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Results of the Independent Radiological Verification Survey of the Remedial Action Performed at 525 S. Main Street Oxford, Ohio (OXO002)

K. R. Kleinhans
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M. E. Murray
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HEALTH SCIENCES RESEARCH DIVISION
Environmental Restoration and Waste Management Non-Defense Programs
(Activity No. EX 20 20 010)

Results of the Independent Radiological Verification Survey of the Remedial Action Performed at 525 S. Main Street, Oxford, Ohio (OXO002)

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ABSTRACT

Between October 1952 and February 1957, National Lead of Ohio (NLO), a primary contractor for the Atomic Energy Commission (AEC), subcontracted certain uranium machining operations to Alba Craft Laboratory, Incorporated, located at 10–14 West Rose Avenue, Oxford, Ohio. In 1992, personnel from Oak Ridge National Laboratory (ORNL) confirmed the presence of residual radioactive materials from the AEC-related operations in and around the facility in amounts exceeding the applicable Department of Energy (DOE) guidelines. Above-guideline radiation levels were also found both indoors and outdoors at 525 S. Main Street, a private residential property in the immediate vicinity of the Alba Craft site. This document reports the findings at this private residence.

Although the amount of uranium found on the properties posed little health hazard if left undisturbed, the levels were sufficient to require remediation to bring radiological conditions into compliance with current guidelines, thus ensuring that the public and the environment are protected. The Remedial Action Contractor for these properties was Bechtel National, Incorporated (BNI).

DOE requires that verification of completed cleanup work at DOE Formerly Utilized Sites Remedial Action Program (FUSRAP) sites such as this shall be performed and documented by an Independent Verification Contractor. The objective of verification activities is to certify that documentation of post-remedial action radiological conditions on the property is adequate, and the remedial action reduced contamination levels to within authorized limits.

A team from ORNL conducted a radiological verification survey of the property at 525 S. Main Street, between November 1993 and December 1994. The survey was conducted at the request of DOE and included directly measured radiation levels, the collection and analysis of soil samples to determine concentrations of uranium and certain other radionuclides, and comparison of these data to the guidelines.

From a review of the post-remedial action report, it can be concluded that the BNI survey procedure used for this property was satisfactory. Furthermore, the results of the independent verification survey of the property at 525 S. Main Street demonstrate that all contaminated areas have been remediated to radionuclide concentrations and activity levels below the applicable guideline limits set by DOE.

Results of the Independent Radiological Verification Survey of the Remedial Action Performed at 525 South Main Street, Oxford, Ohio (OXO002)

INTRODUCTION

During the approximate time between October 1952 and February 1957, National Lead of Ohio (NLO), a primary contractor for the Atomic Energy Commission (AEC), subcontracted certain uranium machining operations to Alba Craft Laboratory, Incorporated, Oxford, Ohio. The facility, located at 10–14 West Rose Avenue, also housed operations involving NLO personnel and NLO uranium material in 1954. It is not known how much material was machined at the site by NLO in 1954, but the total quantity of uranium machined by Alba Craft is estimated at several hundred tons. Figure 1 shows the relative location of the City of Oxford in southwestern Ohio. Figure 2 is a diagram showing the approximate location of the former Alba Craft Laboratory site and 525 S. Main Street in the City of Oxford.

Early investigations of the Alba Craft property had revealed evidence of residual radioactive materials from the AEC-related operations at the site. At the request of the Department of Energy (DOE) under the Formerly Utilized Sites Remedial Action Program (FUSRAP), personnel from Oak Ridge National Laboratory (ORNL) conducted a radiological assessment in 1992. The purpose of the survey was to locate and define the extent of the contamination on the site itself, and to detect whether any of these materials had migrated off-site.* The results of that survey confirmed the early data suggesting that levels of radioactive residuals at the Alba Craft property were elevated above the applicable and appropriate DOE guidelines (Table 1) in and around the building.[1] Radioactive residuals were also found both indoors and outdoors at the residential property at 525 South Main Street directly east of the site. Although the amount of uranium found posed little health hazard if left undisturbed, the levels were sufficient to require cleanup action to bring the property into compliance with current guidelines. The purpose of the process is to insure that the public and the environment are protected.

DOE's Environmental Restoration Program dictates that independent verification (IV) of completed cleanup work at DOE FUSRAP sites shall be performed and documented according to prescribed procedures prior to certification of the property for release for unrestricted use.[2,3] The objective of verification activities is to confirm that the remedial action reduced contamination levels to within authorized limits.

As the designated IV Contractor (IVC) for this site, ORNL's Measurement Applications and Development Group was assigned to validate the remedial action and restoration activities conducted at this property by the Remedial Action Contractor, Bechtel National, Incorporated (BNI). A verification survey of the property was performed during October and November, 1993, and in December and January, 1994.

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*The survey was done by members of the Measurement Applications and Development Group, Health Sciences Research Division, Oak Ridge National Laboratory under DOE contract DE–AC05-96OR22464 with Lockheed Martin Energy Research Corp.

The South Main Street residential property consisted of a two-story partial brick house with a concrete driveway and two concrete porches. Remedial action had been conducted inside the house and in outdoor areas at the north and south sides of the house.[4] Figure 3 shows the layout of the property and the locations of remediated areas outdoors. The indoor remediation is not diagrammed in this report.

SCOPE OF THE SURVEY

The outdoor survey of the property included:

- A gamma scan near the ground surface over 100% of the property.
- Collection of systematic surface and subsurface soil samples.
- Collection of biased surface and subsurface soil samples.
- Measurements of gamma radiation levels at 1 m at soil sample locations .
- A thorough beta-gamma scan of excavated areas.
- On-site field screening using a portable gamma spectrometer to estimate uranium concentrations in soil samples.

The indoor survey of the property included:

- A gamma scan near the surface over accessible areas.
- A beta-gamma scan near the surface of accessible areas including overhead.
- Large area smears were collected and analyzed for removable alpha and beta-gamma activity levels.

SURVEY METHODS

Descriptions of typical survey methods and instrumentation providing guidance for this survey are given in *Procedures Manual for the ORNL Radiological Survey Activities (RASA) Program,* ORNL/TM-8600 (April 1987), and in *Measurement Applications and Development Group Guidelines,* ORNL-6782 (January 1995).[5,6]

SURFACE RADIATION MEASUREMENTS

Indoors, open floor areas were scanned using a Ludlum 2221 meter with a Ludlum 23–1F floor monitor. Space-restricted and elevated areas were then measured using portable gamma and beta-gamma instrumentation. Gamma radiation levels were determined using a portable NaI gamma scintillation meter. Because NaI gamma scintillators are energy dependent, measurements of gamma radiation levels in counts per minute (cpm) are normalized to pressurized ionization chamber (PIC) measurements to estimate gamma exposure rates in μR/h. Using a Geiger-Mueller pancake detector, beta-gamma radiation levels were measured in counts per minute (cpm) near contact with accessible hard surfaces. The cpm were then converted to millirad per hour (mrad/h) and disintegrations per minute over 100 cm^2 (dpm/100 cm^2) for comparison with guideline

values. Gamma exposure rate readings of more than 16 μR/h and/or a direct beta-gamma activity level or dose rate of more than 3,000 dpm/100 cm^2 or 0.05 mrad/h, respectively, triggered a need for further evaluation. Random spot-checks using an ORNL alpha survey meter connected to a zinc sulfide scintillation probe were done to detect directly measured alpha activity levels in open indoor areas.

SAMPLING AND ANALYSES

Systematic surface (0– to 15–cm) soil samples were collected outdoors in all remediated areas at selected locations without regard to radiation levels (e.g., at grid points). Systematic soil samples were also taken at locations surrounding anomalies to define the boundaries of any contamination, and repeatedly at locations where remediation was incomplete. Biased samples were collected at locations of anomalous beta-gamma radiation levels. Where appropriate, subsurface soil samples were taken at these locations at increments of 15 cm below the surface.

