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RADIOLOGICAL SURVEY OF THE FORMER BAKER BROTHERS,INC. SITE, 2551-2555 HARLEAU PLACE, TOLEDO,OHIO (BTO001)

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ABSTRACT

At the request of the U.S. Department of Energy (DOE), a team from Oak Ridge National Laboratory conducted investigative radiological surveys at the REMS, Inc., and the Doug Beet Company, 2551-2555 Harleau Place, Toledo, Ohio (BTO001) in 1988. The purpose of the surveys was to determine whether the property was contaminated with radioactive residues, principally ^{238}U, as a result of work contracted to the Manhattan Engineer District (MED). The survey included gamma scans; directly measured alpha, beta, and gamma radiation levels; transferable contamination levels; and soil, dust, debris, and air sampling for radionuclide analyses. The survey and sampling covered accessible portions of the exterior ground surface, roof, and interiors of buildings.

Results of the surveys demonstrated four general areas having radionuclide concentrations in excess of the DOE Formerly Utilized Sites Remedial Action Program criteria for ^{238}U outdoors and as surface contamination on shelves in one building.

RADIOLOGICAL SURVEY OF THE FORMER BAKER BROTHERS,INC. SITE, 2551-2555 HARLEAU PLACE, TOLEDO, OHIO (BTO001)*

INTRODUCTION

Under jurisdiction of the Army Corps of Engineers in the early 1940s, the Manhattan Engineer District (MED) was established as the lead agency in the development of nuclear energy for defense related projects. Raw materials containing uranium ores were procured, stored, and processed into various uranium oxides, salts, and metals. Fabricators were contracted as needed to form (roll and machine) the metal into various shapes. At contract termination, sites used by contractors were decontaminated according to the criteria and health guidelines then in use. The radiological criteria for releasing sites to unrestricted use were generally site specific and clearly defined. In some instances, however, documentation was limited or nonexistent and conditions at these sites were unknown. Therefore, it was necessary to reevaluate the current radiological conditions at these sites under the U.S. Department of Energy (DOE) Formerly Utilized Sites Remedial Action Program (FUSRAP).

During the early and mid-1940s, Baker Brothers, Inc., in Toledo, Ohio, machined uranium slugs from rolled stock under subcontract to the MED.[1] This commercial property consisted of several buildings located at the intersection of Harleau Place and Post Street, as shown in the 1938 site map in Fig. 1. The buildings were erected in the 1920s of brick with a saw-tooth roof configuration and concrete floors, with the exception of the Post Street Building. Area No. 1 in this building now has aluminum siding, and Area Nos. 3A and 4 have wooden floors. All exterior ground cover is either asphalt or concrete, except in the dirt courtyard north of Building Area No. 8. The Baker Brothers assets were eventually liquidated and the machinery and equipment sold at auction.

Figure 2 shows the current layout of this site. Three of the buildings at this location are currently owned by Romanoff Industries and occupied by either the Doug Beet Company or the REMS, Inc., a division of Siemens-Allis. The first building, consisting of Area Nos. 1, 3, 3A, 4, 5, and 6, is located at 1000 Post Street. This building has 45,000-ft^2 and is used for offices and electric motor repairs. Buildings 3 and 6 were completely refurbished following a fire. Area Nos. 1, 3, and 6 are leased to REMS, Inc.; the rest of this building plus the other buildings are all leased to Doug Beet. Building No. 14, at 2551 Harleau Place, has 8000-ft^2 and is a two-story, unoccupied structure formerly used for offices. Building No. 2 is a two-story, 10,000-ft^2 electric motor shop formerly called the Power House.

*The survey was performed by members of the Measurement Applications and Development Group of the Health and Safety Research Division at Oak Ridge National Laboratory under DOE contract DE-AC05-84OR21400.

A fourth building, located at 2555 Harleau Place, is owned by John Rehkopf but leased to the same used motor brokerage, the Doug Beet Company. This building is 40,000-ft^2 and consists of Area Nos. 7 through 12A. Figures 3 through 10 and 12 through 21 are current photographs of the former Baker Brothers site, with various exterior and two interior views. Figure 11 is an enlargement of the courtyard in the northwest corner of the property.

Baker Brothers machined uranium metal rods into slugs for both Clinton Semi-Works and the Hanford Pile. The MED contract for this operation was temporary and supposedly discontinued when the Hanford facilities were installed. The uranium rods to be machined by Baker Brothers were first extruded by Revere Copper and Brass Corporation. The amount of material machined by Baker Brothers was somewhere between 90 and 300 tons.

According to an old Metallurgical Laboratory Health Division report which was issued following a visit to Baker Brothers on June 21, 1943, heavy fumes were produced by the four lathes used in machining the rods.[2] The pyrophoric uranium chips would spontaneously ignite in the lathe pans and scrap metal containers. An electrostatic precipitator was installed to control the fumes. The cooling system on each of the four lathes was increased to allow greater volumes of lubricant to flow over the turning operation. Containers of scrap metal and the turnings were periodically stored in the machining room and other areas of the plant for periods of several days to several weeks before shipment.

Because the Baker Brothers uranium metal fabrication was apparently related to Atomic Energy Commission (AEC) activities, verification of existing conditions was needed to determine whether the site met current radiological guidelines. The principal radionuclide of concern is ^{238}U.

On June 5, 1989, the preliminary radiological survey at 2551-2555 Harleau Place, Toledo, Ohio, was conducted by members of the Measurement Applications and Development Group of the Oak Ridge National Laboratory (ORNL) at the request of DOE. The survey and sampling at this site covered accessible portions of the plant indoors and outdoors, as indicated in Figs. 22 through 26 and 29 through 31. Figures 27 and 28 are photographs of soil in the northwest corner of the property. In June of 1990, the survey team returned for the subsurface drilling of auger samples. Interior emphasis was on the floors and overhead beams in all buildings. Exterior emphasis was on the ground surface and subsurface, as well as the roofs of buildings. The 100,000-gallon underground cistern behind Building No. 7 was not surveyed. The purpose of this survey was to obtain sufficient radiological measurements for DOE Headquarters to determine whether the site should be designated for remedial action or elimated from FUSRAP.

SURVEY METHODS

The radiological survey included: (1) a surface gamma scan in all accessible areas of the property outdoors and indoors, as well as sections of the roof on all buildings except Nos. 2 and 14; (2) direct gamma exposure measurements using a pressurized ionization chamber (PIC) at one meter above the surface; (3) collection and radionuclide analyses of indoor floor debris and overhead beam dust samples, as well as outdoor soil samples; (4) directly measured and removable alpha and beta-gamma activity levels indoors and outdoors; (5) outdoor auger

soil samples and gamma profiles of auger holes; and (6) air sampling in Building Area Nos. 1, 3, and 3A. The survey methods followed the basic plan outlined in a correspondence from W. D. Cottrell to A. J. Whitman.[3]

Using a portable NaI gamma scintillation meter (No. 3490-51SG), a gamma scan was performed indoors in the accessible areas of all buildings, as well as outdoors and on the roofs, indicated in Figs. 22, 24, and 29. The detectors were held approximately three inches above the surface, and ranges of measurements were recorded and then converted to μR/h. If the surface gamma levels were elevated outdoors, biased and auger soil samples were taken from the areas with the highest gamma radiation levels (Figs. 25 and 26). However, not all auger holes were drilled at elevated surface gamma locations. Because NaI scintillators are energy dependent, measurements of gamma radiation levels are normalized to PIC measurements to determine gamma exposure rates. PIC measuremnet locations are shown in Fig. 25. Systematic dust and debris samples were taken indoors and on the roof at various locations, irrespective of gamma radiation levels (Figs. 24, 30, and 31). The samples were analyzed for ^{226}Ra, ^{232}Th, and ^{238}U content. Indoor air samples were also taken and counted for gross alpha levels (Fig. 30).

To define the extent of possible subsurface soil contamination, auger holes were drilled to depths of approximately 2 m. A plastic pipe was placed in each 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 collimation allows measurement of gamma radiation intensities resulting from contamination within small fractions of the hole depth. Measurements were usually made at 15- or 30-cm intervals. If the gamma readings in the hole were elevated, a soil sample was scraped from the wall of the auger hole at the point showing the highest gamma radiation level. The auger hole loggings were used to select locations where further soil sampling would be useful. A split-spoon sampler was used to collect subsurface samples at known depths. In some auger holes, a combination of split-spoon sampling and side-wall scraping was used to collect samples.

Direct alpha, beta, and gamma radiation measurements were taken outdoors on the roof of Building Nos. 1, 3, 3A, 4, 5, 6, 7, and 9, and indoors in all buildings on various overhead beams, floors, walls, storage bins, and ledges. A beer-mug type scintillation probe (ZnS) with an ORNL meter was used to measure alpha activity levels, and a Geiger-Mueller pancake type probe with a Bicron meter was used for the beta-gamma dose rates. Smears from 100-cm^2 areas were taken at some of the indoor and roof locations to establish removable alpha and beta-gamma activity levels. Smear sample locations are shown in Figs. 24, 30, and 31. Comprehensive descriptions of all survey methods and instrumentation have been presented in another report.[4]

SURVEY RESULTS

Applicable DOE guidelines are summarized in Table 1.[5,6,7] The normal background radiation levels for the Ohio area are presented in Table 2.[8] These data are provided for comparison with survey results presented in this section. All direct measurement results presented in this report are gross readings; background radiation levels have not been subtracted.

Similarly, background concentrations have not been subtracted from radionuclide concentrations measured in soil and dust/debris samples. Removable radioactivity levels (smears) are reported in disintegrations per minute (dpm) per 100 cm^2 with background subtracted.

Outdoor Survey Results

Gamma Exposure Rate Measurements

Gamma radiation levels measured during a scan of the property surface outdoors are given in Fig. 22. Gamma exposure rates generally ranged from 6 to 13 μR/h on the ground surface. Several elevated areas were found. The highest value of 490 μR/h was discovered in the enclosed courtyard located in the northwest corner of the property. An enlargement of this area is provided in Fig. 23. Radiation levels in this courtyard range from 6 to 490 μR/h, with the extent of possible contamination indicated by crosshatching in Fig. 23. Multiple elevated spots were found. The courtyard was overgrown with vegetation as shown in Figs. 12 through 21. Biased soil samples B4 through B12 were collected in this area. The second area of elevated gamma levels was found on the northeast side of Building No. 14, with a maximum measurement of 130 μR/h. Biased soil sample B2 and auger samples A10 through A14, A18, A19, A21, and A27 were all collected from this region. The third area of contamination was discovered in the southeast corner of the property, at the intersection of Harleau Place and Post Street. The gamma radiation in this area measured 32 μR/h in this spot. Biased soil sample B3 and auger samples A3 through A6 were taken from this area. The fourth elevated area was located on the fence line just east of Building Area No. 1, with radiation levels ranging from 15 to 18 μR/h. Auger samples A2 and A7 were taken from here.

The accessible roof areas of Building Nos. 1, 3 through 6, and 7 through 12A were surveyed (Fig. 24). Gamma levels on these roofs measured 6 to 18 μR/h. Slight elevations in gamma levels were found generally over all the concrete and asphalt areas of the plant; some of this can be attributed to naturally occurring radioactive substances present in bricks, concrete, granite, and other such materials used in paving and building construction.

Biased Soil Samples

Biased soil samples (B) were collected from various locations on the property outdoors for radionuclide analyses; laboratory results are provided in Table 3. Biased soil samples are taken from those regions exhibiting elevated levels of gamma radiation. Their locations are shown in Fig. 25 as B1 through B12. Concentrations of radium, thorium, and uranium in these samples ranged from 0.45 to <11.65 pCi/g, from 0.35 to <17.15 pCi/g, and from 2.91 to 160,000 pCi/g, respectively. Although no specific guideline for uranium concentration has been derived for this site, concentrations of 35 to 40 pCi/g have been applied at FUSRAP sites elsewhere (Table 1). However, radium and thorium values in most of the biased samples in Table 3 were near or below the background levels of these radionuclides found in the Ohio area (Table 2). These values correspond to the gamma levels measured in this parking area, shown in the PIC-10 area of Fig. 22. The location of B1 was selected and sampled because

of the slightly elevated gamma measurement found in this area. Sample B1 contained a high percentage of coal ash. The ratio of ^{238}U to ^{226}Ra in this sample indicates that these two radionuclides are in equilibrium and therefore are most likely a natural occurrence. Coal ash usually has slightly elevated levels of naturally occurring uranium, radium, and thorium which are concentrated during coal combustion. Nevertheless, several auger samples (A15 through A17 and A28) were taken to determine the nature and depth of possible contamination.

Samples B4 through B12 were all taken from the courtyard in the northwest corner of the property. The courtyard contained several areas which had elevated levels of uranium-238, with sample B10A having the highest value (38,000 pCi/g). Samples B5, B6A through B6B, and B7A through B7D were collected from the PIC-3 area in the courtyard, with ^{238}U values peaking at 5500 pCi/g, 790 pCi/g, and 2100 pCi/g, respectively. In the corner of this courtyard near Building No. 8, sample B9A produced uranium levels of 1300 pCi/g. Figures 27 and 28 show closeups of greenish-yellow soil taken from B11. The greenish-yellow color is typical for some uranium compounds. The uranium concentration in sample B11A was 11,000 pCi/g. Samples (B12A through B12C) were taken inside one of the concrete bunkers in this courtyard, which contained a maximum uranium concentration of 4100 pCi/g in B12A. Because the courtyard was completely enclosed and therefore excluded the drilling rig, no auger samples were taken from this area. However, hand sampling indicated the contamination was in the top few centimeters of soil.

The highest concentrations of uranium were found in sample B2, northwest of Building No. 14 in the PIC-11 area, with a value of 160,000 pCi/g. Several auger samples were collected in this area (A10 through A14, A18 through A19, A21, and A27). Near the corner of Post Street and Harleau Place, the PIC-9 area had a uranium level of 360 pCi/g in sample B3A. Auger samples A3 through A6 were taken from this area.

Systematic Roof Debris Samples

Two roof debris samples were collected for radionuclide analyses; laboratory results are provided in Table 4. The sample locations are shown in Fig. 24 as D6 on Building Area No. 3 and as D7 on Building Area No. 8. Concentrations of radium, thorium, and uranium in these two samples ranged from 0.30 to 0.65 pCi/g, from 0.20 to 0.39 pCi/g, and from 1.09 to 1.31 pCi/g, respectively. Both samples were below DOE guidelines (Table 1), as well as below normal soil background levels for the Ohio area (Table 2).

Auger Hole Soil Samples and Gamma Logging

Varying thicknesses of subsurface soil were sampled from depths of 0 to 225 cm in auger holes (A) drilled at 26 separate locations indicated in Fig. 25. The results of analyses of these samples are given in Table 3. Concentrations of radium, thorium, and uranium in these samples ranged from 0.49 to 4.46 pCi/g, 0.10 to 2.63 pCi/g, and 0.50 to 1600 pCi/g, respectively. The highest concentration of uranium (1600 pCi/g) found in the auger holes was located on northwest side of Building No. 14 (PIC-11 area) in sample A10A between 0 and 15 cm. This auger hole was drilled to a depth of 180 cm; significantly elevated uranium concentrations were found down to 150 cm. Peak uranium concentrations were between

60 and 75 cm (220 pCi/g), 120 and 135 cm (680 pCi/g), and 135 and 150 cm (130 pCi/g). This area corresponds to the highest biased sample concentration of ^{238}U, which measured 160,000 pCi/g in B2. Other auger samples collected in this PIC area were A11 through A14, A18 through A19, A21, and A27. Of these samples, A11 through A14 also had elevated spots of uranium-238 above the DOE guidelines (Table 1). Though not as concentrated as in A10, these spot values ranged from 17.17 to 49.05 pCi/g for uranium (Table 3).

In the PIC-9 area at the southeast corner of the property, auger samples were taken from four holes (A3 through A6). Of these, samples A3A through A3C and sample A3E were all above previously used DOE guideline values for uranium. The peak value for this hole was 570 pCi/g; the hole was contaminated to a depth of 75 cm, with a value of 140 pCi/g at this depth. The other three holes had no significant concentrations of radionuclides. Two auger holes (A2 and A7) were drilled just east Building Area No. 1, one inside the fence and one just outside the fence. Both of these holes were contaminated with ^{238}U, hole A2 producing a peak value of 180 pCi/g and hole A7, 140 pCi/g. Auger holes A1, A8, A9, A15 through A17, A22 through A25, and A28 presented no significant concentrations of radionuclides. Of these holes, the maximum radionuclide concentration was in sample A15A with a value of 5.20 pCi/g for uranium.

Gamma logging was performed in 25 of the 27 auger holes to characterize and further define the extent of possible contamination. Number A20 was skipped over and never used. Two locations, A26 and A27, refused the auger near the surface. The logging technique used here is not radionuclide specific. However, logging data, in conjunction with soil analyses data, may be used to estimate regions of elevated radionuclide concentrations in auger holes when compared with background levels for the area. Following a comparison of these data, it appears that any shielded scintillator measurements of 1000 counts per minute (cpm) (or unshielded scintillator measurements of 6000 cpm) or greater generally indicate the presence of elevated concentrations of ^{226}Ra and/or ^{232}Th. Shielded scintillator data from the gamma profiles of the logged auger holes are graphically represented in Figs. 32 through 53.

Auger holes A2, A7, and A25 were logged with an unshielded probe. Of these three, measurements in hole A25, which was drilled to a depth of 0.6 m south of Building No. 2, were all below 6000 cpm (unshielded). Unshielded measurements in auger holes A2 and A7, which were taken just east of Building Area No. 1, were both elevated, recording 17,000 cpm at a depth of 0.15 m in A2 and 12,000 cpm at the same depth in A7. Gamma levels fell off to 7000 cpm and 7500 cpm at maximum depths of 0.9 m and 0.8 m, respectively for A2 and A7. Auger holes A10 and A11, in the PIC-11 area, produced the highest shielded measurements of 2614 cpm and 2777 cpm at the surface, respectively, falling to approximately 1000 cpm at or near 0.3 m and continuing to decline to the 700s at maximum depths of 1.4 m and 1.5 m, respectively. Other auger holes drilled in PIC-11 area (A12 through A14, A18 through A19, and A21) were all near or below 1000 cpm.

Of the four auger holes (A3 through A6) drilled in the PIC-9 area, only A3 had elevated gamma levels. Drilled near the southeast corner of the property, Hole A3 produced a maximum recording of 1740 cpm at a depth of 0.5 m, thereafter decreasing, with final levels in the 600s and 700s toward the bottom of the hole (1.2 m). Of the four auger holes (A15 through A17 and A28) in the PIC-10 area, only A17 was elevated above 1000 cpm with any significance. The maximum level recorded in this hole was 1203 cpm at 0.15 m; gamma measurements declined sharply below this depth to the 500s, rising back to the 700s at the

bottom of the hole (1.7 m). The six remaining auger holes (A1, A8, A9, and A22 through A24), drilled in the PIC-6, PIC-7, and PIC-8 areas, were all near or below 1000 cpm. These findings support both the gamma scans and the soil data analyses for this property.

Alpha and Beta-Gamma Activity Levels on the Roof

Measurements of direct and removable radioactivity levels were taken from accessible roof areas (Building Area Nos. 4, 6, 7, and 8), as shown in Fig. 24. The results of these measurements are given in Table 5. All direct alpha measurements on the accessible roof areas were well below the DOE average guideline of 5000 dpm/100 cm^2 for uranium alpha emitters (Table 1).* All direct beta-gamma measurements were also below the DOE guideline of 0.20 mrad/h averaged over not more than 1 m^2 (Table 1).

Nine smear samples were obtained from the same areas of the roof; their locations are indicated in Fig. 24 as circled numbers; results of analyses are given in Table 5. Smears taken from the roof showed all measurements of removable alpha contamination from a 100-cm^2 area were below the minimum detectable activity (MDA) of 10 dpm for alpha; both alpha and beta-gamma were well below the DOE guideline of 1000 dpm/100 cm^2 for removable uranium contamination (Table 1).

Indoor Survey Results

Gamma Exposure Rate Measurements

Gamma radiation levels measured on overhead beams, shelves, and during floor scans inside all buildings are given in Fig. 29. Gamma exposure rates generally ranged from 5 to 29 μR/h in Building Area Nos. 1 and 3 through 6, from 18 to 32 μR/h in Building 2, from 5 to 18 μR/h in Building Area Nos. 7 through 12A, and from 10 to 13 μR/h in Building 14. The highest radiation levels were generated by the firebrick and brick walls in Building Area Nos. 1 and 5, measuring 29 μR/h, and Building No. 2, measuring 32 μR/h (Fig. 29). The slight elevations in gamma levels are typical of the naturally occurring radioactive substances present in bricks, concrete, granite, and other such materials used in paving and building construction. Otherwise, none of the indoor gamma measurements were elevated above DOE guideline values (Table 1).

Systematic Dust and Debris Samples

Eleven dust and debris samples from overhead beams, mezzanines, and floors were systematically collected for radionuclide analyses; laboratory results are provided in Table 4. The sample locations are shown in Figs. 30 and 31, as D1 through D5, D11 through D15, and

*The instrument-specific minimum detectable activity (MDA) for directly measured and removable alpha radiation levels are 60 and 20 dpm/100 cm^2, respectively. For directly measured and removable beta-gamma radiation the respective MDA's are 0.01 mrad/h and 200 dpm/100 cm^2.

D20. Concentrations of radium, thorium, and uranium in these samples ranged from 0.22 to 0.80 pCi/g, from 0.22 to 0.49 pCi/g, and from 0.81 to 5400 pCi/g, respectively. The highest radionuclide concentrations were found in debris sample D2 in the mezzanine shelves of Building Area No. 5, with a uranium concentration of 5400 pCi/g. Other debris samples from this area (D11 through D15) produced radionuclide levels near or below normal background levels for the Ohio area (Table 2) and well below DOE guidelines (Table 1).

