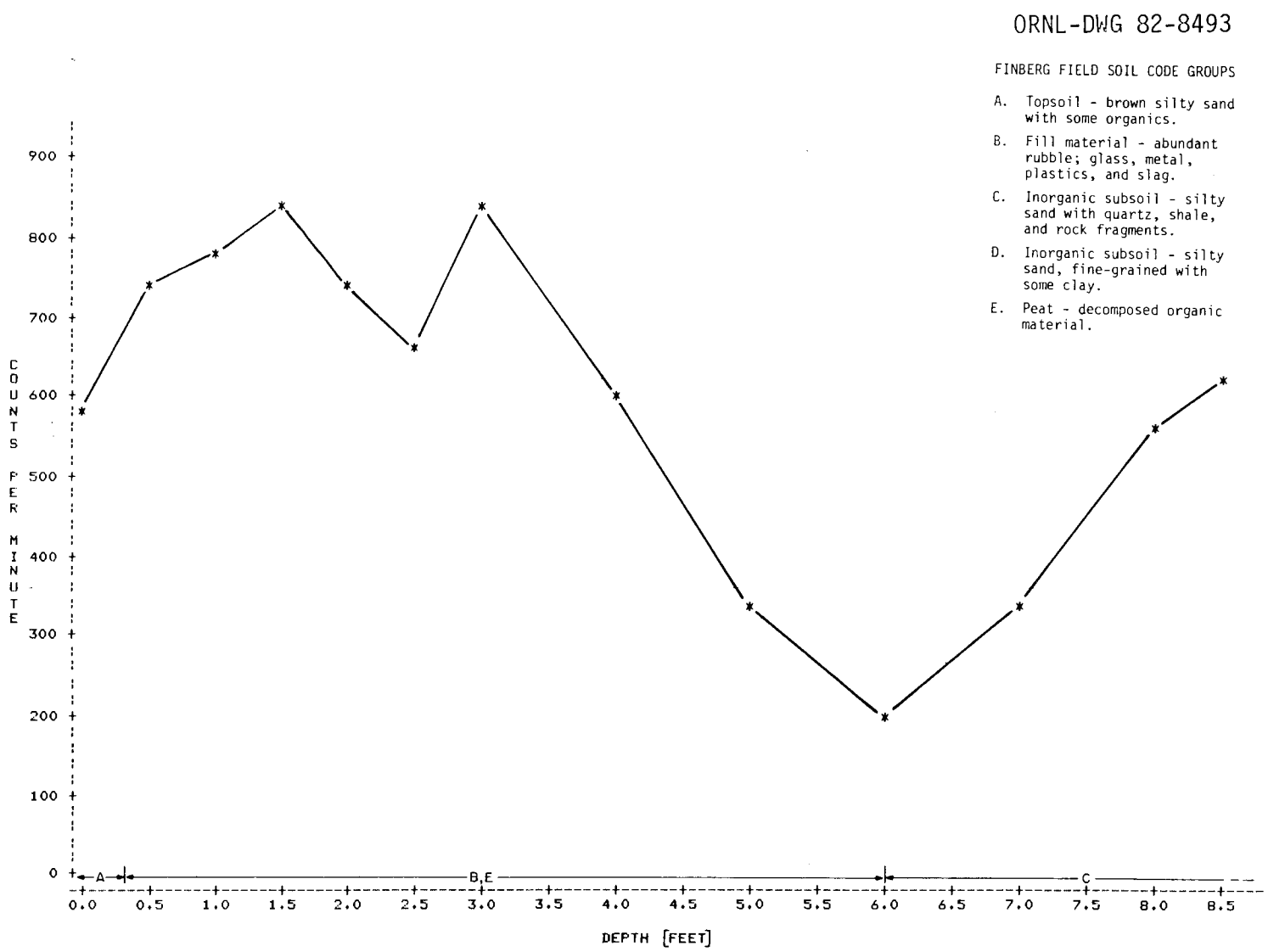

Fig. 6. Gamma-ray profile of Drill Hole 4.

ORNL-DWG 82-8494

FINBERG FIELD SOIL CODE GROUPS

A. Topsoil - brown silty sand with some organics.

B. Fill material - abundant rubble; glass, metal, plastics, and slag.

C. Inorganic subsoil - silty sand with quartz, shale, and rock fragments.

D. Inorganic subsoil - silty sand, fine-grained with some clay.

E. Peat - decomposed organic material.

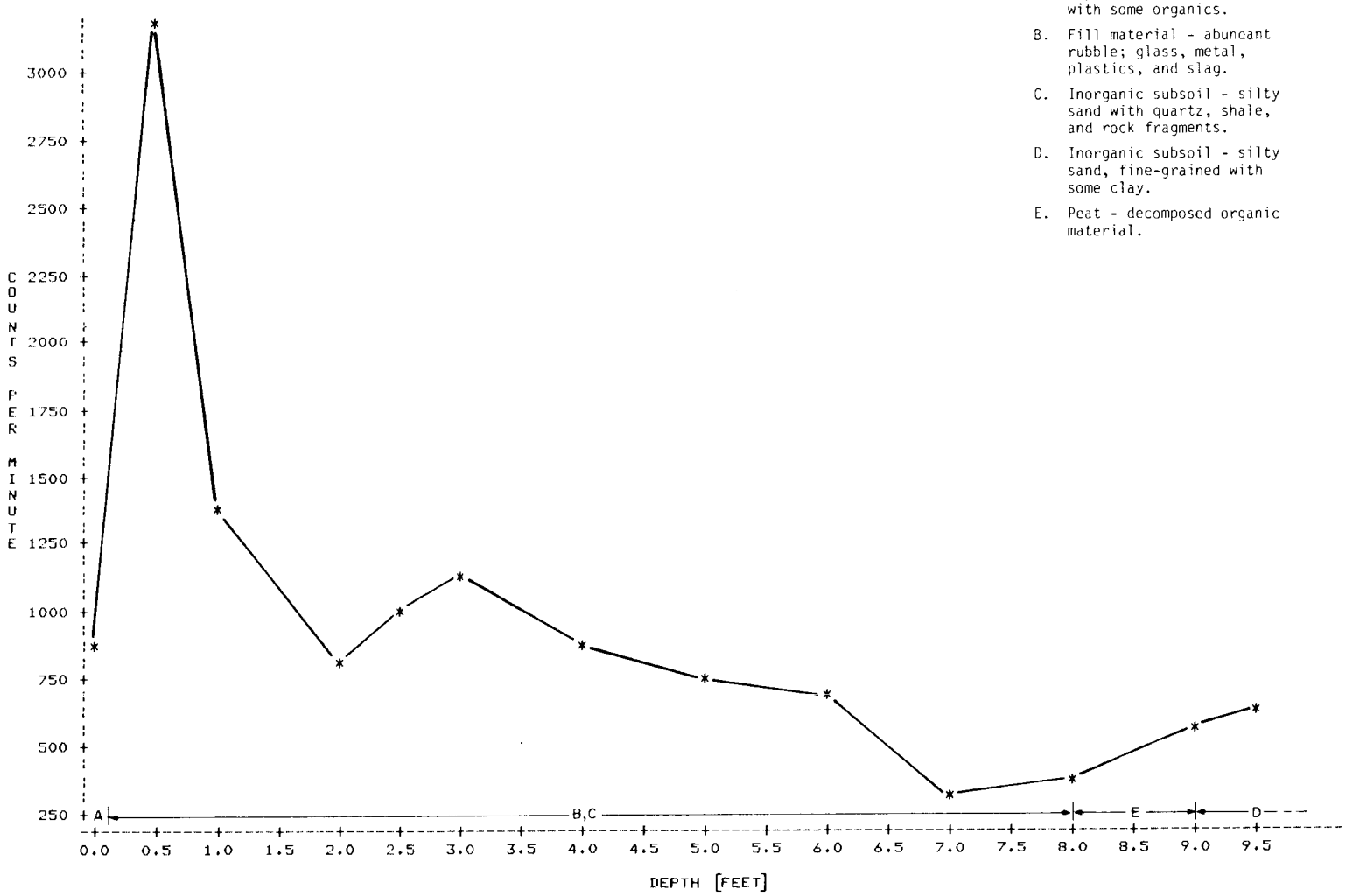

Fig. 7. Gamma-ray profile of Drill Hole 5.

ORNL-DWG 82-8495

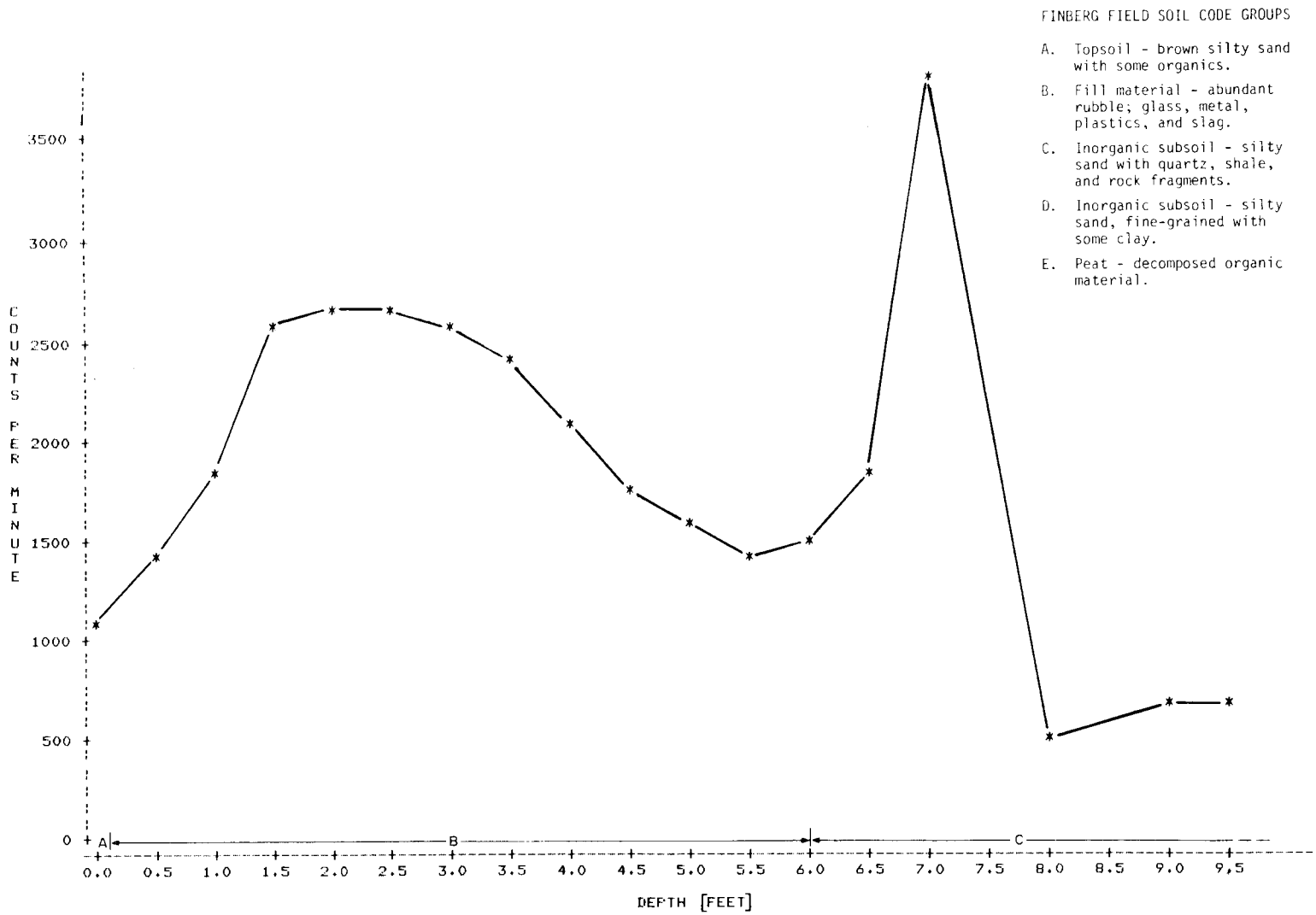

Fig. 8. Gamma-ray profile of Drill Hole 6.