During the December and January activities, a new screening device was used to provide an estimate of uranium content (pCi/g) in the field. The procedure consisted of on-site analyses of freshly collected soil samples using a portable gamma spectrometer. The results of the analyses were then used along with the beta-gamma measurements to make an immediate assessment. The reliability of the field screening method was established at another site by comparison of the field-estimated uranium concentration in a specific sample to the results found from later laboratory analysis of that same sample. When the comparisons proved to be dependable, the field screening method was relied upon to provide the basis for an immediate decision on further remedial action. The assessment, remediation, and verification processes were thereby considerably expedited. Furthermore, the approach was conservative in that the maximum uranium concentration resulting from multiple field analyses done on a single sample was selected for comparison with the derived site-specific ^{238}U guideline (17.5 pCi/g, Table 1). The process of drying, weighing, grinding, and homogenizing samples according to the required QA procedures was done in the laboratory later as confirmation of radionuclide concentrations. This report details both field and laboratory analysis results for samples collected by ORNL in successfully remediated locations. In addition, selected samples collected and analyzed earlier by BNI were later split and re-analyzed by ORNL for verification of results.

Selected indoor areas were assessed for possible removable alpha and beta-gamma activity levels by wiping surfaces with cloths (smears) that were subjected to gross counting at the site and later laboratory spectrometry analysis.

SURVEY RESULTS

Current DOE guidelines for sites included within FUSRAP are summarized in Table 1; the derived site-specific guideline for ^{238}U is also listed.[7] Typical background radiation levels for the Oxford, Ohio, area are presented in Table 2. These data are provided for comparison with the

survey results presented in this report. Gamma radiation levels are reported in gross μR/h. Background concentrations have not been subtracted from radionuclide concentrations in soil, debris, or other materials.

The verification survey at this property was initiated by ORNL on October 25, 1993, immediately following BNI's notification that some indoor areas had been cleaned sufficiently to satisfy the guidelines (Table 1). All subsequent verification was done sporadically inside and outside the residence in response to BNI's activities in those locations.

OUTDOOR RESULTS

On December 5, 1994, BNI notified ORNL that the outdoor remedial activities at 525 S. Main Street had been completed. Two separate grid systems were established on the property to allow the precise location of measurements and samples (Figs. 4 and 5). ORNL then surveyed the five excavated locations comprising one large area and two small areas south of the house, and two smaller areas north of the house (Fig. 3). A gamma walkover survey and a thorough beta-gamma scan of these areas were conducted. Table 3 details analytical results for concentrations of ^{238}U in soil samples collected from this property following remediation of all areas.

North Yard

Beta-gamma scanning over the two excavated areas in the north yard (Fig. 4) revealed several anomalies (i.e., beta activity at >3,000 dpm/cm^2) on both sides of the driveway although gamma exposure rates were no more than 8 μR/h. The areas were re-sampled at nine systematic locations (VS1 to VS9) and seven biased locations. Field screening of the systematic samples showed ^{238}U concentrations ranging from less than background to 12 pCi/g (Table 3). Field screening for five of the biased samples showed values exceeding the ^{238}U soil contamination guidelines for Oxford with a maximum concentration of 79 pCi/g. ORNL requested that BNI conduct further remediation in these areas. Photographs showing views of the excavated areas in progress are shown on Figs. 6 and 7.

ORNL repeated the beta-gamma scanning on December 8 following re-excavation of those areas of the north yard. Several anomalies were again found on both sides of the driveway. Field screening of samples VB1 through VB10 taken from the east side of the driveway showed concentrations of ^{238}U ranging from 2 to 17 pCi/g (Table 3), values less than the guideline (Table 1). That area was released to BNI for final restoration. Field screening indicated concentrations of ^{238}U ranging from 31 to 140 pCi/g in three samples from the area on the west side of the driveway. Additional cleanup of that area was requested and performed.

On December 15, ORNL performed another beta-gamma scan of the area on the west side of the driveway with the result that more anomalies were found. Biased samples again collected from the re-excavated area were shown by field screening to contain concentrations of ^{238}U exceeding the limit (to a maximum of 70 pCi/g,).

Following a third excavation of the west side of the driveway on December 16, beta-gamma scanning revealed additional anomalous areas indicating that radioactive residuals still remained. The anomalies (to 63 pCi/g ^{238}U) were confirmed by field screening of additional soil samples.

A fourth attempt by BNI to remove all contamination west of the driveway was followed by an ORNL beta-gamma scan on December 28. Several more anomalies were found, and soil samples were again collected. Field screening of newly collected soil samples VB21 and VB22 indicated ^{238}U at concentrations of 9.2 and 14 pCi/g, respectively. Because these values are less than the maximum derived guideline of 17.5 pCi/g (Table 1), the area was released to BNI for complete restoration of the property.

South Yard

The three excavated areas in the yard south of the house showed no anomalies during the scans. Gamma exposure rates ranged from 3 to 8 μR/h and beta-gamma measurements were <3,000 dpm/100 cm^2. Because the results were comparable to typical background and less than DOE guidelines, no biased samples were collected. Systematic samples (VS10 through VS14) were collected at five locations from the three excavated areas in the south yard (Fig. 8). Field screening of these samples showed ^{238}U concentrations ranging from less than background to 4.9 pCi/g, well below the site-specific soil contamination guideline of 17.5 pCi/g derived for the Oxford, Ohio sites (Table 1). ORNL then released the remediated south yard areas to BNI for restoration. Final analytical results in soil samples from those areas are shown in Table 3.

INDOOR RESULTS

Areas remediated inside the house included the den, its sub-floor and the crawlspace beneath it, an upstairs bedroom and its sub-floor, and the bathroom in the garage. At various times during remediation and verification, the original hardwood floors in the den and in the bedroom above the garage had been removed by either BNI or a private flooring contractor hired by the owner. ORNL also requested that BNI remove some parts of cabinets and shelves throughout the dwelling (living areas, etc.) to allow access to areas beneath and behind the structures. All measured areas showed results less than guidelines (Table 1). The following discussion of activities is arranged according to room or area.

Den, Sub-floor, and Crawlspace

October 25, 1993, the ORNL team found elevated beta-gamma activity levels in the den following removal of the tarpaper that had underlain the hardwood flooring. Anomalous areas ranged from 3,000 to 12,000 dpm/100 cm^2 (0.05 to 0.2 mrad/h). Two spots were remediated with tape. Additional BNI remediation lowered all previously ORNL-identified anomalies in this area of the den to acceptable levels (Table 1). A 100% walkover scan with gamma scintillators

revealed exposure rates ranging from 6 to 10 μR/h, values well below the guideline of 20 μR/h above background (Table 1). Spot-checking with alpha scintillators showed activity levels of 7.2–29 dpm/100 cm^2. Results of analysis of five smear samples (VT7 - VT11, Fig. 9) were all less than minimum detectable activity (MDA, Table 4).*

On January 6, 1994, ORNL conducted verification activities as BNI remediated the crawl space beneath the den. After BNI removed a section of the sub-floor and a few floor joists, TMA/Eberline** and ORNL surveyed the joists and the fireplace hearth facing. In general, the fireplace hearth facing had beta-gamma activity levels ranging from 1,100 to 3,000 dpm/100 cm^2 (0.02 to 0.05 mrad/h). A particle or shaving (apparently uranium) had beta-gamma activity levels of 60,000 dpm/100 cm^2 (1 mrad/h). Anomalous beta-gamma activity levels in other locations in the crawl space ranged from 5,400 to 60,000 dpm/100 cm^2 (0.09 to 1 mrad/h). The elevated spots were remediated by BNI and ORNL. ORNL re-surveyed the area and collected additional smears showing analytical results of all to be less than MDA.