Alpha and Beta-Gamma Activity Levels

Measurements of direct and removable radioactivity levels were taken near or in the same vicinity as the dust and debris samples, indicated as circled numbers in Figs. 30 and 31. The results of these measurements are given in Table 5. Of the 73 sample locations on both floor levels, only four (Nos. 28 through 30 and 48) produced any significant anomalies. All four were from the same shelves as debris sample D2. Sample location 28 had directly measurable alpha levels of 1900 dpm/100cm^2 and direct beta-gamma levels of 2.25 mrad/h. Sample location 29 had direct alpha levels of 5400 dpm/100cm^2 and direct beta-gamma levels of 0.03 mrad/h. Sample locations 30 and 48 had direct beta-gamma levels of 7 mrad/h and 2 to 5 mrad/h, respectively. Only location 29 exceeded the DOE average residual value of 5000 dpm/100 cm^2 for uranium alpha emitters (Table 1). Sample locations 28, 30, and 48 were in excess of the DOE surface dose rate limit of 0.20 mrad/h averaged over not more than 1 m^2 (Table 1). With the exception of these four samples (28, 29, 30, and 48), all other direct alpha and beta-gamma measurements were below the DOE guidelines.

Seventy-three smear samples were obtained from the same areas, indicated in Figs. 30 and 31 as circled numbers. Analyses of these smears (Table 5) showed all measurements of removable alpha and beta-gamma radiation from a 100-cm^2 area were below the DOE guideline value of 1000 dpm/100 cm^2 for removable uranium (Table 1), with the exception of smear 48. This sample produced removable alpha levels of 1600 dpm/100 cm^2 and removable beta-gamma levels 2900 dpm/100 cm^2. Both were above DOE guidelines.

Air Samples

Six indoor air samples were collected in Building Area Nos. 1, 3, and 3A. The locations of the air sampling instruments are indicated in Fig. 30 as Z1 through Z6. Samples were taken 1.5 m above floor level (breathing zone) in each of these three building areas to measure airborne activity in their vicinities. Analysis of air samples for ^{238}U exhibits concentrations less than the MDA.*

*The MDA for ^{238}U is less than 3% of the guideline value of 1.0 E-13 μCi/ml, from the U.S. DOE Order 5400.5, April 1990, via inhaled air, Y-Class.

SIGNIFICANCE OF FINDINGS

Survey results of soil, dust, and debris sample analyses and radiation measurements taken at 2551-2555 Harleau Place revealed radionuclide concentrations above DOE guideline values (Table 1) in several outdoor areas and one indoor location at this site. The primary contaminant of concern is ^{238}U. Outdoors, the gamma scans identified four areas of significant contamination, PIC areas 1 through 5, PIC-11 area, PIC-9 area, and a 1-m^2 spot at the fence on Post Street (Fig. 22). The maximum gamma radiation level was measured in the first of these four areas, the enclosed courtyard on the northwest corner of the property; the maximum gamma level was 490 μR/h, and the area contained several locations of significant ^{238}U contamination. The second major area was the parking area northwest of Building No. 14 (PIC-11), with a high of 130 μR/h; the third area was in the southeast corner of the property (PIC-9), with a maximum of 32 μR/h; and the fourth was a spot on the Post Street property line just east of Building Area No. 1, which measured 18 μR/h.

Soil sample analyses (Table 3) correspond to the gamma measurements taken on this property. Although no generic DOE guidelines exist for uranium (Table 1), levels of 35 to 40 pCi/g or greater have been used at other sites. The PIC-11 area produced the highest concentrations of uranium on the entire property, which measured 160,000 pCi/g in biased sample B2; additionally, elevated uranium levels were found in auger holes A10, A11, and A12 (Table 3). The maximum uranium concentration in the enclosed courtyard measured 38,000 pCi/g in biased sample B10A; elevated uranium levels were found in most of the courtyard samples B4 through B12. The PIC-9 area rendered its maximum uranium concentrations in auger hole A3, with a level of 570 pCi/g; biased sample location B3 in this area contained uranium levels up to 360 pCi/g. The spot at the fence on the property line produced its maximum uranium value of 180 pCi/g in auger hole A2; auger hole A7 contained similar values of uranium. No contamination above guidelines was found on the accessible roof areas.

The indoor measurements were significantly elevated above DOE guideline values (Table 1) in only one area, located in some shelf bins on the mezzanine of Building Area No. 5 (Fig. 31). Residual alpha activity levels ranged from 1900 to 5400 dpm/cm^2, and residual beta-gamma activity levels ranged from 2.25 to 7 mrad/h. Removable alpha and beta-gamma contamination was demonstrated in Smear 48, with an alpha level of 1600 dpm/cm^2 and a beta-gamma level of 2900 dpm/cm^2. These activity levels are in excess of DOE guidelines for both residual and removable concentrations of uranium (Table 1). The dust and debris sample D2 taken from this area supported these findings, with 5400 pCi/g of uranium contamination. The shelf bins were in an isolated and unused area of the building. Because of the isolation and low use factor, any personnel exposure would be extremely low. Air samples taken in Building Area Nos. 1, 3, and 3A were all below MDA for alpha and beta levels of radioactivity.

In conclusion, several outdoor areas contained soil contaminated with uranium in excess of DOE guidelines. One small area indoors had debris and surface contamination in excess of these guidelines.

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7. Nuclear Regulatory Commission, *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).

8. T. E. Myrick, B. A. Berven, and F. F. Haywood, *State Background Radiation Levels: Results of Measurements Taken During 1975-1979*, ORNL/TM-7343, Oak Ridge National Laboratory (November 1981).

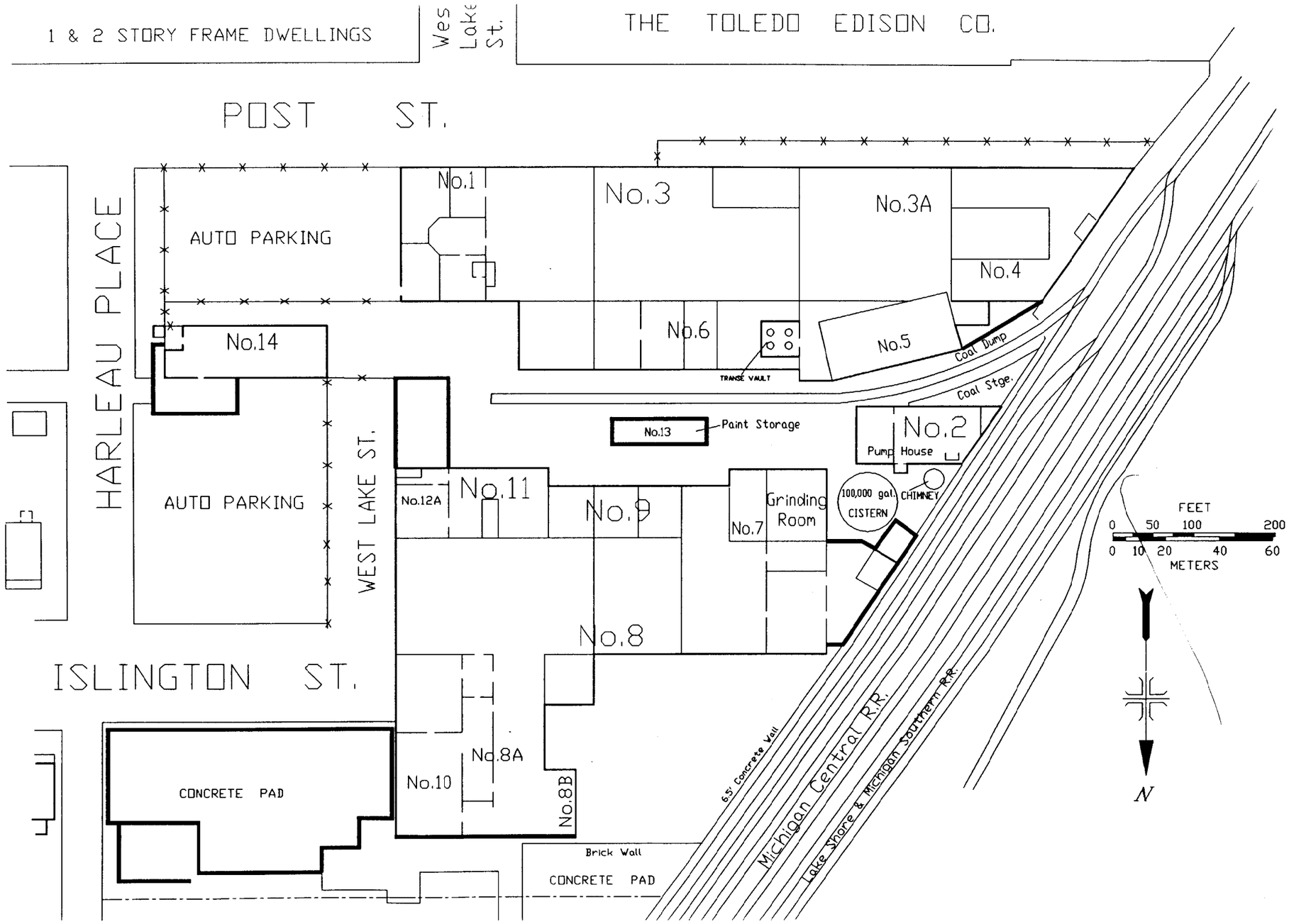

Fig. 1. Site map of the former Baker Brothers, Inc., in 1938 at 2551-2555 Harleau Place, Toledo, Ohio (BTO001).

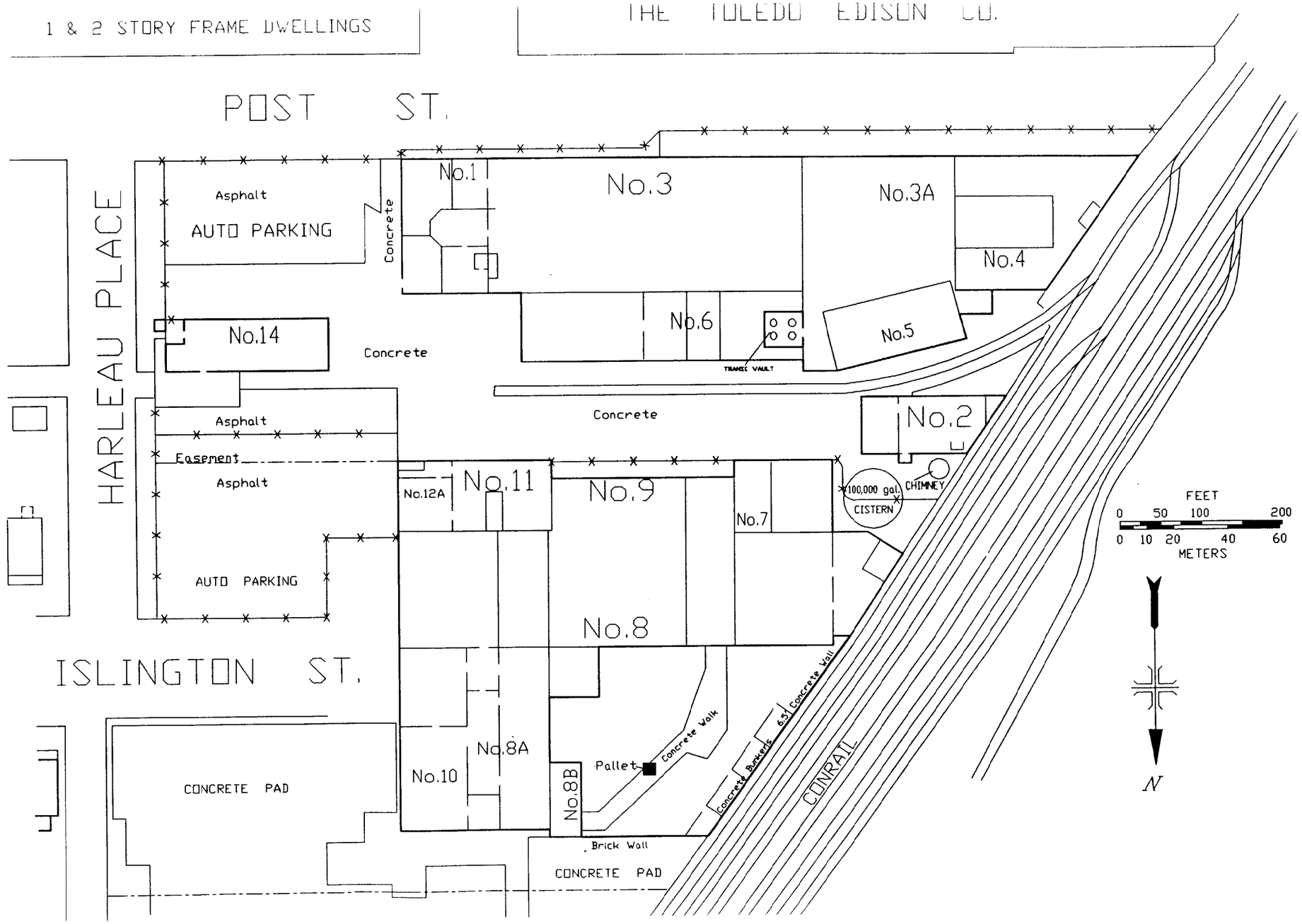

Fig. 2. Current site map of the REMS, Inc., and Rehkopf properties at 2551-2555 Harleau Place, Toledo, Ohio (BTO001).

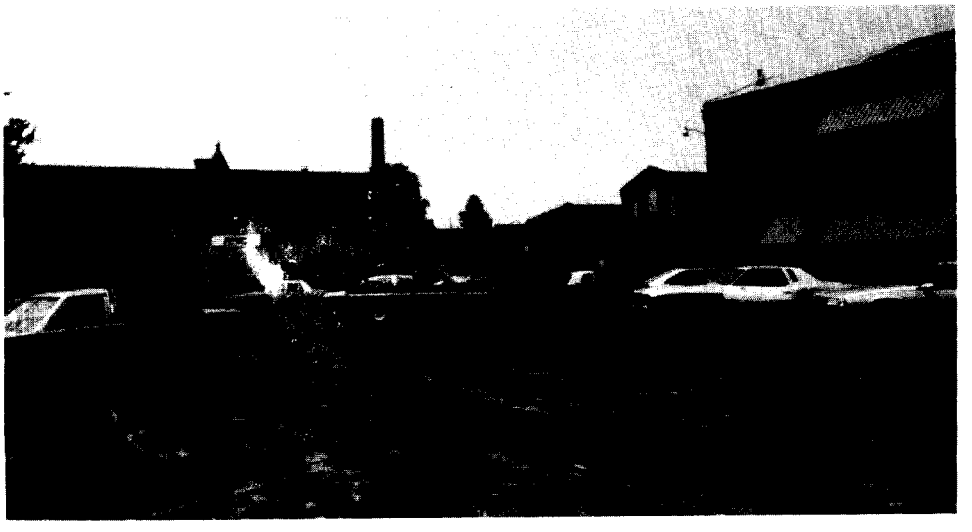

Fig. 3. Northwestward view of Building Area No. 1 on the left, Building No. 14 on the right, and the entrance to Building Area No. 12A in between, at REMS, Inc., 2551-2555 Harleau Place, Toledo, Ohio (BTO001).

Fig. 4. Eastward view of Building No. 14, showing contaminated site at sample location B2, at REMS, Inc., 2551-2555 Harleau Place, Toledo, Ohio (BTO001).

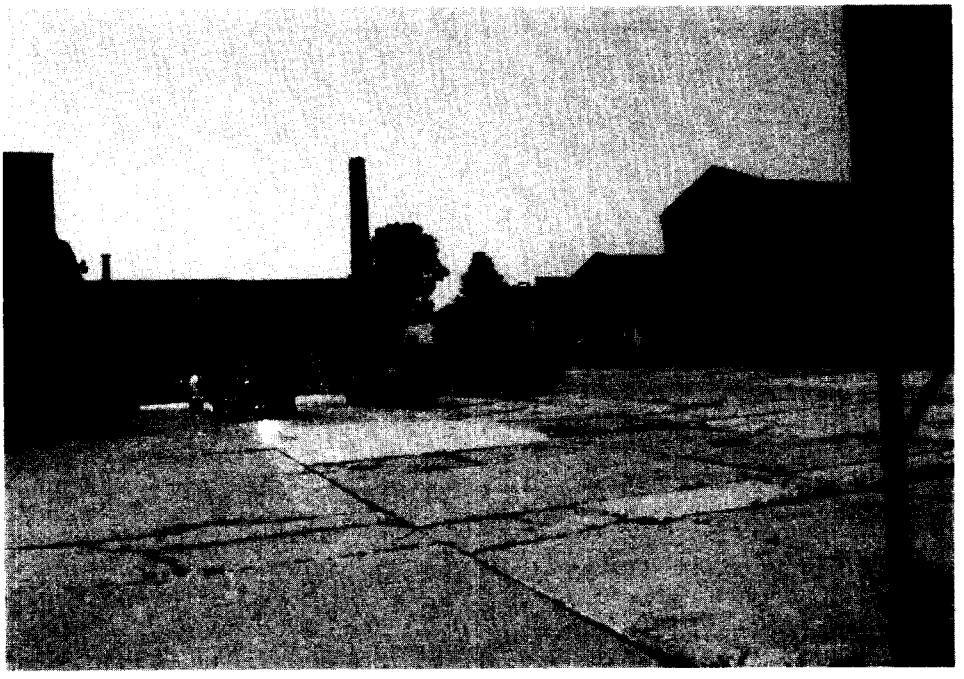

Fig. 5. Westward view of Building Area No. 6 on the left (with metal siding) and the entrance to Building Area No. 12A on the right at REMS, Inc., 2551-2555 Harleau Place, Toledo, Ohio (BTO001).

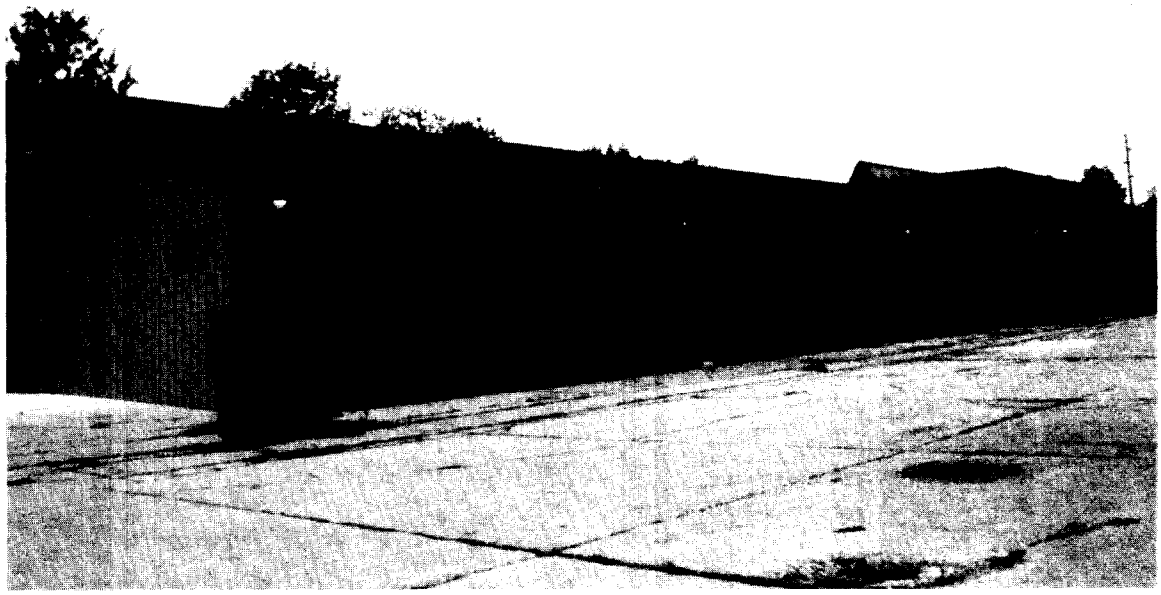

Fig. 6. Southwestward view of Building Area No. 6 at REMS, Inc., 2551-2555 Harleau Place, Toledo, Ohio (BTO001).

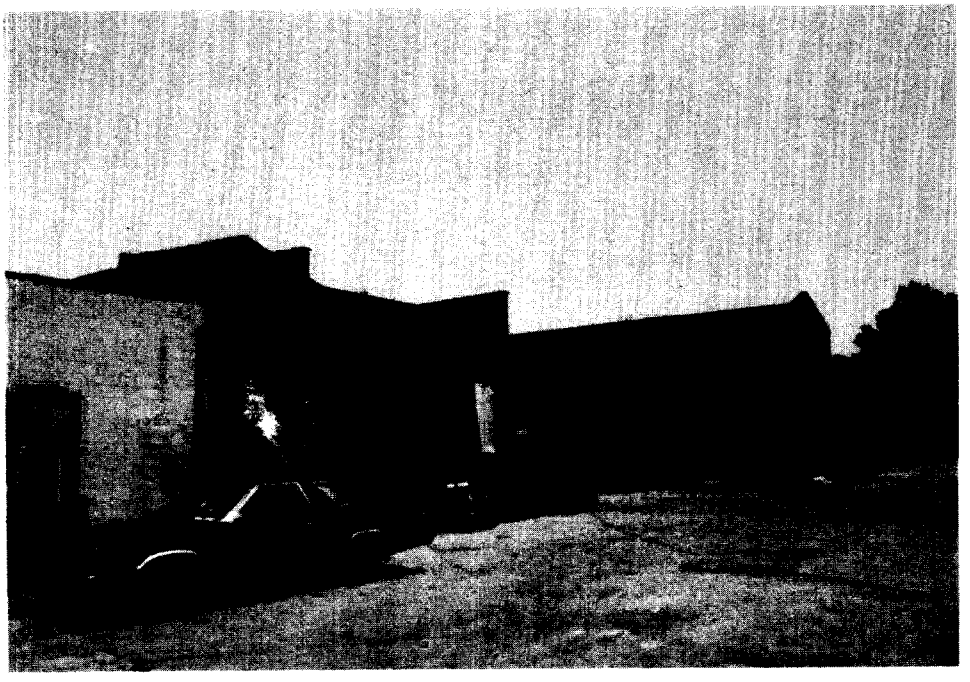

Fig. 7. Eastward view of Building Area No. 7 on the left and Building Area No. 12A on the right at Doug Beet Company, 2551-2555 Harleau Place, Toledo, Ohio (BTO001).