ORNL-DWG 82-8496

FINBERG FIELD SOIL CODE GROUPS

A. Topsoil - brown silty sand with some organics.

B. Fill material - abundant rubble; glass, metal, plastics, and slag.

C. Inorganic subsoil - silty sand with quartz, shale, and rock fragments.

D. Inorganic subsoil - silty sand, fine-grained with some clay.

E. Peat - decomposed organic material.

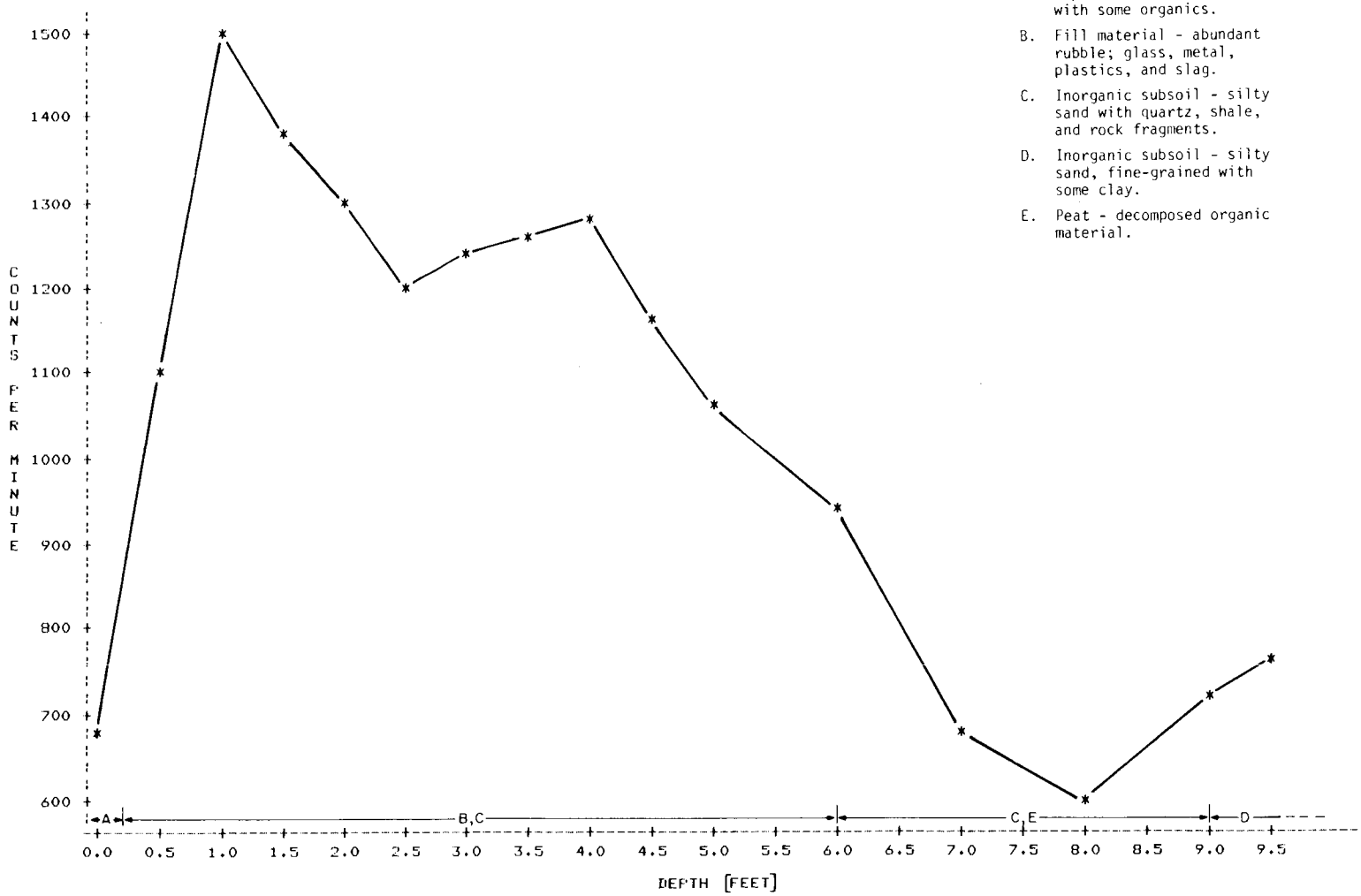

Fig. 9. Gamma-ray profile of Drill Hole 7.

ORNL-DWG 82-8497

FINBERG FIELD SOIL CODE GROUPS

A. Topsoil - brown silty sand with some organics.

B. Fill material - abundant rubble; glass, metal, plastics, and slag.

C. Inorganic subsoil - silty sand with quartz, shale, and rock fragments.

D. Inorganic subsoil - silty sand, fine-grained with some clay.

E. Peat - decomposed organic material.

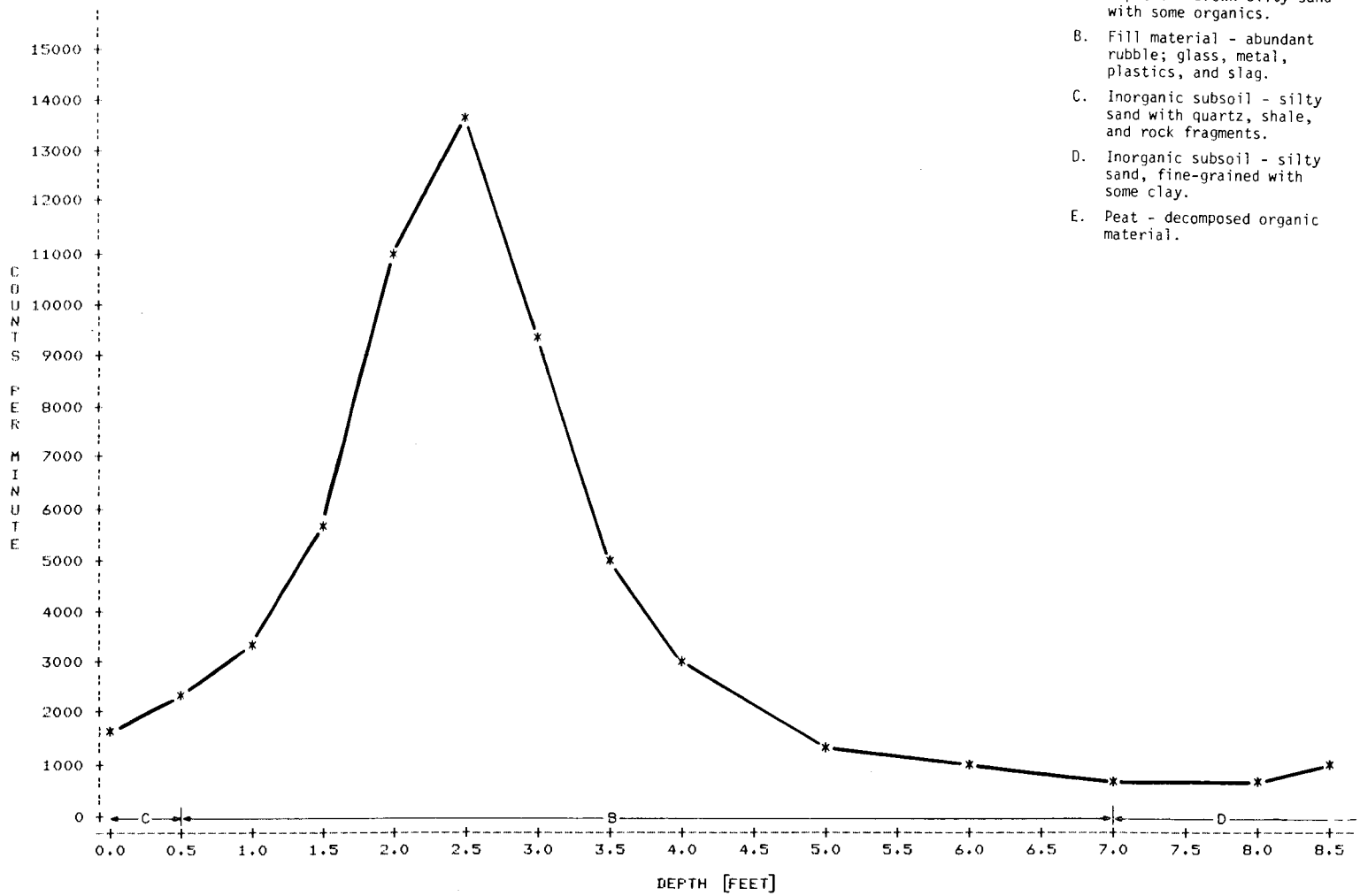

Fig. 10. Gamma-ray profile of Drill Hole 8.

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FINBERG FIELD SOIL CODE GROUPS

A. Topsoil - brown silty sand with some organics.

B. Fill material - abundant rubble; glass, metal, plastics, and slag.

C. Inorganic subsoil - silty sand with quartz, shale, and rock fragments.

D. Inorganic subsoil - silty sand, fine-grained with some clay.

E. Peat - decomposed organic material.

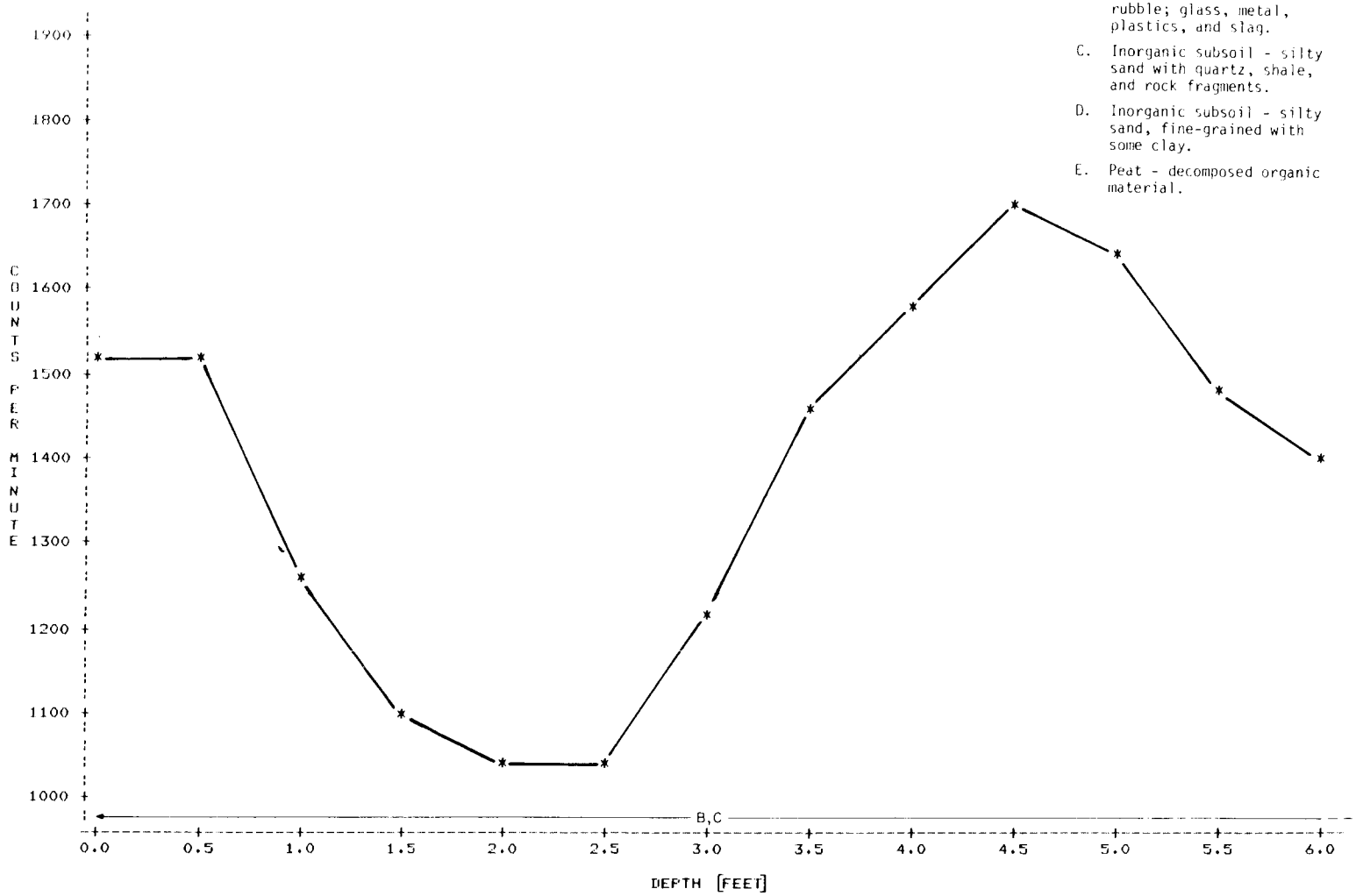

Fig. 11. Gamma-ray profile of Drill Hole 9.