The following day, ORNL personnel surveyed the dirt floor and the wooden floor supports in the crawl space beneath the den. Approximately 10 elevated spots were found between the fireplace hearth and the raised dirt area in the crawl space. Soil readings were >3,000 dpm /100 cm^2 beta-gamma; spots over the horizontal surfaces of the fireplace footer ranged from 4,500 to 90,000 dpm/100 cm^2 (0.08 to 1.5 mrad/h). ORNL surveyed approximately 45 ft^2 of soil in this area, including characterizing, remediating, and verifying activities. A beta-gamma anomaly reading 10,000 dpm/100 cm^2 (0.18 mrad/h) was found approximately seven feet west of the center of the hearth. This spot was remediated and verified by ORNL. A beta-gamma anomaly measuring 19,000 dpm/100 cm^2 (0.32 mrad/h) was found on the bottom of the south baseboard. This area was also remediated and verified by ORNL. All surfaces of the three floor joists west of the fireplace hearth were surveyed with the result that two beta-gamma anomalies measuring 5,400 and 6,900 dpm/100 cm^2 (0.09 and 0.12 mrad/h) were found. These were then remediated by BNI and verified by ORNL. After remediation, beta-gamma activity levels on all surfaces of the joists ranged from 1,000 to 1,700 dpm/100 cm^2 (0.02 to 0.03 mrad/h). An additional 100 ft^2 of soil west of the raised soil area was also surveyed by ORNL. The background beta-gamma of the soil areas ranged from 1,800 to 2,700 dpm/100 cm^2. Approximately 0.044 m^3 of soil were removed from the crawl space during ORNL's remediation activities. Collected soil and remediation debris collected by ORNL was turned over to BNI for proper disposal.

On January 8, 1994, ORNL continued surveying the crawl space under the den. Generally, beta-gamma activity levels in the crawl space ranged from 2,000 to 3,300 dpm/100 cm^2 (0.03 to 0.05 mrad/h); gamma exposure rates ranged from 6 to 10 μR/h. However, additional anomalies (>3,000 dpm/100 cm^2 beta-gamma) were again identified in the soil and on wood on top of the foundation underneath the door leading from the den to the south porch. The beta-gamma activity levels on the wood were 6,000 to 12,000 dpm/100 cm^2 (0.1 to 0.2 mrad/h). Beta-gamma activity

*The instrument-specific minimum detectable activities (MDAs) for removable alpha and beta-gamma radiation levels are 10 and 200 dpm/100 cm^2, respectively.

*TMA/Eberline is another DOE subcontractor assigned to the property.

levels over the soil surface underneath the door leading to the garage from the den were >3,000 dpm/100 cm^2. Alpha activity levels in the crawl space ranged from 72 to 338 dpm /100 cm^2. Alpha measurements at these slightly higher–than–normal levels generally result from emanation of radon produced from natural radioactivity in the soil. The alpha activity accumulates in areas such as crawlspaces and basements because it cannot dissipate as rapidly as it might in adequately ventilated areas. The levels are well below guidelines (Table 1). Three biased soil samples and four systematic soil samples were taken from the crawl space. BNI decided that these areas would be remediated at a later date.

On March 7, 1994, ORNL resumed verification activities in the crawl space under the den. An anomaly ranging from 6,000 to 21,000 dpm/100 cm^2 (0.1 to 0.36 mrad/h) was brought to the attention of BNI and was subsequently remediated.

East Bedroom Area

Elevated areas found on the east bedroom floor above the garage ranged from 4,500 to 37,000 dpm/100 cm^2 (0.08 to 0.61 mrad/h) beta-gamma. Some removal of the sub-floor was required to remediate all areas to <3,000 dpm/100 cm^2 beta-gamma. A 100% scan with gamma scintillators disclosed exposure rates of 6 to 8 μR/h, values well below the guideline of 20 μR/h above background (Table 1). Spot-checking showed alpha activity levels of less than MDA to 22 dpm/100 cm^2. Four smear samples (VT12 - VT15) were taken from the locations as shown on Fig. 10. The values were less than MDA.

Elevated gamma measurements in an upstairs closet next to the east bedroom led to the discovery of a luminous toggle switch containing radium. The device was concealed behind a wall near the chimney. It was removed and packaged as sample M3. No analysis was performed. The general area showed measurements of 900 to 1,500 dpm/100 cm^2 beta-gamma with no anomalies.

Garage Bathroom

On October 27, 1993, IVC surveying of the bathroom in the garage disclosed areas of elevated beta-gamma activity ranging from 6,000 to 225,000 dpm/100 cm^2 (0.1 to 3.4 mrad/h) in eleven unremediated locations. Approximately 50% of the hidden wooden shelf behind the commode ranged from 3,000 to 30,000 dpm/100 cm^2 (0.05 to 0.65 mrad/h) requiring supplementary BNI remediation. Measurements on the floor areas underneath the shelf and the stairs revealed no anomalies.

Later that afternoon, ORNL repeated the verification survey of the garage bathroom after supplemental BNI remediation. Seven new beta-gamma anomalies were identified, ranging from 4,500 to 15,000 dpm/100 cm^2 (0.08–0.25 mrad/h). A debris sample was collected from the shower drain (Fig. 11). Laboratory analysis later showed that the sample contained 280 pCi/g ^{238}U. ORNL notified BNI that additional remediation of the bathroom floor was required. Remedial action was followed by a 100% scan showing gamma exposure rates ranging from 9 to 12 μR/h, and total (fixed and removable) alpha measurements ranging from 29 to 94 dpm /100 cm^2. Three smear samples were taken from the floor in the locations shown on Fig. 11 (T16, T17,T18). Results showed values of less than MDA for both alpha and beta-gamma measurements. All results are below DOE guidelines (Table 1).

ORNL again surveyed the garage bathroom on the day following more BNI remediation in that room. Four anomalies (>3,000 dpm/100 cm^2 beta-gamma) remained on the bathroom floor. It was decided mutually by ORNL and BNI to delay further remediation and verification of the bathroom floor until later on in the cleanup process.

On March 9, 1994, ORNL confirmed that the remediation in the garage and the bathroom above it was sufficient to meet the guidelines. The floors generally had beta-gamma activity levels ranging from 1,500 to 2,700 dpm/100 cm^2 (0.02 to 0.04 mrad/h), and overhead measurements ranging from 1,200 to 2,200 dpm/100 cm^2 (0.02 to 0.04 mrad/h).

Instrumentation interference from a large collection of assorted metallic materials inside the garage prevented tracing the bathroom shower drain to its terminus. Therefore, that drain as well as two other drains inside the garage were permanently sealed by ORNL to prevent possible access to or redistribution of any contaminants.

INDOOR RESULTS SUMMARY

Final indoor verification was conducted March 9, 1994 by BNI and TMA Eberline with oversight by ORNL. A beta-gamma scan of 100% of accessible floor surfaces was performed. ORNL also made measurements in every third grid block and spot-checked all overhead locations. Floors typically measured 1,500 to 2,700 dpm/100 cm^2 (0.02 to 0.04 mrad/h); overhead areas typically measured 1,200 to 2,200 dpm/100 cm^2 (0.02 to 0.04 mrad/h). Measurements in the garage including the area of the former stairway and bathroom were generally 1,800 dpm /100 cm^2 (0.03 mrad/h). A few locations in the bathroom area measured 1,200 dpm/100 cm^2. Although the area under the gas furnace could not be 100% verified, accessible areas were no higher than 3,600 dpm/100 cm^2 (0.06 mrad/h). Beta-gamma levels were ~3,000 dpm/100 cm^2 (0.05 mrad/h) in the main drain in the garage after remediation (before sealing).

SIGNIFICANCE OF FINDINGS

From a review of the post-remedial action report, it can be concluded that the BNI survey objectives for this property were achieved. Furthermore, the results of the independent verification survey of the property at 525 S. Main Street demonstrate that all contaminated areas have been remediated to radionuclide concentrations and activity levels below the applicable guideline limits set by DOE.