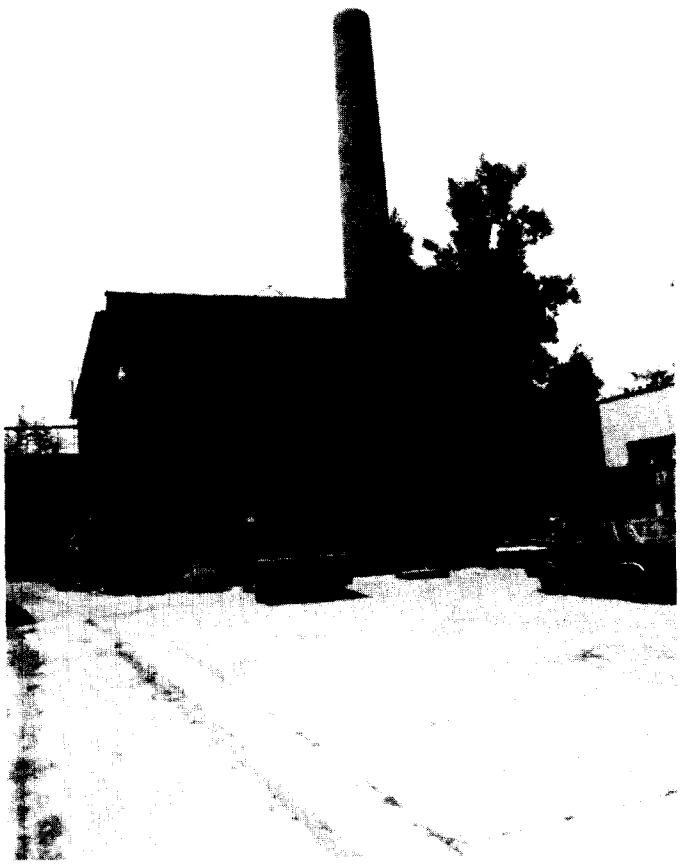

Fig. 8. Westward view of Building No. 2, the former Power House, at Doug Beet Company, 2551-2555 Harleau Place, Toledo, Ohio (BTO001).

Fig. 9. Westward view in Building Area No. 3, showing used motors, at Doug Beet Company, 2551-2555 Harleau Place, Toledo, Ohio (BTO001).

Fig. 10. Eastward view in Building Area No. 5, showing contaminated shelves on the east wall of the mezzanine at Doug Beet Company, 2551-2555 Harleau Place, Toledo, Ohio (BTO001).

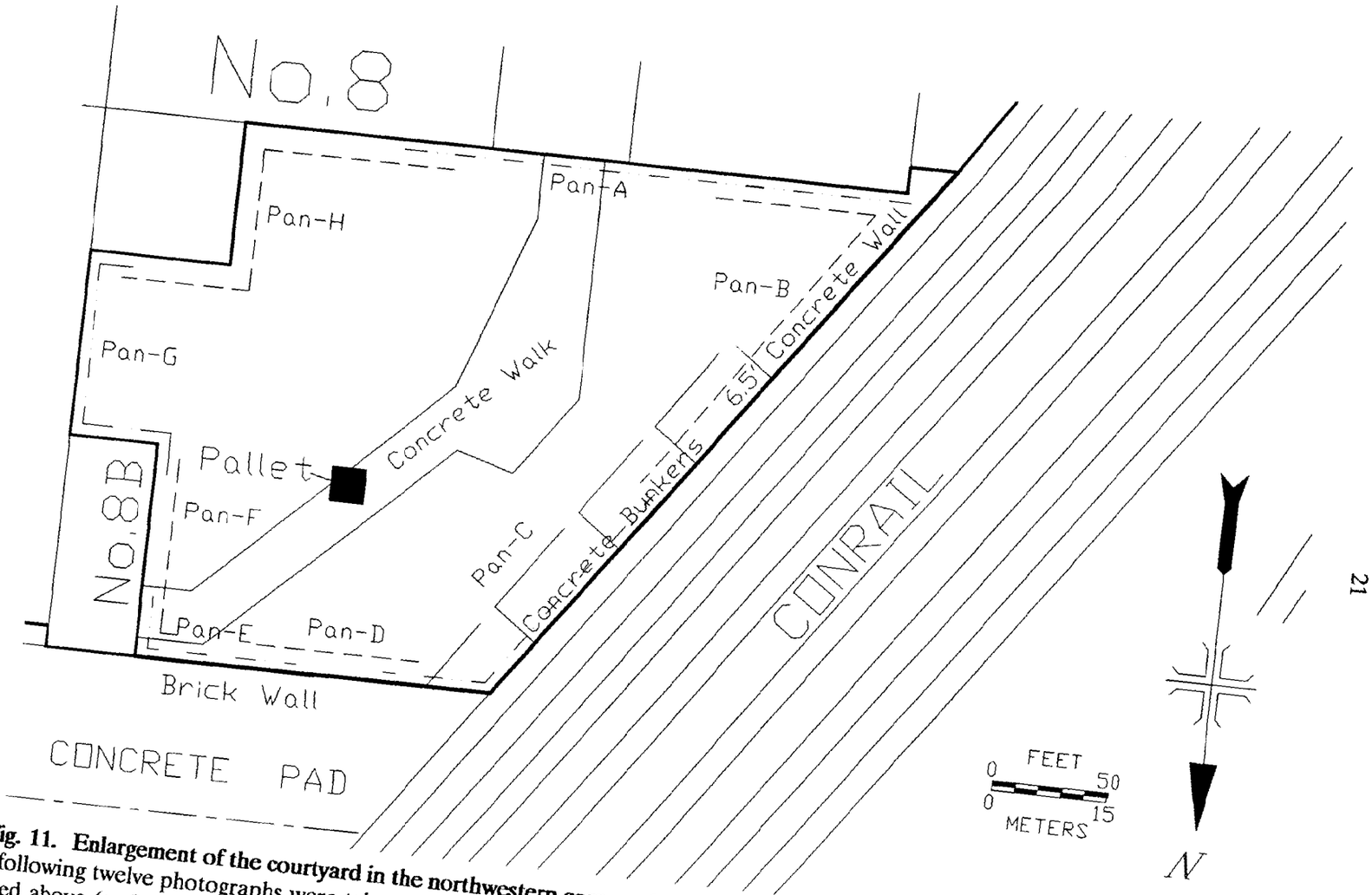

Fig. 11. Enlargement of the courtyard in the northwestern corner of the property at 2551-2555 Harleau Place, Toledo, Ohio (BTO001). The following twelve photographs were taken in this area. Figures 13-20 are a clockwise panoramic view of this area, with the pallet stack marked above (and shown in Fig. 12) used as the center of the pan.

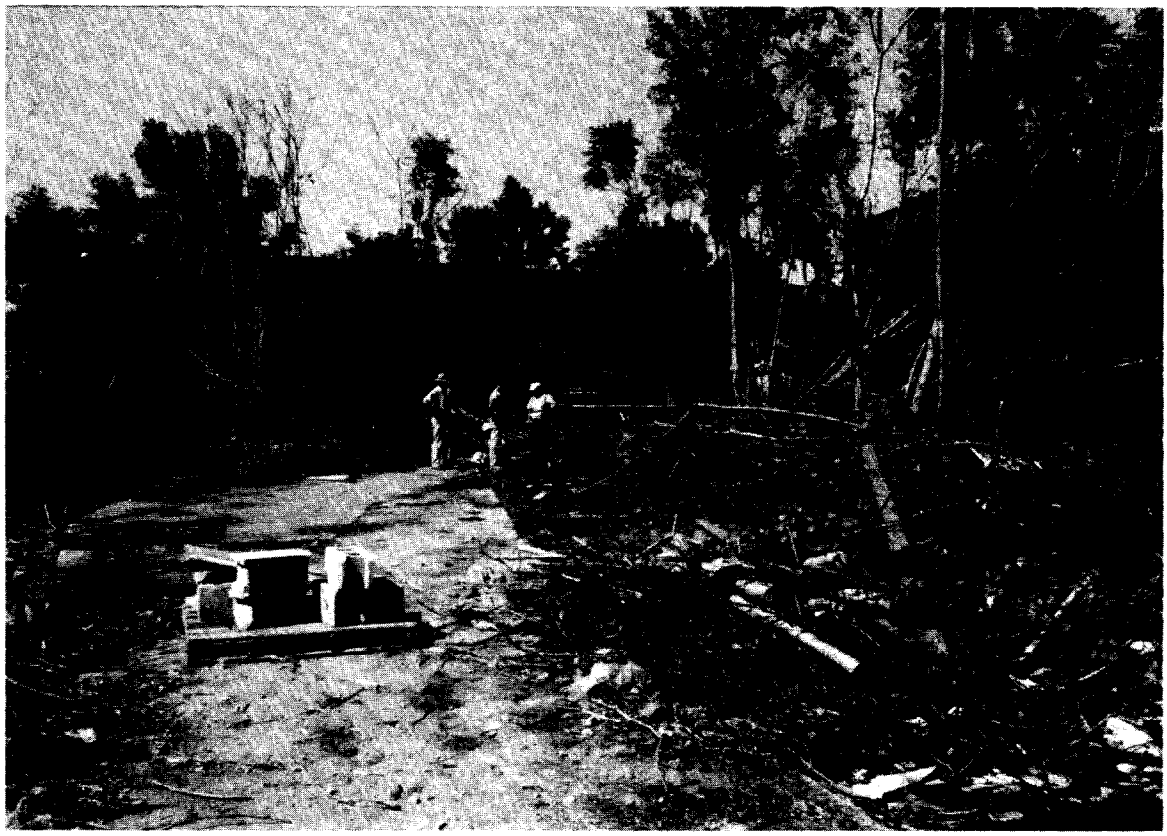

Fig. 12. Northeastward view from the doorway of Building Area No. 8, showing the pallet stack next to survey team members, at 2551-2555 Harleau Place, Toledo, Ohio (BTO001). The pallet stack was the pivot point for the panorama (Pan) views shown in the next eight photographs.

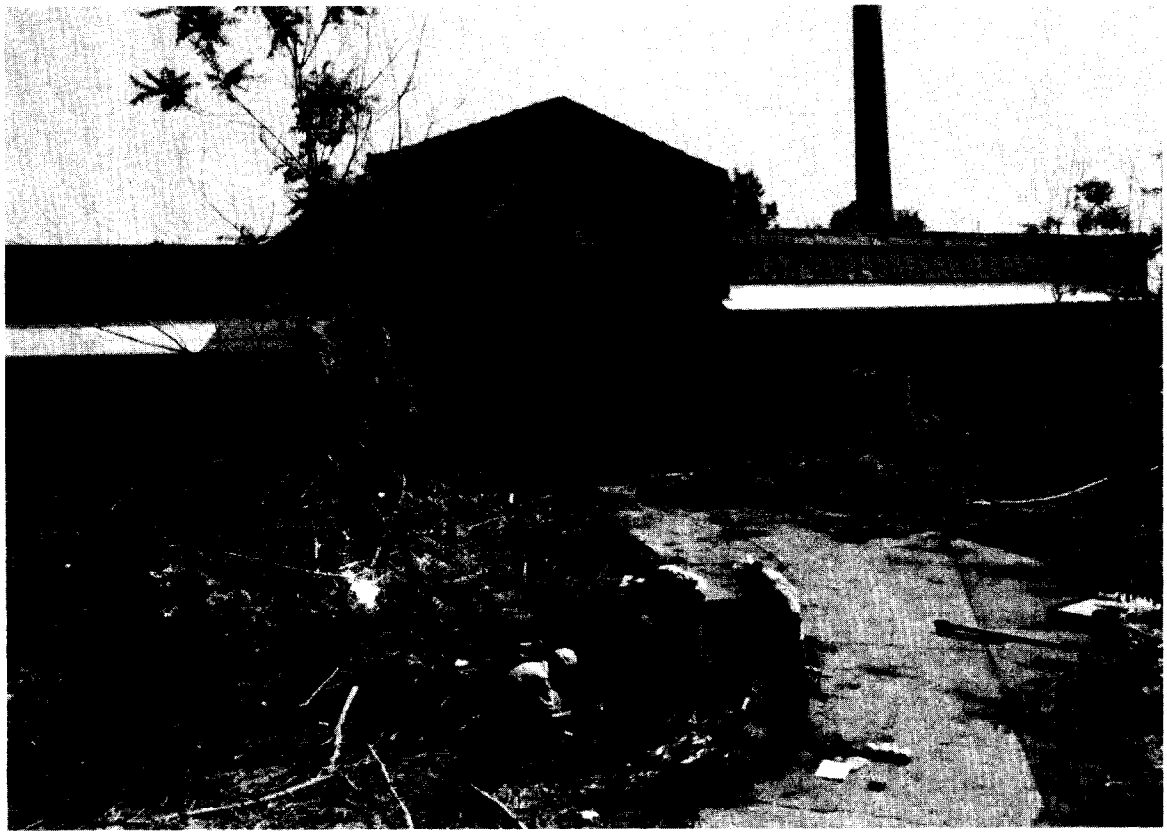

Fig. 13. Pan A of Fig. 11, showing the southern entrance to Building Area No. 8 at 2551-2555 Harleau Place, Toledo, Ohio (BTO001).

Fig. 14. Pan B of Fig. 11, showing the southwestern section of this courtyard at 2551-2555 Harleau Place, Toledo, Ohio (BTO001).

Fig. 15. Pan C of Fig. 11, showing the northwestern section this courtyard at 2551-2555 Harleau Place, Toledo, Ohio (BTO001).

Fig. 16. Pan D of Fig. 11, showing the northern section of this courtyard at 2551-2555 Harleau Place, Toledo, Ohio (BTO001).

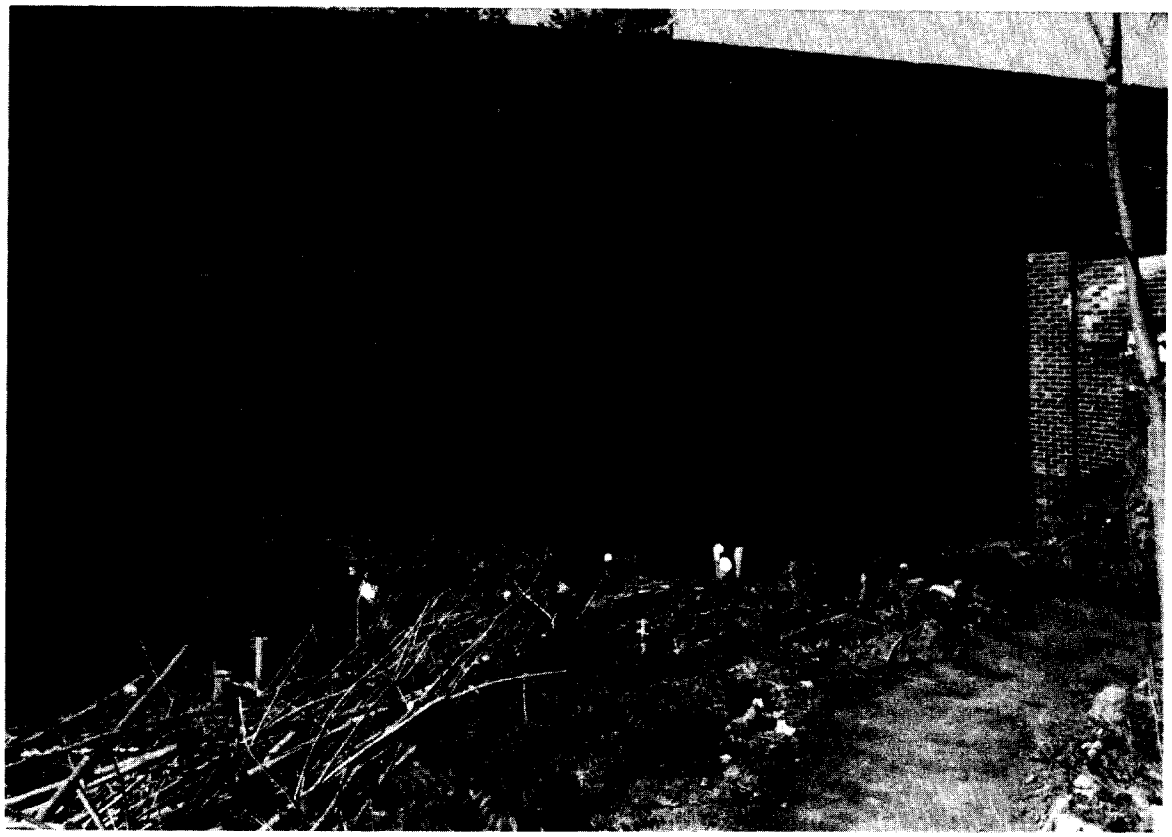

Fig. 17. Pan E of Fig. 11, showing the northeastern corner of this courtyard at 2551-2555 Harleau Place, Toledo, Ohio (BTO001).

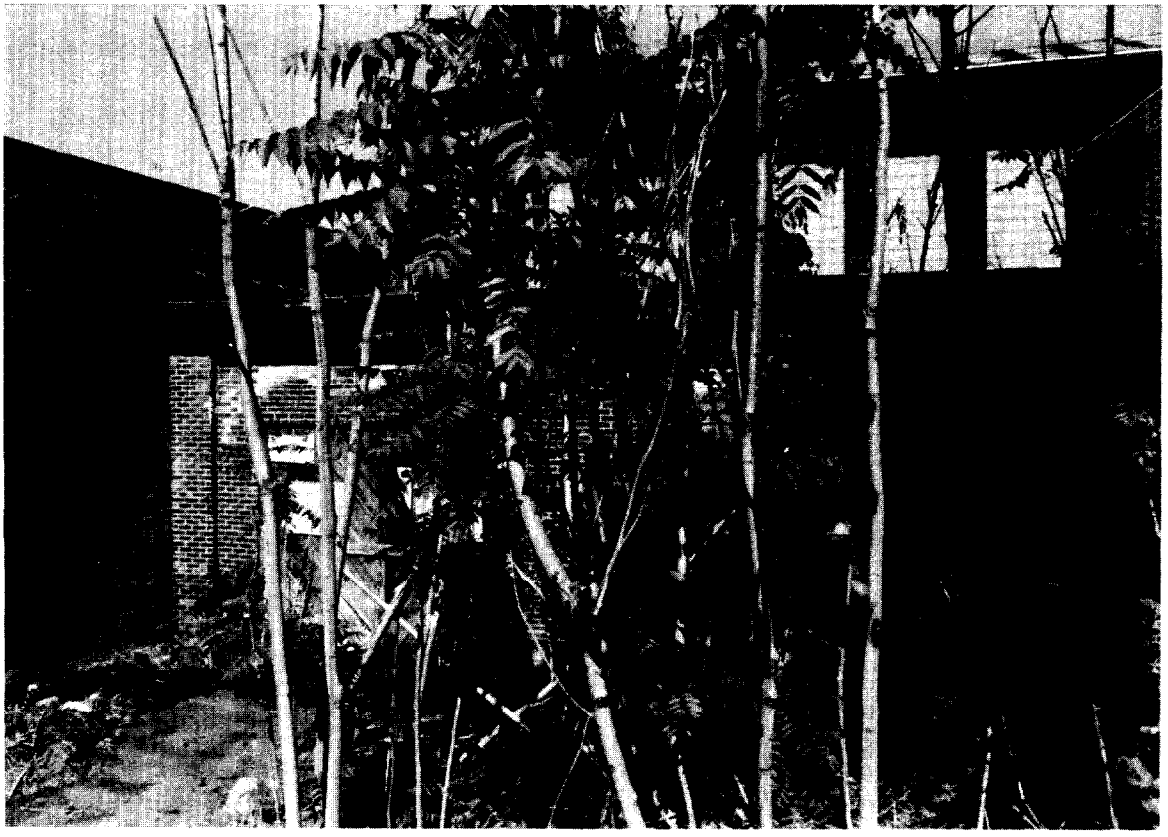

Fig. 18. Pan F of Fig. 11, showing the northeastern section and Building Area No. 8B at 2551-2555 Harleau Place, Toledo, Ohio (BTO001).

Fig. 19. Pan G of Fig. 11, showing the eastern section and Building Area No. 8A at 2551-2555 Harleau Place, Toledo, Ohio (BTO001).

Fig. 20. Pan H of Fig. 11, showing the southeastern section of this courtyard at 2551-2555 Harleau Place, Toledo, Ohio (BTO001).

Fig. 21. Northeastward view of the concrete wall and bunkers in this courtyard next to the railroad tracks at 2551-2555 Harleau Place, Toledo, Ohio (BTO001).

