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RADIOLOGICAL AND RCRA HAZARDOUS WASTE SCOPING SURVEY OF THE EAST END BASEMENT OF BUILDING 9204-1

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OPERATED BY
MARTIN MARIETTA ENERGY SYSTEMS, INC.
FOR THE UNITED STATES
DEPARTMENT OF ENERGY

ORNL/RAP-20

HEALTH AND SAFETY RESEARCH DIVISION

Nuclear and Chemical Waste Programs
(Activity No. GF 01 02 06 0)

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Date of Issue – March 1988

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Work performed as part of the
ENVIRONMENTAL ASSESSMENTS PROGRAM

Prepared by the
OAK RIDGE NATIONAL LABORATORY
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operated by
MARTIN MARIETTA ENERGY SYSTEMS, INC.
for the
U.S. DEPARTMENT OF ENERGY
under Contract No. DE-AC05-84OR21400

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ACKNOWLEDGMENTS

Research for this project was sponsored by the Operations Division of the Oak Ridge National Laboratory (ORNL) in support of the Remedial Action Program (RAP). The authors wish to acknowledge the support of L. D. Bates, RAP manager, T. W. Burwinkle, manager of the Maintenance, Surveillance and Corrective Actions Program (MS&CA), and R. E. Norman of the Site Corrective Measures Program (SCMP) at ORNL, and members of their staffs. The authors recognize the valuable contributions of D. A. Roberts, J. A. Roberts, and T. R. Stewart of the Environmental Assessments group and J. K. Williams of Environmental Information Systems, Health and Safety Research Division, for participation in reporting, graphics, and analysis of data for this survey. In addition, the authors appreciate the assistance with numerical data from T. L. Cox, graduate student, University of Tennessee.

ABSTRACT

An indoor radiological and hazardous waste scoping survey of the east end of the basement of Building 9204-1 (referred to in this report as the east end basement) was conducted in February 1987. The building is an Oak Ridge National Laboratory (ORNL) facility located in the south central portion of Y-12 in Bear Creek Valley. The purposes of the scoping survey were: (1) to identify levels of radioactive contamination and levels of hazardous waste [as defined by the Resource Conservation and Recovery Act (RCRA)] and (2) to determine if the concentrations of these contaminants dictate corrective actions for personnel exposure and/or surface contamination control.

The results show elevated gamma exposure rates ranging from 37 to 1300 μR/h in seven areas totaling ~33 m^2. Furthermore, significantly elevated alpha and beta-gamma activity levels on soil and structural surfaces were measured. The results of radionuclide analysis of soil samples from the areas demonstrated ^{228}Ra and ^{232}Th as equally dominant contaminants. The maximum concentration of each radionuclide was 1200 pCi/g, averaging 220 pCi/g in surface soil and 140 pCi/g in subsurface soil. The RCRA Extraction Procedure Toxicity Characteristic test for eight metals, four insecticides, and two herbicides was negative. Four RCRA hazardous waste characteristics (extraction procedure toxicity, ignitability, corrosivity, and reactivity) were not exhibited by soil samples taken at the survey site. Measurements of airborne radon decay products demonstrated the absence of an inhalation hazard from radon and its progeny. Recommendations, including suggested corrective actions, are given.

RADIOLOGICAL AND RCRA HAZARDOUS WASTE SCOPING SURVEY OF THE EAST END BASEMENT OF BUILDING 9204-1

INTRODUCTION

Building 9204-1 is located in the south central portion of the Y-12 weapons facility in Bear Creek Valley, Oak Ridge, Tennessee. The area of interest is the east end of the basement of the building (referred to in this report as the east end basement) where two sections of the dirt floor have been designated radiation zones and, as such, are roped off to restrict access. Each area measures ~7.5 x 7.5 m (25 x 25 ft) and is separated from the other by a concrete walkway ~1 m (3.2 ft) wide. Approximately 1.5 m (5 ft) above the dirt floor is a system of pipelines that had transported radioactive fluids from one section of the building to another during past processing activities. Elevated radiological measurements would be expected in association with the pipeline system, which is not within the scope of this survey report. The east end portion of the basement of Building 9204-1 is not known to have had any specific function although it has obviously been used for storage. Several views of the basement interior show the two roped-off regions, the overhead pipelines, and the miscellaneous clutter in several areas (Figs. 1 through 5). The source of the radiological contamination has not been verified. It has been reported that a leaking pump had, at one time, deposited a uranium solution from the first floor of the building onto the dirt floor of the basement.[1] Flooding of the areas has occurred during periods of heavy rainfall, arousing concern that environmental transport may cause contamination of adjacent land, surface, and groundwaters. Preliminary radiological characterization surveys have indicated contamination of the basement areas with low-level alpha emitters, with measurements as high as 2000 dpm/100 cm^2.[2] The east end basement of Building 9204-1 has been assigned Waste Area Group (WAG) number 15.0 as Solid Waste Management Unit (SWMU) 15A.3 by the Remedial Action Program (RAP) of the Oak Ridge National Laboratory (ORNL).

A radiological and hazardous waste scoping survey of the east end basement of Building 9204-1 was conducted in February 1987 by the Environmental Assessments group of the Health and Safety Research Division (HASRD) of ORNL at the request of the Maintenance, Surveillance and Corrective Actions (MS&CA) Program of ORNL.

The purpose of the interior scoping survey at this site was to determine what radioactive materials and Resource Conservation and Recovery Act (RCRA) hazardous wastes are present and to determine if their concentrations dictate corrective actions to prevent personnel exposure and/or redistribution of surface contamination. Specifically, the objectives of the survey were to determine the nature and extent of radiological contamination

and the nature and extent of hazardous waste as defined in RCRA by performing the following procedures: (1) measurement of gamma exposure rates throughout the site; (2) collection of surface (0-10 cm) and subsurface (10-25 cm) soil samples to identify types of radionuclides and RCRA hazardous waste at the site; (3) measurement of alpha and beta-gamma activity levels; (4) measurement of airborne radon progeny to identify the potential degree of hazard from these radiological contaminants; and (5) illustration of the areal extent of radiological contamination in conjunction with the Y-12 master grid coordinate system.

This report describes the results of the indoor scoping survey that will be used to determine whether the site is in compliance with applicable U.S. Environmental Protection Agency (EPA), U.S. Department of Energy (DOE), and State of Tennessee environmental and/or health regulations. A summary of the radiological measurements and analysis results, indexed to figures and tables, is presented in Table 1.

SURVEY METHODS

The radiological and RCRA hazardous waste scoping survey at this site included: (1) gamma exposure rates at grid point locations, 1 m above the ground surface and at the ground surface; (2) range of gamma exposure rates obtained during a scan of grid blocks; (3) direct and transferable alpha and beta-gamma activity measurements on surfaces; (4) sampling and analysis of soil from the basement floor; and (5) determination of indoor radon progeny concentrations.

For convenience in reporting results, the entire area to be surveyed was subdivided into 4.6-m (15-ft) grid block subsections, numbered from 1 through 22 as shown on Fig. 6. Additionally, the basement area was arbitrarily divided into Sections I through IV as indicated. Where appropriate, locations of grid points and soil samples corresponding to the intersections of north and east coordinates derived from the Y-12 master grid system are shown.

A comprehensive description of the survey methods and instrumentation is presented in *Procedures Manual for the ORNL Radiological Survey Activities (RASA) Program,* Oak Ridge National Laboratory, ORNL/TM-8600 (April 1987).[3]

SURVEY RESULTS

BACKGROUND AND REGULATORY LEVELS

Typical background radiation and chemical waste levels at ORNL sites vary because of past and present research and development activities, particularly those activities directly involved with radioactive materials and/or chemicals. However, background gamma exposure rates were obtained from 18 measurements taken in uncontaminated areas on the

Oak Ridge Reservation (Fig. 7). In addition, background concentrations of eight radionuclides were determined from soil samples collected at the locations of gamma measurements. These data are listed in Table 2 for comparison with the survey results presented in this section.

Guidelines and limits from several sources are referenced in support of establishing contamination levels at this site (Table 3). Indoor gamma levels and alpha and beta-gamma activity levels measured on interior surfaces are subject to ORNL Health Physics guidelines for establishing radiation control zones. The DOE guideline for internal radiation dose via exposure to airborne radon progeny (as adopted from the EPA, 40 CFR 192) is used herein for comparative purposes. Similarly, remedial action guidelines for surface and subsurface soil concentrations of several radionuclides have been developed for use in DOE's Formerly Utilized Sites Remedial Action Program (FUSRAP) (see Table 3, footnotes c, d, and e). Although these guidelines are not directly applicable for ORNL facilities, they may be useful as a general reference for contamination cleanup and waste control.

In 1980, the EPA, under Subtitle C of RCRA, established regulatory levels for certain metals and pesticides using the Extraction Procedure Toxicity Characteristic (EPTC) test.[4] If the regulatory levels are exceeded, discarded materials or contaminated soils must be managed as hazardous waste. Table 4 presents the maximum concentration of contaminants for the EPTC.

All measurements presented in this report are gross readings; background radiation levels have not been subtracted. Similarly, background concentrations have not been subtracted from radionuclide concentrations in soil samples.

GAMMA EXPOSURE RATE MEASUREMENTS

Accessible areas and structures were scanned with a portable gamma scintillation meter, and the range of gamma radiation levels was recorded. Measurements were also obtained at each grid point at 1 m above the surface and at the surface. Scintillation meter readings are in counts per minute (cpm). These measurements are converted to microroentgens* per hour (μR/h) using the formula:

$$y = x/\mathrm{CF}$$

where

y = the exposure rate in μR/h,

x = the scintillometer measurements in counts per minute (cpm),

CF = the conversion factor determined in the field through a direct correlation between a selected number of Pressurized Ionization Chamber (PIC) measurements and scintillometer measurements.

For this site, where x is less than or equal to 19 thousand cpm (kcpm), CF = 405. Where x is equal to or greater than 20 kcpm, CF = 457.

*The roentgen (R) is a unit that was defined for radiation protection purposes for people exposed to penetrating x rays or gamma radiation. A microroentgen (μR) is one millionth of a roentgen. A milliroentgen (mR) is one thousandth of a roentgen or one thousand microroentgens.

Results of grid point/grid block gamma exposure rate measurements taken in the east end basement of Building 9204-1 are presented in Table 5.

Gamma exposure rates at 1 m above the ground surface ranged from 15 to 140 μR/h and averaged 46 μR/h. Gamma exposure rates at the ground surface at grid points ranged from 11 to 120 μR/h and averaged 45 μR/h. The range of exposure rates was 10 to 1300 μR/h during the scan of the grid blocks. Gamma levels were generally elevated on contact with the overhead pipelines, ranging from 15 to 1600 μR/h.

The seven regions of elevated gamma exposure rates (A through G) and their respective areas of contamination are shown in Fig. 8. The system of overhead pipelines is also indicated. Sections III and IV had previously been posted with radiation hazard tags. Areas of elevated gamma levels found during this survey in these Sections as well as in Section II may be characterized as follows.

Section II: Regions A and B were found to have gamma exposure rate measurements ranging from 88 to 440 μR/h and 37 to 66 μR/h, respectively. The total areas of contamination encompass ~6 m^2 and ~3 m^2, for A and B, respectively. Access to Section II was unrestricted at the time of the survey.

Section III: Regions D and E in grid block 13 encompass ~3.3 and 1.4 m^2, respectively. Elevated gamma exposure rates in Region D ranged from 88 to 1300 μR/h while Region E registered 66 to 240 μR/h on the scintillation meter. Regions F and G in grid block 17 encompass ~2.3 and 14 m^2 with gamma exposure rates of 88 to 180 μR/h and 88 to 390 μR/h, respectively.

Section IV: Region C (~5.2 m^2) had gamma exposure rates ranging from 110 to 220 μR/h.