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ORNL-DWG 92-9817

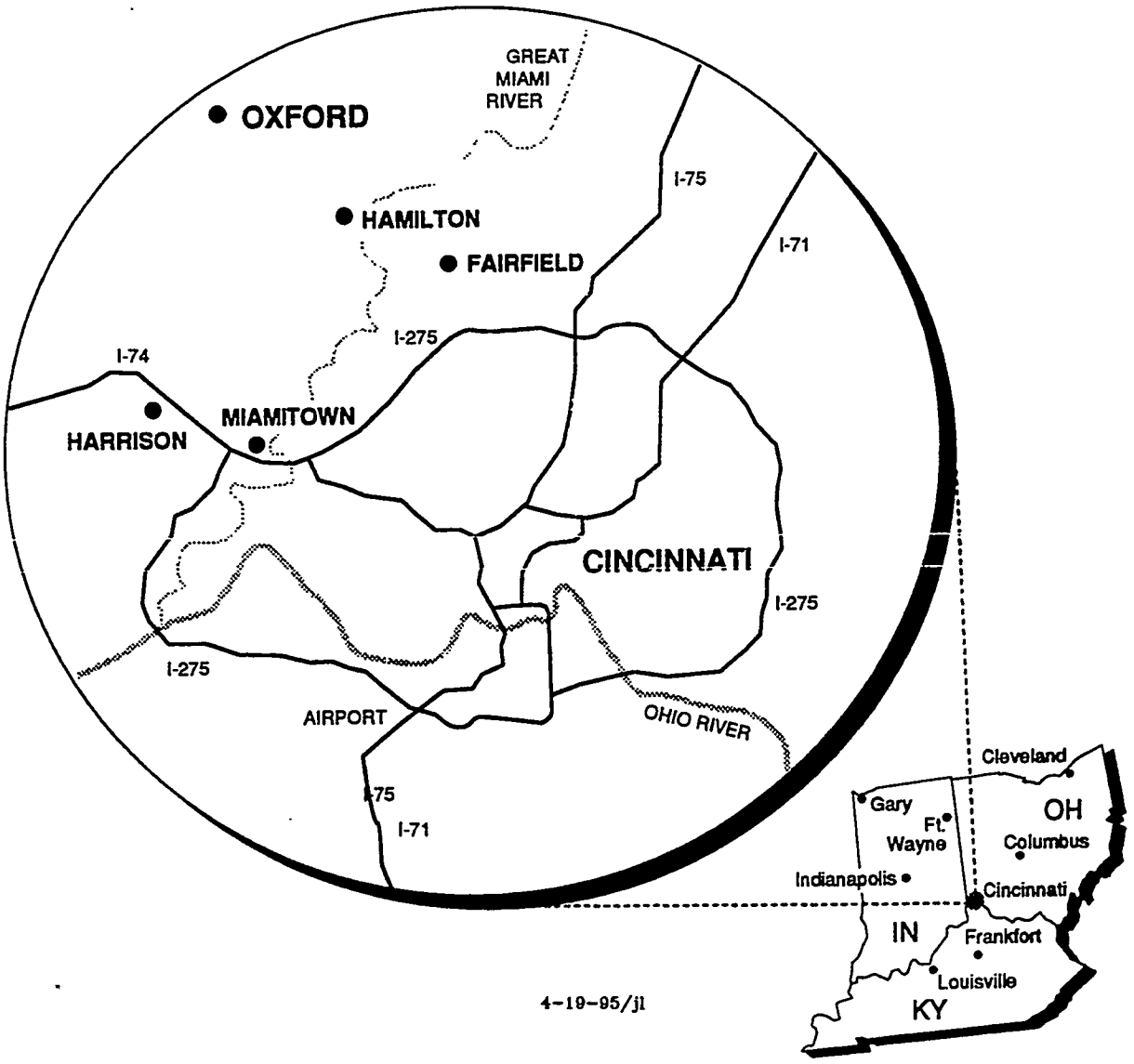

Fig. 1. Diagram showing the general location of Oxford, Ohio.

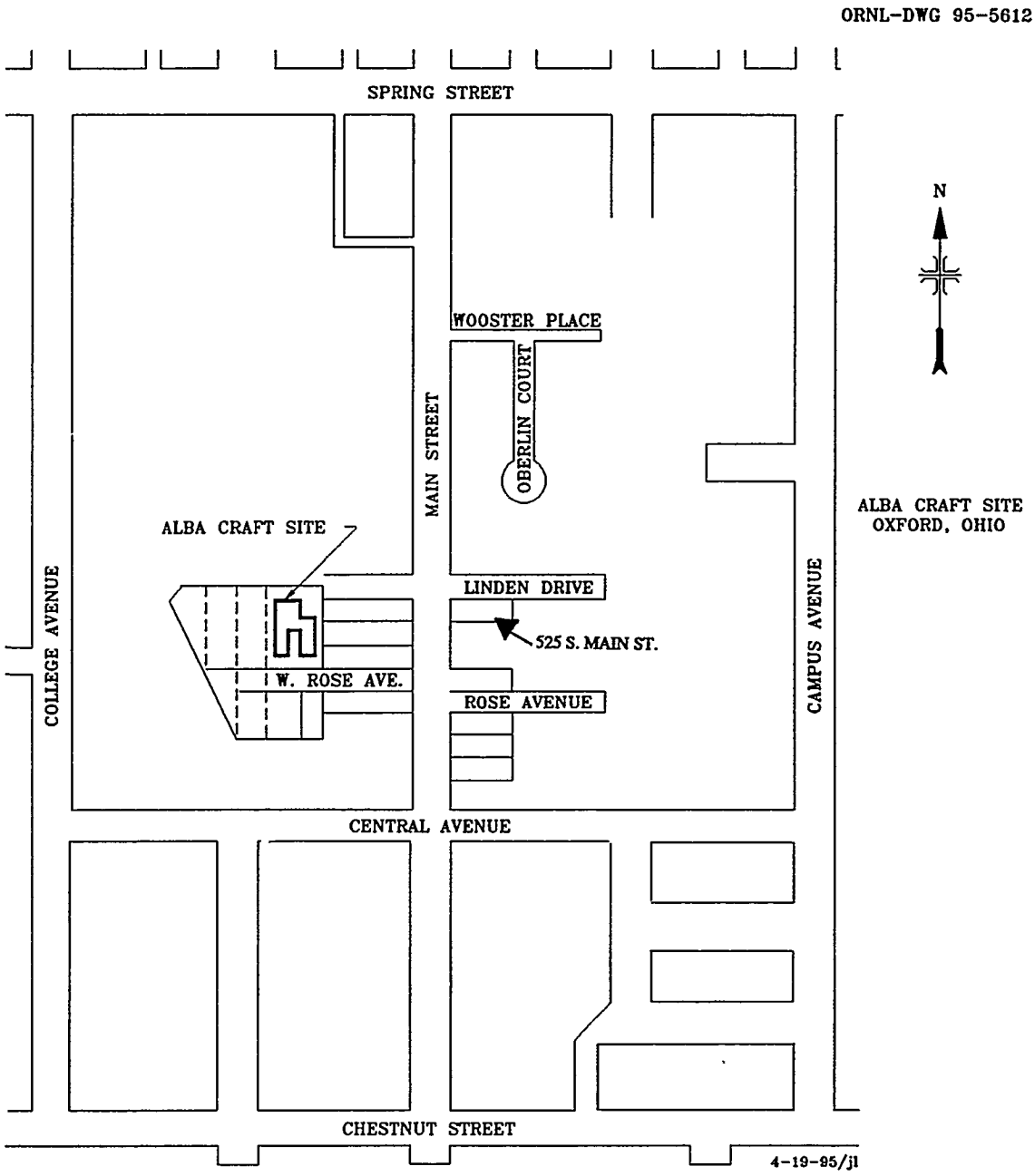

Fig. 2. Diagram showing the general location of the former Alba Craft Laboratory site and 525 S. Main Street, Oxford, Ohio.