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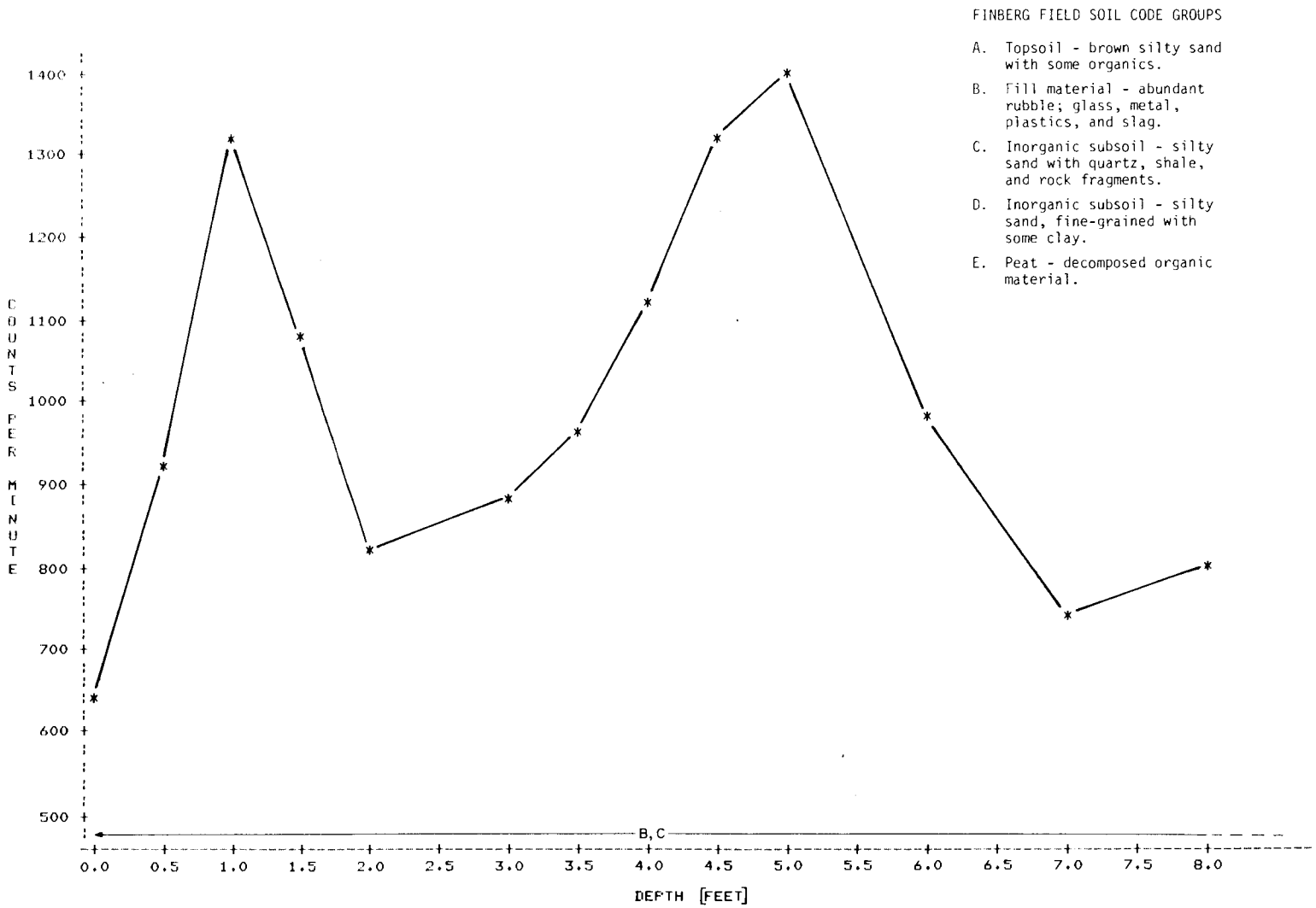

Fig. 12. Gamma-ray profile of Drill Hole 10.

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FINBERG FIELD SOIL CODE GROUPS

A. Topsoil - brown silty sand with some organics.

B. Fill material - abundant rubble; glass, metal, plastics, and slag.

C. Inorganic subsoil - silty sand with quartz, shale, and rock fragments.

D. Inorganic subsoil - silty sand, fine-grained with some clay.

E. Peat - decomposed organic material.

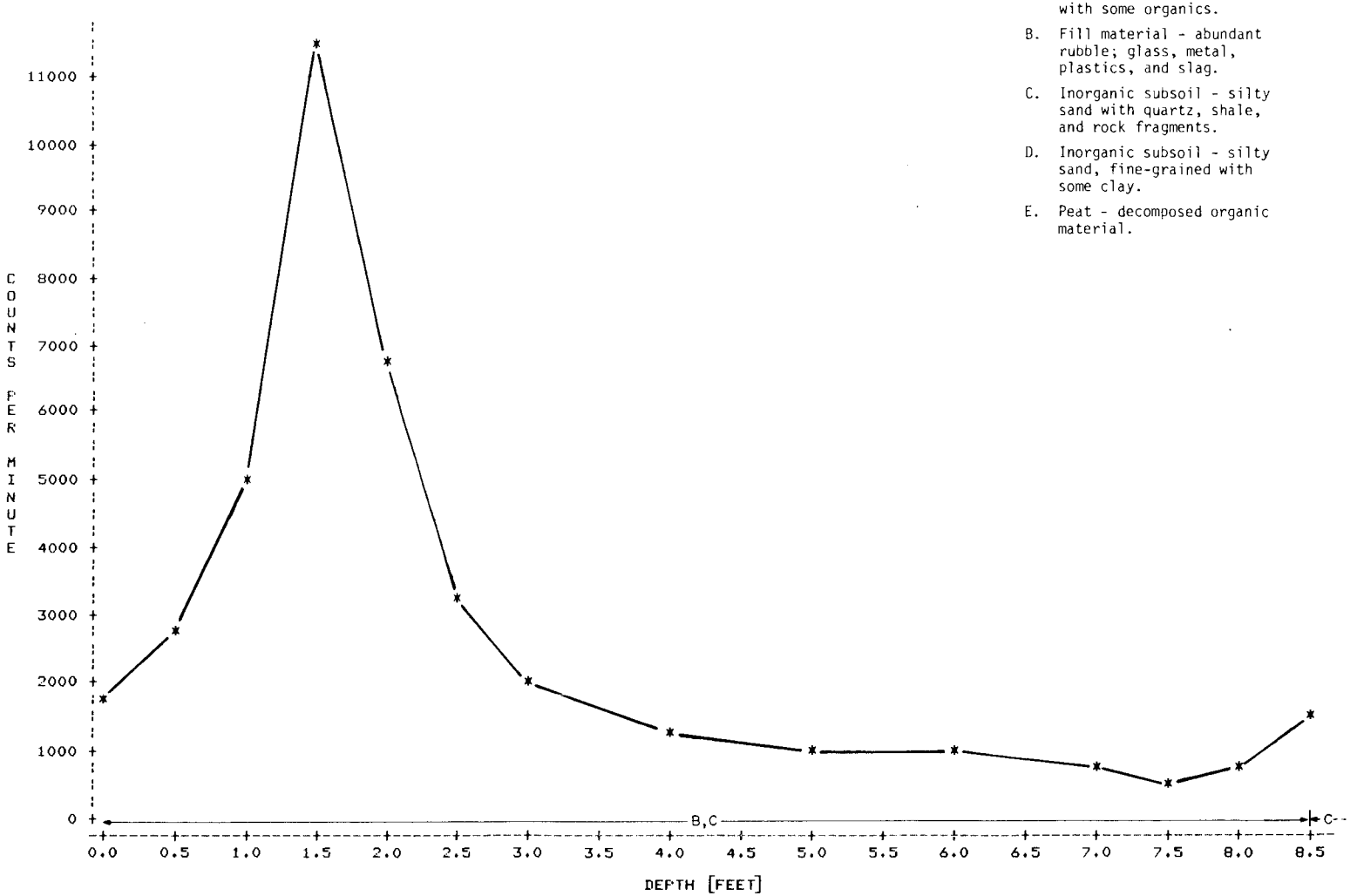

Fig. 13. Gamma-ray profile of Drill Hole 11.

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FINBERG FIELD SOIL CODE GROUPS

A. Topsoil - brown silty sand with some organics.

B. Fill material - abundant rubble; glass, metal, plastics, and slag.

C. Inorganic subsoil - silty sand with quartz, shale, and rock fragments.

D. Inorganic subsoil - silty sand, fine-grained with some clay.

E. Peat - decomposed organic material.

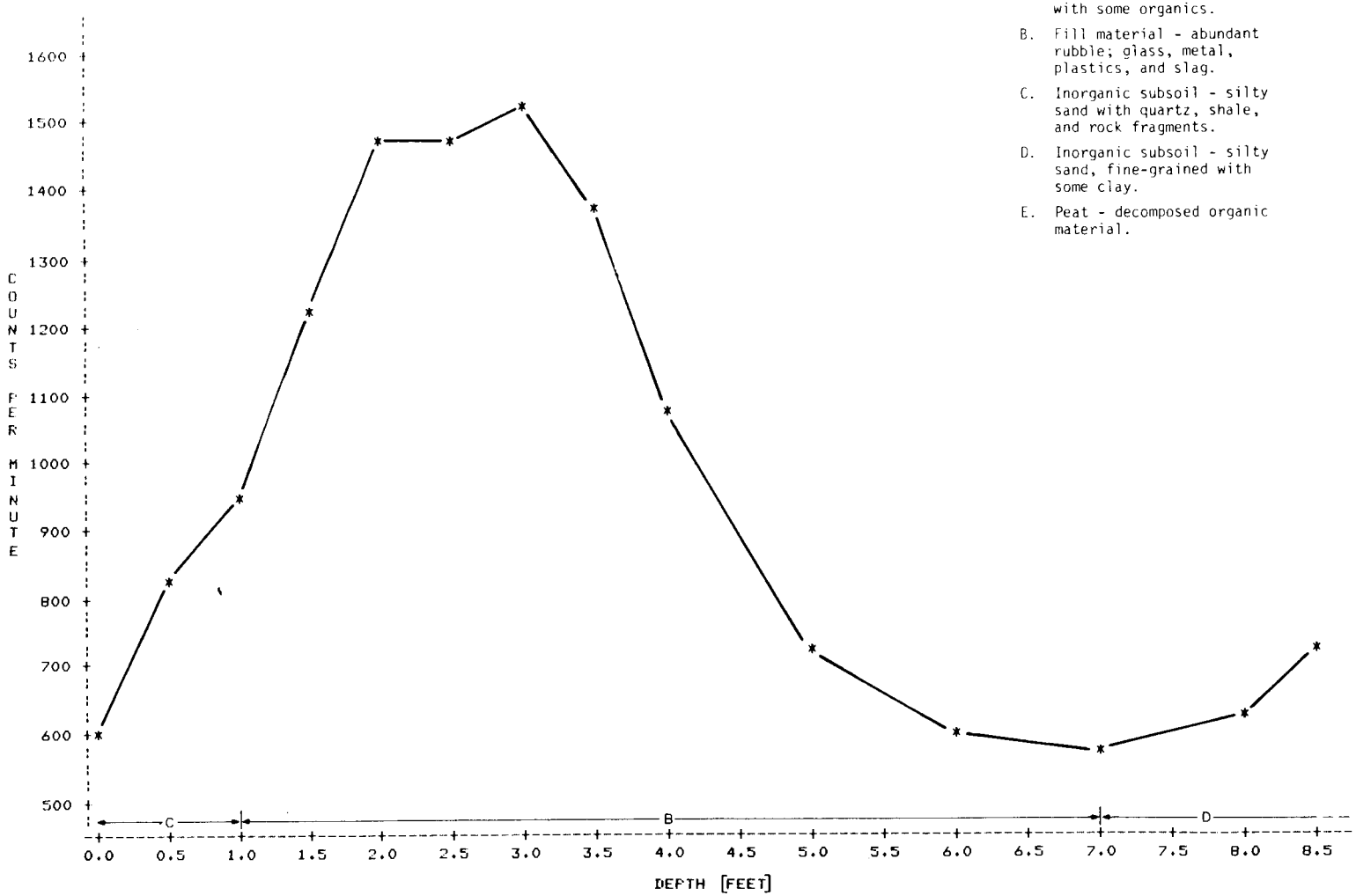

Fig. 14. Gamma-ray profile of Drill Hole 12.