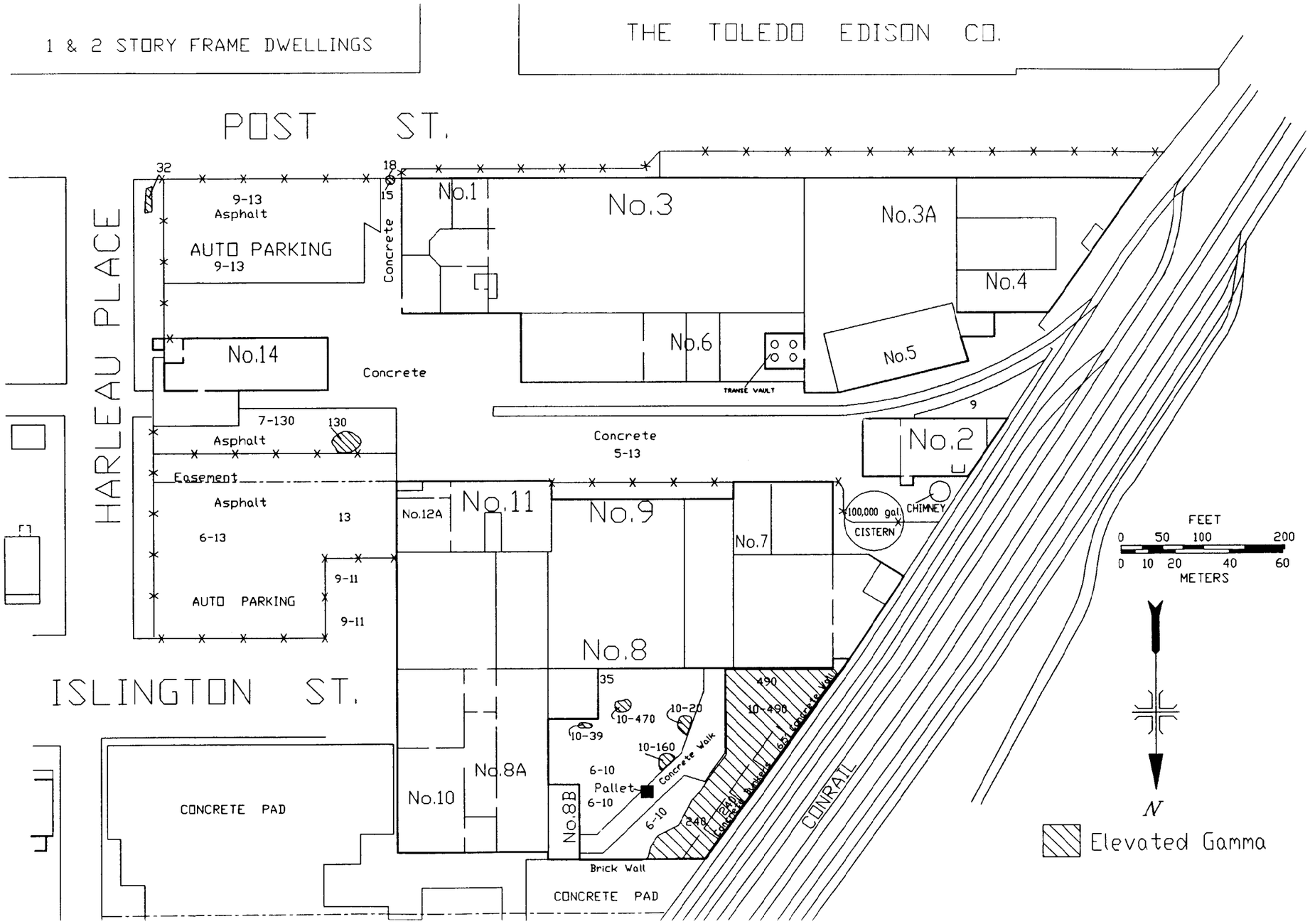

Fig. 22. Gamma radiation levels (μR/h) measured outdoors at 2551-2555 Harleau Place, Toledo, Ohio (BTO001).

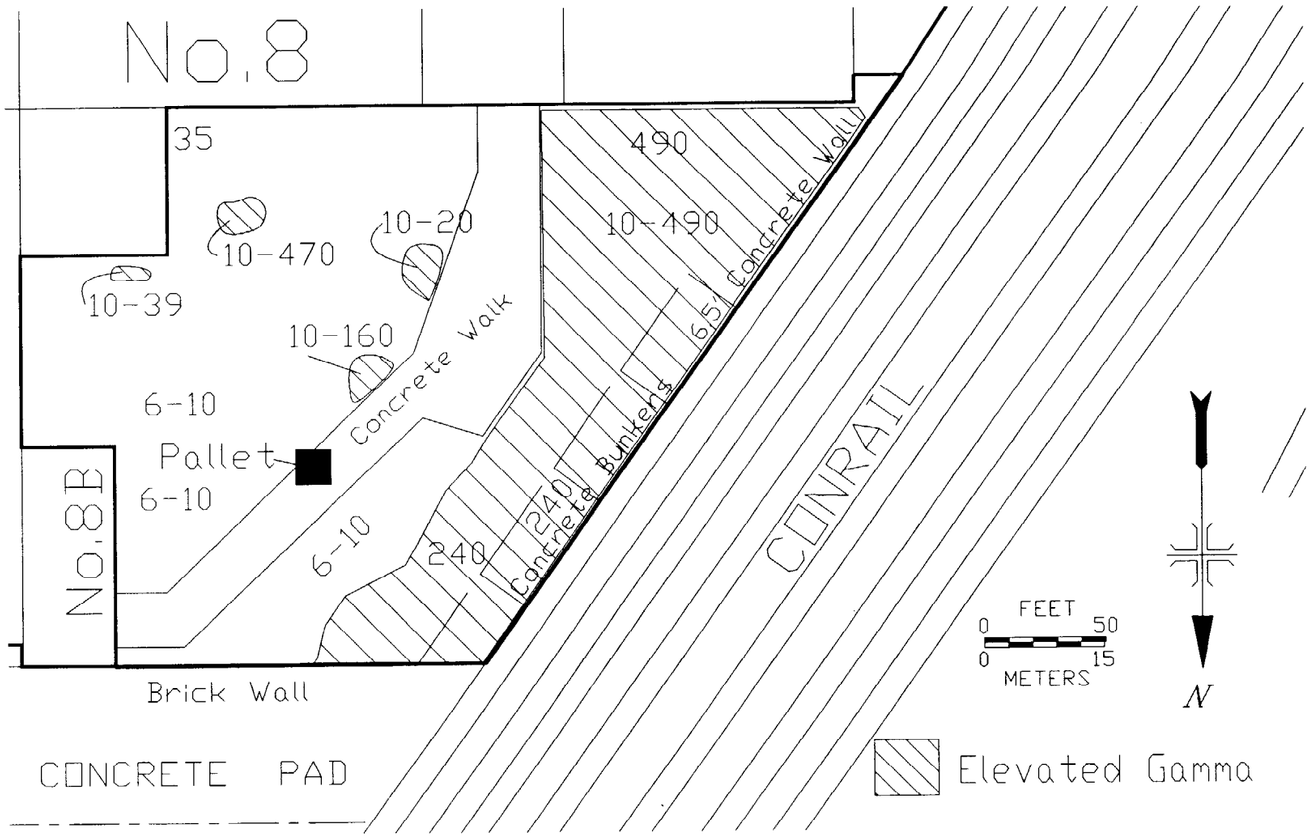

Fig. 23. Enlargement of the northwestern courtyard at 2551-2555 Harleau Place, Toledo, Ohio (BTO001), showing gamma radiation levels (μR/h) .

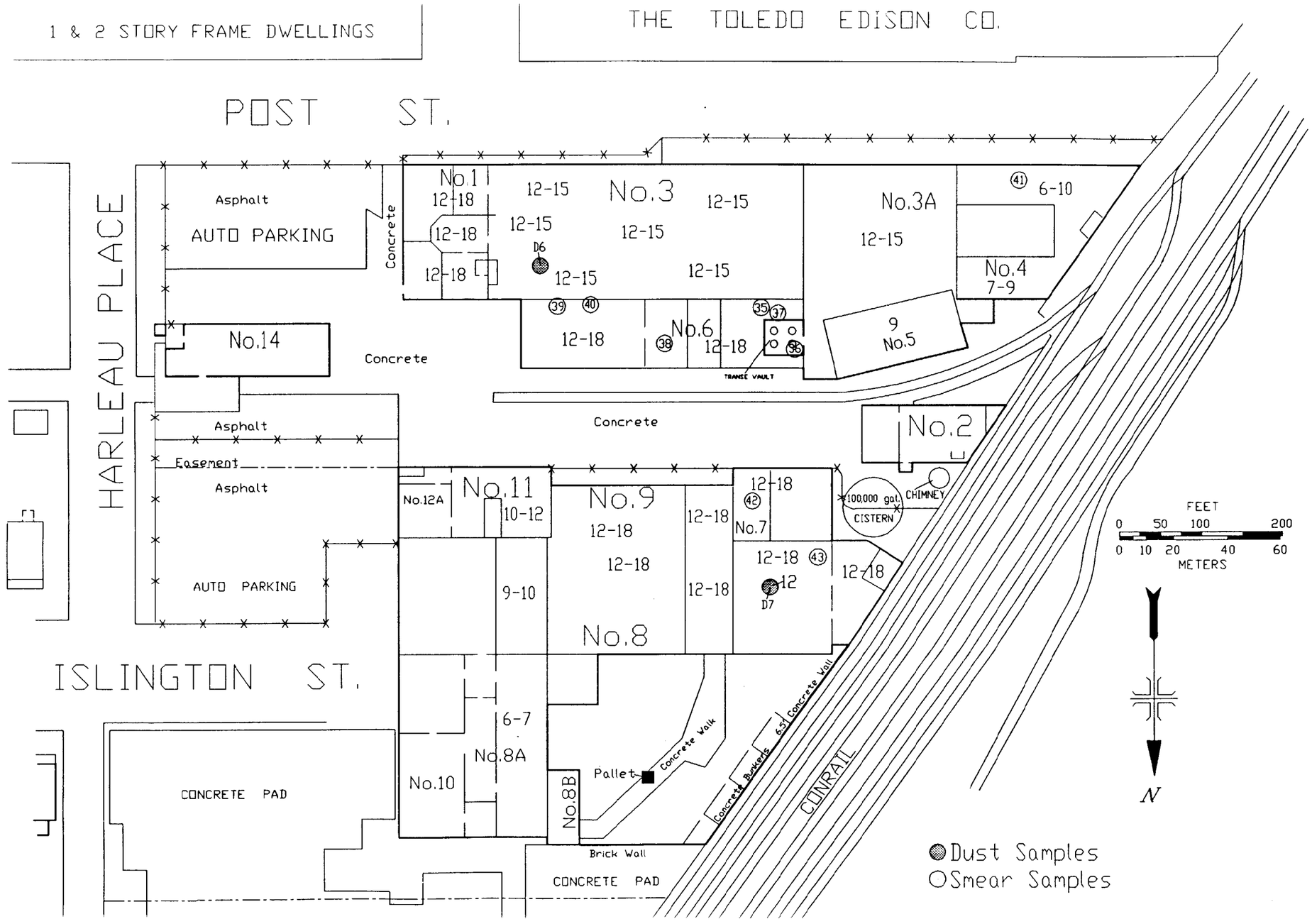

Fig. 24. Gamma radiation levels (μR/h) and debris sampling locations on the roof at 2551-2555 Harleau Place, Toledo, Ohio (BTO001). (Locations of the debris samples are shown as D6 and D7. The 9 smear samples are shown as circled numbers.)

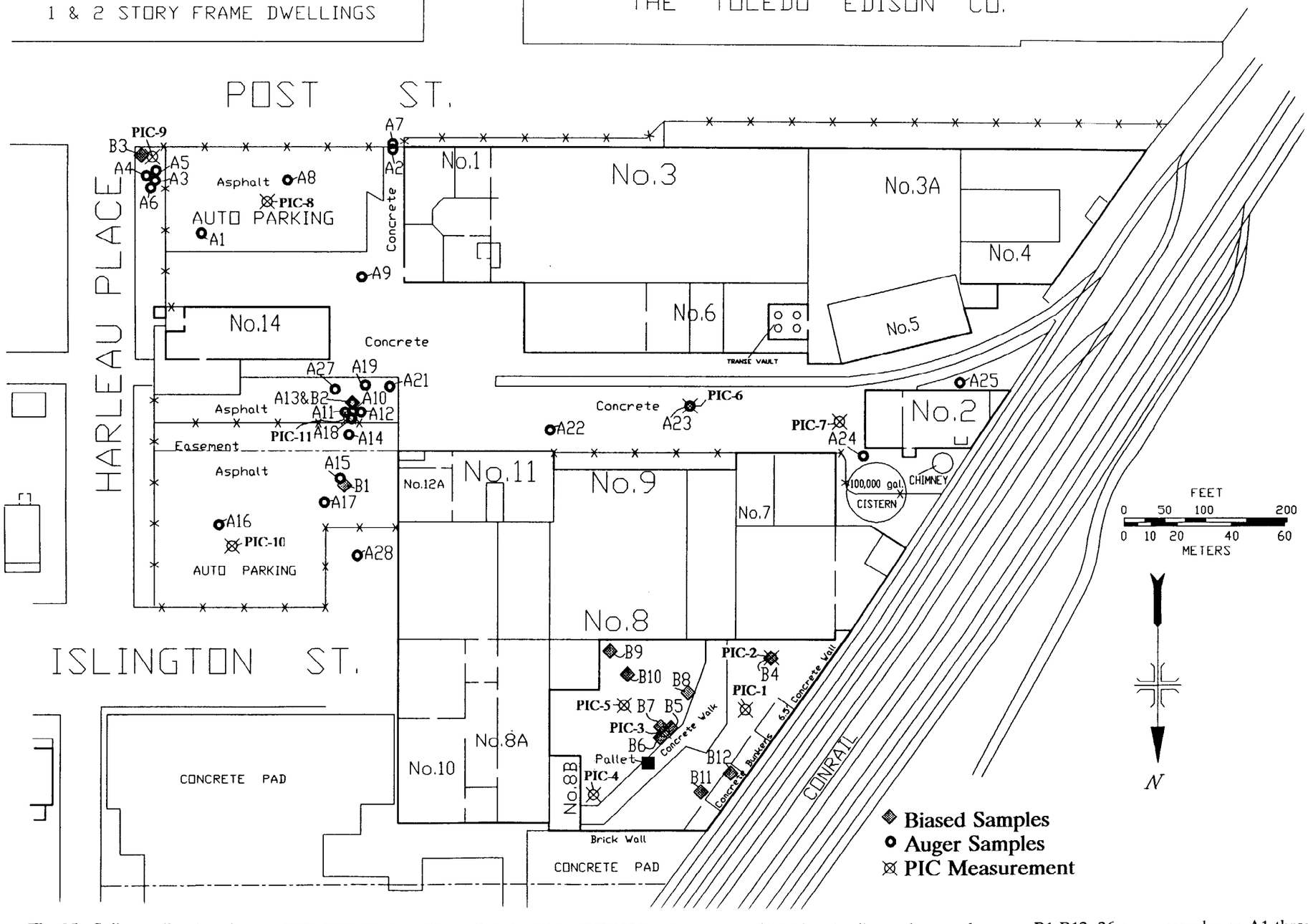

Fig. 25. Soil sampling locations at 2551-2555 Harleau Place, Toledo, Ohio (BTO001). (Locations of 12 biased soil samples are shown as B1-B12; 26 auger samples as A1 through A19, A17, A21 through 25, and A28; and 11 PIC measurements as PIC-1 through PIC-11.)

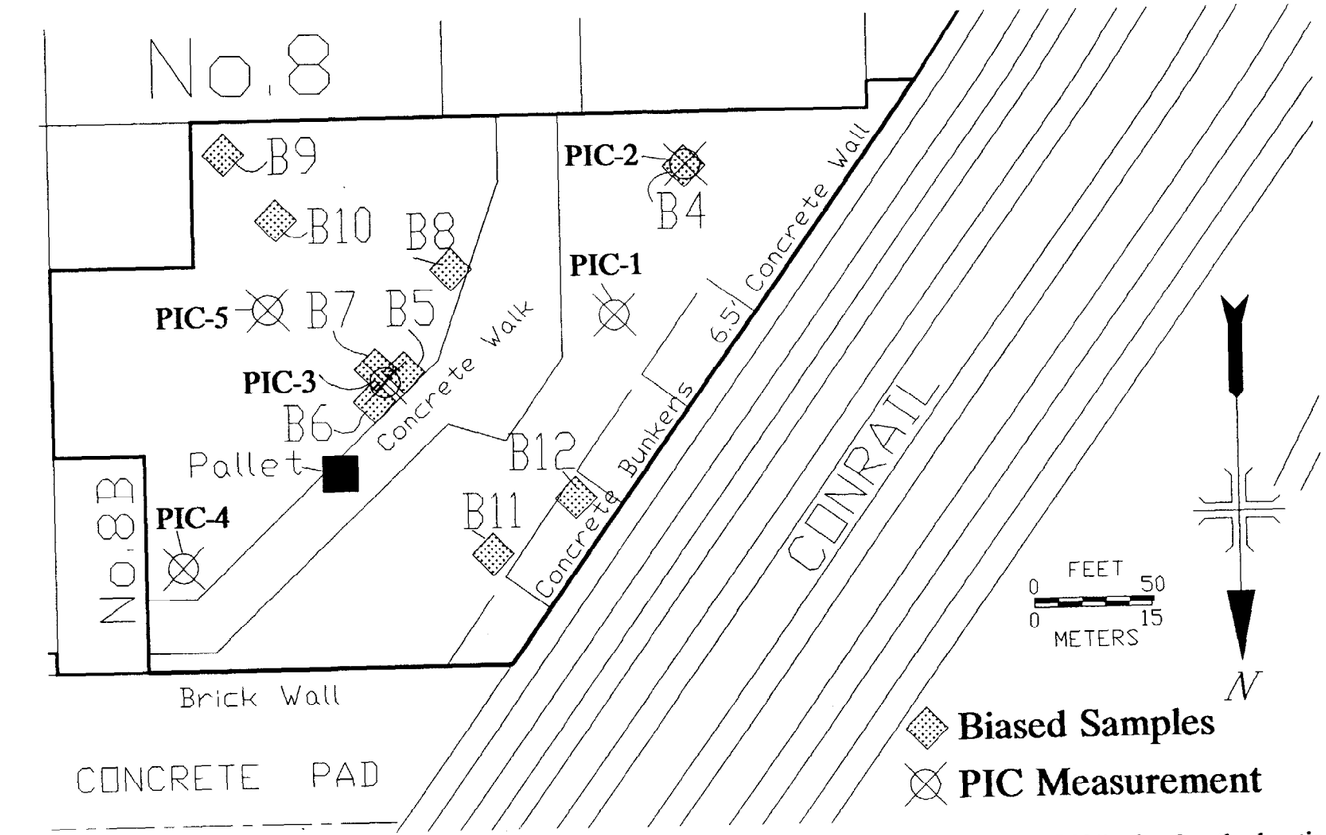

Fig. 26. Enlargement of the northwestern courtyard at 2551-2555 Harleau Place, Toledo, Ohio (BTO001), showing the locations of biased soil samples and PIC measurements.

Fig. 27. Closeup of soil layers in biased sample hole B11 (Fig. 26), showing the 4-inch, greenish-yellow layer under the top soil (2 in. below surface) at 2551-2555 Harleau Place, Toledo, Ohio (BTO001).

Fig. 28. Closeup of greenish-yellow soil removed from biased sample hole B11 (Fig. 26) at 2551-2555 Harleau Place, Toledo, Ohio (BTO001).

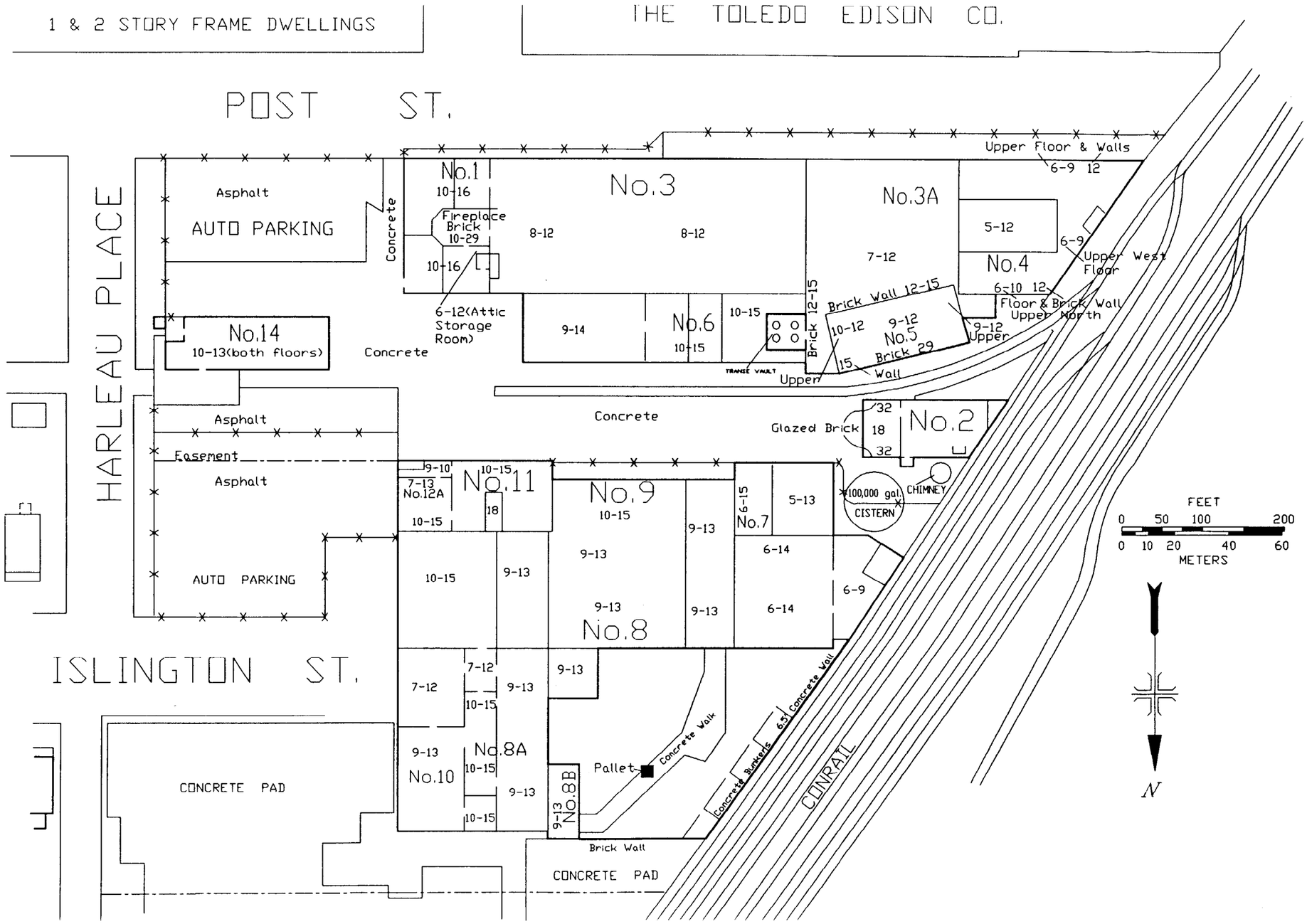

Fig. 29. Gamma radiation levels (μR/h) measured indoors at 2551-2555 Harleau Place, Toledo, Ohio (BTO001).