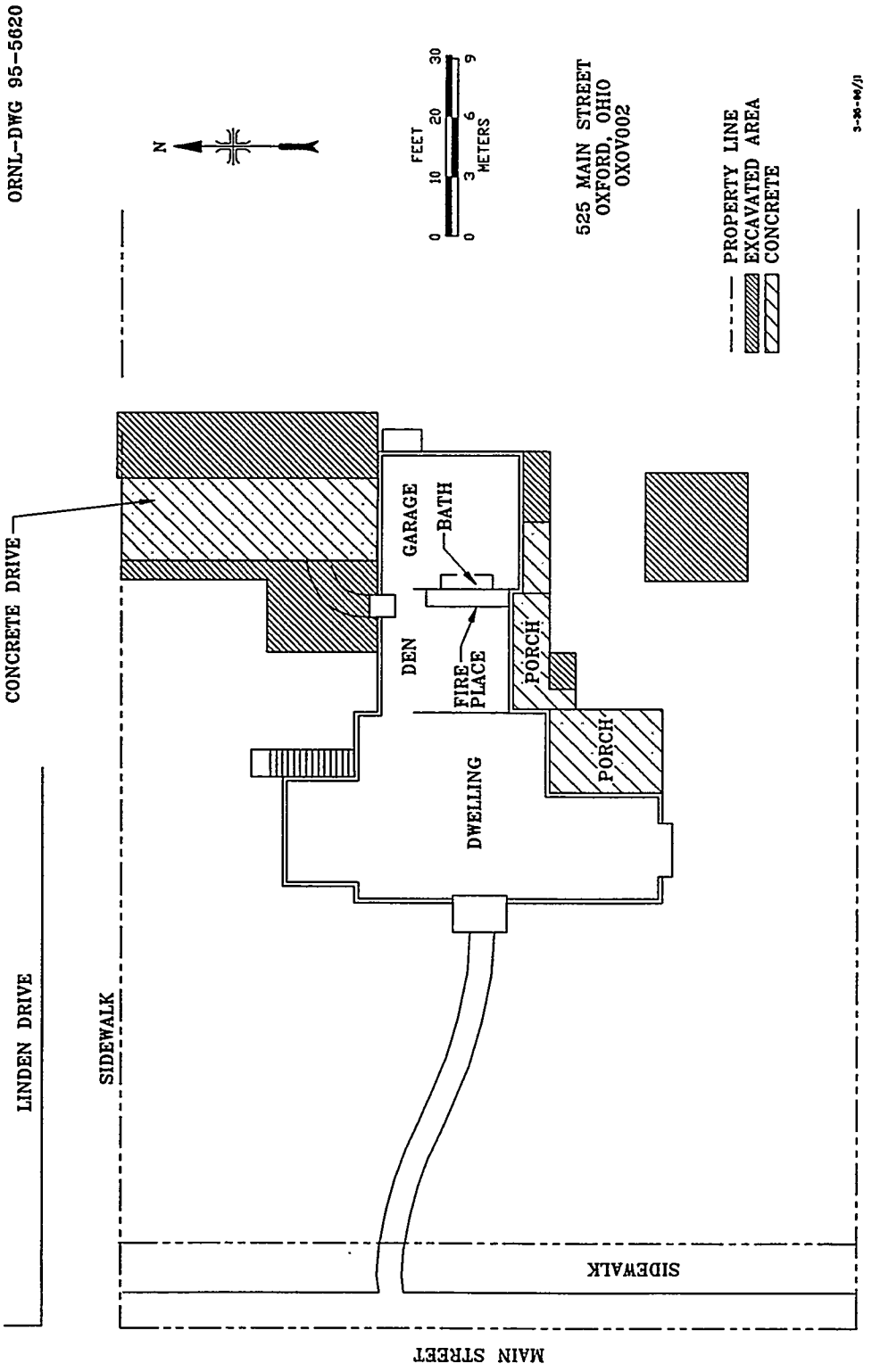

Fig. 3. Diagram showing the layout of the residential property at 525 S. Main Street and the excavated areas.

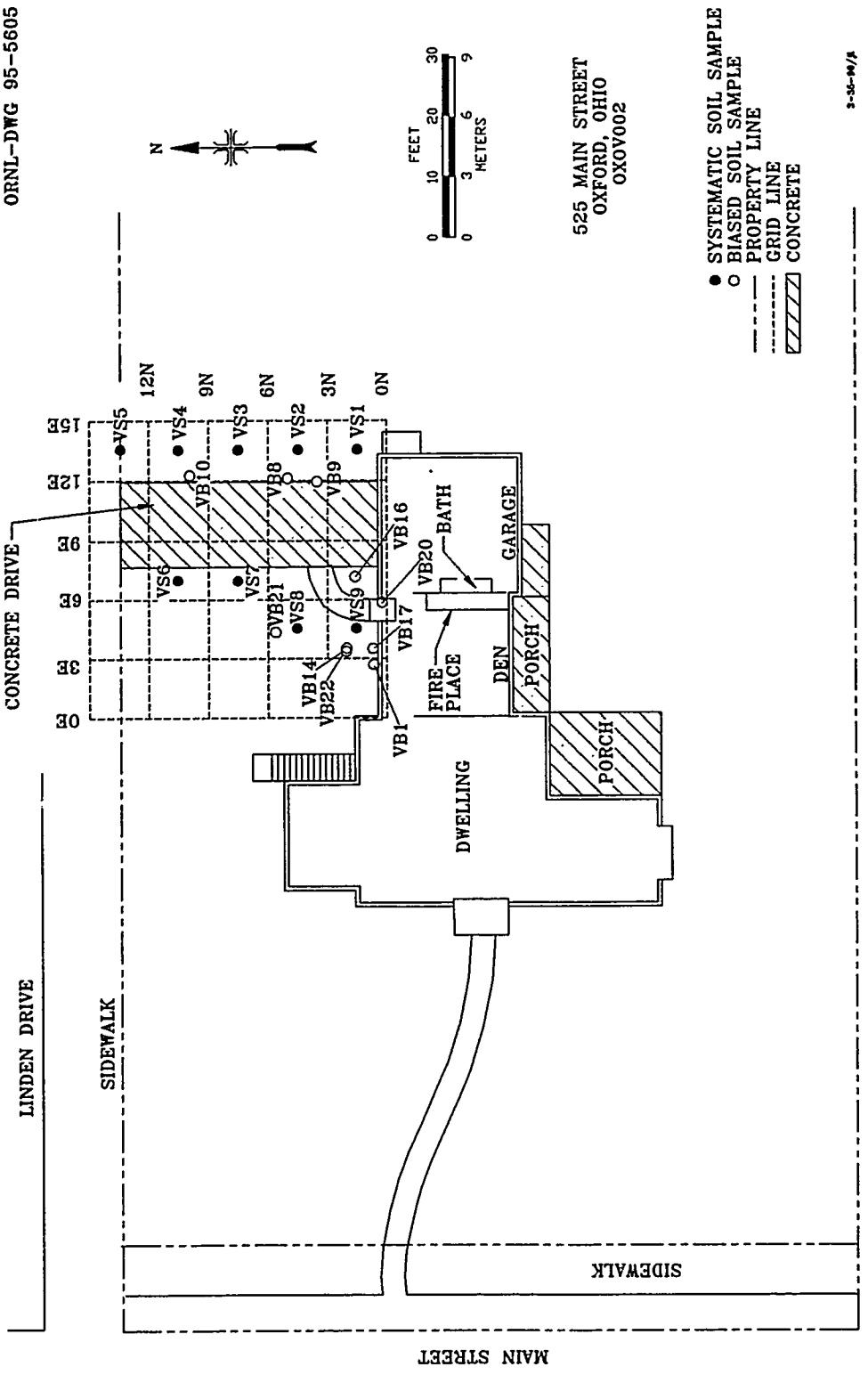

Fig. 4. Diagram showing grid and locations of soil samples collected from the North Yard at 525 S. Main Street.