SURFACE MEASUREMENTS

Directly measured and transferable alpha and beta-gamma activity levels were determined in the locations shown on Fig. 9. The results are listed in Table 6. Direct alpha activities ranged from 90 to 7400 dpm/100 cm^2 and averaged 1200 dpm/100 cm^2. The highest reading (7400 dpm/100 cm^2) was found near grid point 9. Directly measured alpha contamination levels ranged from 170 to 4800 dpm/100 cm^2 on the overhead pipelines.

Beta-gamma dose rates were measured on the ground surface using a portable side-window Geiger-Mueller (G-M) survey meter. Direct beta-gamma measurements ranged from 0.02 to 0.48 millirad* per hour (mrad/h), averaging 0.08 mrad/h.

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*The rad is the unit of absorbed dose and is defined as the amount of radiation required to cause absorption of 100 ergs per gram of medium. (The erg is a unit of energy. One erg in the form of heat will raise the temperature of 1 gram of water about 2.4 x 10^{-8}°C.) A millirad (mrad) is one thousandth of a rad.

Transferable alpha activity levels were a maximum of 117 dpm/100 cm^2 in measurements obtained on structural and ground surfaces as well as on the pipelines above. Three of 15 measurements taken on the ground surface were above background. Removable beta-gamma activity levels were indistinguishable from background at ground level, ranging to 170 dpm/100 cm^2 on the pipelines.

RADON PROGENY MEASUREMENTS

Airborne radon progeny concentrations were measured by pumping air through a filter for 10-min intervals at approximately 24 L/min. The filters, on which particulate radon decay products attached to airborne dust had collected, were counted in an alpha spectrometer. The concentrations of ^{218}Po, ^{214}Pb, and ^{214}Bi (the progeny of ^{222}Rn, itself a decay product of ^{226}Ra) were calculated from the results. The data were then converted to number of working levels (WL).* The results show that the progeny of ^{222}Rn were present at a level of 0.0015 WL. It should be noted that measurements made over a brief period of time often do not reflect average annual conditions. Furthermore, these levels may undergo drastic fluctuations because of changes in the building's ventilation rate and disturbances from mechanical or human activities.

SOIL SAMPLING — RADIONUCLIDES

Twenty-four soil samples were taken from 14 locations at depths of 0 to 10 cm (surface) and 10 to 25 cm (subsurface). Soil sampling locations with regions of elevated gamma exposure rates are shown in Fig. 10, and the results of soil sample analysis (gamma-ray spectrometry) are presented in Table 7. The concentrations [picocuries† per gram (pCi/g)] of seven radionuclides are listed. The results for ^{137}Cs, ^{40}K, ^{211}Pb, ^{226}Ra, ^{228}Ra, ^{232}Th, and ^{234}Th are given in Table 7. Background concentrations of six radionuclides (^{137}Cs, ^{40}K, ^{226}Ra, ^{228}Ra, ^{232}Th, and ^{234}Th) as determined for uncontaminated locations on the Oak Ridge Reservation are provided in Table 2 for comparison with these survey results.

The range and average concentration values [values greater than the minimum detectable activity (MDA)] for each radionuclide are as follows:

Cesium-137 concentrations in soil ranged from 0.012 to 0.89 pCi/g and averaged 0.24 pCi/g, with the maximum value measured in sample 1B (area A).

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*The working level (WL) is a unit that was defined for radiation protection purposes for uranium miners. A WL is any combination of short-lived radon decay products in one liter of air that will result in the ultimate emission of 1.3 x 10^5 MeV of potential alpha particle energy. This is equal to the concentration of the short-lived decay products in equilibrium with 100 pCi/L of ^{222}Rn.

†The curie (Ci) is a unit used to define the radioactivity in a substance and equals that quantity of any radioactive isotope undergoing 2.2 x 10^{12} disintegrations per minute. The picocurie is one million-millionth of a curie, or that amount yielding 2.2 disintegrations per minute.

Potassium-40 concentrations in soil ranged from 7.7 to 26 pCi/g and averaged 14 pCi/g. The maximum value, 26 pCi/g, was found in soil sample 2B from area A and in sample 8 (Section III).

Lead-211 was found in concentrations ranging from 41 to 69 pCi/g, averaging 55 pCi/g in three samples (2B, 7A, and 7B). The maximum value (69 pCi/g) was shown in sample 7A taken from the surface in area G.

Radium-226 concentrations in soil ranged from 0.14 to 2.3 pCi/g and averaged 0.84 pCi/g. The maximum concentration of ^{226}Ra (2.3 pCi/g) was identified in soil sample 5A collected from area E.

Radium-228 concentrations in soil ranged from 0.40 to 1200 pCi/g and averaged 190 pCi/g. Soil sample 4A (Area D) was found to contain the maximum value (1200 pCi/g). The average concentration at a depth of 0 to 10 cm was 220; the average at 10 to 25 cm was 140.

Thorium-232 concentrations in soil ranged from 0.39 to 1200 pCi/g and averaged 190 pCi/g. The maximum concentration of ^{232}Th (1200 pCi/g) was identified in soil sample 4A obtained from contaminated area D. Average concentrations at surface and subsurface depths were 220 and 140 pCi/g, respectively.

Thorium-234 concentrations in soil ranged from 0.71 to 51 pCi/g and averaged 12 pCi/g. The maximum concentration of ^{234}Th (51 pCi/g) was identified in soil sample 4B, area D.

The maximum values of the seven radionuclides were found in soil from areas A, B, D, E, and G, and in samples from both the surface (5 values) and subsurface (5 values). Where direct comparisons were possible, values found in surface soil generally exceeded those found at subsurface depths. This situation is particularly evident when comparing the values for ^{228}Ra and ^{232}Th. The average concentrations for the two dominant radionuclides (^{228}Ra and ^{232}Th) were 220 pCi/g in surface samples and 140 pCi/g in samples from 10 to 25 cm.

The highest to lowest mean concentrations of radionuclides and their values in the 24 soil samples are: ^{228}Ra (190 pCi/g), ^{232}Th (190 pCi/g), ^{211}Pb (55 pCi/g), ^{40}K (14 pCi/g), ^{234}Th (12 pCi/g), ^{226}Ra (0.84 pCi/g), ^{137}Cs (0.24 pCi/g).

The concentrations of ^{235}U and ^{238}U in 24 surface and subsurface soil samples as determined by neutron activation analysis are presented in Table 8. Uranium-235 concentrations in the soil ranged from 0.048 to 26 pCi/g and averaged 2.4 pCi/g. Concentrations as high as 26 pCi of ^{235}U per gram of soil were found in surface soil from hole #6, near region E. Uranium-238 concentrations in soil ranged from 0.77 to 49 pCi/g and averaged 6.5 pCi/g. The maximum concentration of ^{238}U (49 pCi/g) was identified in surface soil from hole #11, area C. Concentrations of both radionuclides were generally higher in surface than in subsurface soil.

SOIL SAMPLING — RCRA HAZARDOUS WASTE

The Resource Conservation and Recovery Act, as enacted by Congress in 1976, gave EPA the statutory authority to promulgate specific regulations governing the disposal of solid and hazardous wastes.[5] The first major codification in the *Code of Federal Regulations* was in 1980, and in 1984 substantial amendments were added that provided more detail and specific requirements. Effective October 25, 1986, ORNL was granted a permit by the Tennessee Department of Health and Environment, Division of Solid Waste Management, authorizing the storage of hazardous waste at the Hazardous Waste Storage Facility, Building 7652.[6] Issuance of this permit is in accordance with the Tennessee Hazardous Waste Management Act.

Two mechanisms were established for identifying a solid waste as hazardous: (1) an EPA hazardous waste list and (2) a set of EPA-defined hazardous waste characteristics. A solid waste not listed as a hazardous waste is deemed hazardous if it exhibits one of four characteristics: extraction procedure (EP) toxicity, ignitability, corrosivity, or reactivity.

EP Toxicity

The EP toxicity characteristic was designed to identify wastes that may leach hazardous concentrations of specific toxic constituents (see Table 4). EPA testing protocol requires leaching a sample of solid waste with an acetic acid solution (pH 5.0 $\pm$ 0.2) for 24 h and then testing the extract for contaminants identified in the Safe Drinking Water Act. Waste displays the EP toxicity characteristic if it exhibits concentrations of a toxic constituent 100 times those stated in the National Interim Primary Drinking Water Standards (DWS).

Table 9 gives the results of the EP toxicity test for eight RCRA metals (arsenic, barium, cadmium, chromium, lead, selenium, silver, and mercury) in nine soil samples. All contaminant values are well below the maximum concentration for the EP toxicity characteristic. Table 10 shows the results of the EP toxicity test for four RCRA insecticides and two herbicides [Lindane, Endrin, Toxaphene, Methoxychlor, 2,4-D, and 2,4,5-TP (Silvex)]. All values are well below those given in Table 4 for the maximum concentration of contaminants for characteristic of EP toxicity.

Ignitability

A solid waste displays the characteristic of ignitability if it meets one of four criteria.

1. It is a liquid (other than an aqueous solution containing <24% alcohol by volume) with a flash point <60°C (140°F).
2. It is a nonliquid that under normal conditions can cause fire through friction, absorption of moisture, or spontaneous chemical changes, and it burns so vigorously when ignited that it creates a hazard.
3. It is an ignitable compressed gas [as defined by U.S. Department of Transportation (DOT) regulations in 49 CFR 173.300].
4. It is an oxidizer (as defined by DOT regulations in 49 CFR 173.151).

The ignitability characteristic of seven biased soil samples is shown in Table 11. For all soil samples tested, the flash point was >70°C, which is in compliance with the above-stated criteria.

Corrosivity

A solid waste displays the characteristic of corrosivity if it meets one of two criteria.

1. It is aqueous and has a pH of ≤2.0 or ≥12.5.
2. It corrodes steel at a rate of >6.35 mm (0.250 in.) per year at a test temperature of 55°C (130°F).

Table 11 shows the corrosivity characteristic of nine soil samples. The pH ranged from 6.69 (sample 1A, area A) to 8.55 (2A, area A), and the average pH was 7.71 (slightly basic). These values indicate that the soil samples do not display the corrosivity characteristic.

Reactivity

The characteristic of reactivity is exhibited if wastes are extremely unstable, to the point of reacting violently or exploding during stages of waste management (e.g., when mixed with water or heated), or if wastes are cyanide- or sulfide-bearing and can generate toxic gases, vapors, or fumes when exposed to pHs between 2 and 12.5.

The nine soil samples listed in Table 11 were tested for the presence of sulfide and cyanide. For all samples tested, sulfide was <1.0 mg/g, and cyanide was <2.0 μg/g. Until EPA has determined specific limiting concentration levels for reactive cyanide and sulfide in solid wastes, interim guidelines currently requiring EPA action are available.[7] These levels are 250 and 500 mg/kg of waste for total releasable cyanide (HCN) and total releasable sulfide (H_2S), respectively. These values indicate that the samples tested do not display the reactivity characteristic.

SIGNIFICANCE OF FINDINGS

Seven areas of elevated radiological measurements were identified in the east end basement of Building 9204-1. Measurements exceeding guidelines included directly measured alpha and beta-gamma activity levels on surfaces, and soil radionuclide concentrations. Transferable contamination levels were negligible, and measurements of airborne radon decay products demonstrated the absence of any radiological inhalation hazard from radon and its progeny. Testing for RCRA hazardous wastes was negative. The results for areas of the basement within the scope of this survey (i.e., excluding the overhead pipelines) are detailed below.

Measurements of gamma levels taken in the east end basement of Building 9204-1 determined that exposure rates at 1 m above the ground surface at grid points ranged from 15 to 140 μR/h and averaged 46 μR/h. Additionally, gamma exposure rates at the

ground surface at grid points ranged from 11 to 120 μR/h and averaged 45 μR/h. Gamma exposure rates were found to be elevated in seven separate regions of the site, ranging from 37 to 1300 μR/h. The total area of contamination was calculated to be ~33 m^2. By way of comparison, background gamma exposure rates (determined from 18 measurements taken at 9 locations in uncontaminated areas on the Oak Ridge Reservation) at 1 m above the ground surface averaged 10 μR/h and ranged from 8 to 13 μR/h; background gamma exposure rates at the ground surface averaged 13 μR/h and ranged from 10 to 17 μR/h.