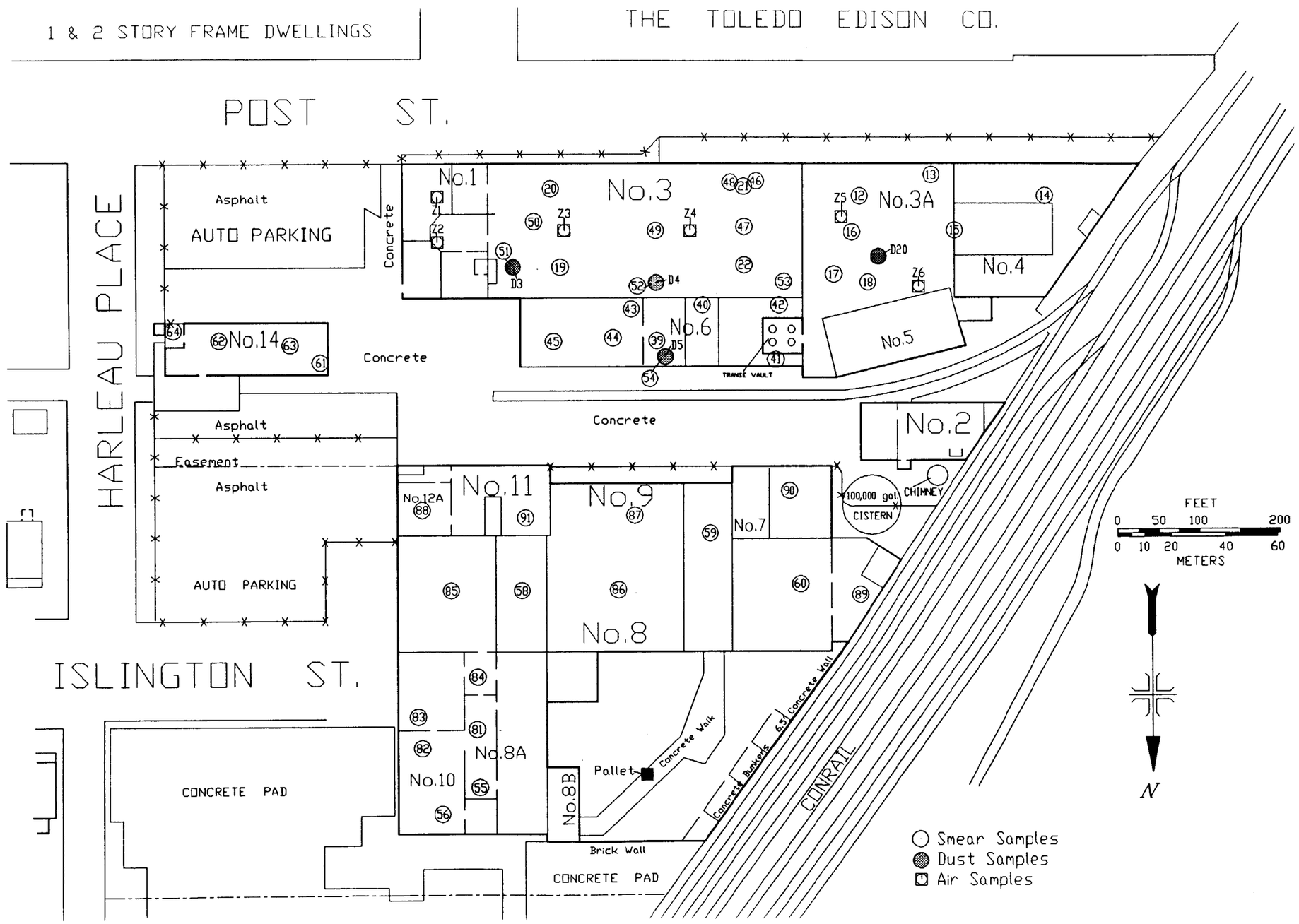

Fig. 30. Air, smear, dust, and debris sampling locations on the first floor at 2551-2555 Harleau Place, Toledo, Ohio (BTO001). (Locations of the 6 air samples are shown as Z1-Z6; 47 smear samples as circled numbers; 4 dust and debris samples as D3-D5 and D20.)

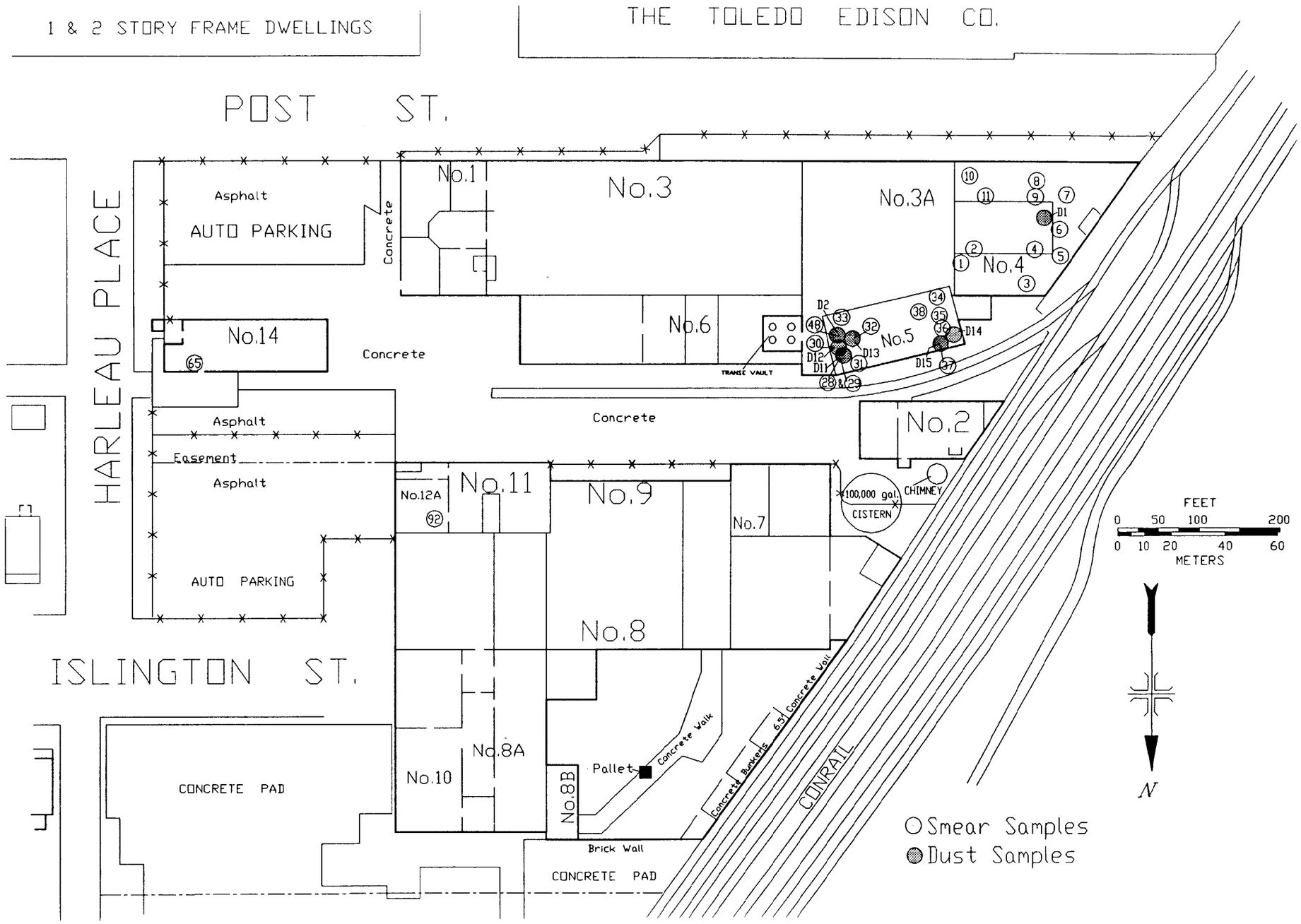

Fig. 31. Smear, dust, and debris sampling locations on the second floor at 2551-2555 Harleau Place, Toledo, Ohio (BTO001). (Locations of the 25 smear samples are shown as circled numbers and 7 dust and debris samples as D1, D2, and D11-D15.)

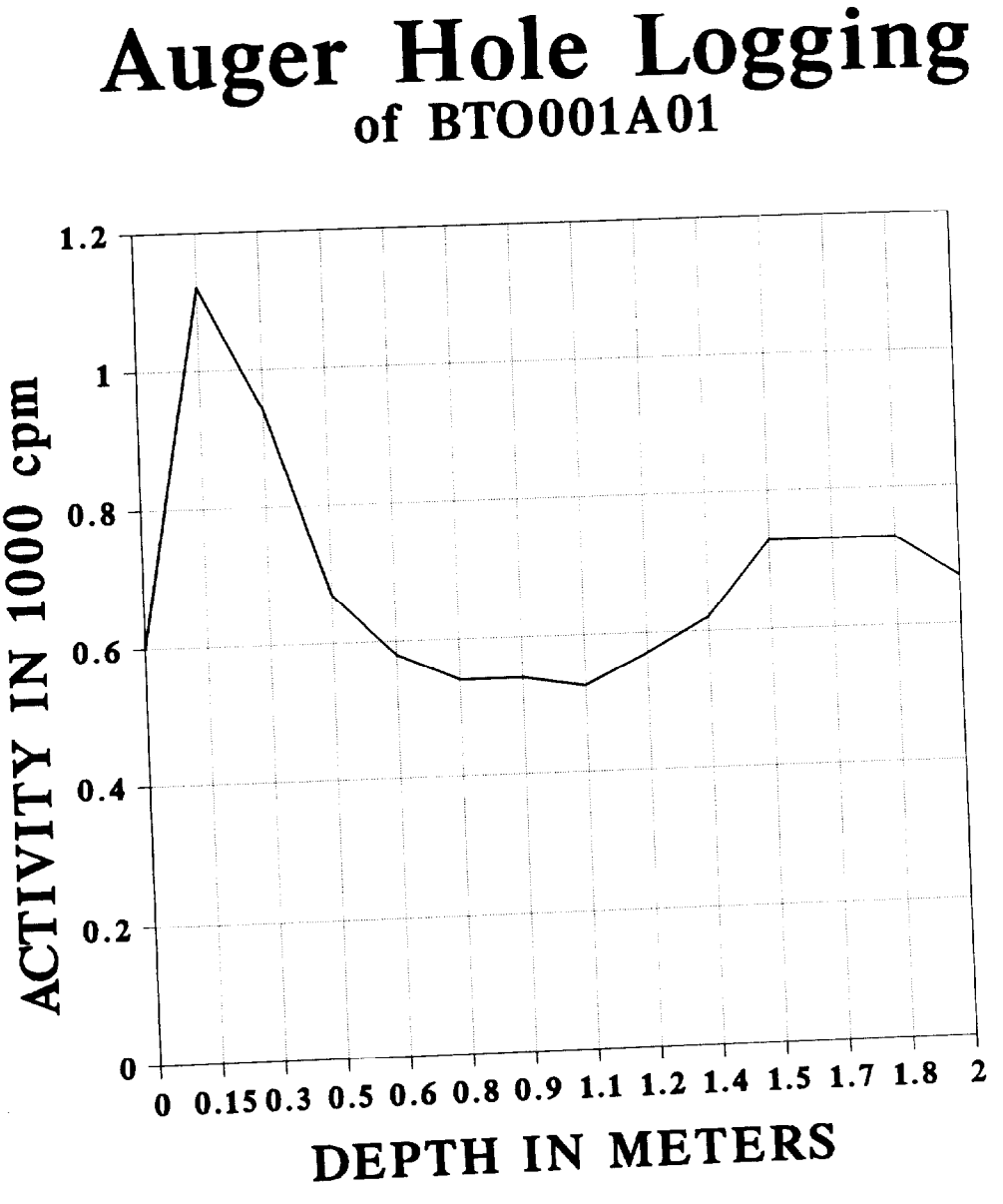

Fig. 32. Gamma profile for auger hole 1 at 2551-2555 Harleau Place, Toledo, Ohio.

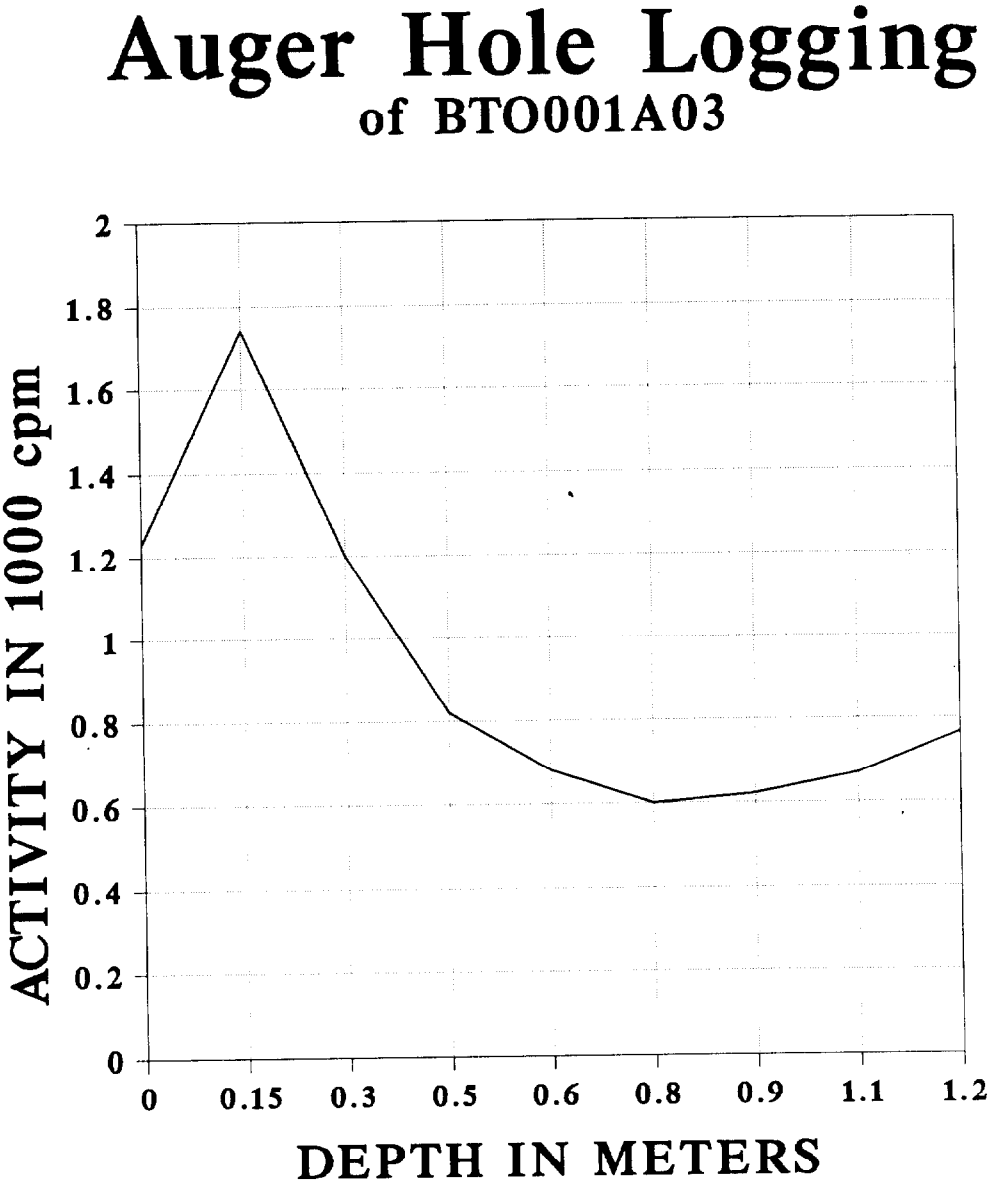

Fig. 33. Gamma profile for auger hole 3 at 2551-2555 Harleau Place, Toledo, Ohio.

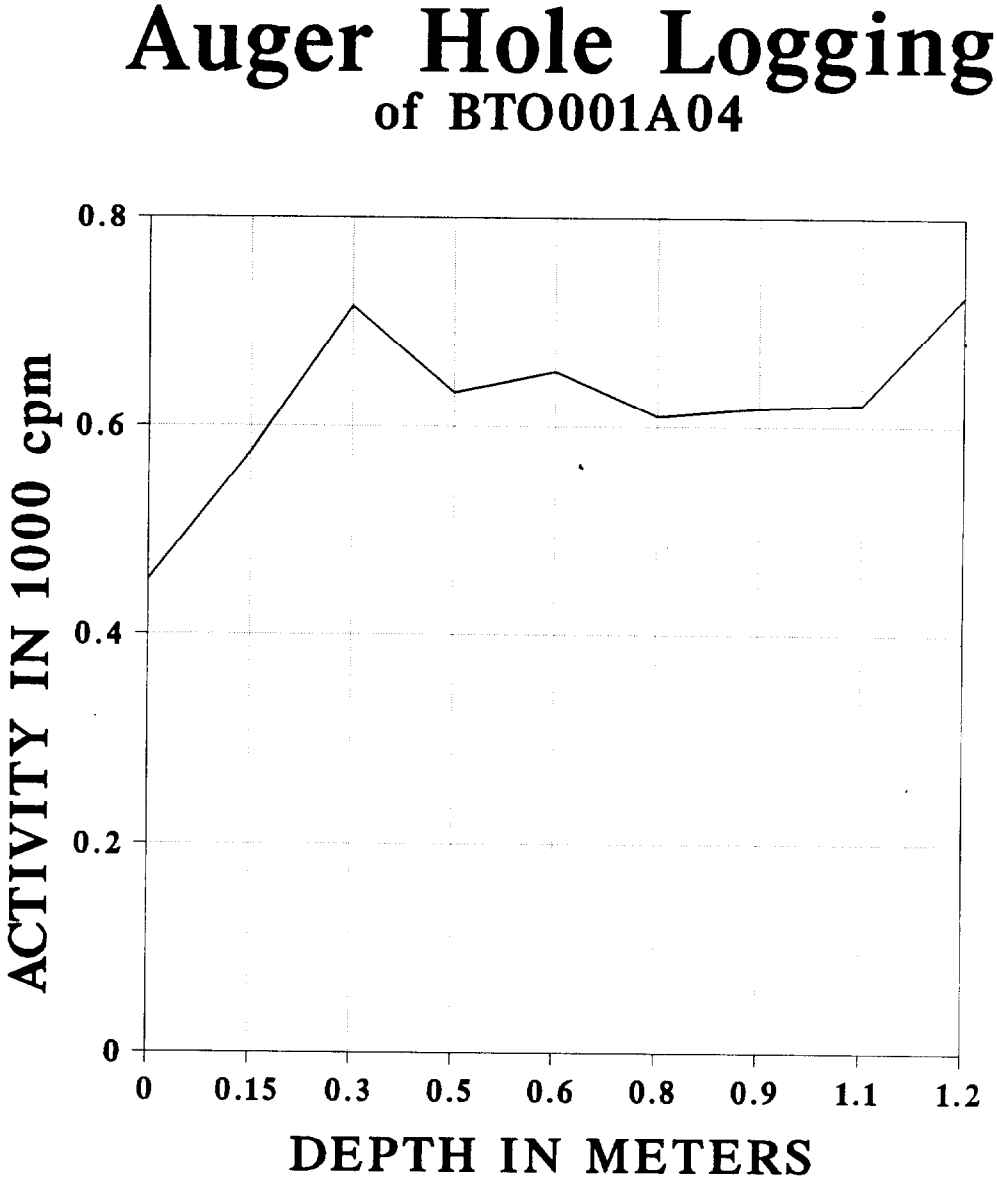

Fig. 34. Gamma profile for auger hole 4 at 2551-2555 Harleau Place, Toledo, Ohio.