ORNL-DWG 82-8502

FINBERG FIELD SOIL CODE GROUPS

A. Topsoil - brown silty sand with some organics.

B. Fill material - abundant rubble; glass, metal, plastics, and slag.

C. Inorganic subsoil - silty sand with quartz, shale, and rock fragments.

D. Inorganic subsoil - silty sand, fine-grained with some clay.

E. Peat - decomposed organic material.

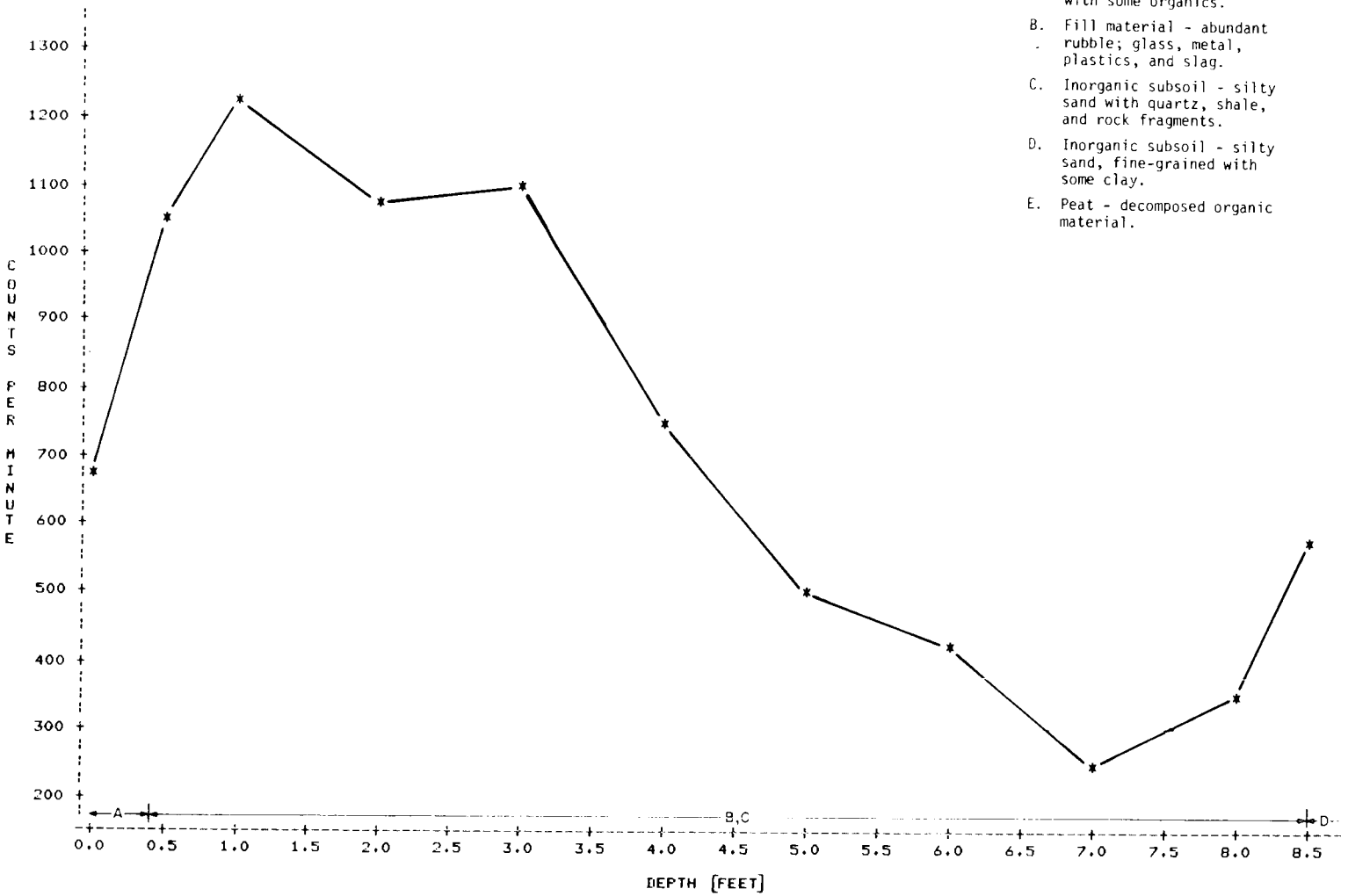

Fig. 15. Gamma-ray profile of Drill Hole 13.

ORNL-DWG 82-8503

FINBERG FIELD SOIL CODE GROUPS

A. Topsoil - brown silty sand with some organics.

B. Fill material - abundant rubble; glass, metal, plastics, and slag.

C. Inorganic subsoil - silty sand with quartz, shale, and rock fragments.

D. Inorganic subsoil - silty sand, fine-grained with some clay.

E. Peat - decomposed organic material.

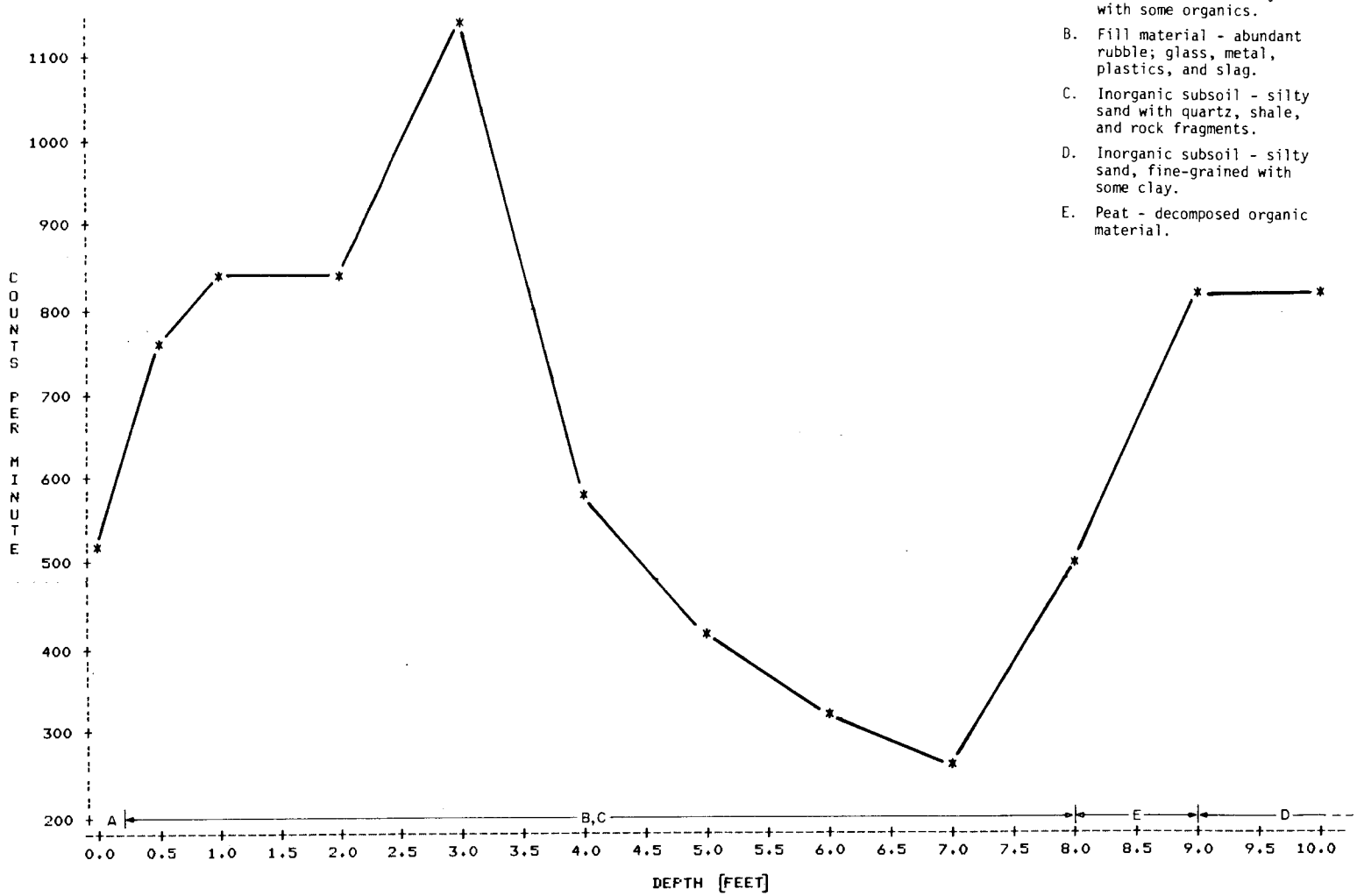

Fig. 16. Gamma-ray profile of Drill Hole 14.