The results of analysis to determine the concentrations of seven radionuclides, specifically ^{137}Cs, ^{40}K, ^{211}Pb, ^{226}Ra, ^{228}Ra, ^{232}Th, and ^{234}Th, in 24 soil samples show ^{228}Ra and ^{232}Th as the dominant detectable radionuclides. They were found to be present in approximately equal concentrations, suggesting secular equilibrium. Concentrations were higher in surface than in subsurface samples. The maximum (1200 pCi/g, found in sample 4A from area D) and overall average (190 pCi/g) concentrations of the two radionuclides were the same. Were the DOE surface soil remedial action guidelines applicable for this site, the surface ^{228}Ra and ^{232}Th maxima (1200 pCi/g) would exceed by a factor of 240 the generic criterion of 5 pCi/g for the radionuclides. The maximum concentration of ^{137}Cs, 0.89 pCi/g, measured in soil at a depth of 0 to 10 cm, may be compared to a maximum permissible concentration of 80 pCi/g over an area of 100 m^2. The maximum concentration of ^{238}U in surface soil on this site (49 pCi/g) was well below the criterion of 75 pCi/g.

Directly measured alpha activity levels ranged from 90 to 7400 dpm/100 cm^2, averaging 1200 dpm/100 cm^2, on soil and structural surfaces. Direct beta-gamma dose rates determined at the same locations ranged from 0.02 to 0.48 mrad/h, averaging 0.08 mrad/h. The ORNL guidelines for directly measured alpha and beta-gamma activity levels are 300 dpm/100 cm^2 and 0.25 mrad/h (averaged over 1 m^2), respectively. The average alpha value measured on soil and structural surfaces, 1200 dpm/100 cm^2, exceeds the guideline by a factor of 4. Although the average beta-gamma dose rate, 0.08 mrad/h, is well below the guideline value of 0.25 mrad/h, the maximum value (0.48 mrad/h) exceeds it.

One measurement of transferable alpha activity, 117 dpm/100 cm^2, exceeded the ORNL guideline value of 30 dpm/100 cm^2. It was identified in Section II (location 7B) to which access was unrestricted at the time of this survey. All other values were insignificant. All removable beta-gamma levels were indistinguishable from background.

Measurement of airborne radon progeny revealed ^{222}Rn decay products present at 0.0015 WL. This value demonstrates the absence of any radiological inhalation hazard from radon and its decay products. The guideline used by DOE in its remedial action assessment of formerly utilized sites is 0.03 WL.

The results of the Extraction Procedure Toxicity Characteristic test for seven RCRA metals (arsenic, barium, cadmium, chromium, selenium, silver, and mercury), four insecticides (Lindane, Endrin, Toxaphene, and Methoxychlor), and two herbicides [2,4-D and 2,4,5-TP (Silvex)] in seven soil samples indicate all contaminants were below their respective regulatory levels. Soil samples did not exhibit RCRA hazardous waste characteristics for ignitability, corrosivity, or reactivity.

RECOMMENDATIONS

Analyses of indoor radiological data from this scoping survey indicate a potential environmental and/or health hazard resulting primarily from the presence of significantly elevated concentrations of ^{228}Ra and ^{232}Th in the soil of which the basement floor is comprised. Although the site is not heavily trafficked nor easily accessible, we recommend removal of the contaminated soil. ORNL guidelines for surface contamination are exceeded on soil and structures in the basement, and the possibility of environmental transport of the contaminated soil strengthens our recommendation that the current situation warrants attention. Furthermore, radionuclide concentrations in the soil exceed FUSRAP values promulgated by DOE. As is stated by DOE with respect to these guidelines, "every reasonable effort shall be made to remove any source of radionuclide that exceeds 30 times the appropriate soil limit irrespective of the average concentration in the soil." On this site, the guideline value of 5 pCi/g for ^{232}Th and ^{228}Ra in surface soil is exceeded by the average concentrations (220 pCi/g) by a factor of 44.

Currently, Sections III and IV are bounded by ropes on which "radiation hazard" tags are attached. Since the soil containing radioactive residuals in Sections II, III, and IV may easily be transferred to objects or to the soles of shoes, we suggest that they be posted as "contamination zones" until such time as remedial action is conducted. This type of tag is determined to be the most appropriate zoning sign based on ORNL guidelines (see Sect. 2.7 of the ORNL Health Physics Manual). Directly measured alpha contamination levels in Section II were found to range from 160 to 2200 dpm/100 cm^2. The only measurement of direct beta-gamma activity exceeding the ORNL standard was detected in Section II.

According to original estimates, corrective action would consist of the removal and disposal of ~28 m^3 (1000 ft^3) of soil.[2] This estimate was based on an assumption that removal of the top 20 cm of soil would eliminate the contamination and that the contamination was confined to Sections III and IV. However, Section II has been found to be contaminated, and the results of radionuclide analysis suggest that, in some areas, particularly in areas A, D, and G, the depth of removal should be increased (see Table 7, soil samples 2, 4, and 7).

No peripheral hazards that would impact remedial activities were noted other than the overhead, radioactive pipelines that will restrict free movement to some extent. Maneuverability of excavation and removal equipment may be hindered due to the confined nature of the area with the result that required safety precautions may be somewhat unwieldy. Other than the fact that contaminated soil presents both a redistribution and a potential inhalation hazard, no additional difficulty in ensuring proper health and safety protection for personnel is anticipated.

These recommendations are in accordance with the radiation safety policy of ORNL to conduct all operations in such a manner that personnel exposures to radiation or contamination are maintained at a level as low as is reasonably achievable (ALARA).

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7. U.S. Environmental Protection Agency, *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods: Lab Manual,* Vol. IC, 3rd Ed., EPA/SW-846, Office of Solid Waste and Emergency Response, Washington, D.C. (November 1986), Sects. 7.3.3.1 and 7.3.4.1.

ORNL-PHOTO 8097-87

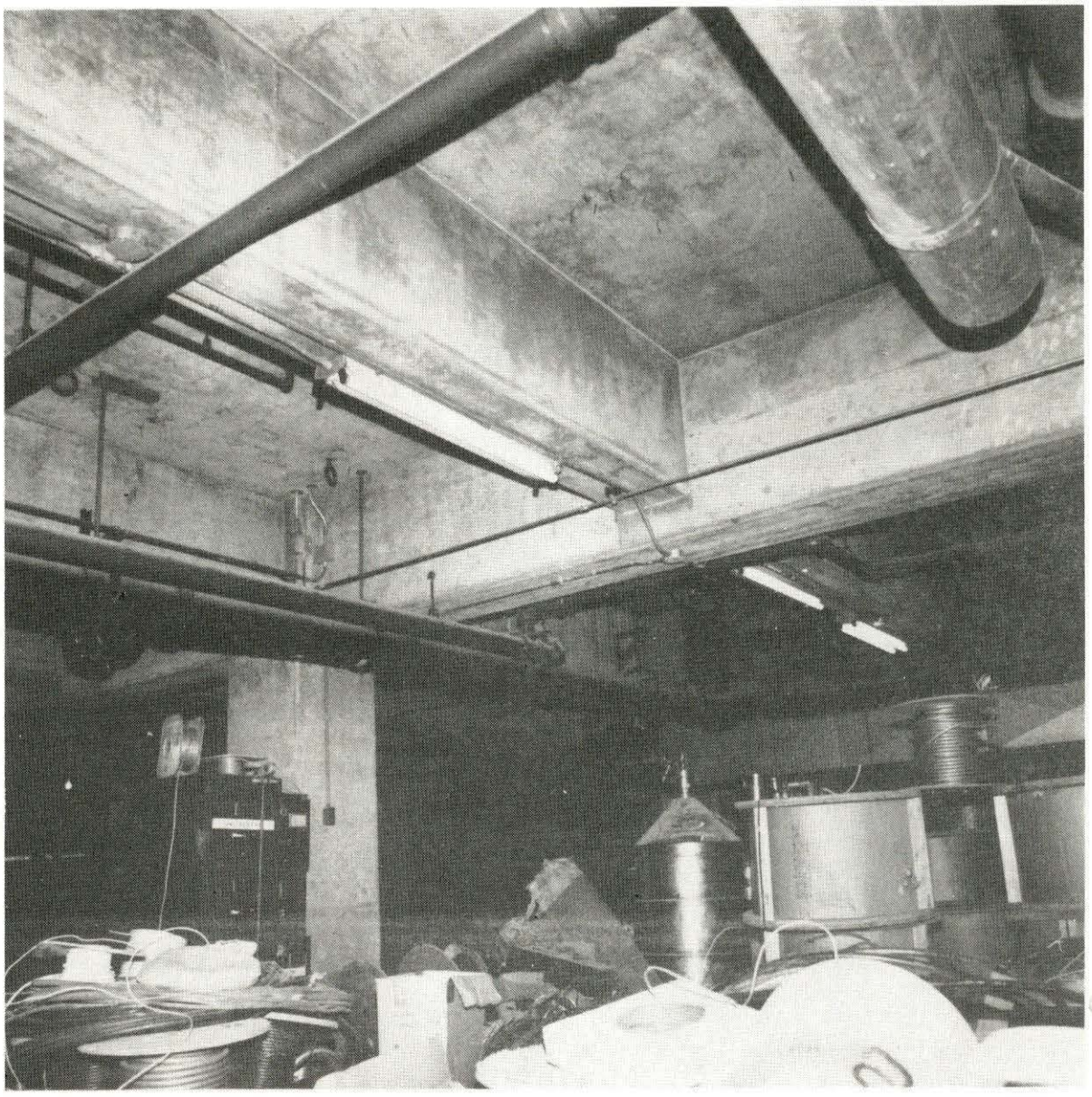

Fig. 1. East end basement of Building 9204-1, looking northeast into Section I.