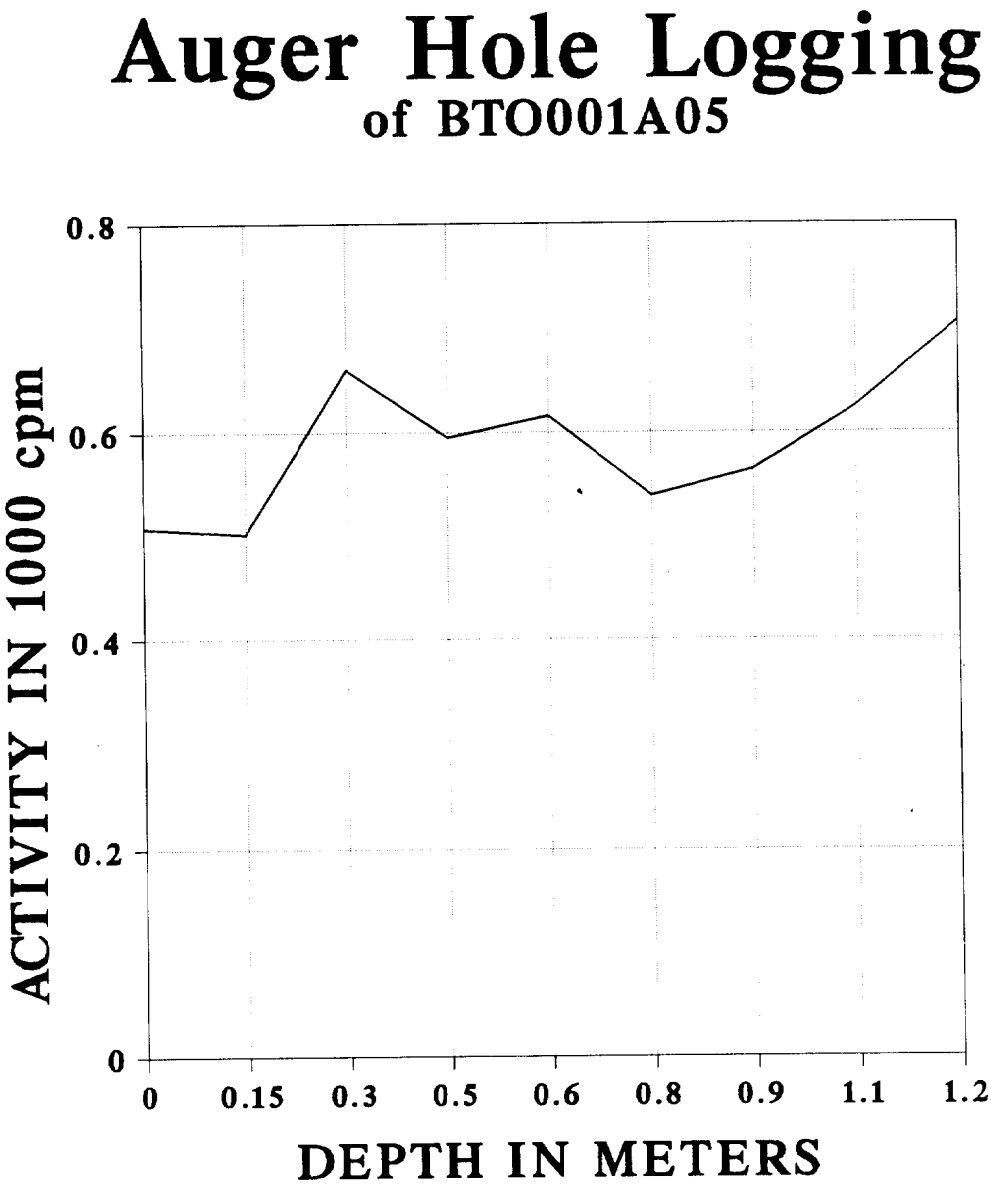

Fig. 35. Gamma profile for auger hole 5 at 2551-2555 Harleau Place, Toledo, Ohio.

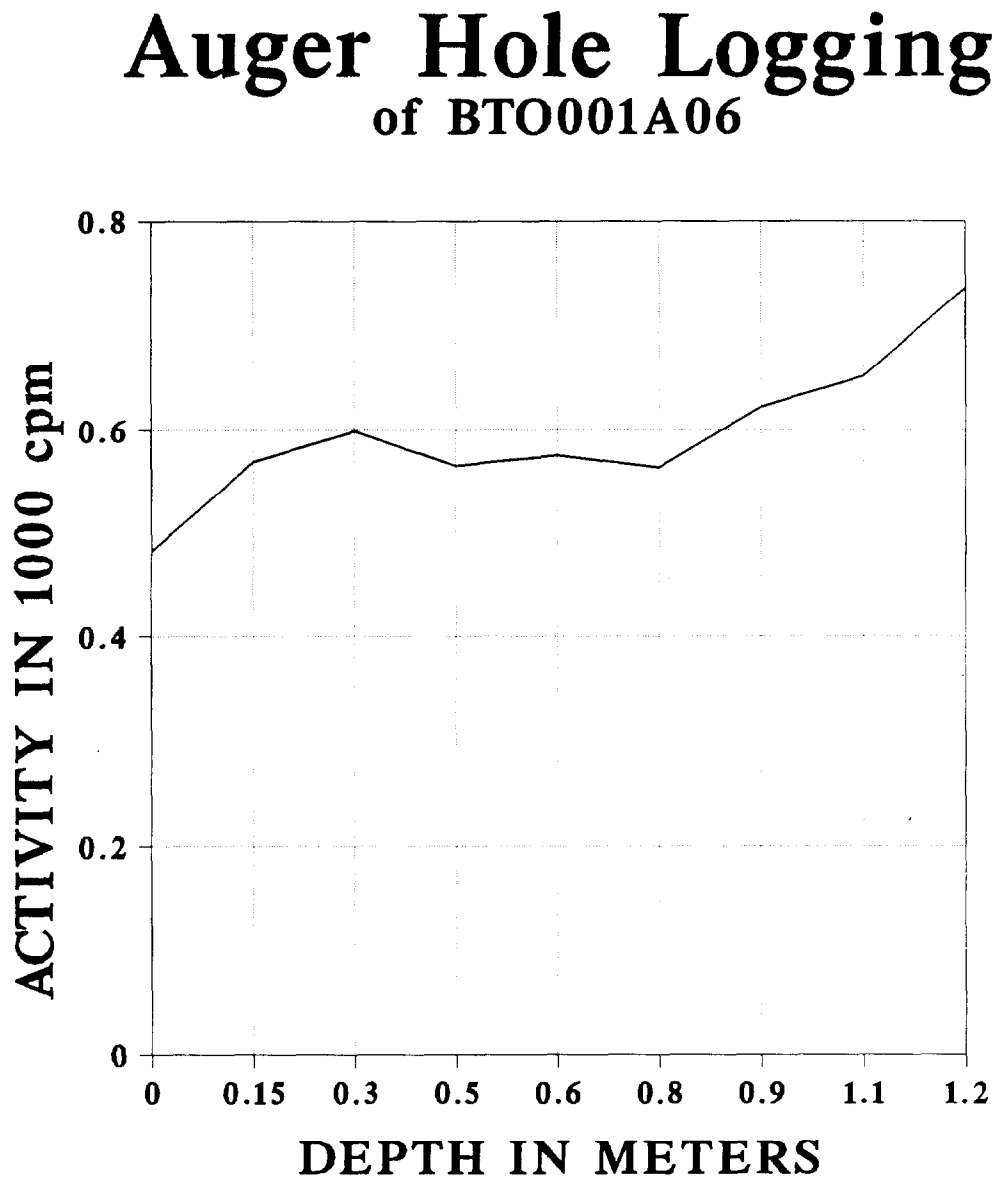

Fig. 36. Gamma profile for auger hole 6 at 2551-2555 Harleau Place, Toledo, Ohio.

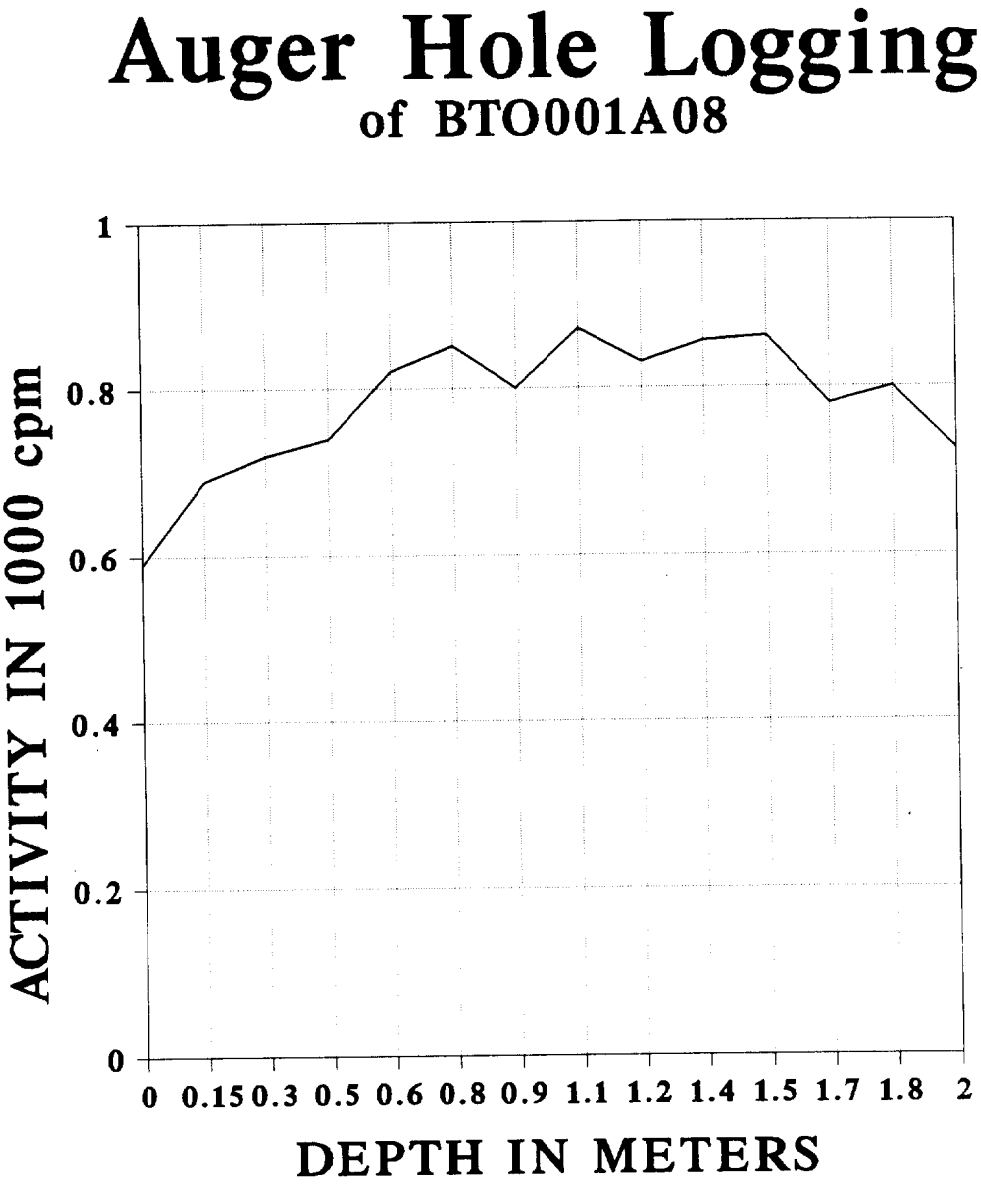

Fig. 37. Gamma profile for auger hole 8 at 2551-2555 Harleau Place, Toledo, Ohio.

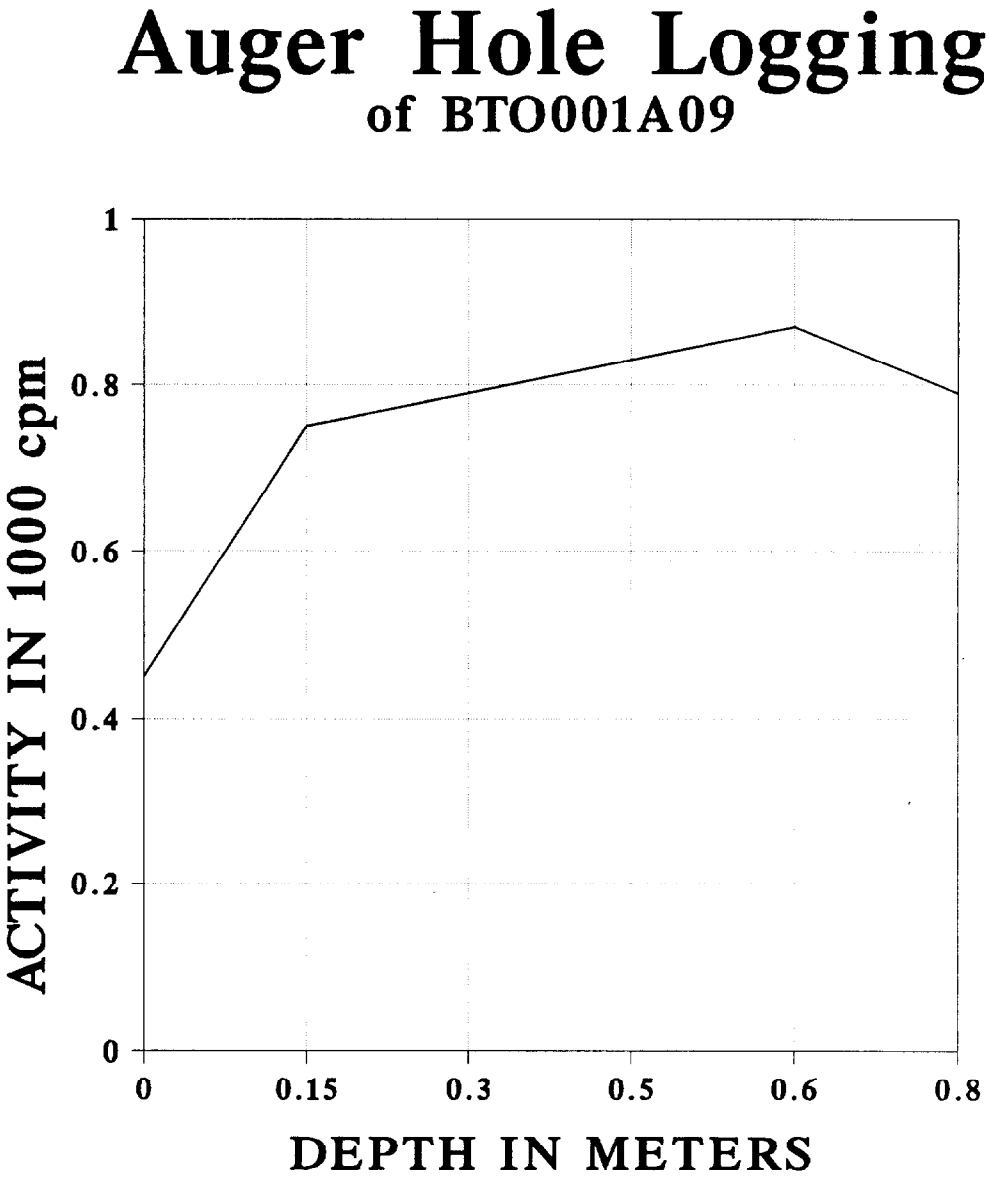

Fig. 38. Gamma profile for auger hole 9 at 2551-2555 Harleau Place, Toledo, Ohio.

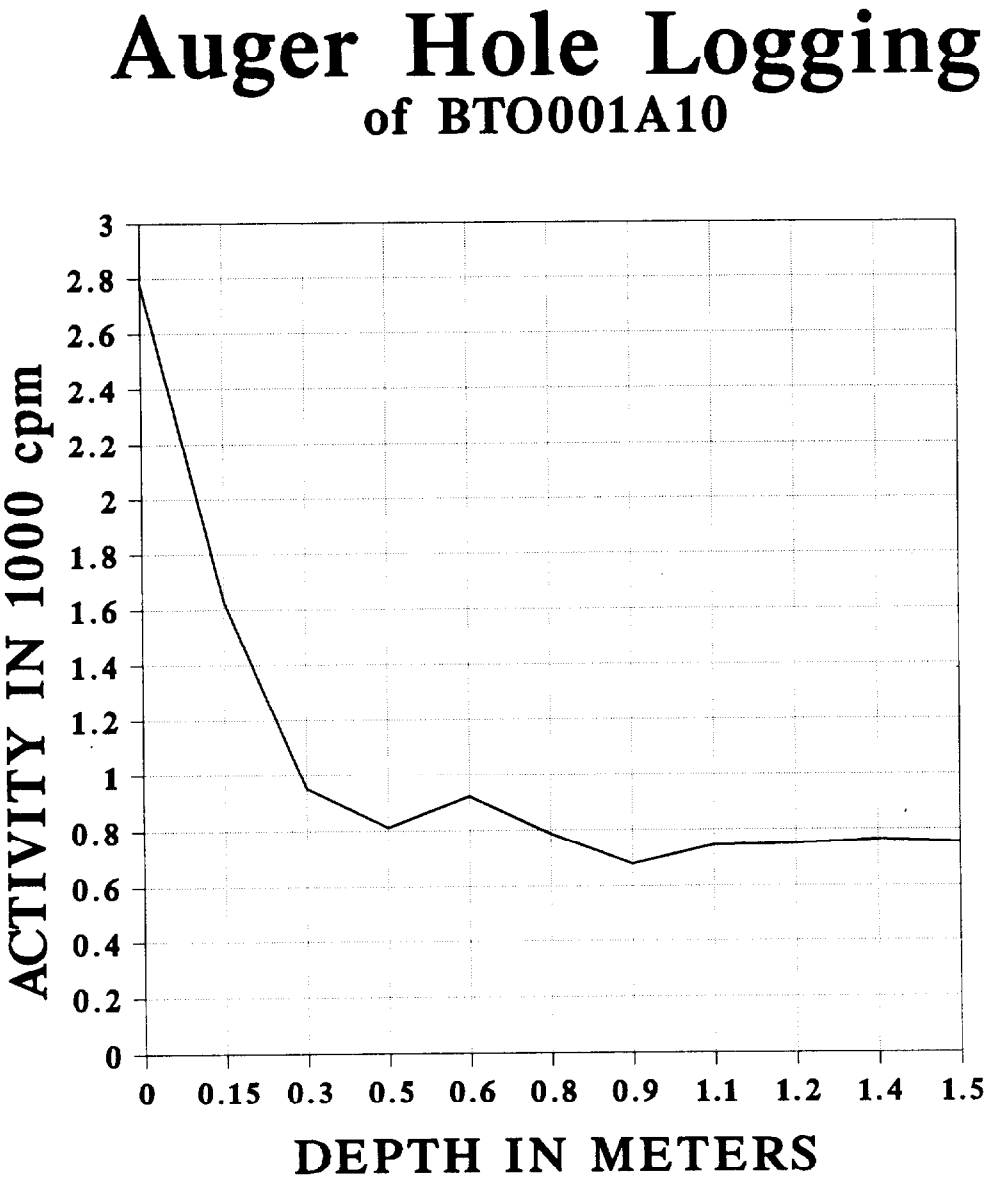

Fig. 39. Gamma profile for auger hole 10 at 2551-2555 Harleau Place, Toledo, Ohio.

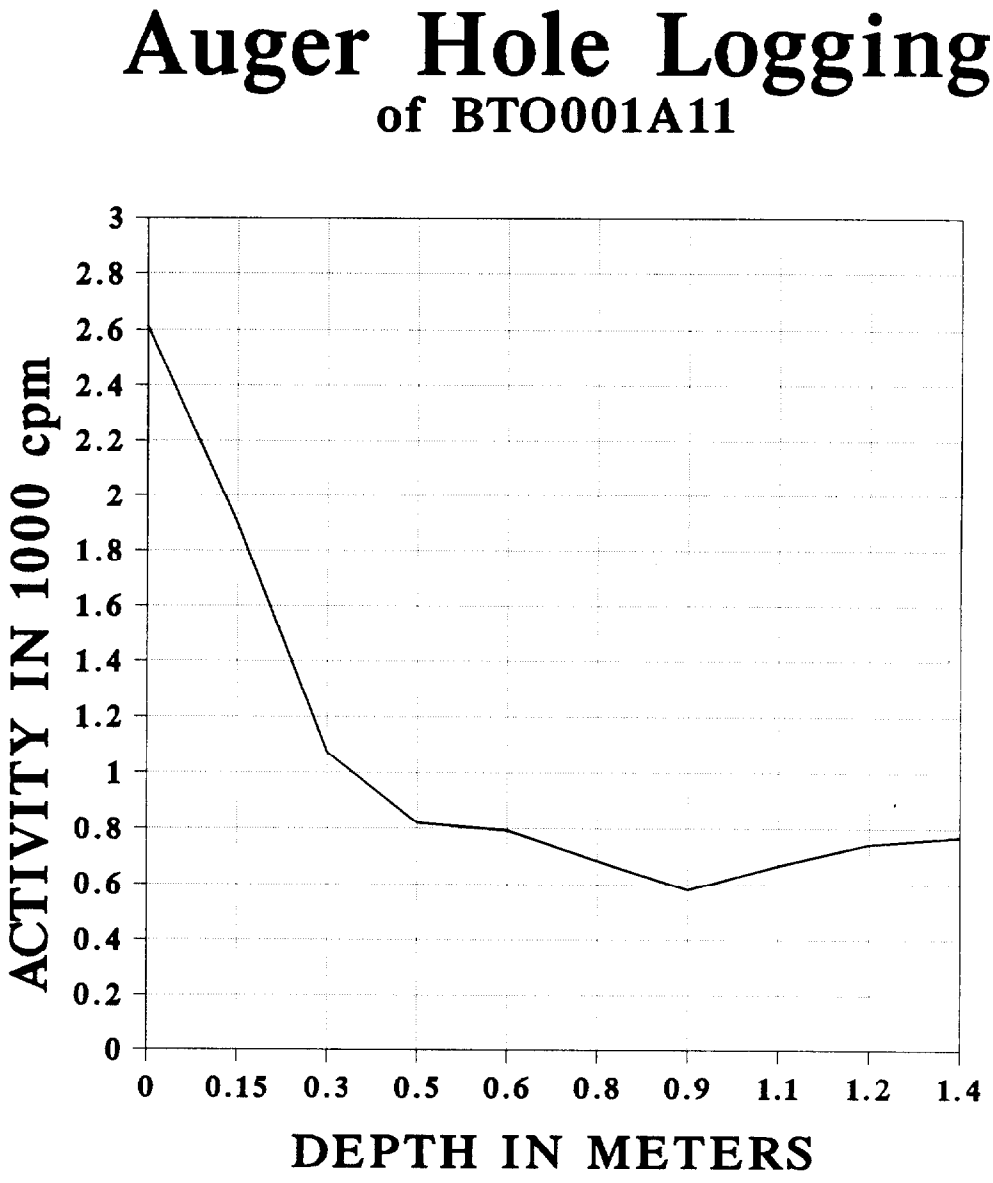

Fig. 40. Gamma profile for auger hole 11 at 2551-2555 Harleau Place, Toledo, Ohio.