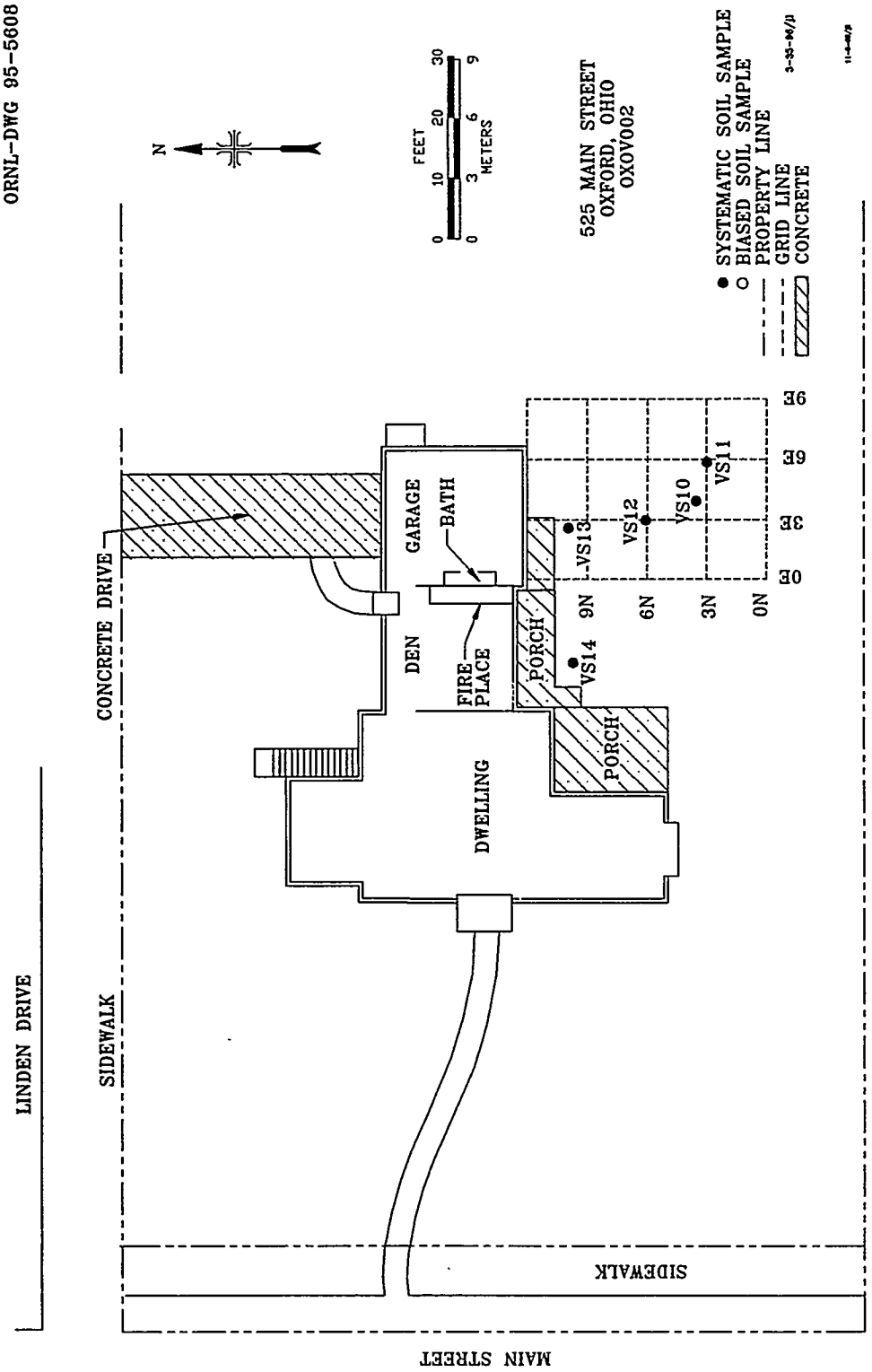

Fig. 5. Diagram showing grid and locations of soil samples collected from the South Yard at 525 S. Main Street.

ORNL-PHOTO 9879-95

Fig. 6. Photograph showing excavated areas in the north yard on each side of the driveway at 525 S. Main Street.

ORNL-PHOTO 9880-95

Fig. 7. Photograph showing excavated area in the north yard on the west side of the driveway at 525 S. Main Street.

ORNL-PHOTO 9881-95

Fig. 8. Photograph showing excavated areas in the south yard at 525 S. Main Street.

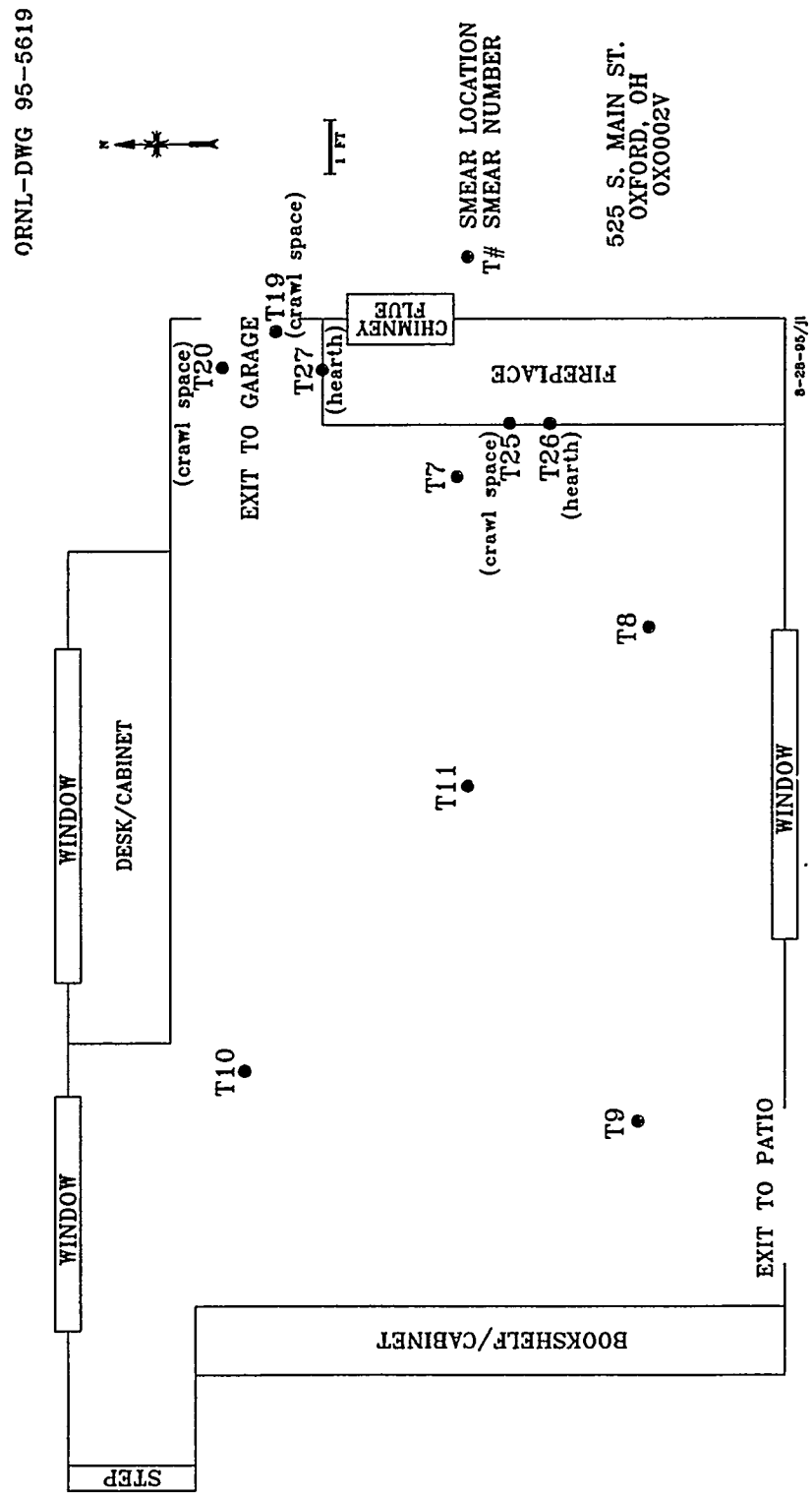

Fig. 9. Diagram showing layout and locations of smears taken in the den and the areas beneath the floor.