ORNL-PHOTO 8095-87

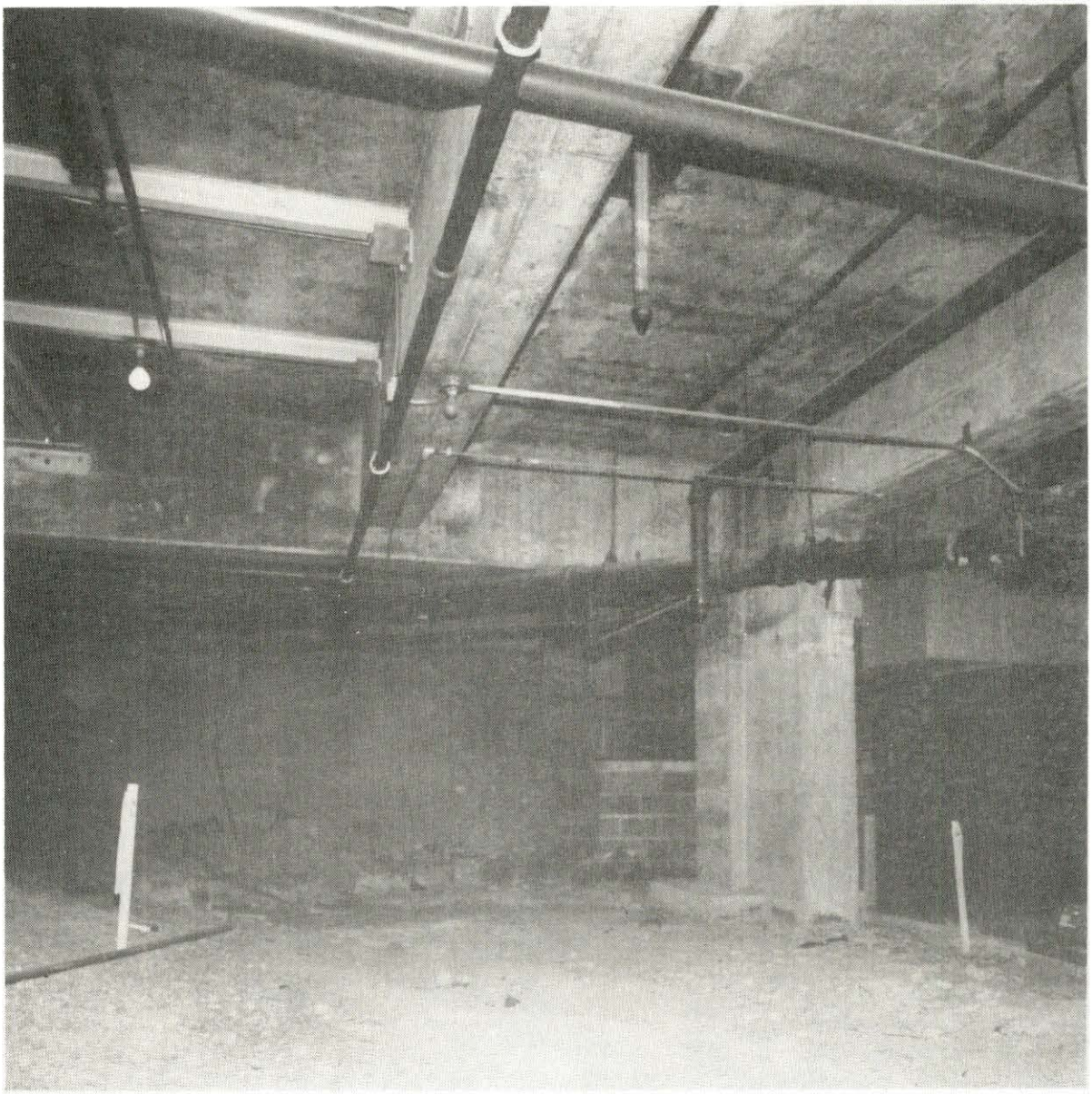

Fig. 2. East end basement of Building 9204-1, looking north into Section II.

ORNL-PHOTO 8092-87

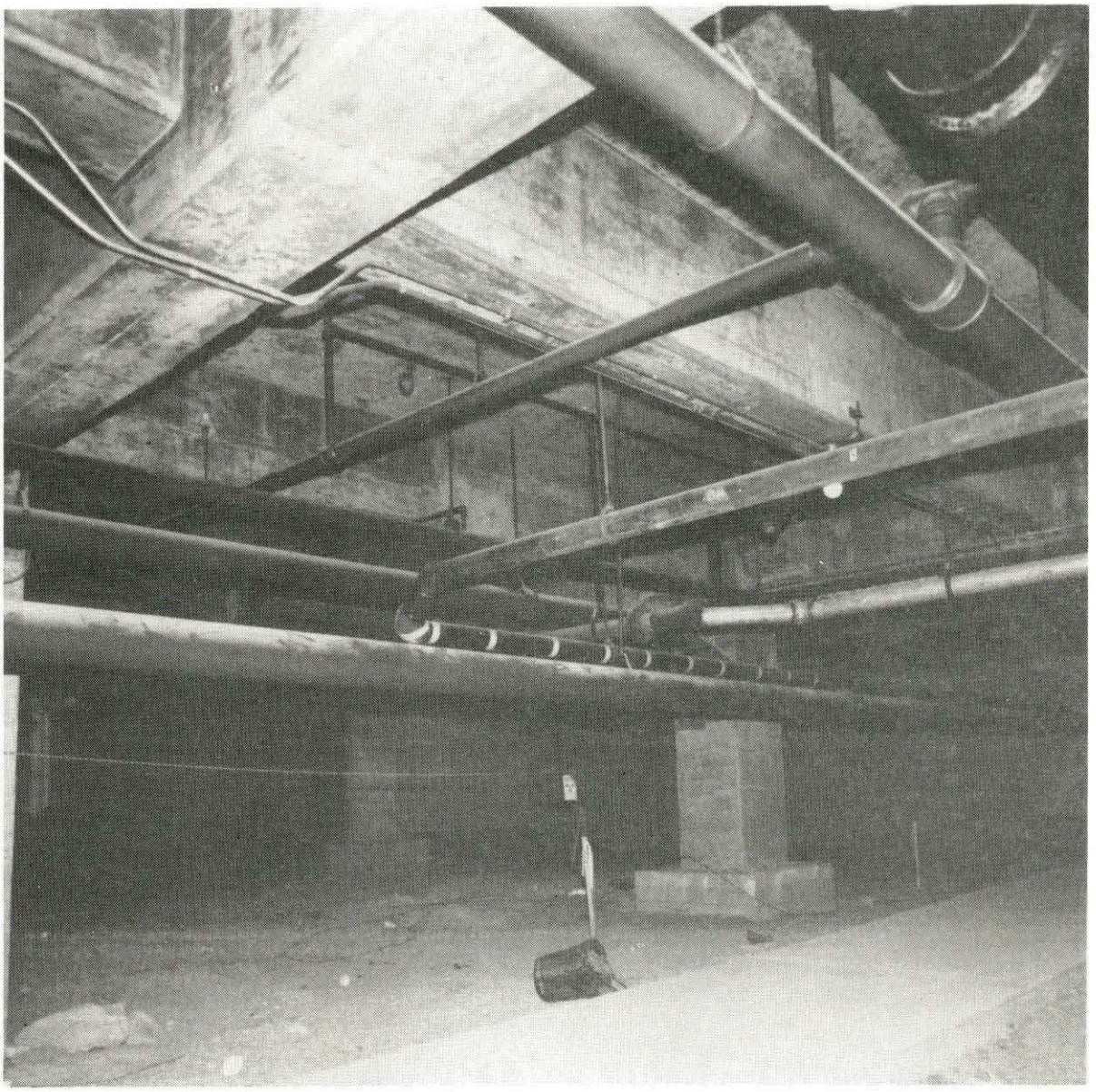

Fig. 3. East end basement of Building 9204-1, looking south into Section III.

ORNL-PHOTO 8099-87

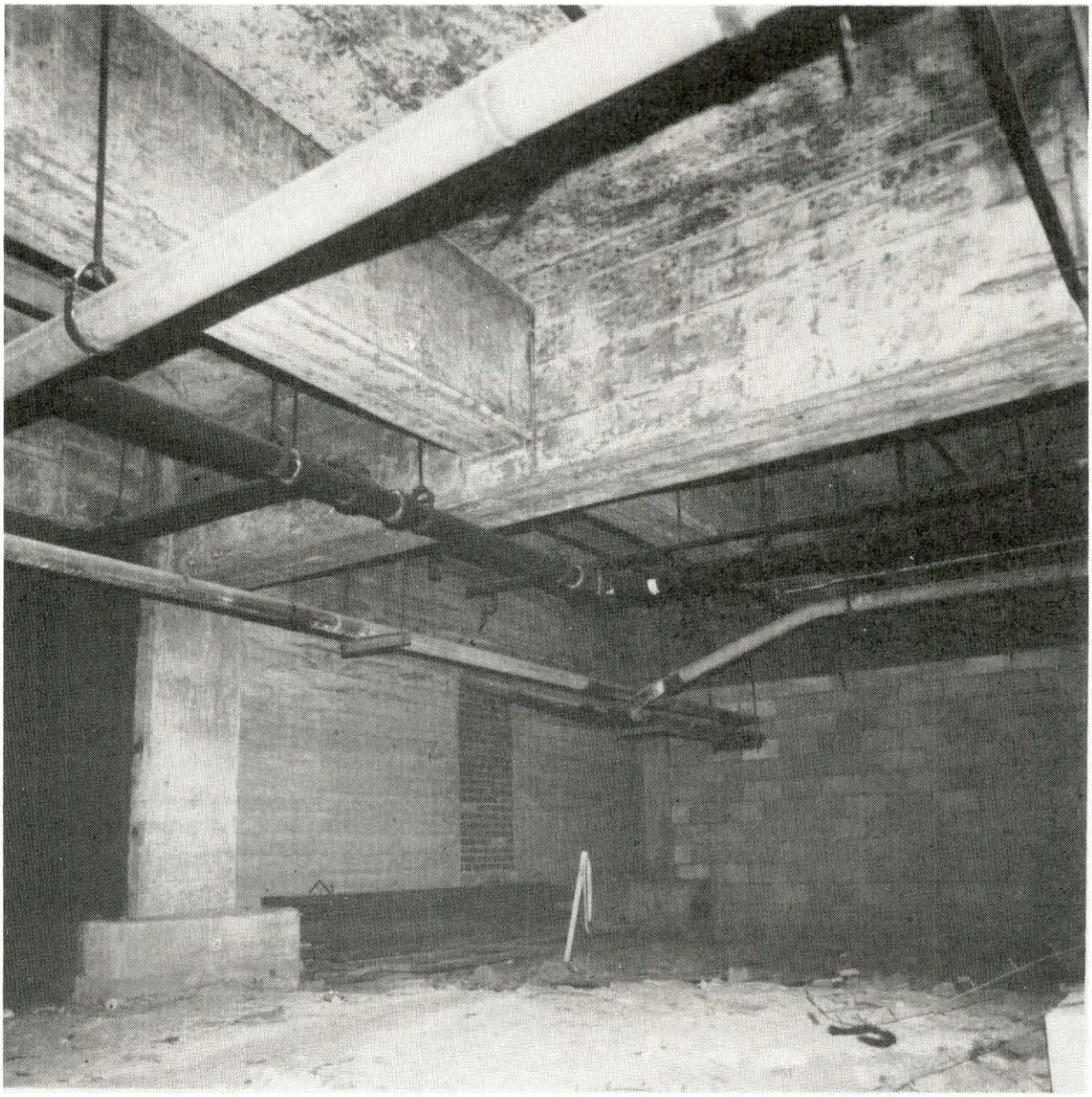

Fig. 4. East end basement of Building 9204-1, looking southwest at radiation zone, Section III.

ORNL-PHOTO 8090-87

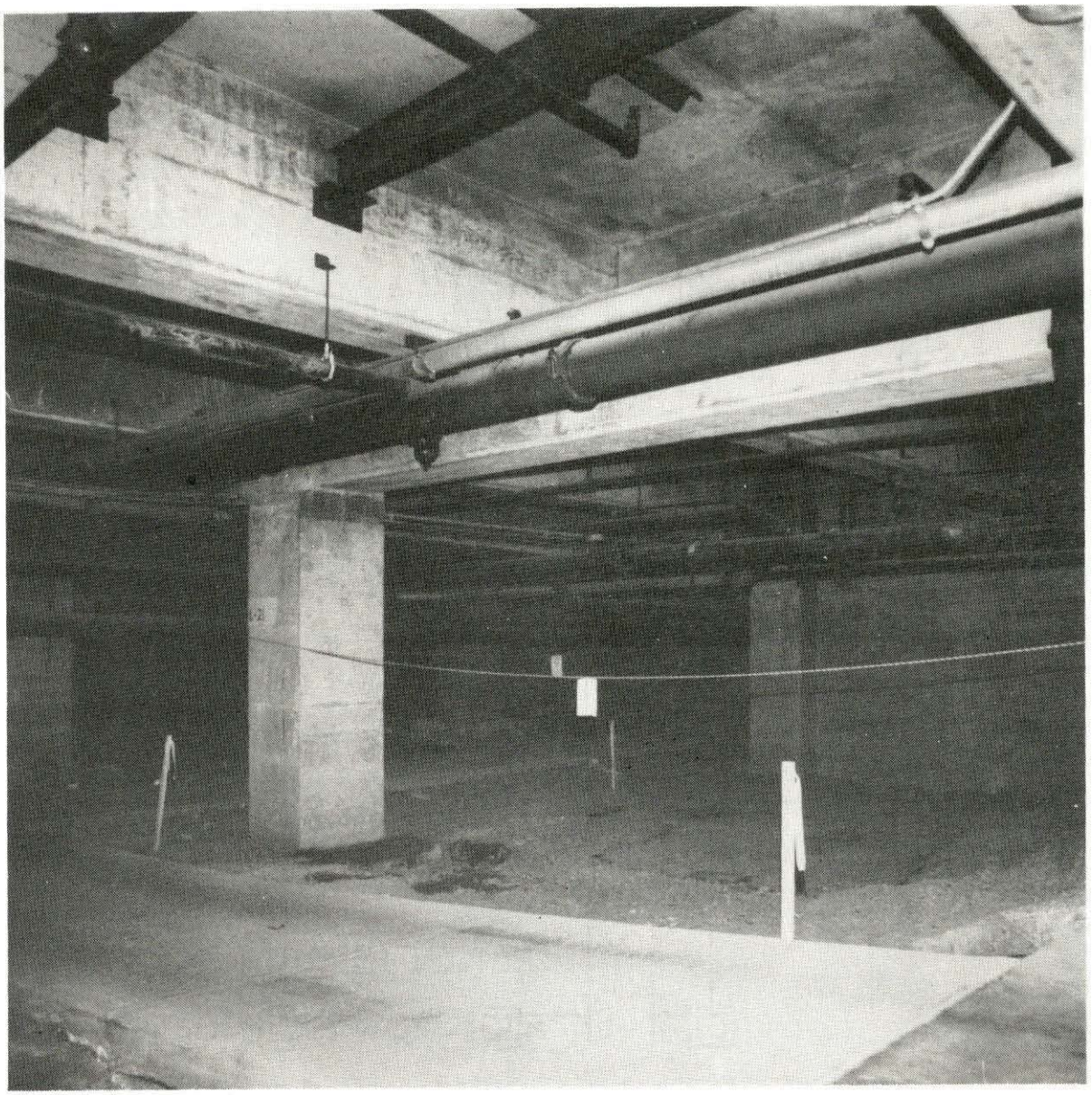

Fig. 5. East end basement of Building 9204-1, looking southeast at radiation zone, Section IV.