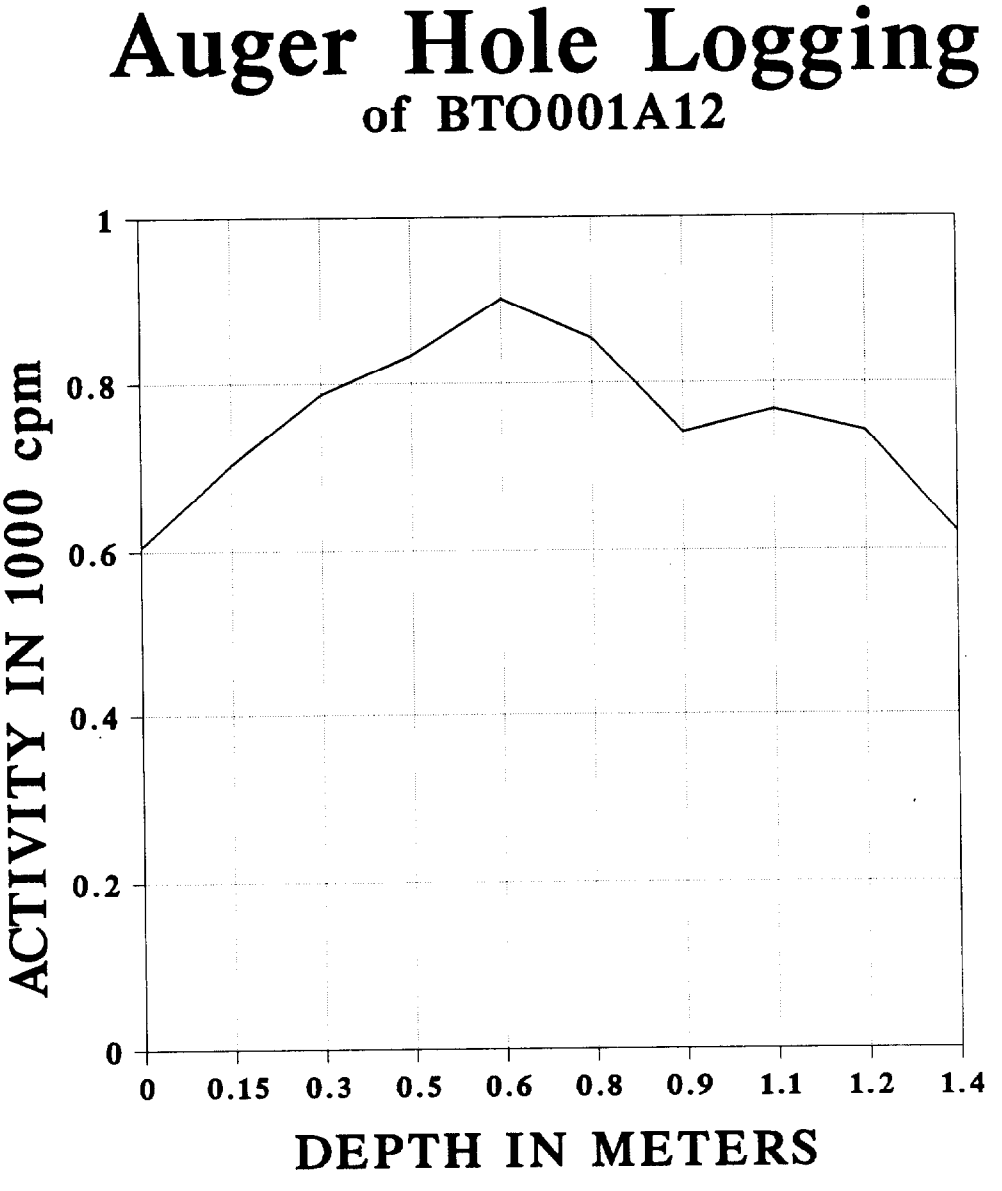

Fig. 41. Gamma profile for auger hole 12 at 2551-2555 Harleau Place, Toledo, Ohio.

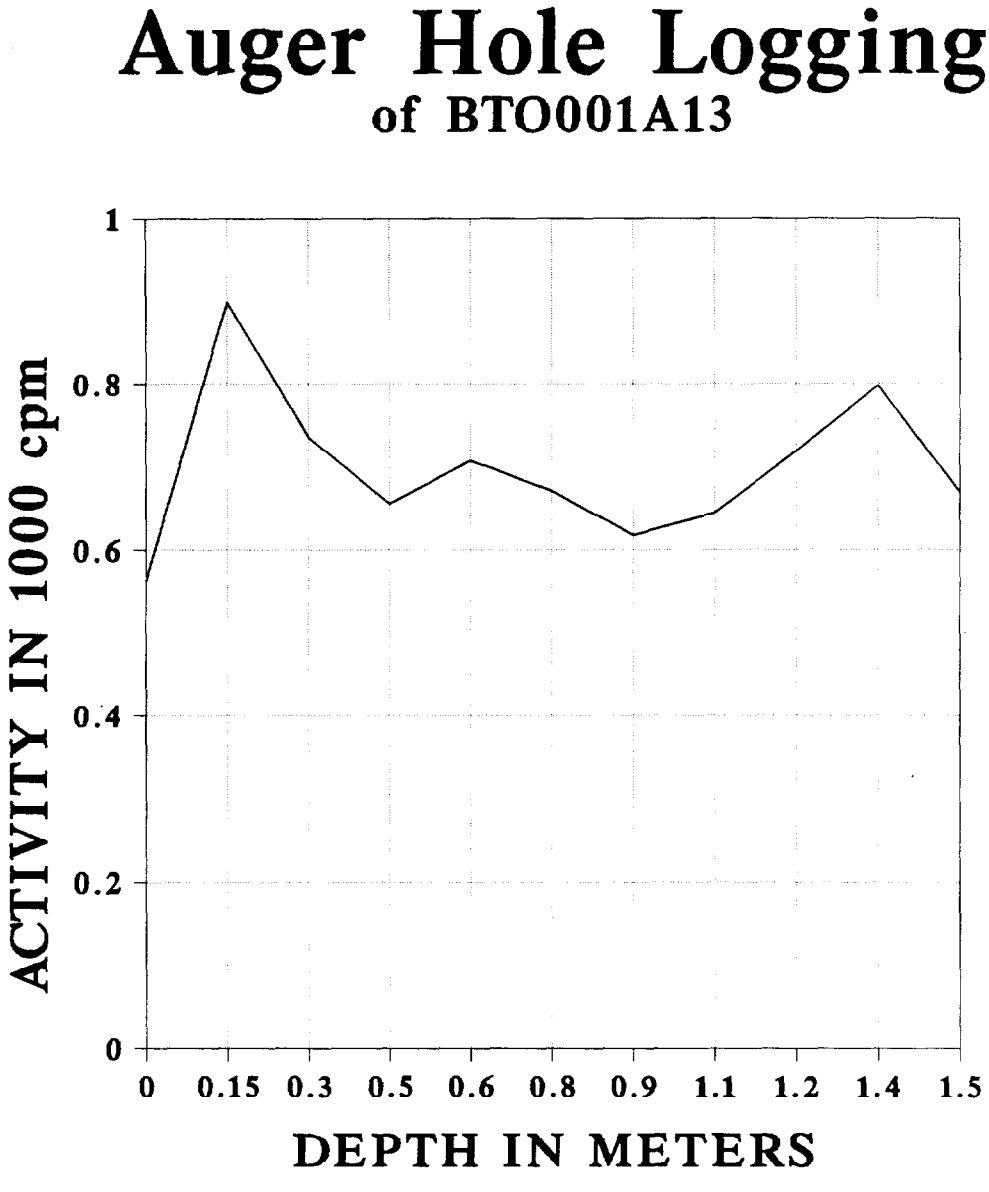

Fig. 42. Gamma profile for auger hole 13 at 2551-2555 Harleau Place, Toledo, Ohio.

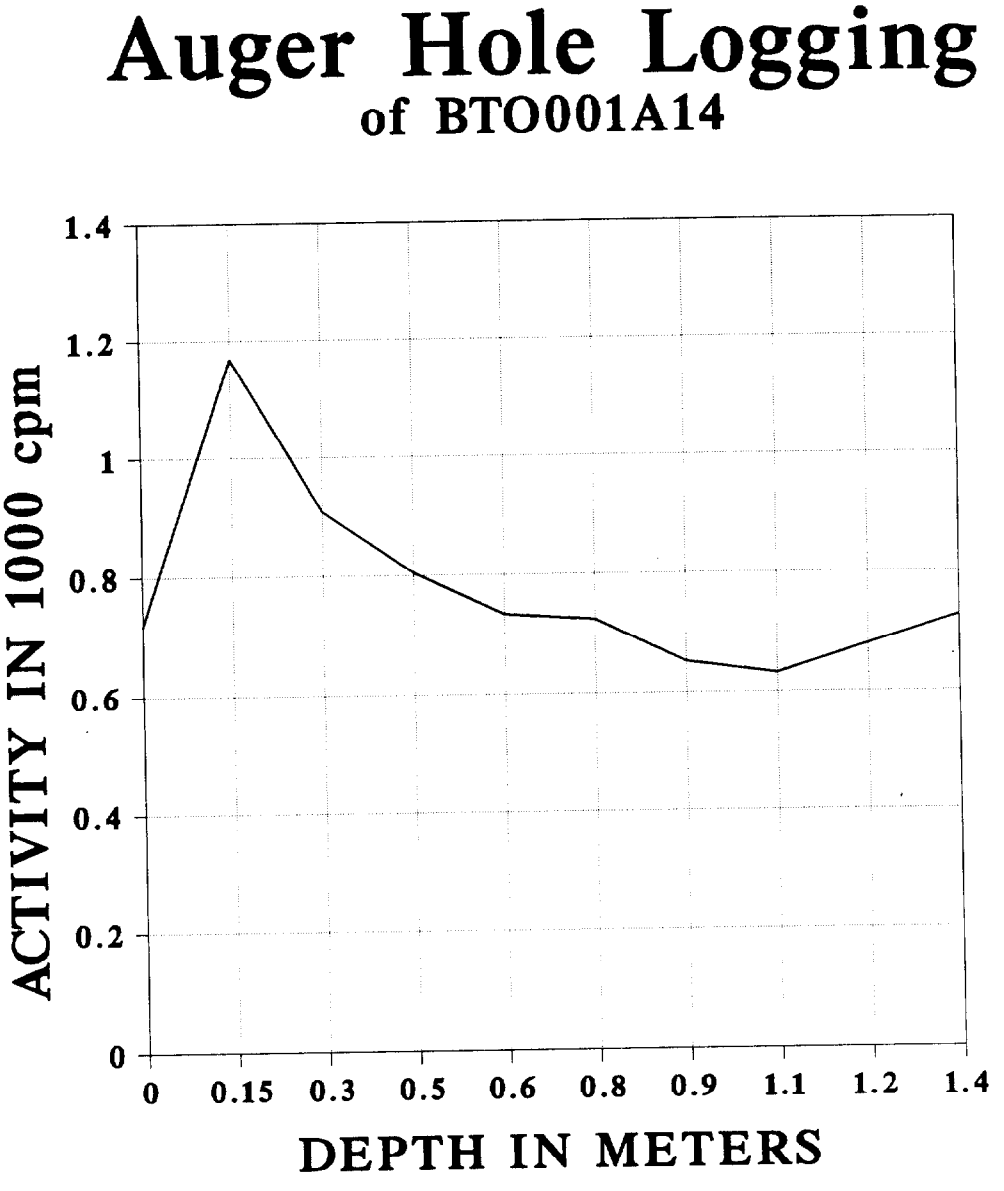

Fig. 43. Gamma profile for auger hole 14 at 2551-2555 Harleau Place, Toledo, Ohio.

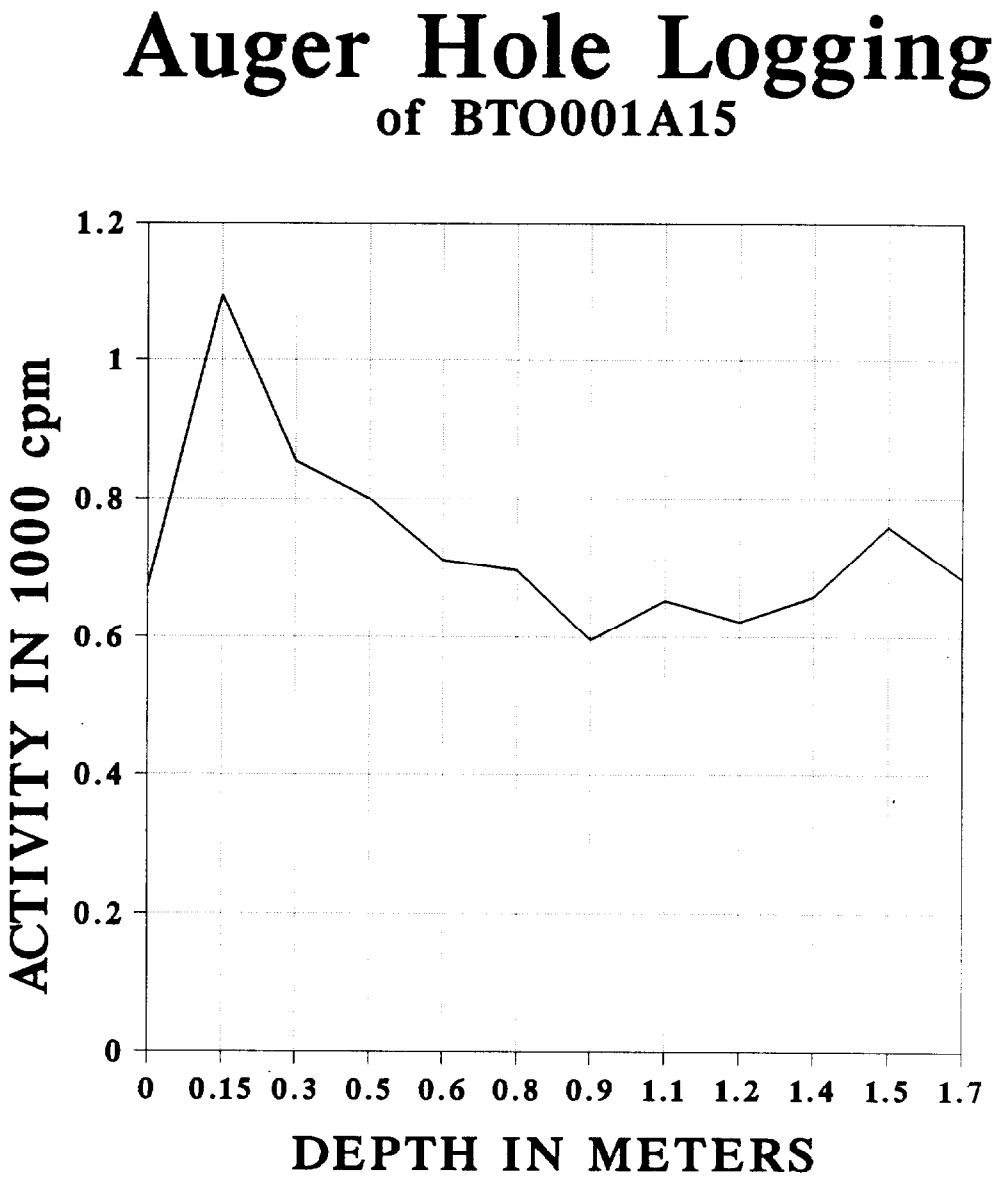

Fig. 44. Gamma profile for auger hole 15 at 2551-2555 Harleau Place, Toledo, Ohio.

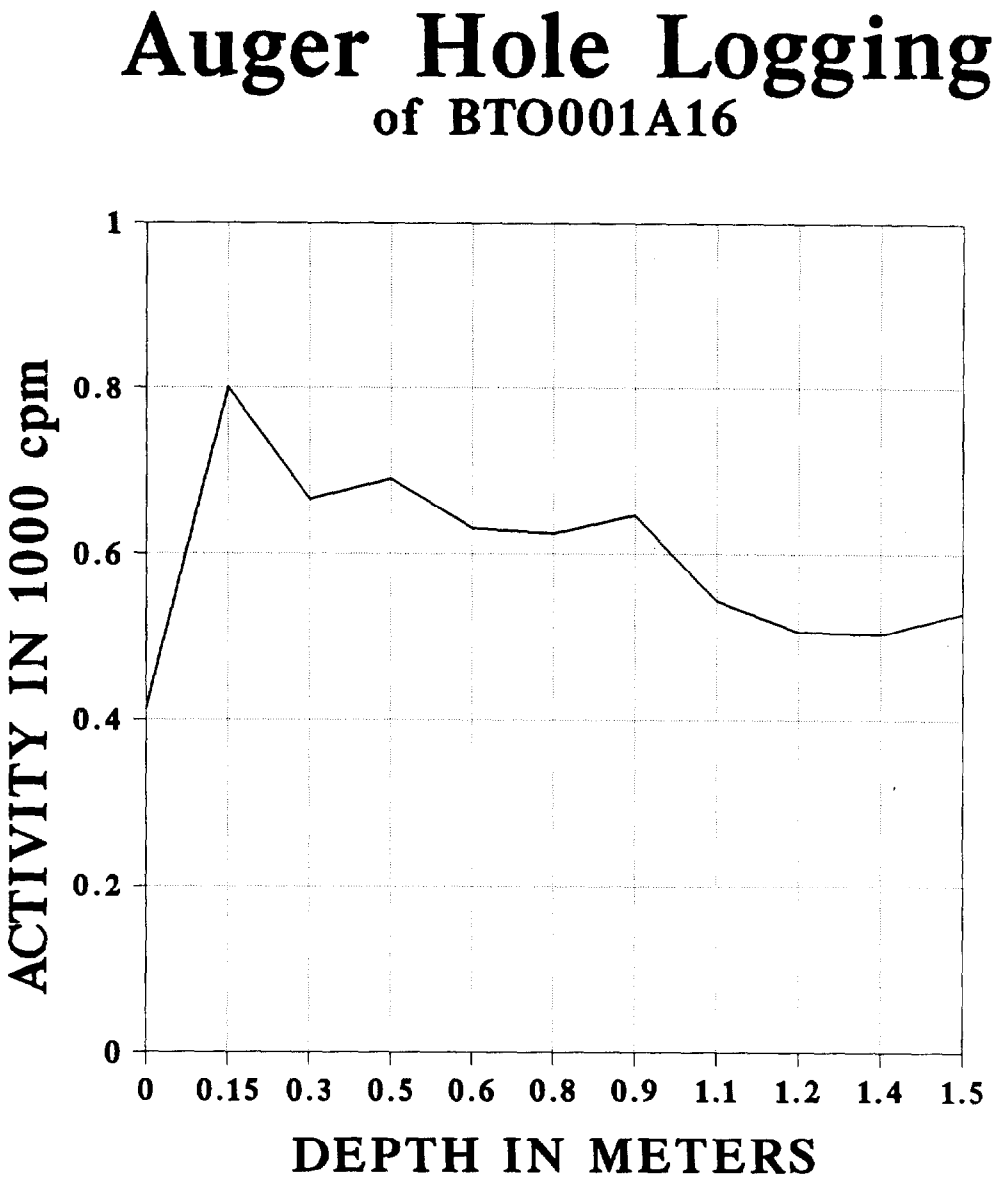

Fig. 45. Gamma profile for auger hole 16 at 2551-2555 Harleau Place, Toledo, Ohio.