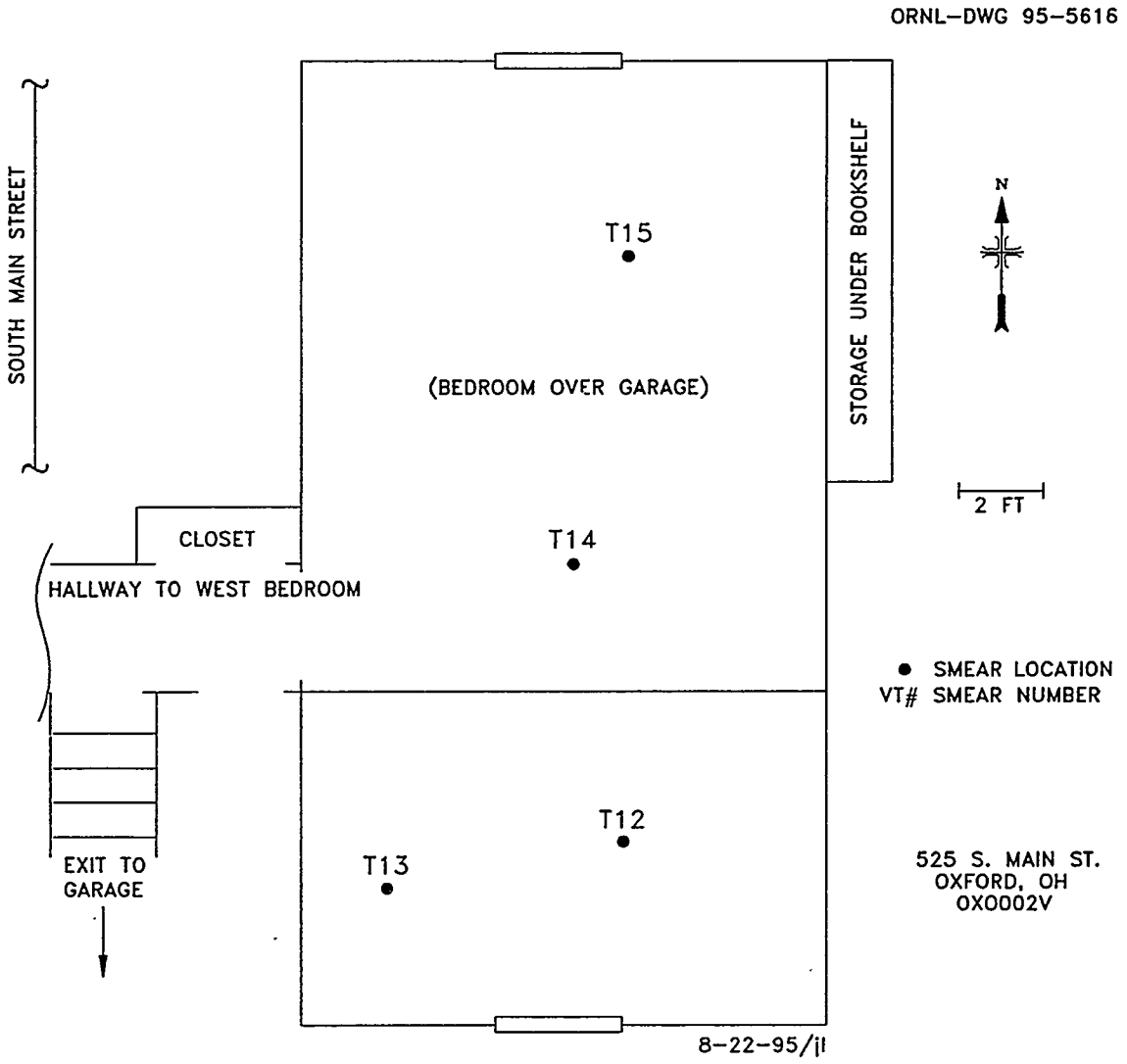

Fig. 10. Diagram showing layout and locations of smears taken in the east bedroom area.

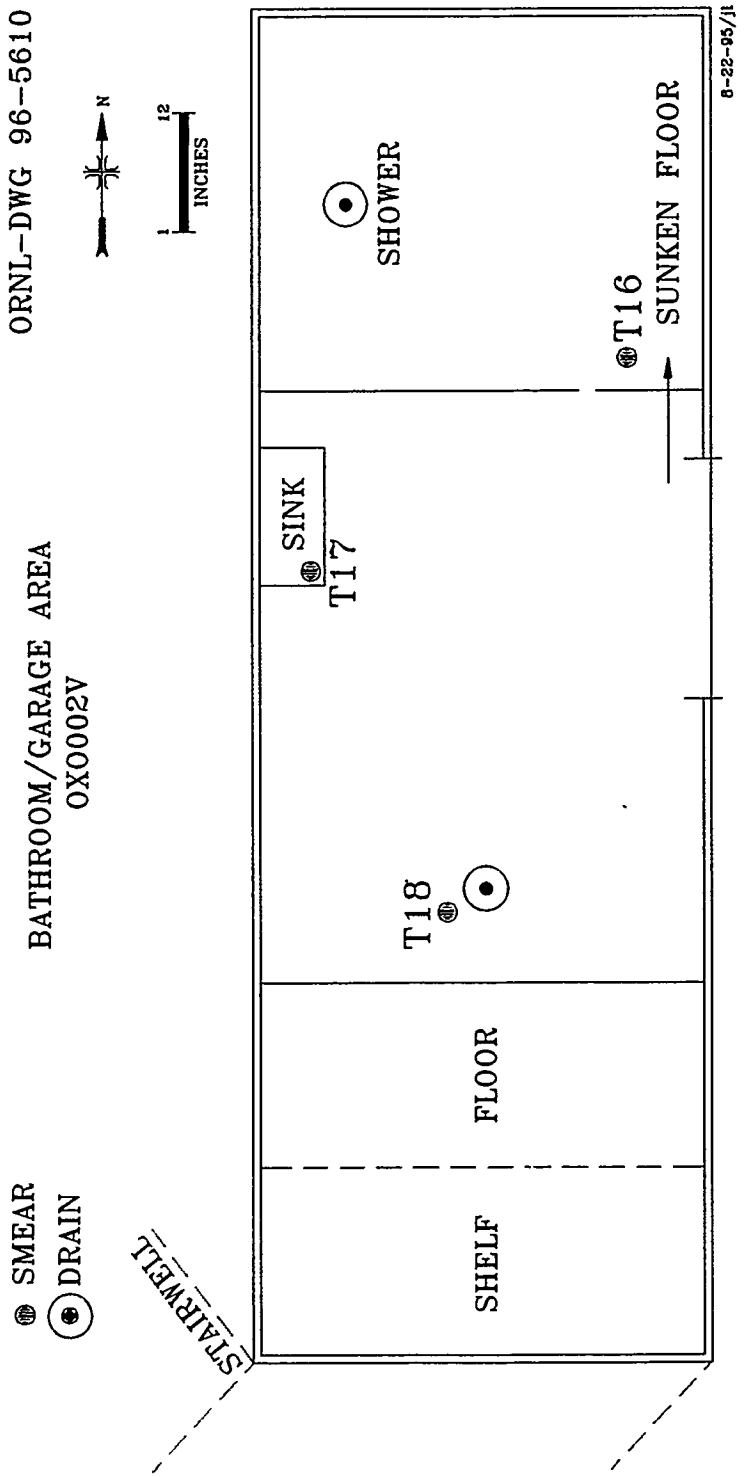

Fig. 11. Diagram showing layout and locations of smears taken in the garage bathroom.