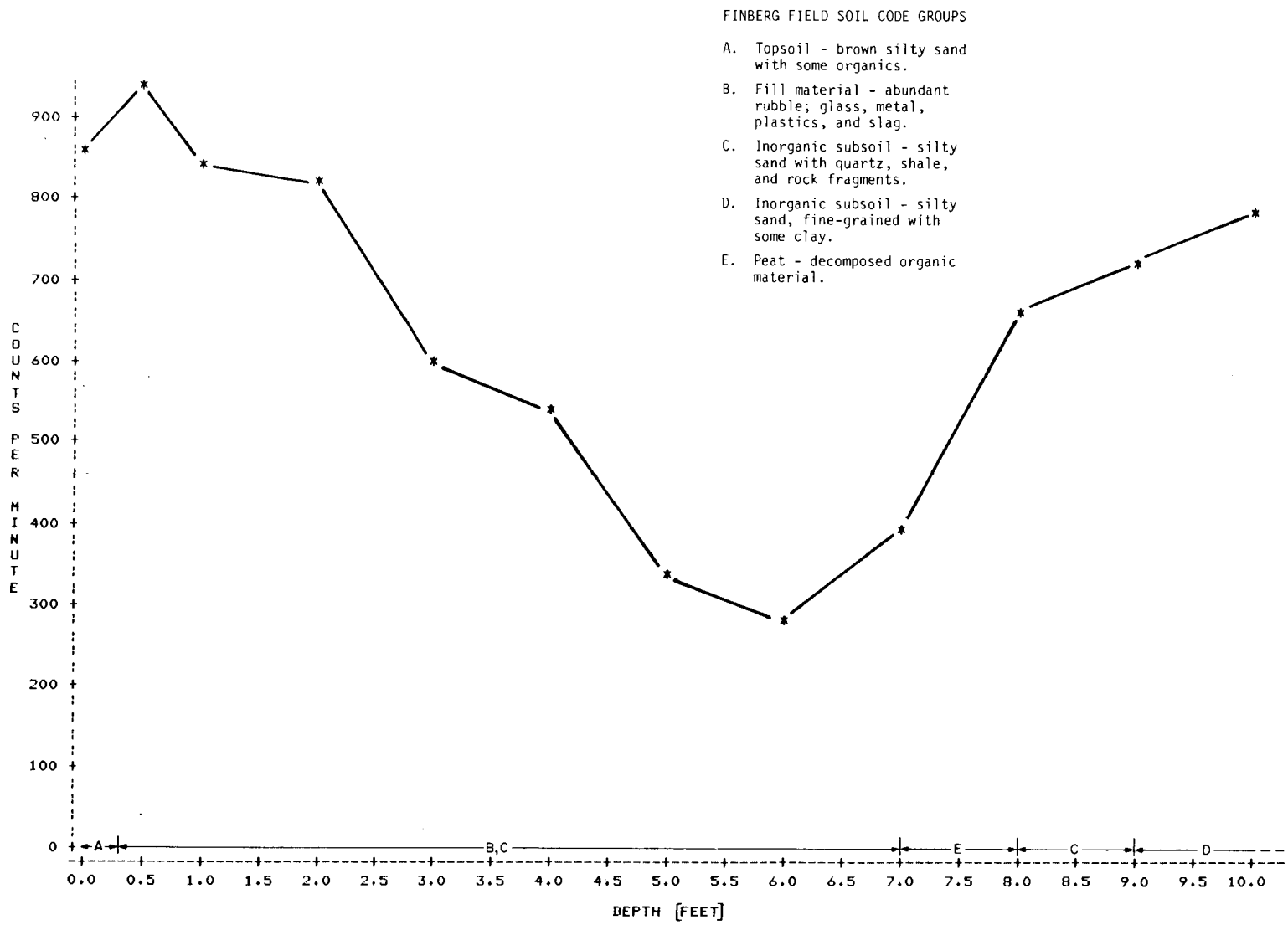

Fig. 17. Gamma-ray profile of Drill Hole 15.

ORNL-DWG 82-8505

FINBERG FIELD SOIL CODE GROUPS

A. Topsoil - brown silty sand with some organics.

B. Fill material - abundant rubble; glass, metal, plastics, and slag.

C. Inorganic subsoil - silty sand with quartz, shale, and rock fragments.

D. Inorganic subsoil - silty sand, fine-grained with some clay.

E. Peat - decomposed organic material.

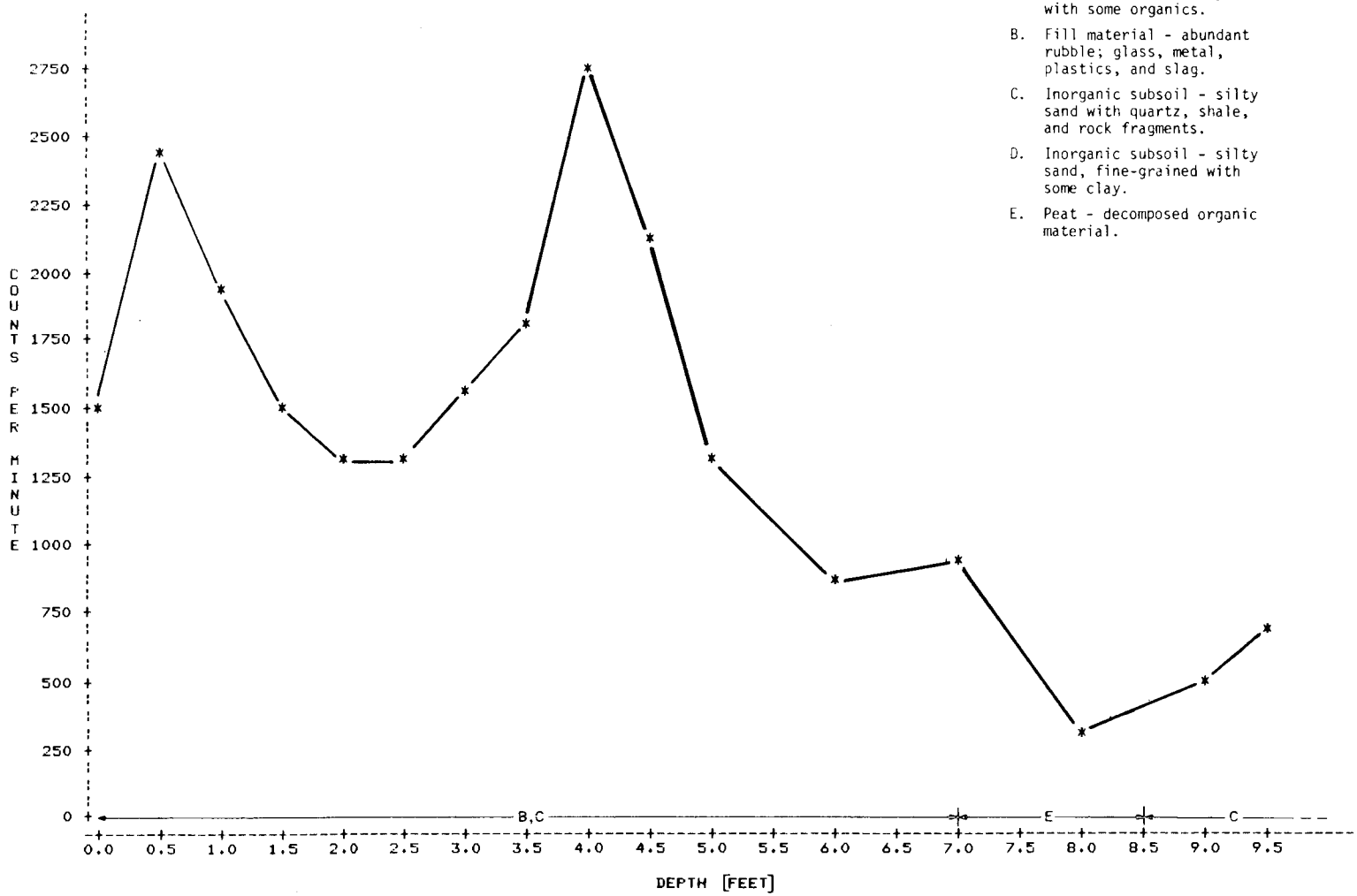

Fig. 18. Gamma-ray profile of Drill Hole 16.

ORNL-DWG 82-8506

FINBERG FIELD SOIL CODE GROUPS

A. Topsoil - brown silty sand with some organics.

B. Fill material - abundant rubble; glass, metal, plastics, and slag.

C. Inorganic subsoil - silty sand with quartz, shale, and rock fragments.

D. Inorganic subsoil - silty sand, fine-grained with some clay.

E. Peat - decomposed organic material.

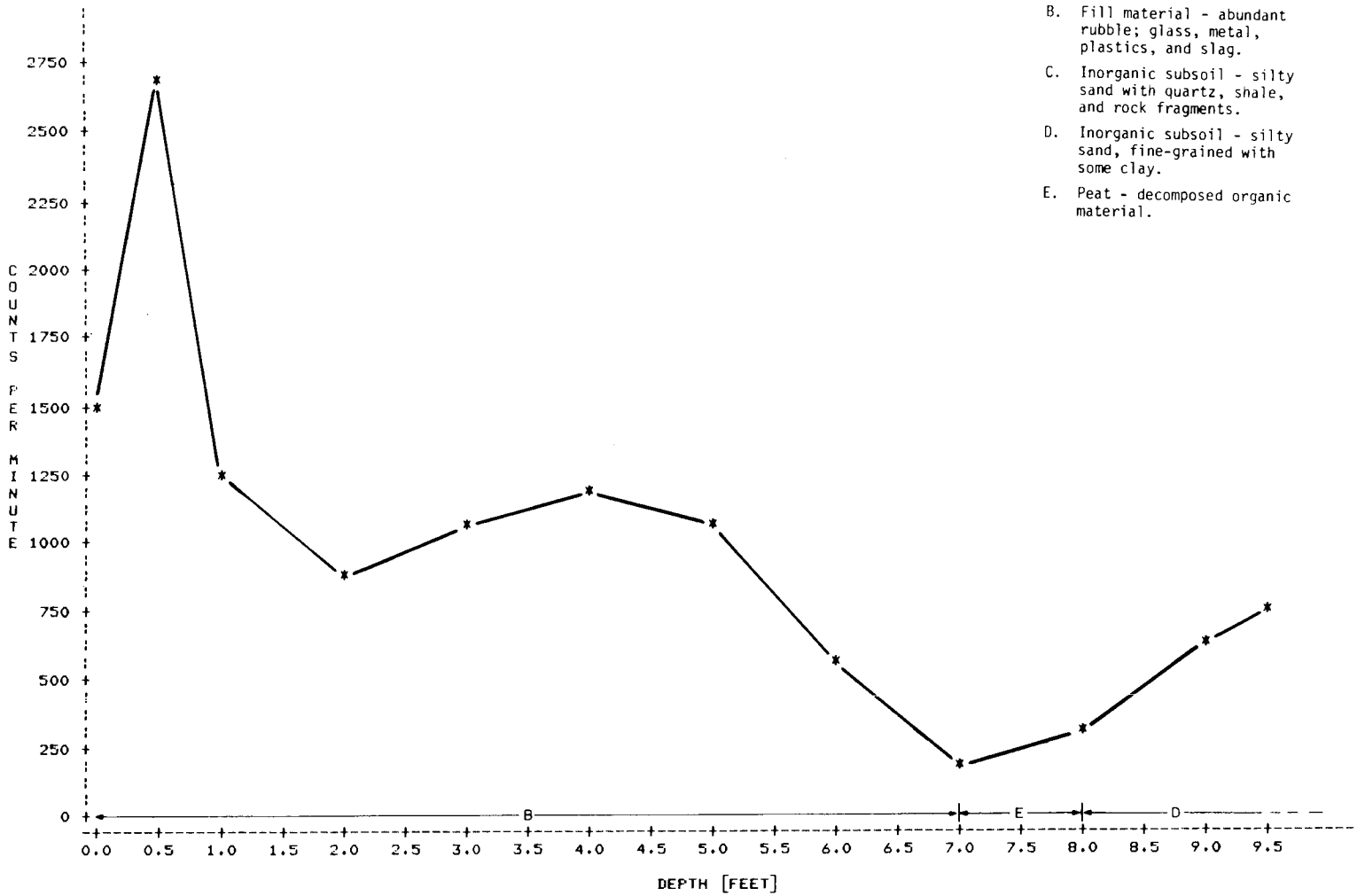

Fig. 19. Gamma-ray profile of Drill Hole 17.