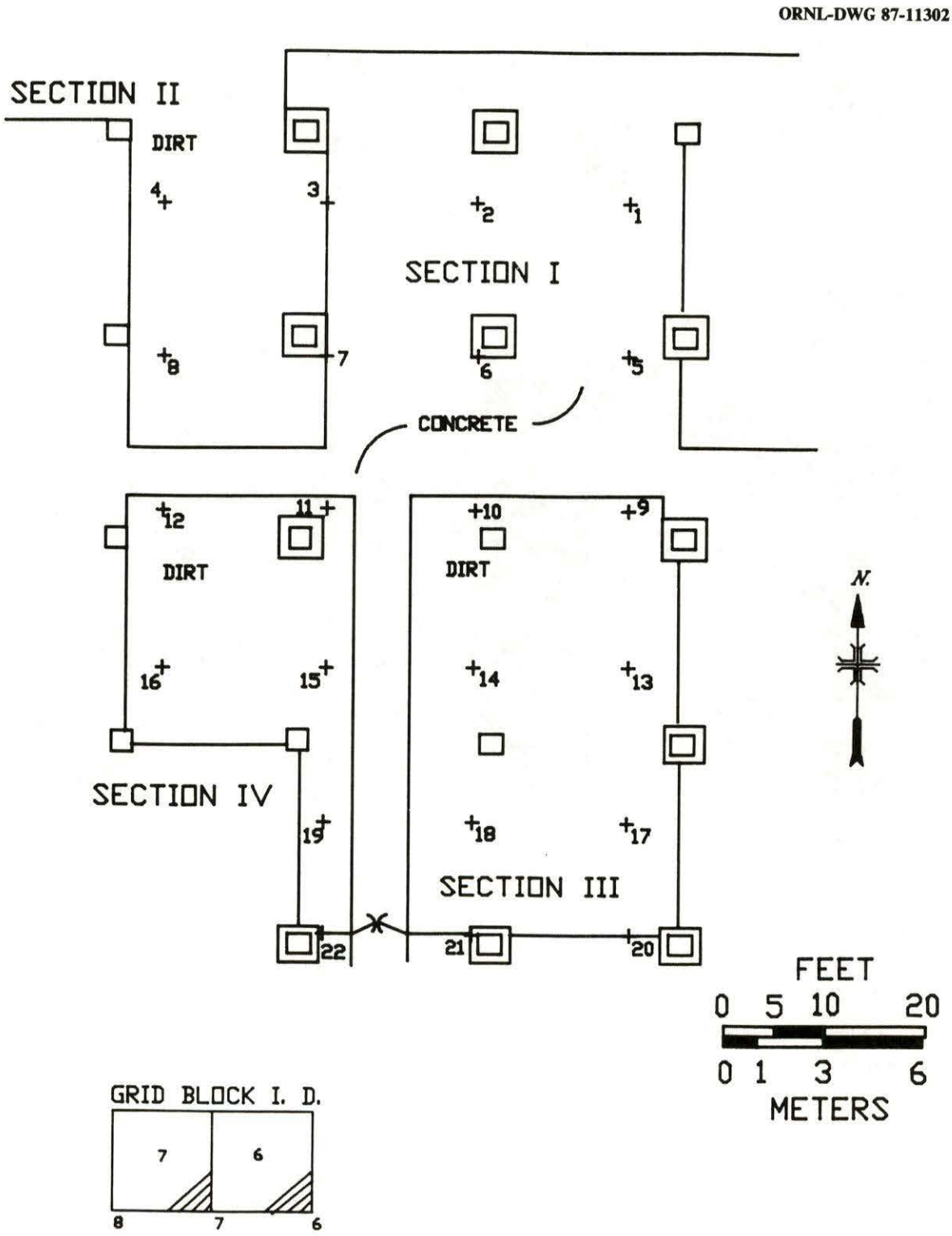

Fig. 6. Scaled drawing of the grid system used in the indoor survey of the east end basement of Building 9204-1.

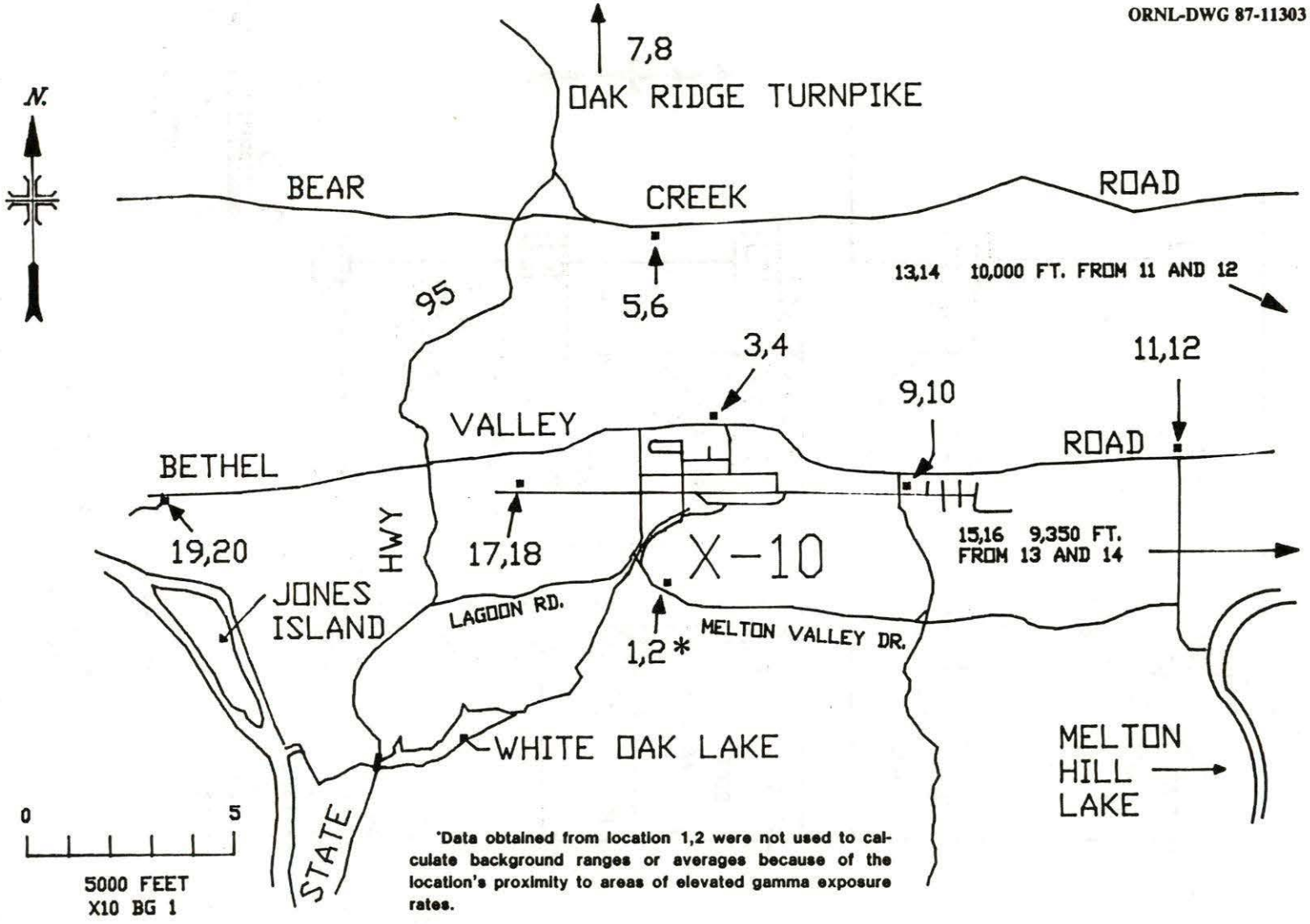

Fig. 7. Locations of gamma exposure rate measurements in uncontaminated areas on the Oak Ridge Reservation.

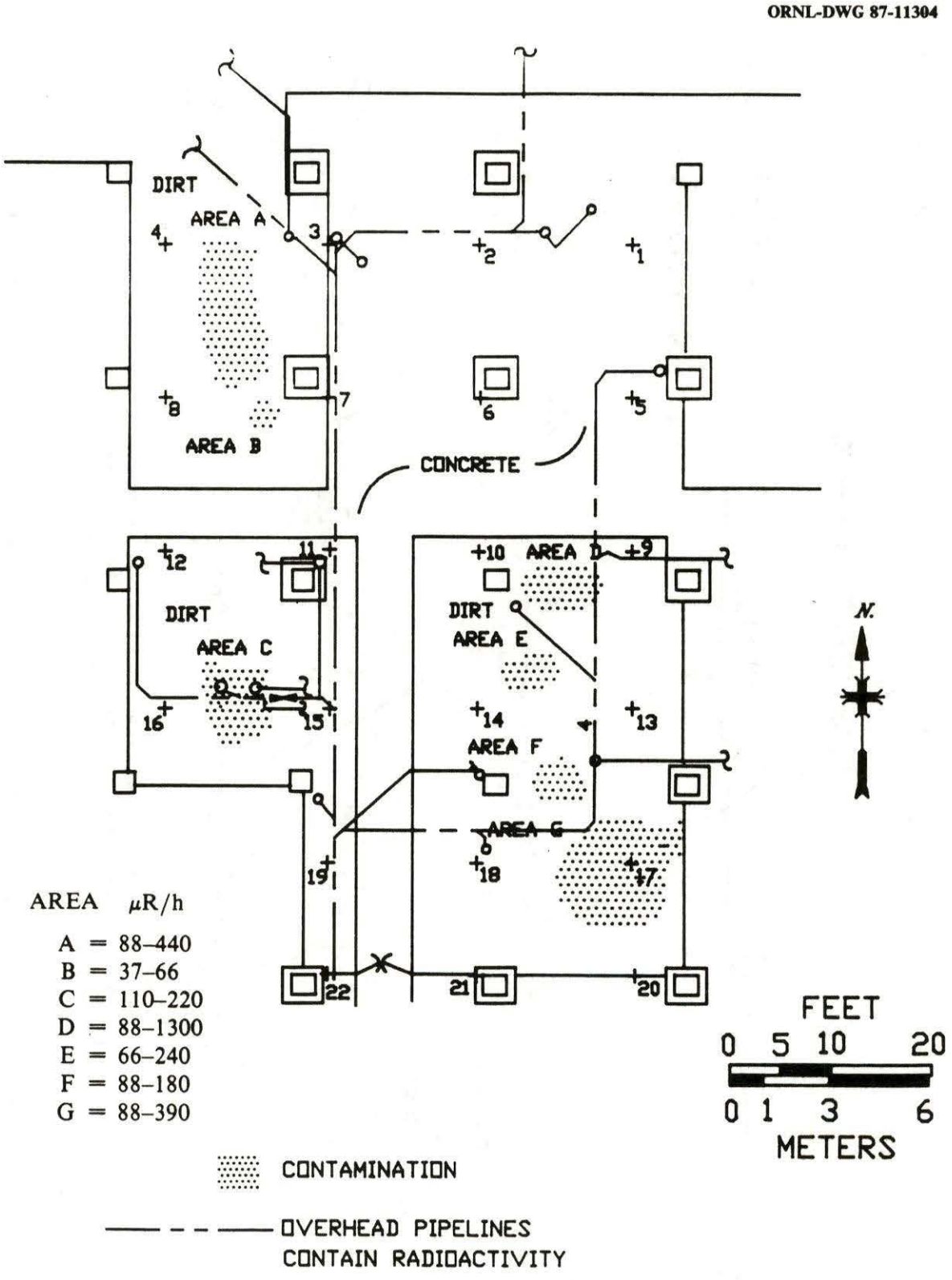

Fig. 8. Regions of elevated gamma exposure rates and locations of overhead pipelines in the east end basement of Building 9204-1.