Table 1. Applicable guidelines for protection against radiation
(Limits for uncontrolled areas)

Mode of exposure	Exposure conditions	Guideline value
Gamma radiation	Indoor gamma level (above background)	20 μR/h[a]
Total residual surface contamination[b]	^{238}U,^{235}U, U-natural (alpha emitters) or Beta-gamma emitters[c]	
	Fixed and removable	15,000 dpm/100 cm2
	Average	5,000 dpm/100 cm2
	Removable	1,000 dpm/100 cm^2
	Maximum dose rate in any 100-cm^2 area	1.0 mrad/h

[a]The 20 μR/h shall comply with the basic dose limit (100 mrem/yr) when an appropriate-use scenario is considered.

[b]DOE surface contamination guidelines are consistent with *NRC Guidelines for Decontamination at Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for By-Product, Source, or Special Nuclear Material,* May 1987.

[c]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, ^{126}I, ^{125}I.

Sources: Adapted from U. S. Department of Energy, *Radiation Protection of the Public and the Environment,* DOE Order 5400.5, April 1990 and U.S. Department of Energy, *Guidelines for Residual Radioactive Material at FUSRAP and Remote SFMP Sites,* Rev. 2, March 1987; and *U. S. Department of Energy Radiological Control Manual,* DOE N5480.6 (DOE/EH-256T), June 1992.

Table 2. Background radiation levels and concentrations of selected radionuclides in soil samples taken near Oxford, Ohio

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]	6 – 9	8
Concentration of radionuclides in soil (pCi/g dry wt)[b]		
^{238}U	0.86 – 2.2	1.3
^{226}Ra	1.0 – 2.5	1.9
^{232}Th	0.71 – 0.99	0.89

[a]Results of measurements taken at three locations near Oxford, Ohio.

[b]Results of analysis of soil samples obtained from three locations near Oxford, Ohio.

Source: T. E. Myrick, B. A. Berven, and F. F. Haywood, *State Background Measurements Taken During 1975-1979*, ORNL/TM–7343, November, 1981.

Table 3. Results of radionuclide analysis of soil samples collected from the property at 525 South Main Street, Oxford, Ohio

Sample I.D.	Grid location [b]	Depth (cm)	Radionuclide concentration (pCi/g)[a] ^{238}U[c] Field	^{238}U[c] Lab	^{226}Ra	^{232}Th
			Systematic samples[d] (North yard)			
VS1	1.5N, 13.6E	0-15	4.8	2.3 ± 0.41	1.2 ± 0.09	1.4 ± 0.13
VS2	4.5N, 13.6E	0-15	0.87	2.3 ± 0.49	1.0 ± 0.07	0.73 ± 0.11
VS3	7.5N, 13.6E	0-15	7.3	2.1 ± 0.50	1.2 ± 0.07	0.96 ± 0.12
VS4	10.5N, 13.6E	0-15	2.5	1.3 ± 0.26	1.3 ± 0.08	1.1 ± 0.12
VS5	13.45N, 13.6E	0-15	12	9.3 ± 0.96	1.4 ± 0.09	1.1 ± 0.14
VS6	10.5N, 7.1E	0-15	7.4	7.2 ± 1.0	1.0 ± 0.15	0.80 ± 0.20
VS7	7.5N, 7.1E	0-15	1.7	4.8 ± 1.0	1.1 ± 0.07	0.89 ± 0.12
VS8	4.5N, 4.5E	0-15	*e*	2.1 ± 0.26	0.94 ± 0.07	0.83 ± 0.12
VS9	1.5N, 4.5E	0-15	8.8	11 ± 1.4	1.3 ± 0.09	1.1 ± 0.14
			(South Yard)			
VS10A	3.5N, 4E	0-15	*e*	0.80 ± 0.34	0.39 ± 0.05	0.45 ± 0.09
VS10B	3.5N, 4E	15-30	4.9	2.4 ± 0.28	0.83 ± 0.07	0.99 ± 0.12
VS11	3N, 6E	0-15	*e*	1.4 ± 0.65	1.1 ± 0.07	0.93 ± 0.2
VS12	6N, 3E	0-15	1.5	1.1 ± 0.24	1.3 ± 0.08	0.96 ± 0.13
VS13	10N, 2.5E	0-15	*e*	3.2 ± 0.30	0.90 ± 0.06	0.64 ± 0.11
VS14	10N, 4.5W	0-15	4.3	3.6 ± 0.35	1.3 ± 0.09	0.92 ± 0.11
			Biased samples[f]			
VB1	0.7N, 2.85E	0-15	7.4	4.0 ± 0.62	1.0 ± 0.08	1.0 ± 0.12
VB8A	5N, 12.2E	0-15	12	13 ± 0.72	0.85 ± 0.07	0.75 ± 0.11
VB8B	5N, 12.2E	15-30	17	14 ± 1.3	0.96 ± 0.08	0.92 ± 0.13
VB9	3.5N, 12.1E	0-15	2.0	5.5 ± 0.72	0.78 ± 0.06	0.59 ± 0.10
VB10	10N, 12.3E	0-15	6.3	5.7 ± 0.60	1.0 ± 0.08	1.1 ± 0.12
VB14	2N, 3.5E	0-15	14	16 ± 1.5	1.0 ± 0.07	0.97 ± 0.13
VB16	1.8N, 7.3E	0-15	14	13 ± 0.75	1.2 ± 0.08	1.3 ± 0.14
VB17	0.8N, 3.5E	0-15	7.6	2.9 ± 0.51	1.1 ± 0.08	1.0 ± 0.13
VB20	0.44N, 6E	0-15	8.2	8.3 ± 0.38	1.2 ± 0.09	1.2 ± 0.14
VB21	5.8N, 4.4E	0-15	14	4.6 ± 0.83	1.1 ± 0.08	0.94 ± 0.13
VB22	2N, 3.2E	0-15	9.2	6.5 ± 0.30	1.1 ± 0.08	1.1 ± 0.13

[a] Indicated counting error is at the 95% confidence level (± 2 σ).

[b] Locations are shown on Figs. 4 and 5.

[c] Field analyses provide a quick estimate of ^{238}U concentrations for cleanup recommendations in the field and do not provide a counting error. Laboratory analyses provide the most accurate results.

[d] Systematic samples are collected without regard to gamma exposure rates.

[e] Sample concentration was less than background.

[f] Biased samples were collected from locations of previous anomalies.

Table 4. Results of analysis of smear samples collected from indoor surfaces in the residence at 525 S. Main Street, Oxford, Ohio

Sample ID	Location[a]	Location detail	Removable contamination	
			Alpha (dpm/100 cm^2)[b]	Beta-gamma (dpm/100 cm^2)[c]
T7	Den	Floor	<MDA	<MDA
T8	Den	Floor	<MDA	<MDA
T9	Den	Floor	<MDA	<MDA
T10	Den	Floor	<MDA	<MDA
T11	Den	Floor	<MDA	<MDA
T12	Bedroom over garage	Floor	<MDA	<MDA
T13	Bedroom over garage	Floor	<MDA	<MDA
T14	Bedroom over garage	Floor	<MDA	<MDA
T15	Bedroom over garage	Floor	<MDA	<MDA
T16	Garage bathroom	Shower floor	<MDA	<MDA
T17	Garage bathroom	Floor	<MDA	<MDA
T18	Garage bathroom	Floor	<MDA	<MDA

[a]Locations of smears are shown on Figs. 9 through 11.

[b]The instrument-specific minimum detectable activity for removable alpha activity levels is 10 dpm/100 cm^2.

[c]The instrument-specific minimum detectable activity for beta-gamma activity levels is 200 dpm/100 cm^2.

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