ORNL-DWG 82-8507

FINBERG FIELD SOIL CODE GROUPS

A. Topsoil - brown silty sand with some organics.

B. Fill material - abundant rubble; glass, metal, plastics, and slag.

C. Inorganic subsoil - silty sand with quartz, shale, and rock fragments.

D. Inorganic subsoil - silty sand, fine-grained with some clay.

E. Peat - decomposed organic material.

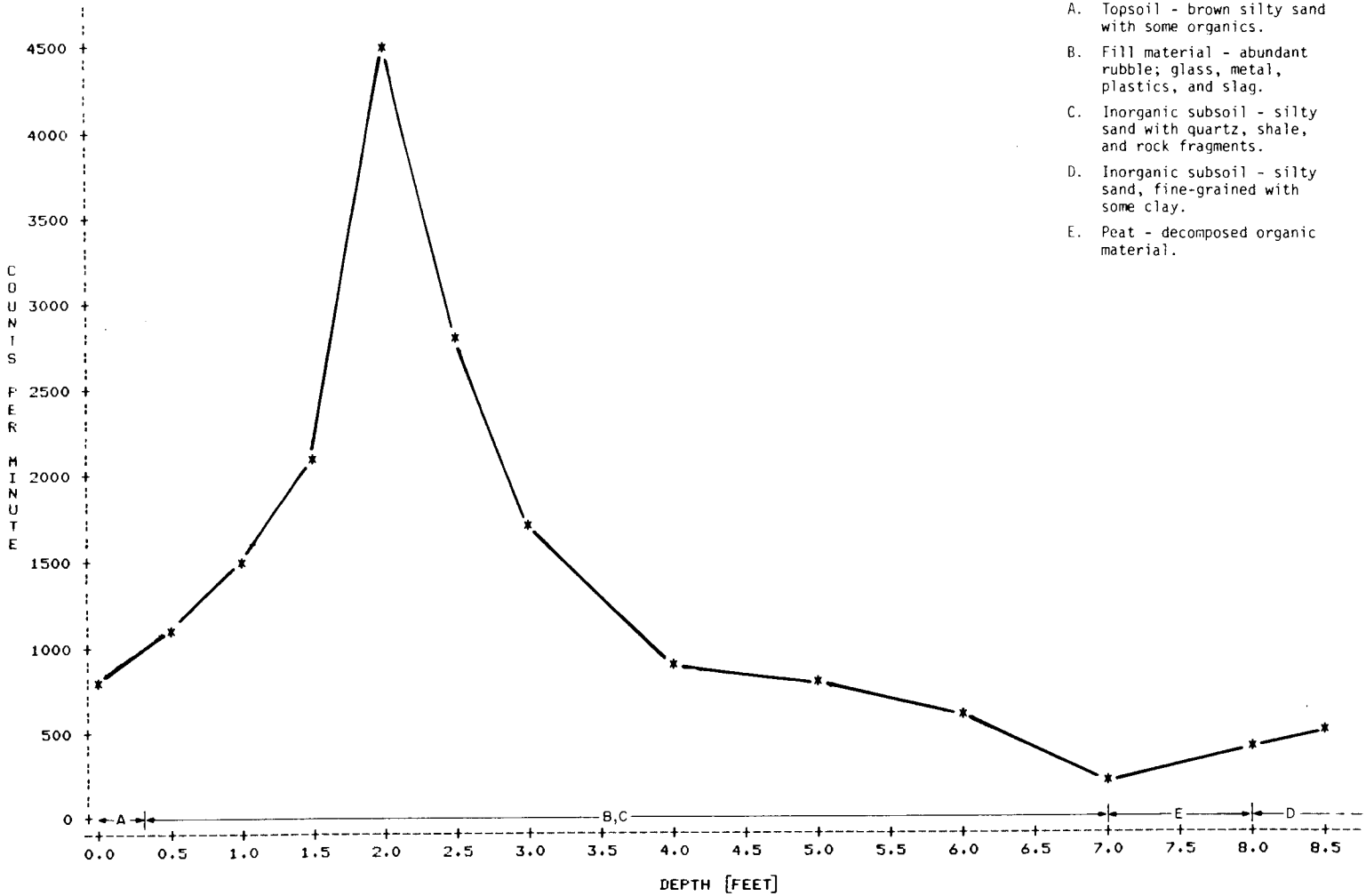

Fig. 20. Gamma-ray profile of Drill Hole 18.

ORNL-DWG 82-8508

FINBERG FIELD SOIL CODE GROUPS

A. Topsoil - brown silty sand with some organics.

B. Fill material - abundant rubble; glass, metal, plastics, and slag.

C. Inorganic subsoil - silty sand with quartz, shale, and rock fragments.

D. Inorganic subsoil - silty sand, fine-grained with some clay.

E. Peat - decomposed organic material.

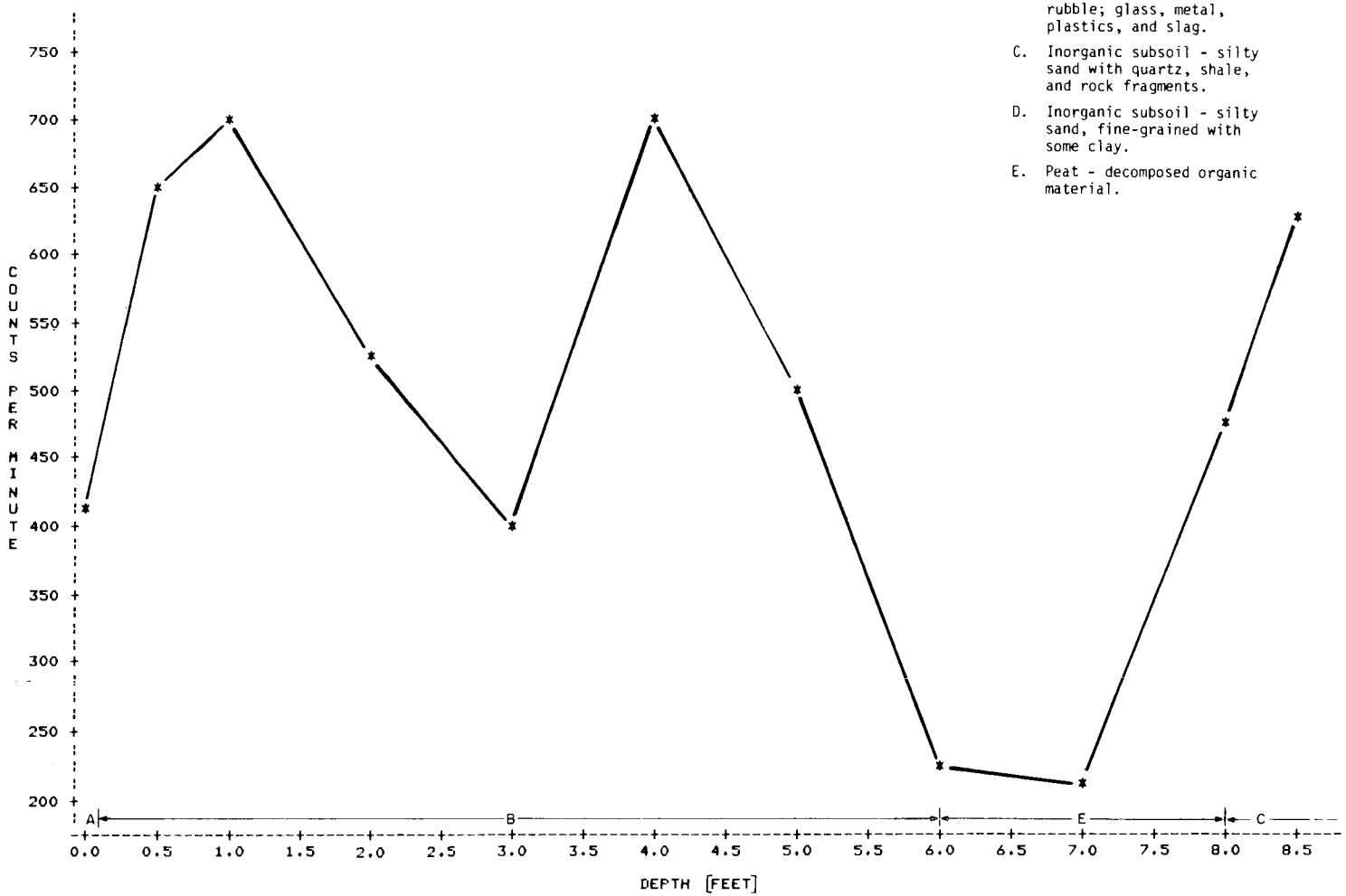

Fig. 21. Gamma-ray profile of Drill Hole 19.

ORNL-DWG 82-8509

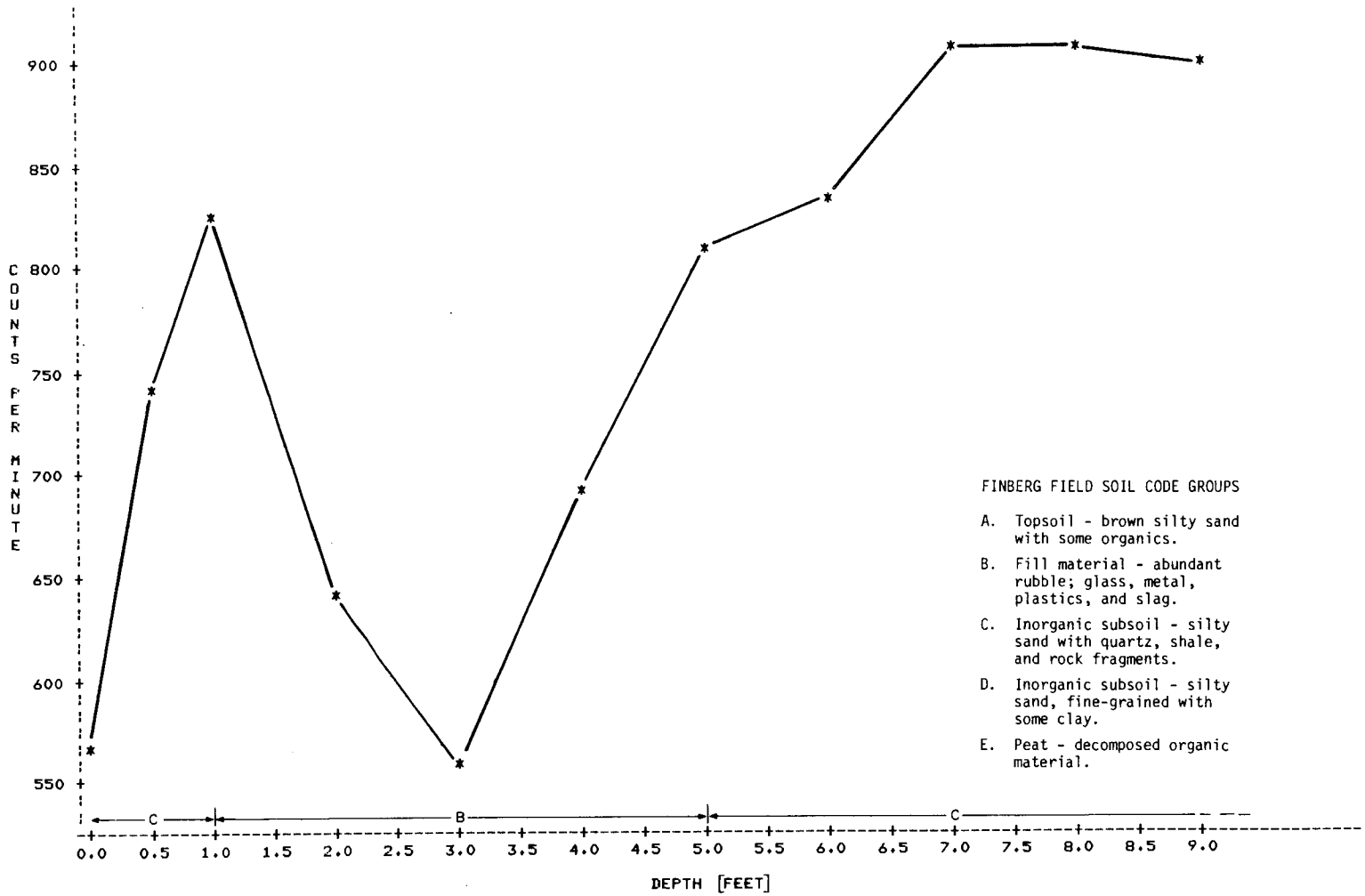

Fig. 22. Gamma-ray profile of Drill Hole 20.