ORNL-DWG 87-11305

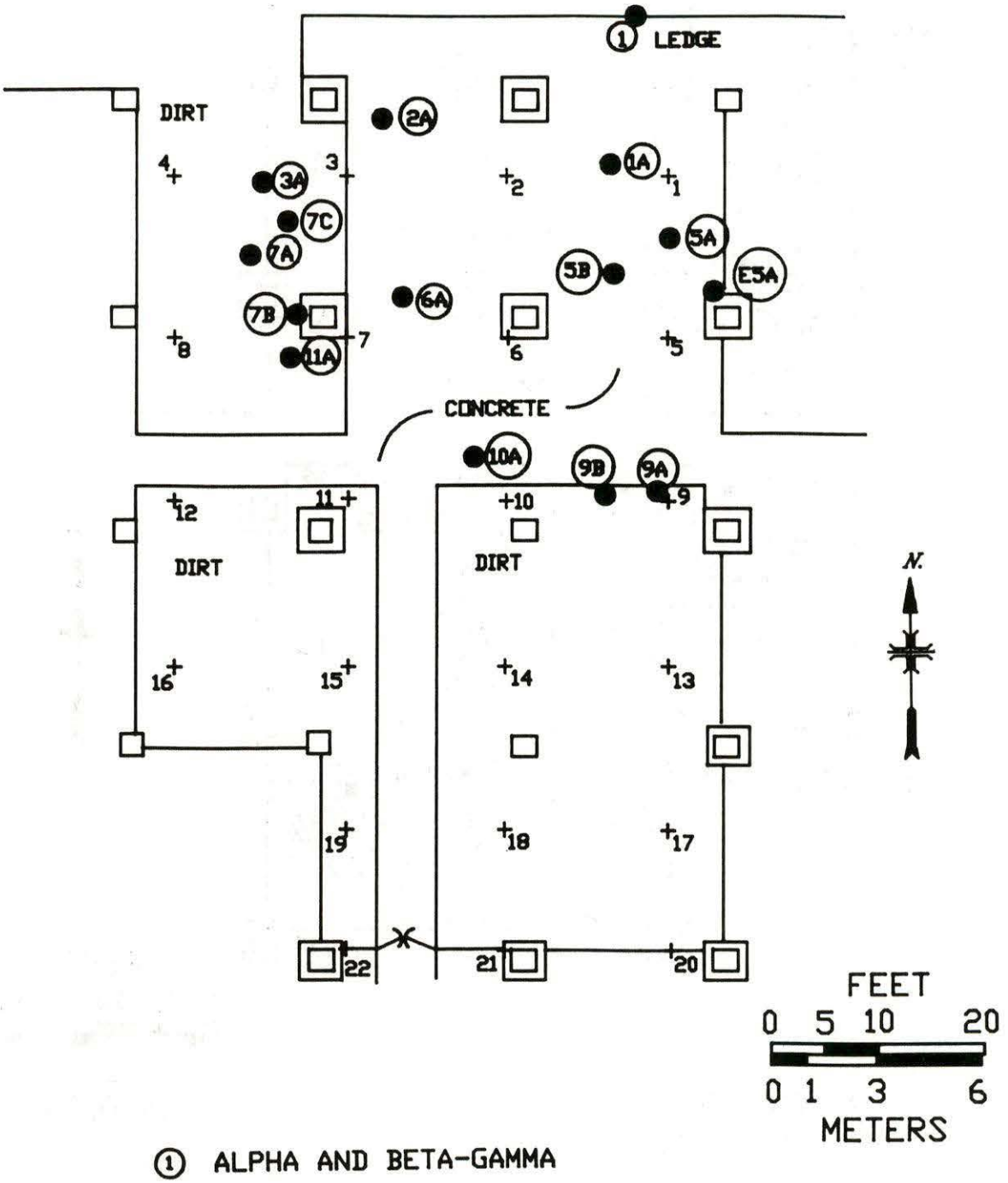

Fig. 9. Locations of alpha and beta-gamma measurements in the east end basement of Building 9204-1.

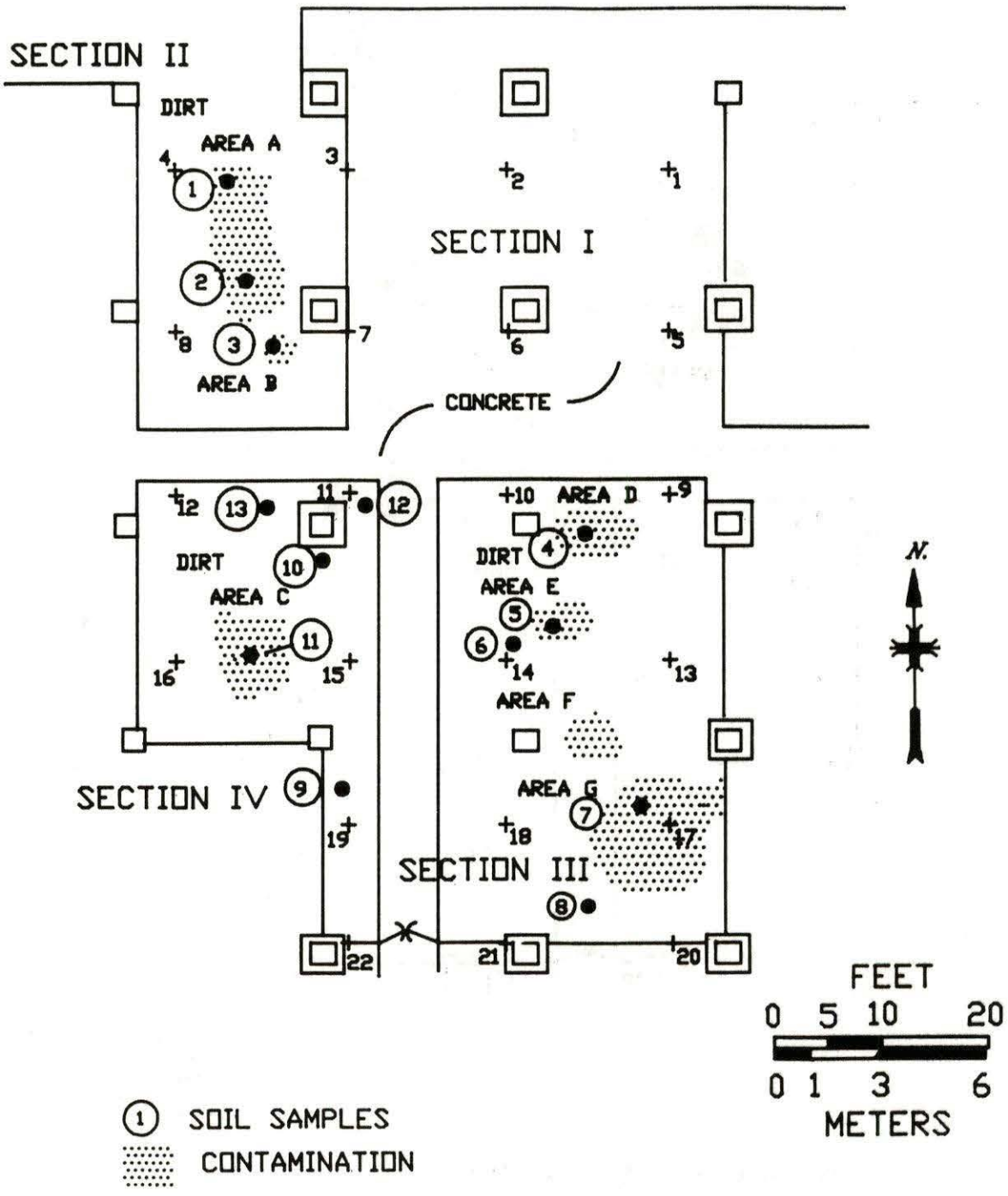

Fig. 10. Locations of soil samples and regions of elevated gamma exposure rates in the east end basement of Building 9204-1.

Table 1. Summary of indoor measurements and soil sample results for the east end basement of Building 9204-1, indexed to figures and tables

Measurement or sample type	Number of measurements or samples	Range[a]	Mean[a]	Figure number and location	Table number and location
Grid point measurements					
Gamma exposure rates at 1 m (μR/h)	18	15-140	46	Fig. 8, p. 20	Table 5, p. 30
Gamma exposure rates at surface (μR/h)	18	11-120	45	Fig. 8, p. 20	Table 5, p. 30
Directly measured surface contamination					
Alpha activity (dpm/100 cm^2)	15	90-7400	1200	Fig. 9, p. 21	Table 6, p. 31
Beta-gamma dose rate (mrad/h)	15	0.02-0.48	0.08	Fig. 9, p. 21	Table 6, p. 31
Transferable Surface contamination					
Alpha activity (dpm/100 cm^2)	15	12-117	–	Fig. 9, p. 21	Table 6, p. 31
Beta-gamma activity (dpm/100 cm^2)	15	b	b	Fig. 9, p. 21	Table 6, p. 31
Radon daughter measurements					
^{222}Rn decay products (WL)	1	0.0015	–	–	–
RCRA hazardous waste characteristics					
EP toxicity test – 8 metals	9	–	–	Fig. 10, p. 22	Table 9, p. 35
EP toxicity test – 4 insecticides and 2 herbicides	7	–	–	Fig. 10, p. 22	Table 10, p. 36
Ignitability, corrosivity, and reactivity	9	–	–	Fig. 10, p. 22	Table 11, p. 37

Table 1 (continued)

Measurement or sample type	Number of measurements or samples	Range[a]	Mean[a]	Figure number and location	Table number and location
		Region A (6 m^2)			
Scan, gamma exposure rates near surface (μR/h)	–	88-440	–	Fig. 8, p. 20	Table 5, p. 30
Concentration of selected radionuclides in soil (pCi/g dry wt)					
^{137}Cs	2	0.24-0.89	0.56	Fig. 10, p. 22	Table 7, p. 32
^{40}K	3	7.7-26	14	Fig. 10, p. 22	Table 7, p. 32
^{211}Pb	1	54	–	Fig. 10, p. 22	Table 7, p. 32
^{226}Ra	3	0.38-1.2	0.66	Fig. 10, p. 22	Table 7, p. 32
^{228}Ra	4	4.0-460	180	Fig. 10, p. 22	Table 7, p. 32
^{232}Th	4	4.0-450	180	Fig. 10, p. 22	Table 7, p. 32
^{234}Th	1	2.6	–	Fig. 10, p. 22	Table 7, p. 32
		Region B (3 m^2)			
Scan, gamma exposure rates near surface (μR/h)	–	37-66	–	Fig. 8, p. 20	Table 5, p. 30
Concentration of selected radionuclides in soil (pCi/g dry wt)					
^{137}Cs	2	0.045-0.065	0.055	Fig. 10, p. 22	Table 7, p. 32
^{40}K	2	8.4-8.5	8.4	Fig. 10, p. 22	Table 7, p. 32
^{226}Ra	2	0.40-0.41	0.40	Fig. 10, p. 22	Table 7, p. 32
^{228}Ra	2	2.4-4.5	3.4	Fig. 10, p. 22	Table 7, p. 32
^{232}Th	2	2.4-4.5	3.4	Fig. 10, p. 22	Table 7, p. 32
^{234}Th	1	1.2	–	Fig. 10, p. 22	Table 7, p. 32

Table 1 (continued)

Measurement or sample type	Number of measurements or samples	Range[a]	Mean[a]	Figure number and location	Table number and location
	Region C (5.2 m^2)				
Scan, gamma exposure rates near surface (μR/h)	–	110-220	–	Fig. 8, p. 20	Table 5, p. 30
Concentration of selected radionuclides in soil (pCi/g dry wt)					
^{40}K	1	16	–	Fig. 10, p. 22	Table 7, p. 32
^{228}Ra	2	120-210	160	Fig. 10, p. 22	Table 7, p. 32
^{232}Th	2	120-210	160	Fig. 10, p. 22	Table 7, p. 32
^{234}Th	2	20-47	34	Fig. 10, p. 22	Table 7, p. 32
	Region D (3.3 m^2)				
Scan, gamma exposure rates near surface (μR/h)	–	88-1300	–	Fig. 8, p. 20	Table 5, p. 30
Concentration of selected radionuclides in soil (pCi/g dry wt)					
^{226}Ra	2	1.8-2.2	2.0	Fig. 10, p. 22	Table 7, p. 32
^{228}Ra	2	810-1200	1000	Fig. 10, p. 22	Table 7, p. 32
^{232}Th	2	790-1200	1000	Fig. 10, p. 22	Table 7, p. 32
^{234}Th	1	51	–	Fig. 10, p. 22	Table 7, p. 32

Table 1 (continued)

Measurement or sample type	Number of measurements or samples	Range[a]	Mean[a]	Figure number and location	Table number and location
	Region E (1.4 m^2)				
Scan, gamma exposure rates near surface (μR/h)	–	66-240	–	Fig. 8, p. 20	Table 5, p. 30
Concentration of selected radionuclides in soil (pCi/g dry wt)					
^{40}K	1	14	–	Fig. 10, p. 22	Table 7, p. 32
^{226}Ra	2	0.57-2.3	1.4	Fig. 10, p. 22	Table 7, p. 32
^{228}Ra	2	8.0-790	400	Fig. 10, p. 22	Table 7, p. 32
^{232}Th	2	7.9-790	400	Fig. 10, p. 22	Table 7, p. 32
	Region F(2.3 m^2)[c]				
Scan, gamma exposure rates near surface (μR/h)	–	88-180	–	Fig. 8, p. 20	Table 5, p. 30
	Region G (14 m^2)				
Scan, gamma exposure rates near surface (μR/h)	–	88-390	–	Fig. 8, p. 20	Table 5, p. 30
Concentration of selected radionuclides in soil (pCi/g dry wt)					
^{137}Cs	1	0.35	–	Fig. 10, p. 22	Table 7, p. 32
^{211}Pb	2	4.0-69	36	Fig. 10, p. 22	Table 7, p. 32
^{226}Ra	2	1.3-1.7	1.5	Fig. 10, p. 22	Table 7, p. 32
^{228}Ra	2	230-360	300	Fig. 10, p. 22	Table 7, p. 32
^{232}Th	2	230-360	300	Fig. 10, p. 22	Table 7, p. 32

[a]For soil samples, values less than the minimum detectable activity (MDA) were excluded.
[b]All transferable beta-gamma measurements were indistinguishable from background.
[c]No soil samples were taken.

Table 2. Background radiation levels and concentration of selected radionuclides in soil samples taken on the Oak Ridge Reservation

Type of radiation measurement or sample	Radiation level or radionuclide concentration	
	Range	Average
Gamma exposure rate at 1 m above ground surface (μR/h)[a]	8-13	10
Gamma exposure rate at ground surface (μR/h)[a]	10-17	13
Concentration of selected radionuclides in soil (pCi/g dry wt)[b]		
^{137}Cs	0.045-2.6	0.77
^{40}K	2.6-19	10
^{226}Ra	0.40-1.3	0.93
^{228}Ra	0.46-1.7	0.88
^{232}Th	0.44-1.8	0.90
^{234}Th	1.0-3.2	1.9
^{235}U	0.025-0.061	0.044
^{238}U	0.53-1.5	1.0

[a]Values were obtained from 18 measurements taken from 9 locations on the Oak Ridge Reservation. (See Fig. 7 for locations.)

[b]These radionuclide concentrations represent values above the minimum detectable activity (MDA). Values for ^{137}Cs, ^{40}K, ^{226}Ra, ^{228}Ra, ^{232}Th, and ^{234}Th were obtained by gamma spectrometry analysis of 12 soil samples taken from 3 locations on the Oak Ridge Reservation. Values for ^{235}U and ^{238}U were obtained by neutron activation analysis of 21 soil samples taken from 6 locations on the Oak Ridge Reservation.

Table 3. Guidelines for protection against radiation

Mode of exposure	Exposure conditions	Guideline value	Guideline source
Gamma radiation	Minimum dose rate required for radiation control zone	0.003 rem/h	[a]
Surface alpha contamination	Contamination fixed on structural surfaces	300 dpm/100 cm^2	[a]
	Removable alpha	30 dpm/100 cm^2	[a]
Surface beta	Removable beta-gamma[b]	1000 dpm/100 cm^2	[a]
Beta-gamma dose rates	Surface dose rate averaged over not more than 1 m^2	0.25 mrad/h	[a]
Exposure to ^{222}Rn daughters	Average annual radon daughter concentration (including background)	0.03 WL	[c]
Radionuclide concentrations in soil	Maximum permissible concentration of the following radionuclides in soil above background levels averaged over 100 m^2 area ^{232}Th ^{228}Ra ^{226}Ra	5 pCi/g averaged over the first 15 cm of soil below the surface; 15 pCi/g when averaged over 15-cm thick soil layers more than 15 cm below the surface	[c]
	Concentration limit in surface soil above background levels based on dose estimates from major exposure pathways		
	^{137}Cs	80 pCi/g over a 100 m^2 area of contamination	[d]
	^{238}U	75 pCi/g over a 140 m^2 (1.5 m deep) waste field exposed at the surface	[e]

[a]Oak Ridge National Laboratory, Health Physics Manual, Sects. 2.5 and 2.7.

[b]Beta-gamma emitters (radionuclides with decay modes other than alpha emission or spontaneous fission) except ^{90}Sr, ^{228}Ra, ^{223}Ra, ^{227}Ac, ^{133}I, ^{131}I, ^{129}I, ^{126}I, and ^{125}I.

[c]U. S. Department of Energy, *Guidelines for Residual Radioactivity at Formerly Utilized Sites Remedial Action Program and Remote Surplus Facilities Management Program Sites* (July 1985).

[d]J. W. Healy, J. C. Rodgers, and C. L. Wienke, *Interim Soil Limits for D&D Projects*, Los Alamos Scientific Laboratory, LA-UR-79-1865-Rev., Los Alamos, N.M. (1979). Cited in U.S. Department of Energy, *Radiological Guidelines for Application to DOE's Formerly Utilized Sites Remedial Action Program*, Oak Ridge Operations, ORO-831 (March 1983).

[e]T. L. Gilbert, P. C. Chee, M. J. Knight, J. M. Peterson, C. J. Roberts, J. E. Robinson, S. Y. H. Tsai, and Y. C. Yuan, *Pathways Analysis and Dose Estimates for Assessment of Health Effects for Formerly Utilized MED/AEC Sites*, ORO-832 (1983). Prepared for the Formerly Utilized Sites Remedial Action Program, U.S. Department of Energy, Oak Ridge, TN, by the Division of Environmental Impact Studies, Argonne National Laboratory, Argonne, IL.

Table 4. Maximum concentration of contaminants for toxicity characteristic by extraction procedure[a]

EPA hazardous waste identification number	Contaminant	Chemical Abstracts Registry number	Maximum concentration (mg/L)
D004	Arsenic	7440-38-2	5.0
D005	Barium	7440-39-3	100
D006	Cadmium	7440-43-9	1.0
D007	Chromium	1333-82-0	5.0
D008	Lead	7439-92-1	5.0
D009	Mercury	7439-97-6	0.2
D010	Selenium	7782-49-2	1.0
D011	Silver	7440-22-4	5.0
D012	Endrin (1,2,3,4,10,10-hexachloro-1,7-epoxy-1,4,4a,5,6,7,8,8a-octahydro-1,4-endo, endo-5,8-dimethano-naphthalene)	72-20-8	0.02
D013	Lindane (1,2,3,4,5,6-hexachlorocyclohexane, gamma isomer)	58-89-9	0.4
D014	Methoxychlor (1,1,1-Trichloro-2,2-bis [p-methoxyphenyl]ethane)	72-43-5	10
D015	Toxaphene ($C_{10}H_{10}Cl_8$, Technical chlorinated camphene, 67-69 percent chlorine)	8001-35-2	0.5
D016	2,4-D (2,4-Dichlorophenoxyacetic acid)	94-75-7	10
D017	2,4,5-TP Silvex (2,4,5-Trichlorophenoxypropionic acid)	93-76-5	1.0

[a]40 CFR 261.24, Ch 1 (7-1-85 Edition) Characteristics of EP toxicity.

Table 5. Results of gamma exposure rate measurements in the east end basement of Building 9204-1

Grid point[a]	Location[b]		Grid point measurements[c] (μR/h)		Range of gamma exposure rates during scan of grid blocks[d] (μR/h)
	North	East	Gamma exposure rate at 1 m	Gamma exposure rate at the surface	
1	29557	58011	15	11	10-25
2	29559	57997	23	16	15-35
3	29560	57982	47	44	15-44
4	29562	57967	25	20	15-25
5	29542	58010	20	19	11-25
6	29544	57995	30	19	17-46
7	29546	57980	66	44	25-390
8	29547	57965	30	25	20-25
9	29527	58008	44	66	17-66
10	29529	57993	48	44	25-98
11	29531	57978	140	120	27-98
12	29532	57963	27	27	25-27
13	29512	58006	55	44	44-1300
14	29514	57991	55	48	48-88
15	29516	57976	66	55	37-220
16	29518	57961	44	44	37-44
17	29497	58004	48	120	44-330
18	29499	57989	44	44	44-66
19	29501	57974	[e]	[e]	40-76
20	29485	58003	-	-	37-55
21	29487	57988	-	-	44-55
22	29489	57973	-	-	40-44

[a]Grid point locations are shown on Fig. 6.
[b]North and east coordinates are derived from the Y-12 master grid plan.
[c]Grid point measurements are discrete measurements at each grid point.
[d]Grid block measurements are obtained by a surface gamma scan of each grid block.
[e]Inaccessible.

Table 6. Alpha and beta-gamma activity levels in the east end basement of Building 9204-1

Location numbers[a]	Directly measured contamination		Transferable alpha[b] (dpm/100 cm^2)
	Alpha (dpm/100 cm^2)	Beta-gamma dose rate (mrad/h)	
1	150	0.05	[c]
1A	300	0.04	[c]
2A	130	0.03	[c]
3A	270	0.04	[c]
5A	90	0.03	15
5B	380	0.02	[c]
E5A	2200	0.03	[c]
6A	90	0.08	6
7A	1100	0.48	[c]
7B	2200	0.15	117
7C	160	0.04	12
9A	7400	0.08	[c]
9B	1800	0.07	[c]
10A	130	0.05	[c]
11A	1800	0.08	[c]

[a]Location numbers are shown on Fig. 9.