ORNL-DWG 82-8510

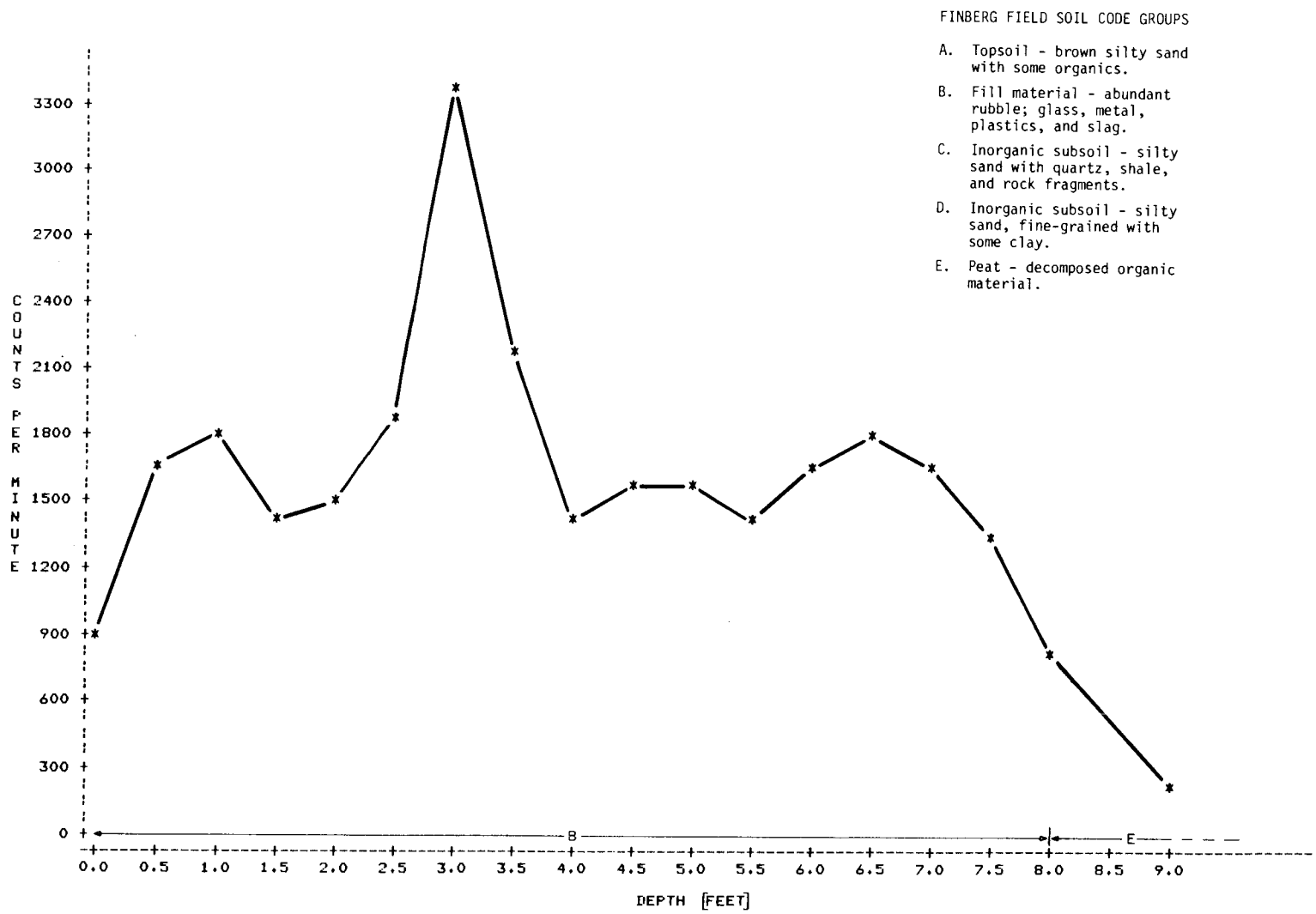

Fig. 23. Gamma-ray profile of Drill Hole 21.

ORNL-DWG 82-8511

FINBERG FIELD SOIL CODE GROUPS

A. Topsoil - brown silty sand with some organics.

B. Fill material - abundant rubble; glass, metal, plastics, and slag.

C. Inorganic subsoil - silty sand with quartz, shale, and rock fragments.

D. Inorganic subsoil - silty sand, fine-grained with some clay.

E. Peat - decomposed organic material.

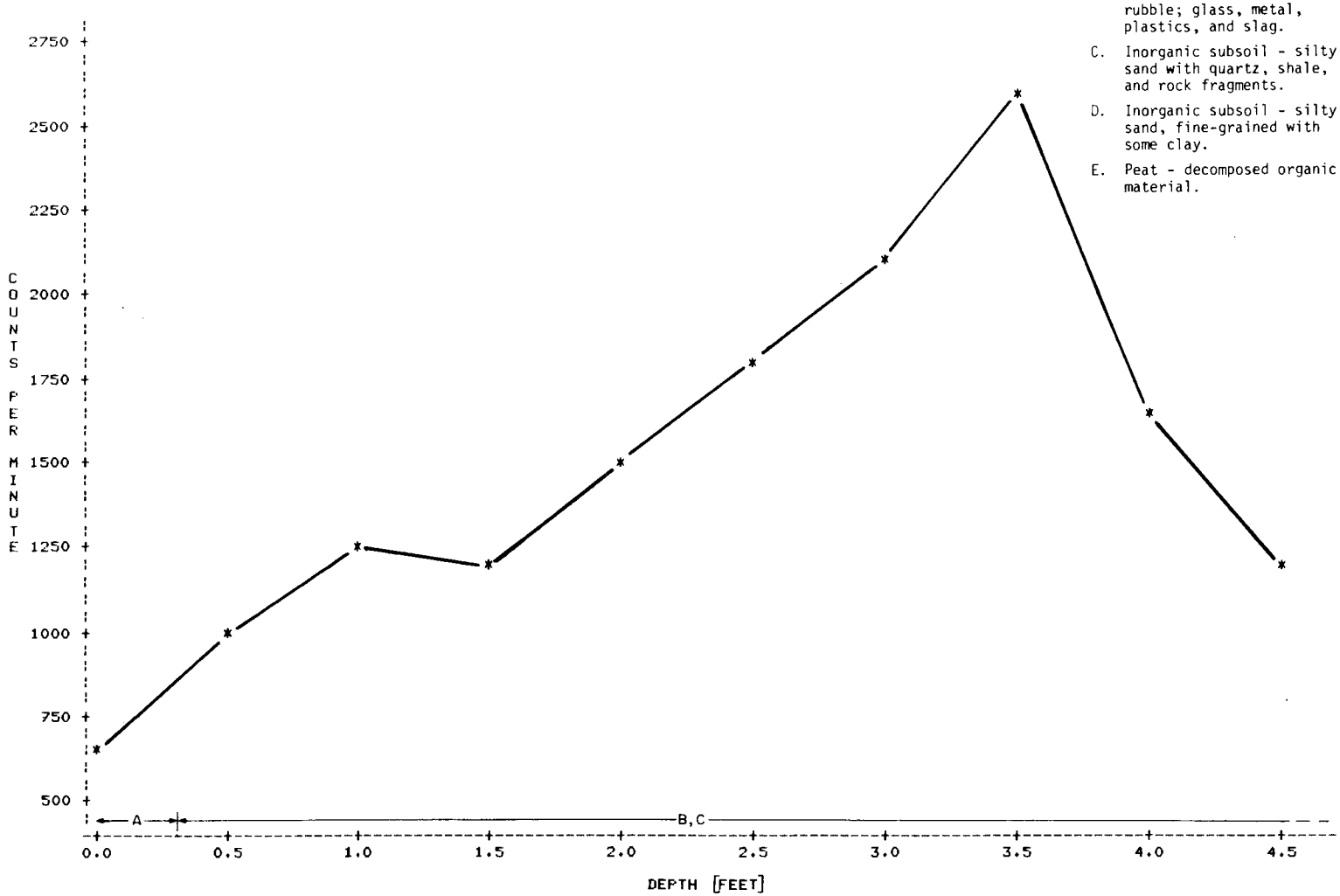

Fig. 24. Gamma-ray profile of Drill Hole 22.

ORNL-DWG 82-8512

FINBERG FIELD SOIL CODE GROUPS

A. Topsoil - brown silty sand with some organics.

B. Fill material - abundant rubble; glass, metal, plastics, and slag.

C. Inorganic subsoil - silty sand with quartz, shale, and rock fragments.

D. Inorganic subsoil - silty sand, fine-grained with some clay.

E. Peat - decomposed organic material.

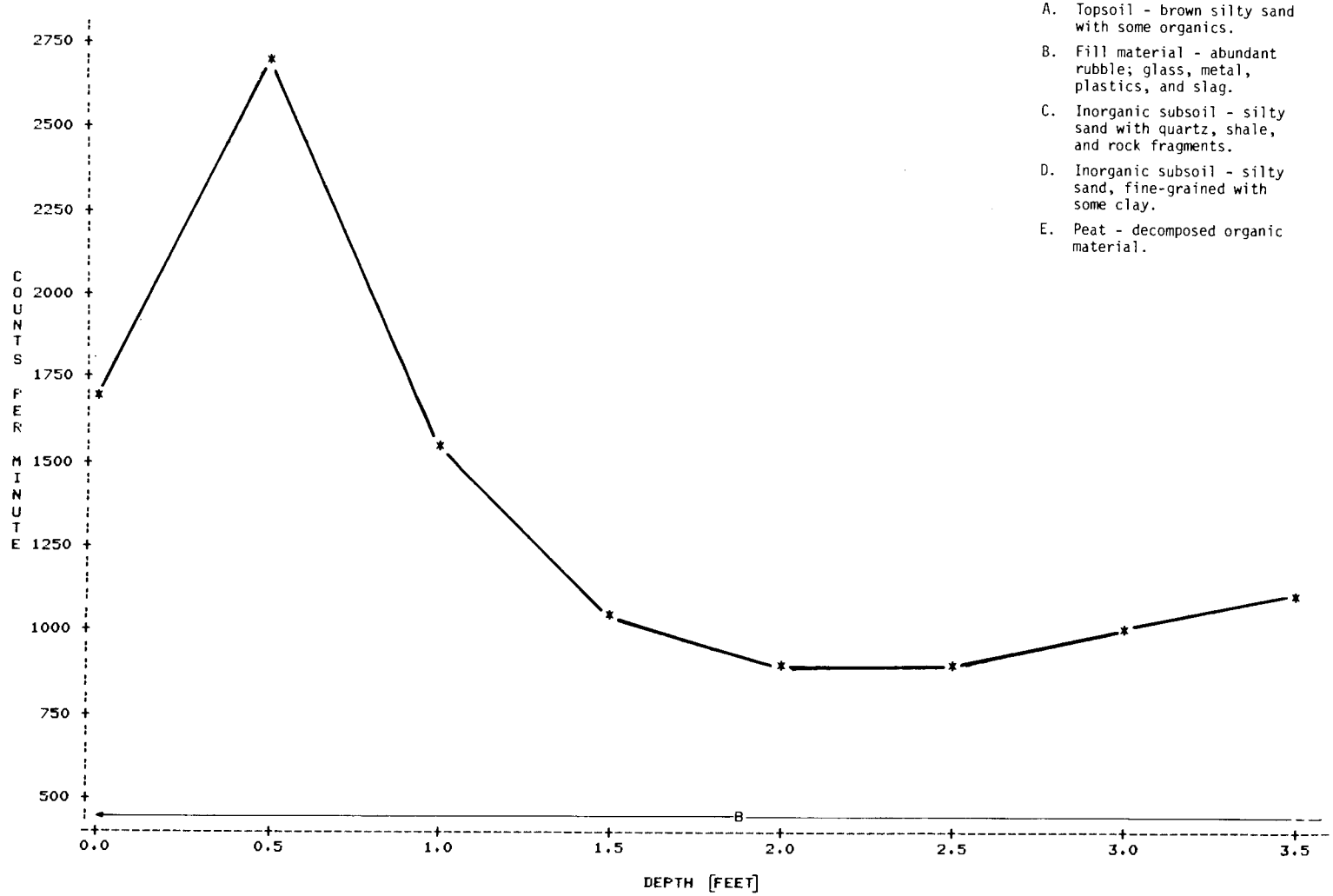

Fig. 25. Gamma-ray profile of Drill Hole 23.