[b]Transferable beta-gamma activity levels were indistinguishable from background.

[c]Measurement was indistinguishable from background.

Table 7. Concentration of radionuclides in soil samples from the east end basement of Building 9204-1

Hole/ sample ID[a]	Location[b]		Depth (cm)	Radionuclide concentration (pCi/g dry wt)[c,d]						
	North	East		^{137}Cs	^{40}K	^{211}Pb	^{226}Ra	^{228}Ra	^{232}Th	^{234}Th
1A	29560	57971	0-10	0.24 ± 0.05	7.7 ± 0.8	<0.92	0.38 ± 0.01	4.8 ± 0.2	4.8 ± 0.3	2.6 ± 4
1B	29560	57971	10-25	0.89 ± 0.06	7.8 ± 0.7	<0.89	0.39 ± 0.04	4.0 ± 0.2	4.0 ± 0.2	<2.9
2A	29551	57971	0-10	<0.72	<5.3	<17	<1.3	460 ± 40	450 ± 40	<60
2B	29551	57971	10-25	<0.47	26 ± 5	54 ± 10	1.2 ± 0.9	260 ± 9	260 ± 20	<42
3A	29544	57977	0-10	0.065 ± 0.05	8.5 ± 0.8	<0.85	0.41 ± 0.06	4.5 ± 0.4	4.5 ± 0.3	1.2 ± 0.1
3B	29544	57977	10-25	0.045 ± 0.04	8.4 ± 0.7	<0.73	0.40 ± 0.04	2.4 ± 0.2	2.4 ± 0.3	<2.4
4A	29522	58001	0-10	<1.3	<11	<34	2.2 ± 0.6	1200 ± 50	1200 ± 80	e
4B	29522	58001	10-25	<0.62	e	<16	1.8 ± 0.6	810 ± 30	790 ± 50	51 ± 30
5A	29514	58001	0-10	<1.2	e	e	2.3 ± 0.7	790 ± 30	790 ± 50	<110
5B	29514	58001	10-25	<0.043	14 ± 0.9	<1.1	0.57 ± 0.1	8.0 ± 0.3	7.9 ± 0.5	<3.7
6A	29514	57992	0-10	<0.043	12 ± 0.7	<0.68	0.41 ± 0.08	0.81 ± 0.07	0.80 ± 0.07	7.8 ± 1
6B	29514	57992	10-25	0.22 ± 0.06	11 ± 0.8	<0.65	0.43 ± 0.09	0.59 ± 0.1	0.56 ± 0.1	4.9 ± 2
7A	29499	58002	0-10	<0.75	e	69 ± 20	1.7 ± 0.2	360 ± 7	360 ± 20	<63
7B	29499	58002	10-25	0.35 ± 0.7	e	41 ± 20	1.3 ± 0.7	230 ± 6	230 ± 20	e
8	29491	57998	0-10	<0.052	26 ± 1	<0.85	0.86 ± 0.07	1.7 ± 0.2	1.7 ± 0.09	2.8 ± 3
9	29502	57975	0-10	<0.057	24 ± 1	<0.91	0.98 ± 0.2	1.6 ± 0.3	1.5 ± 0.3	1.9 ± 1
10A	29525	57975	0-10	0.25 ± 0.05	11 ± 0.7	<0.68	0.42 ± 0.04	1.7 ± 0.3	1.7 ± 0.2	<1.9
10B	29525	57975	10-25	0.23 ± 0.05	12 ± 0.7	<0.63	0.41 ± 0.08	0.48 ± 0.2	0.47 ± 0.1	0.99 ± 0.8
11A	29518	57965	0-10	<0.33	f	<7.1	<0.52	210 ± 8	210 ± 10	47 ± 20
11B	29518	57965	10-25	<0.41	16 ± 4	<9.7	<0.75	120 ± 10	120 ± 10	20 ± 10

Table 7 (continued)

Hole/ sample ID[a]	Location[b] North	Location[b] East	Depth (cm)	Radionuclide concentration (pCi/g dry wt)[c,d] ^{137}Cs	^{40}K	^{211}Pb	^{226}Ra	^{228}Ra	^{232}Th	^{234}Th
12	29528	57978	0-10	0.065 ± 0.04	10 ± 0.7	<0.60	0.34 ± 0.06	0.70 ± 0.08	0.72 ± 0.09	<1.6
13A	29532	57972	0-10	0.012 ± 0.02	12 ± 0.8	<0.44	0.20 ± 0.02	0.49 ± 0.05	0.49 ± 0.05	1.4 ± 3
13B	29532	57972	10-25	<0.039	11 ± 0.7	<0.60	0.14 ± 0.04	0.40 ± 0.1	0.39 ± 0.08	0.71 ± 0.8
AA	g	g	0-10	<0.11	22 ± 2	<2.1	0.72 ± 0.2	6.9 ± 0.4	6.8 ± 0.4	<6.4

[a]Soil sample hole locations are shown on Fig. 10.
[b]North and East coordinates are derived from the Y-12 master grid plan.
[c]Indicated counting error is at the 95% confidence level ($\pm\sigma$).
[d]Values preceded by "<" denote less than the minimum detectable activity (MDA).
[e]Interfering gamma energies from other isotopes resulted in false values.
[f]MDA values were not available.
[g]Section II, under a section of pipe showing elevated gamma levels.

Table 8. Concentration of ^{235}U and ^{238}U in soil samples from the east end basement of Building 9204-1

Hole/ sample ID[a]	Location[b]		Depth (cm)	Radionuclide concentration (pCi/g dry wt)[c,d]	
	North	East		^{235}U	^{238}U
1A	29560	57971	0-10	0.050	<2.6
1B	29560	57971	10-25	0.048	<2.5
2A	29551	57971	0-10	0.70	2.2
2B	29551	57971	10-25	0.34	1.4
3A	29544	57977	0-10	0.13	1.3
3B	29544	57977	10-25	0.90	1.9
4A	29522	58001	0-10	2.7	14
4B	29522	58001	10-25	2.9	2.1
5A	29514	58001	0-10	1.1	5.4
5B	29514	58001	10-25	0.13	3.9
6A	29514	57992	0-10	26	12
6B	29514	57992	10-25	16	5.7
7A	29499	58002	0-10	1.4	3.9
7B	29499	58002	10-25	1.3	6.1
8	29491	57998	0-10	0.13	3.2
9	29502	57975	0-10	0.36	3.1
10A	29525	57975	0-10	0.17	0.93
10B	29525	57975	10-25	0.057	1.3
11A	29518	57965	0-10	1.9	49
11B	29518	57965	10-25	0.70	18
12	29528	57978	0-10	0.058	2.0
13A	29532	57972	0-10	0.084	1.3
13B	29532	57972	10-25	0.075	0.77
AA	e	e	0-10	0.060	3.4

[a]Soil sample hole locations are shown on Fig. 10.
[b]North and East coordinates are derived from the Y-12 master grid plan.
[c]Analytical error of measurement results is $< \pm 5\%$ (95% confidence level).
[d]Values with "<" sign denote less than the minimum detectable activity (MDA).
[e]Section II, under a section of pipe showing elevated gamma levels.

Table 9. Results of the Extraction Procedure Toxicity Characteristic test for eight RCRA metals in biased soil samples from the east end basement of Building 9204-1

Hole/ sample ID[a]	Location[b]		Depth (cm)	Concentration (mg/L)[c,d]							
	North	East		Arsenic (As)	Barium (Ba)	Cadmium (Cd)	Chromium (Cr)	Lead (Pb)	Selenium (Se)	Silver (Ag)	Mercury (Hg) (μg/mL)
1A	29560	57971	0-10	<0.10	0.40	<0.0050	<0.040	3.1	<0.20	<0.050	<0.0002
2A	29551	57971	0-10	<0.20	0.24	<0.010	<0.080	<0.40	<0.40	<0.10	0.0003
2B	29551	57971	10-25	<0.10	0.73	<0.0050	<0.040	<0.20	<0.20	<0.050	0.0007
4A	29522	58001	0-10	<0.10	0.43	<0.0050	<0.040	<0.20	<0.20	<0.050	0.18
6A	29514	57992	0-10	<0.10	0.25	0.089	<0.040	<0.20	<0.20	<0.050	0.0003
7A	29499	58002	0-10	<0.10	1.0	0.047	<0.040	5.1	<0.20	<0.050	<0.0002
7B	29499	58002	10-25	<0.10	0.50	0.035	<0.040	1.9	<0.20	<0.050	<0.0002
10A	29525	57975	0-10	<0.20	0.17	<0.010	<0.080	<0.40	<0.40	<0.10	<0.0002
11A	29518	57965	0-10	<0.10	0.25	0.030	<0.040	<0.20	<0.20	<0.050	0.11

[a]Soil sample hole locations are shown on Fig. 10.

[b]North and East coordinates are derived from the Y-12 master grid plan.

[c]Arsenic, barium, cadmium, chromium, lead, selenium, and silver analyses were performed in accordance with EPA procedure 6010.

[d]The inductive coupled plasma spectrometer (ICP) method was used to measure all metals except mercury. The mercury analysis was performed by the cold vapor atomic absorption (CVAA) method.

Table 10. Results of the Extraction Procedure Toxicity Characteristic test for four RCRA insecticides and two herbicides in biased soil samples from the east end basement of Building 9204-1

Hole/ sample ID[a]	Location[b]		Depth (cm)	Detection Limit (mg/L)					
	North	East		Lindane[c] 4P[e]	Endrin[c] 14P[e]	Toxaphene[c] 25P[e]	Methoxychlor[c] 400[e]	2,4-D[d] 401[e]	2,4,5-TP (Silvex)[d] 402[e]
2A	29551	57971	0-10	<0.002	<0.0002	<0.005	<0.008	<0.01	<0.01
4A	29522	58001	0-10	<0.002	<0.0002	<0.005	<0.008	<0.01	<0.01
6A	29514	57992	0-10	<0.002	<0.0002	<0.005	<0.008	<0.01	<0.01
7A	29499	58002	0-10	<0.002	<0.0002	<0.005	<0.008	<0.01	<0.01
7B	29499	58002	10-25	<0.002	<0.0002	<0.005	<0.008	<0.01	<0.01
10A	29525	57975	0-10	<0.002	<0.0002	<0.005	<0.008	<0.01	<0.01
11A	29518	57965	0-10	<0.002	<0.0002	<0.005	<0.008	<0.01	<0.01

[a]Soil sample hole locations are shown on Fig. 10.
[b]North and East coordinates are derived from the Y-12 master grid plan.
[c]Electron capture detector.
[d]High performance liquid chromatography.
[e]National Pollution Discharge Elimination System (NPDES) compound number.

Table 11. Ignitability, corrosivity, and reactivity characteristics of biased soil samples from the east end basement of Building 9204-1

Hole/ sample ID[a]	Location[b]		Depth (cm)	Ignitability flash point[c] (°C)	Corrosivity (pH)	Reactivity[d]	
	North	East				Sulfide (mg/g)	Cyanide[e] (CN) (μg/g)
1A	29560	57971	0-10	>70	6.69	0.107	0.18
2A	29551	57971	0-10	>70	8.55	0.07	<0.1
2B	29551	57971	10-25	>70	6.78	0.151	0.12
4A	29522	58001	0-10	>70	8.07	0.672	0.54
6A	29514	57992	0-10	>70	8.14	0.103	<0.1
7A	29499	58002	0-10	>70	7.50	0.152	0.74
7B	29499	58002	10-25	>70	7.26	0.069	0.31
10A	29525	57975	0-10	>70	8.46	0.088	<0.1
11A	29518	57965	0-10	>70	7.97	0.504	1.59

[a]Soil sample hole locations are shown on Fig. 10.
[b]North and East coordinates are derived from the Y-12 master grid system.
[c]EPA procedure 1010.
[d]Wet sample values.
[e]EPA procedure 9010.