ORNL-DWG 82-8513

FINBERG FIELD SOIL CODE GROUPS

A. Topsoil - brown silty sand with some organics.

B. Fill material - abundant rubble; glass, metal, plastics, and slag.

C. Inorganic subsoil - silty sand with quartz, shale, and rock fragments.

D. Inorganic subsoil - silty sand, fine-grained with some clay.

E. Peat - decomposed organic material.

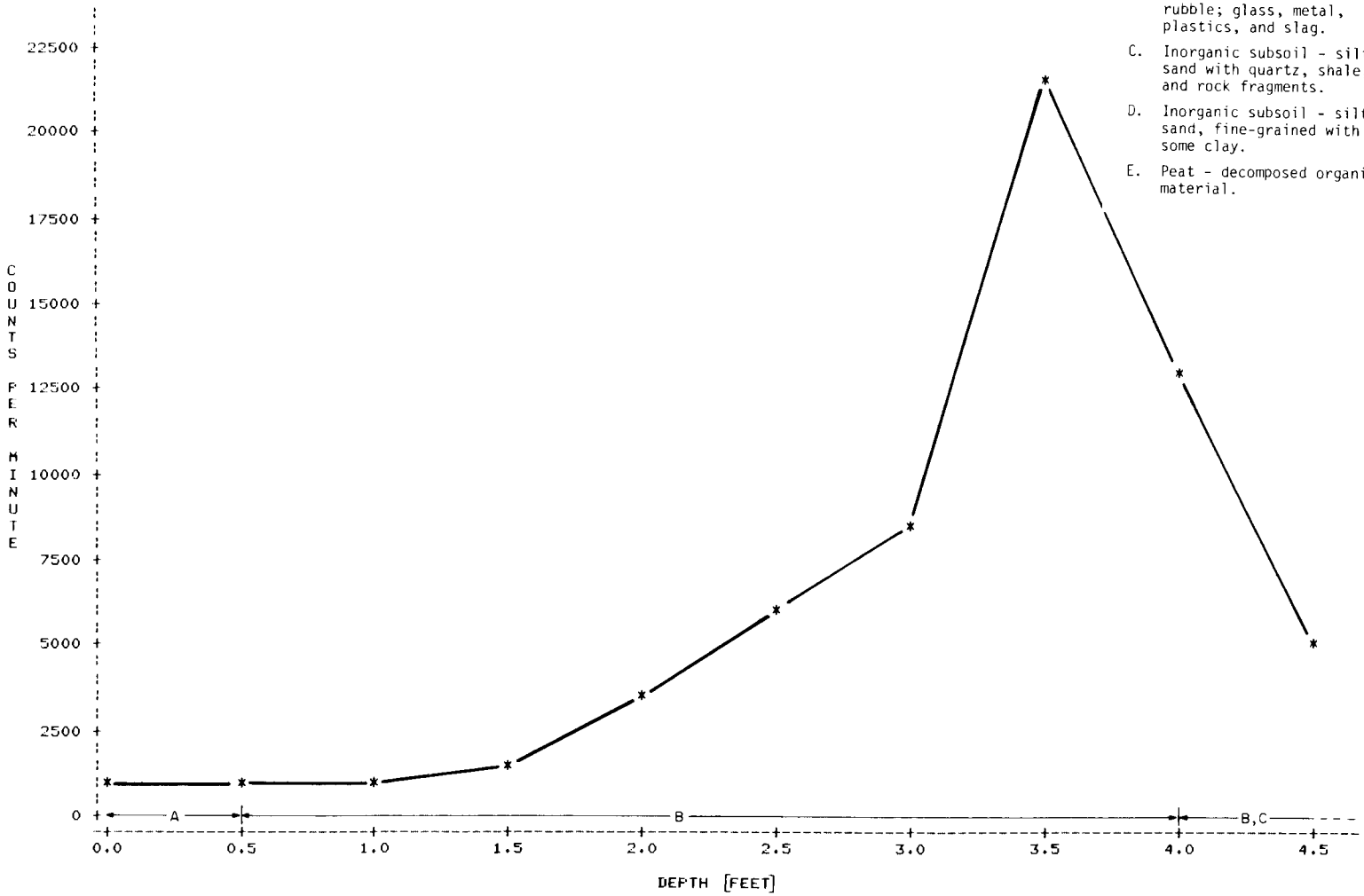

Fig. 26. Gamma-ray profile of Drill Hole 24.

ORNL-Photo 3081-81

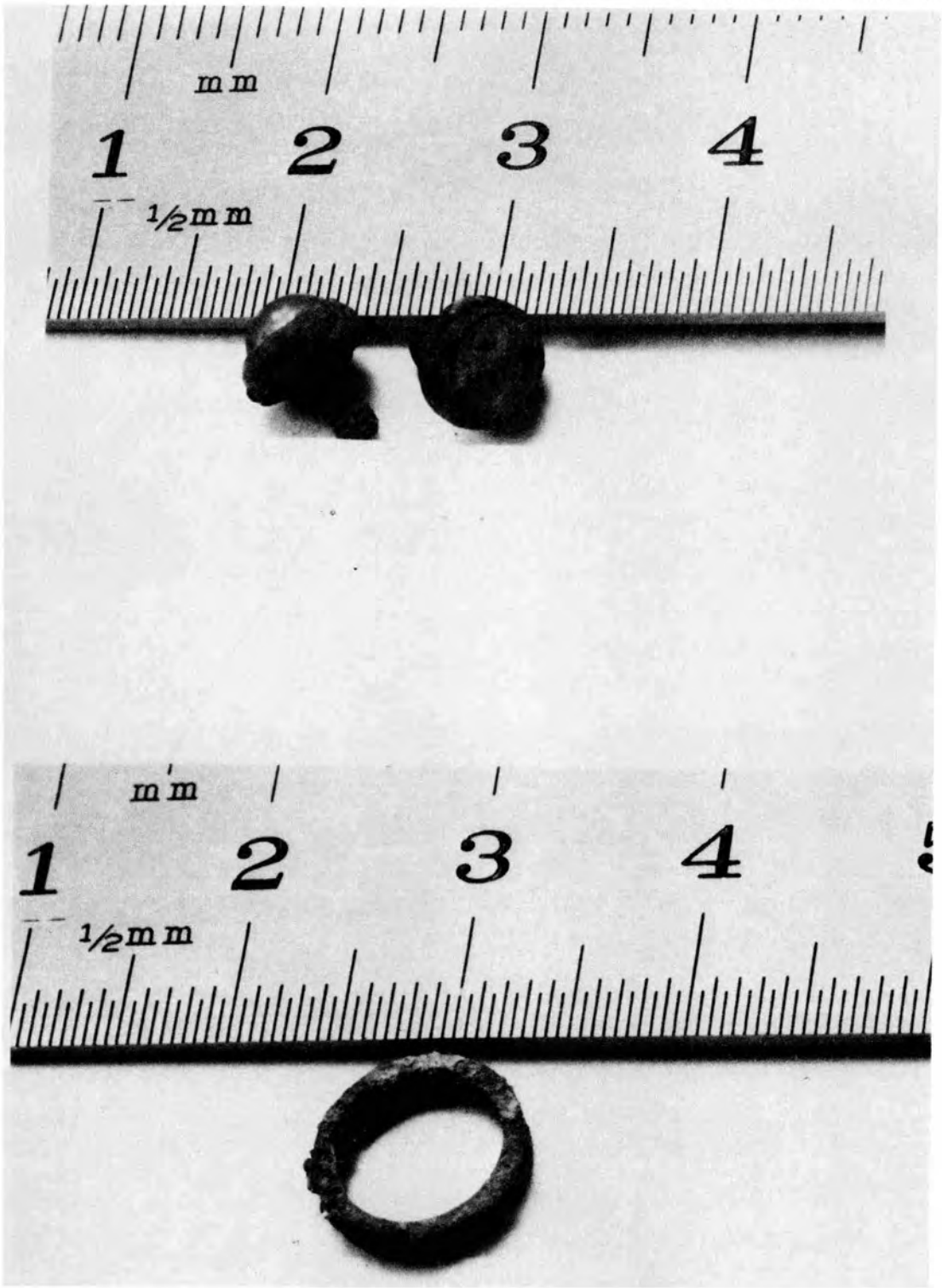

Fig. 27. View of two types of ^{226}Ra-bearing objects found in landfills in the Attleboro, Massachusetts, area.

Table 1. Coordinates of drill holes in Finberg Field Playground

Hole number	Angle[a]	Distance (ft)[a]
1	213° 45'	161
2	220° 15'	166
3	226° 15'	175
4	231° 45'	183
5	207° 15'	150
6	201° 00'	141
7	192° 45'	132
8	177° 15'	130
9	166° 00'	139
10	162° 15'	103
11	175° 30'	100
12	186° 30'	113
13	203° 30'	126
14	216° 00'	147
15	228° 00'	162
16	196° 00'	163
17	204° 30'	167
18	215° 00'	178
19	224° 15'	193
20	247° 30'	256
21	193° 15'	221
22	215° 00'	172
23	204° 00'	164
24	214° 00'	155

[a]Coordinates of drill holes are given in terms of angle (degrees and minutes), and distance (ft) from "set stake" (Fig. 2) which is 455.86 ft from center of Bishop St.

Table 2. Concentration of ^{226}Ra and ^{238}U in soil samples

Hole number	Depth of sample (ft)	^{226}Ra (pCi/g)[a]	^{238}U (pCi/g)[b]
1	3.0 - 3.5	2.7 ± 0.13	2.5
2	2.5 - 3.0	2.6 ± 0.04	1.4
3	@1.0	2.1 ± 0.34	2.4
4	@3.0	2.2 ± 0.05	2.3
5	@1.0	2.7 ± 0.05	1.2
6	2.0 - 3.0	2.4 ± 0.04	1.6
7	1.0 - 2.0	3.0 ± 0.04	2.8
8	2.0 - 3.0	6.9 ± 0.14	0.81
9	3.0 - 4.0	4.5 ± 0.18	2.3
10	4.0 - 5.0	2.6 ± 0.08	2.1
11	1.0 - 2.0	280 ± 4	1.1
12	2.0 - 3.0	3.5 ± 0.06	3.2
13	0.5 - 1.0	2.7 ± 0.02	2.2
14	@3.0	4.3 ± 0.09	2.1
15	1.0 - 2.0	2.0 ± 0.06	2.2
16	3.5 - 4.5	6.0 ± 0.13	1.2
17	0 - 1.0	0.68 ± 0.03	0.52
18	@2.0	3.9 ± 0.06	0.93
19	1.0 - 2.0	1.8 ± 0.04	1.4
20	1.0 - 2.0	0.99 ± 0.10	0.80
21	@3.0	3.0 ± 0.04	1.1
22	0 - 1.5	2.4 ± 1.8	1.6
	1.5 - 3.0	1.5 ± 0.03	1.7
	3.0 - 4.5	6.7 ± 0.73	1.0
23	0 - 1.5	3.5 ± 0.08	0.90
	1.5 - 2.5	[c]	[c]
	2.5 - 4.0	1.7 ± 0.03	1.4
	4.0 - 5.5	2.4 ± 0.09	1.6
24	0 - 1.5	0.93 ± 0.02	0.63
	1.5 - 2.5	2.5 ± 0.05	2.2
	2.5 - 4.0	1.8 ± 0.04	0.88

[a]Indicated counting error associated with these concentrations are two sigma (95% confidence level).

[b]Errors associated with these concentrations are ±3%.

[c] No sample taken.

Table 3. Concentration of ^{226}Ra, ^{238}U, ^{230}Th, and ^{210}Pb in water samples collected from drill holes

Hole number	Depth at which water was encountered (ft)	Concentration of radionuclide (pCi/L)[a]			
		^{226}Ra	^{238}U	^{230}Th	^{210}Pb
1	6.5	5.9 ± 2.2	<0.03	<1.9	2.7 ± 2.7
2	7.0	5.9 ± 2.2	<0.03	0.81 ± 0.54	1.1 ± 2.4
4	6.0	0.81 ± 1.1	<0.03	<1.1	5.7 ± 2.7
5	8.0	1.9 ± 1.1	<0.03	<1.4	2.2 ± 3.0
CGw[b]		30	40,000	2,000	100
EPA[c]		5			

[a]Indicated errors associated with these concentrations are two sigma (95% confidence level).

[b]Concentration guide for water, 10 CFR 20.

[c]Maximum contaminant level for ^{226}Ra and ^{228}Ra combined as given in 40 CFR 141.15.

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