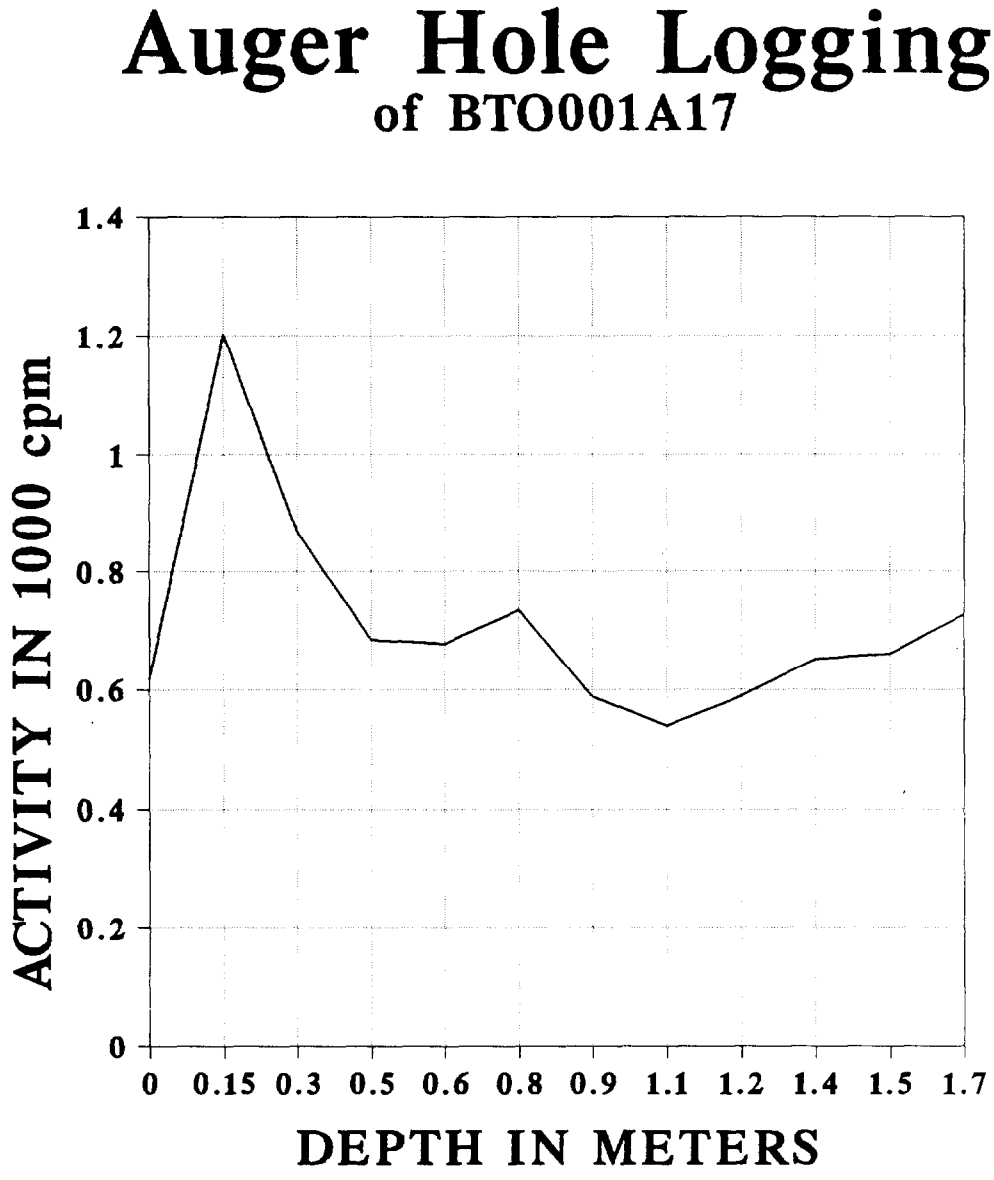

Fig. 46. Gamma profile for auger hole 17 at 2551-2555 Harleau Place, Toledo, Ohio.

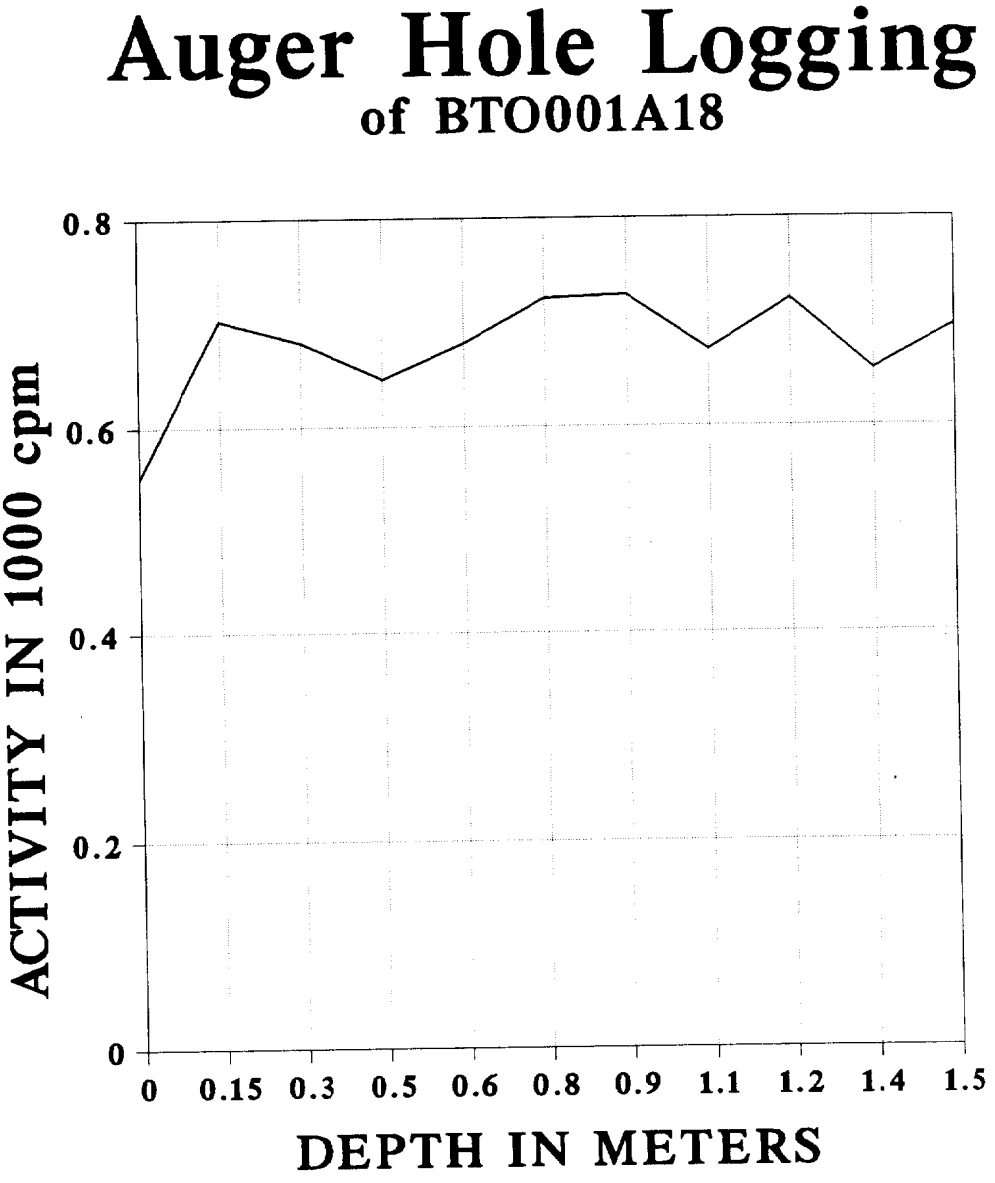

Fig. 47. Gamma profile for auger hole 18 at 2551-2555 Harleau Place, Toledo, Ohio.

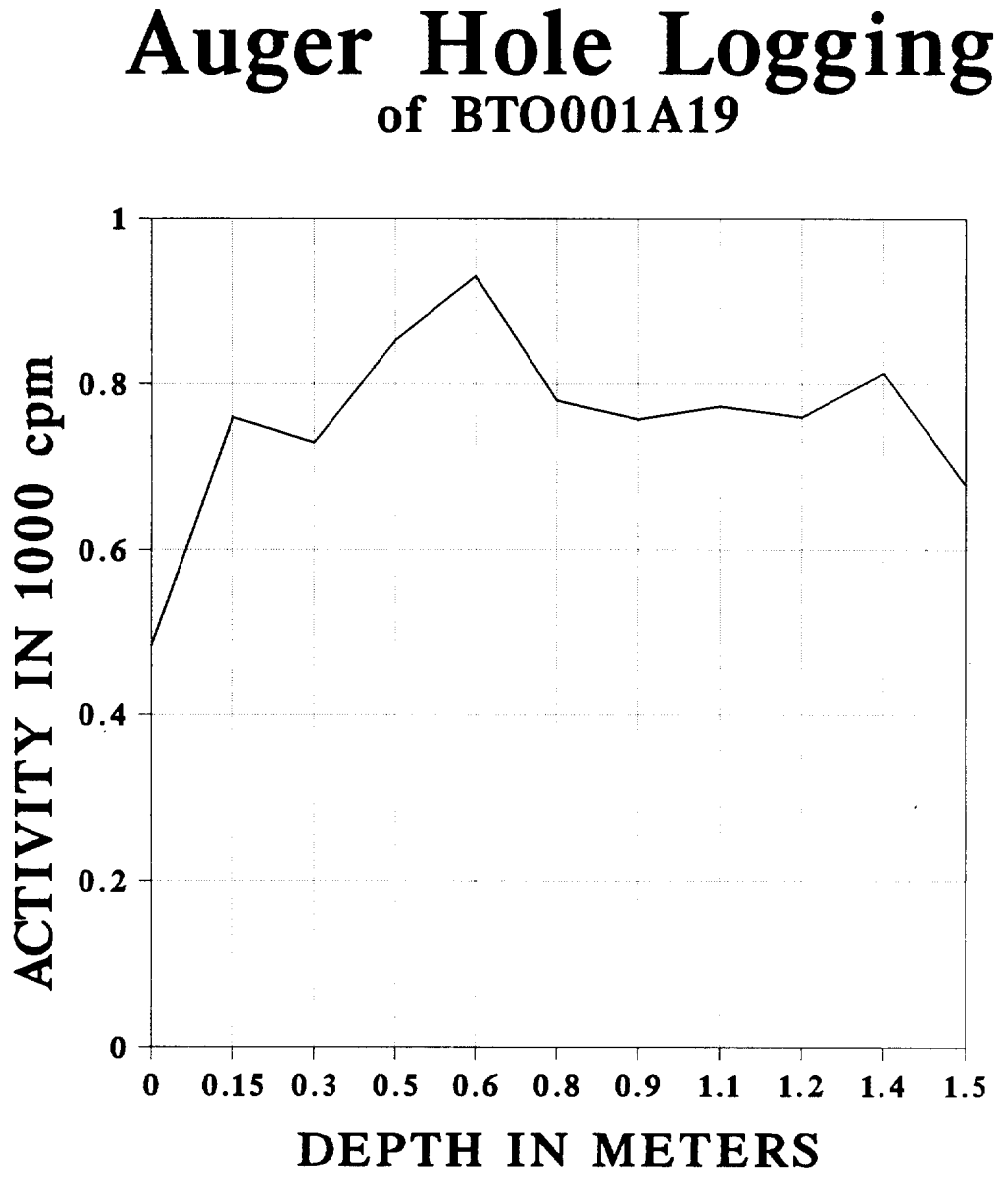

Fig. 48. Gamma profile for auger hole 19 at 2551-2555 Harleau Place, Toledo, Ohio.

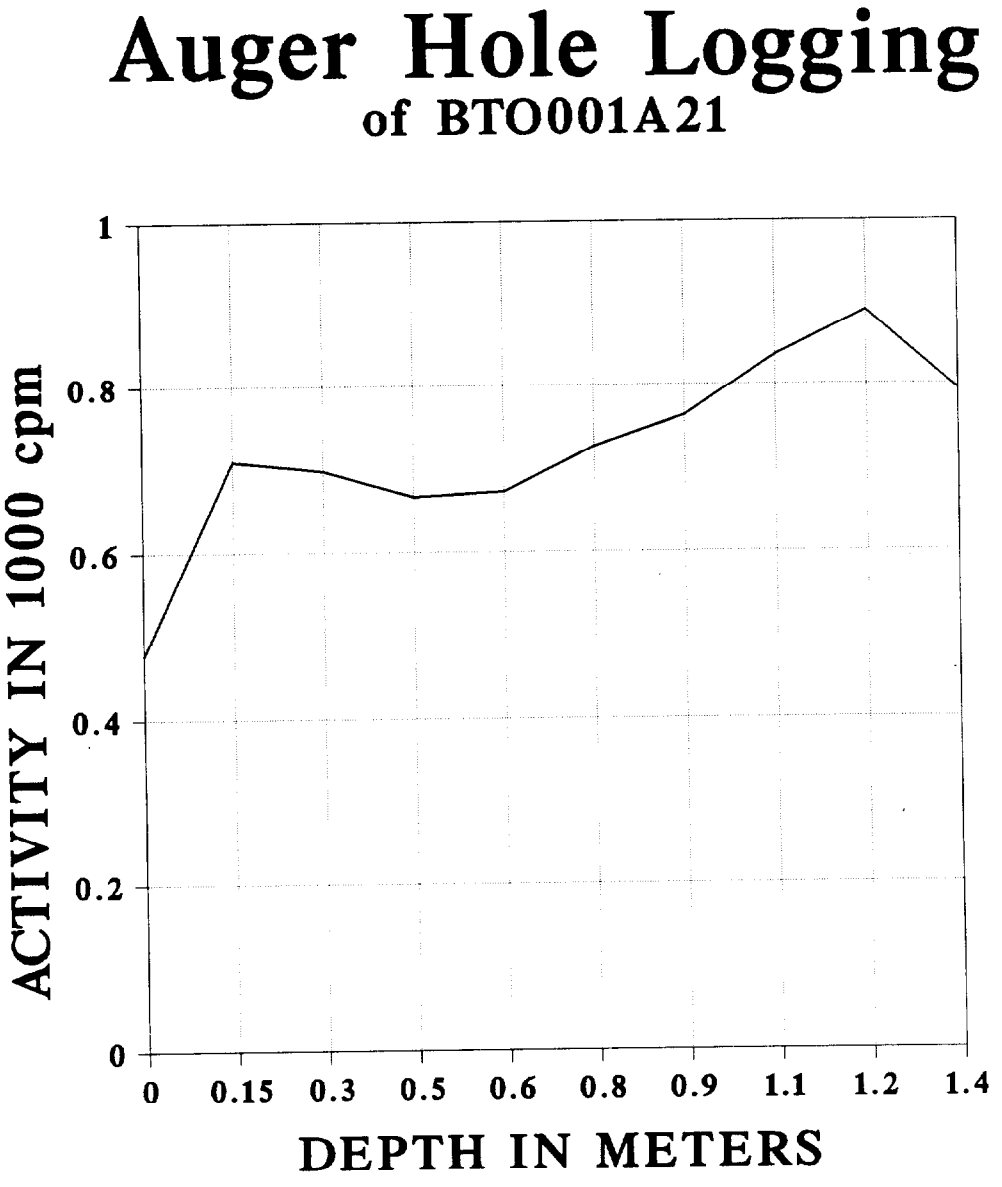

Fig. 49. Gamma profile for auger hole 21 at 2551-2555 Harleau Place, Toledo, Ohio.

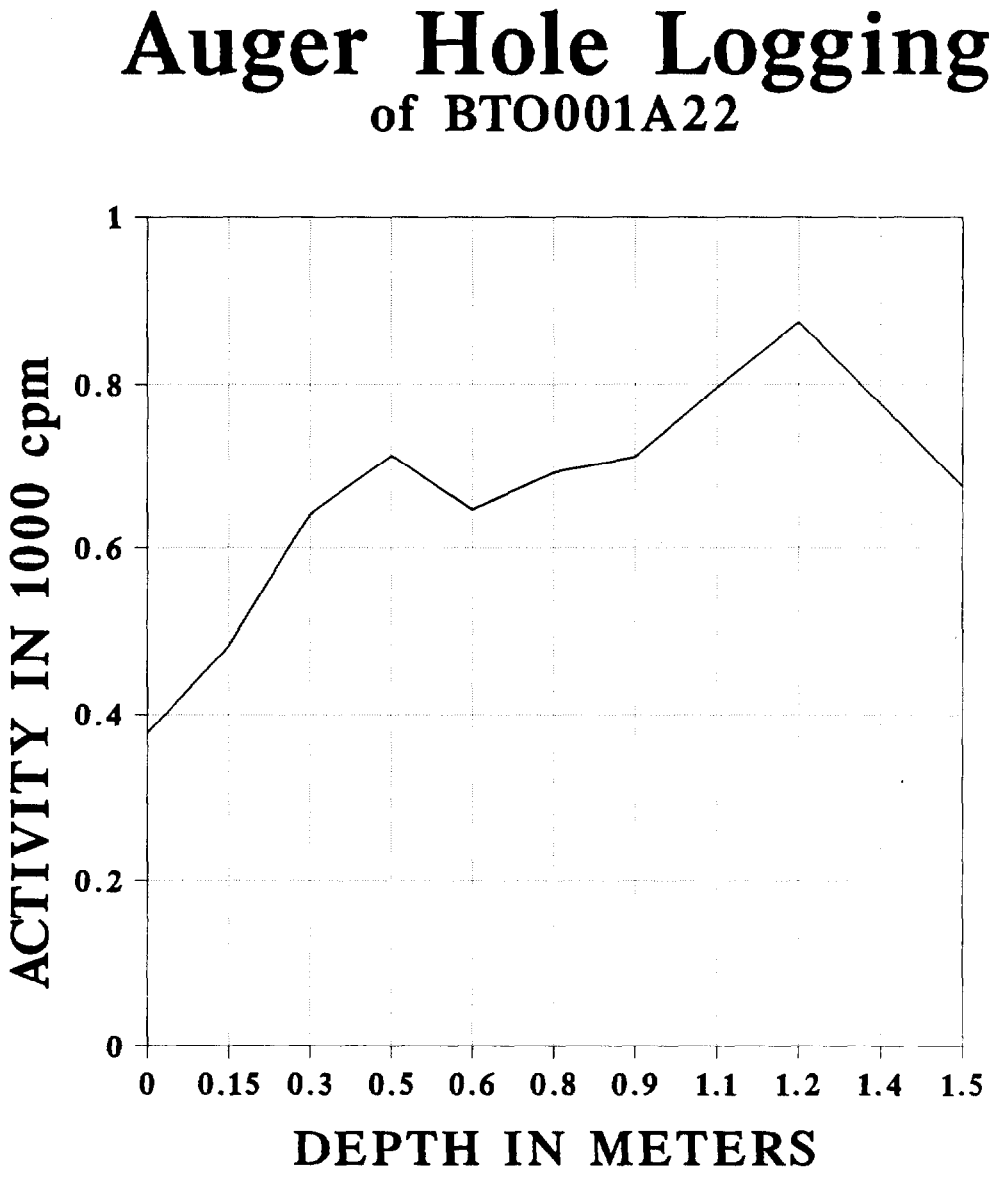

Fig. 50. Gamma profile for auger hole 22 at 2551-2555 Harleau Place, Toledo, Ohio.

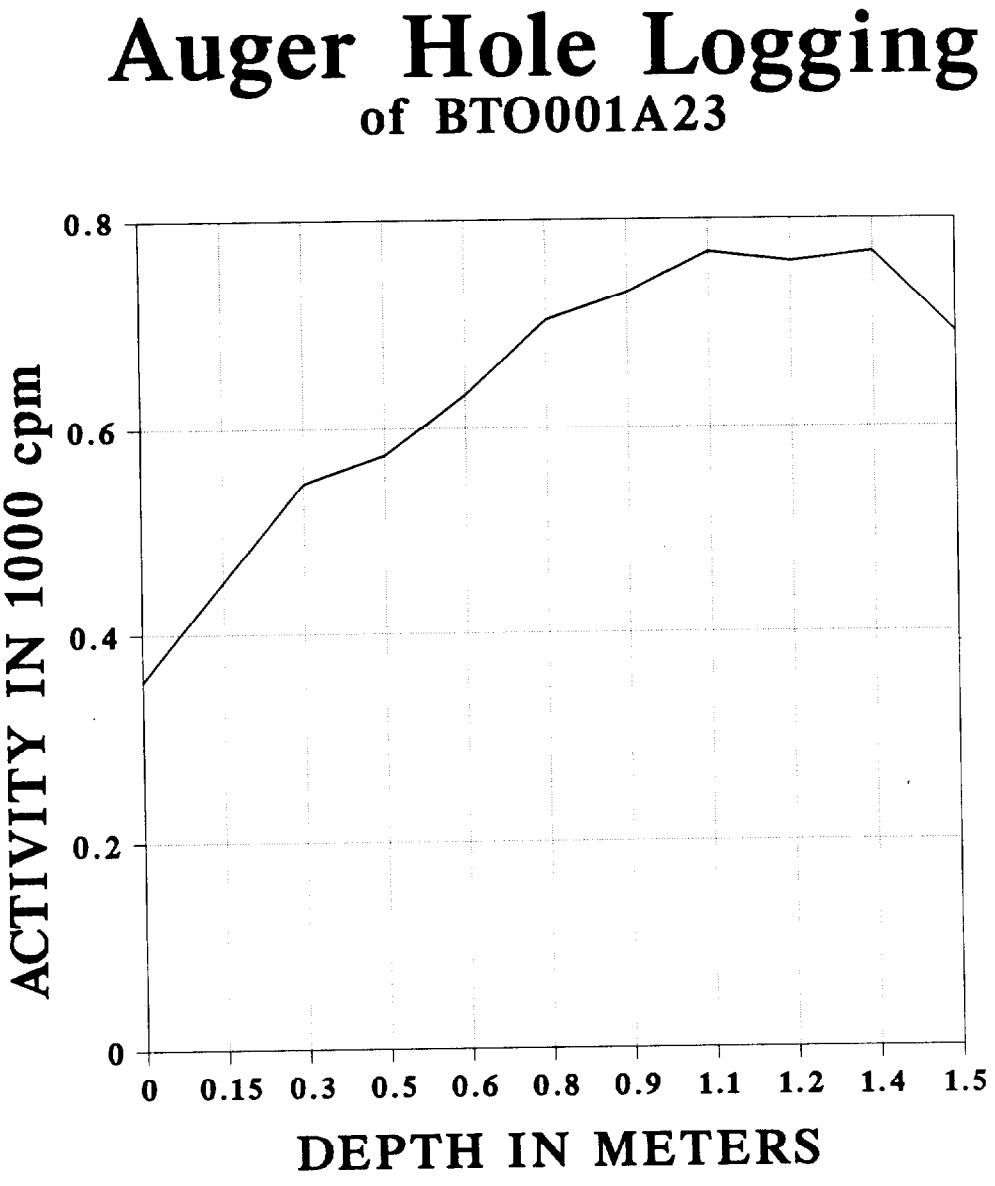

Fig. 51. Gamma profile for auger hole 23 at 2551-2555 Harleau Place, Toledo, Ohio.

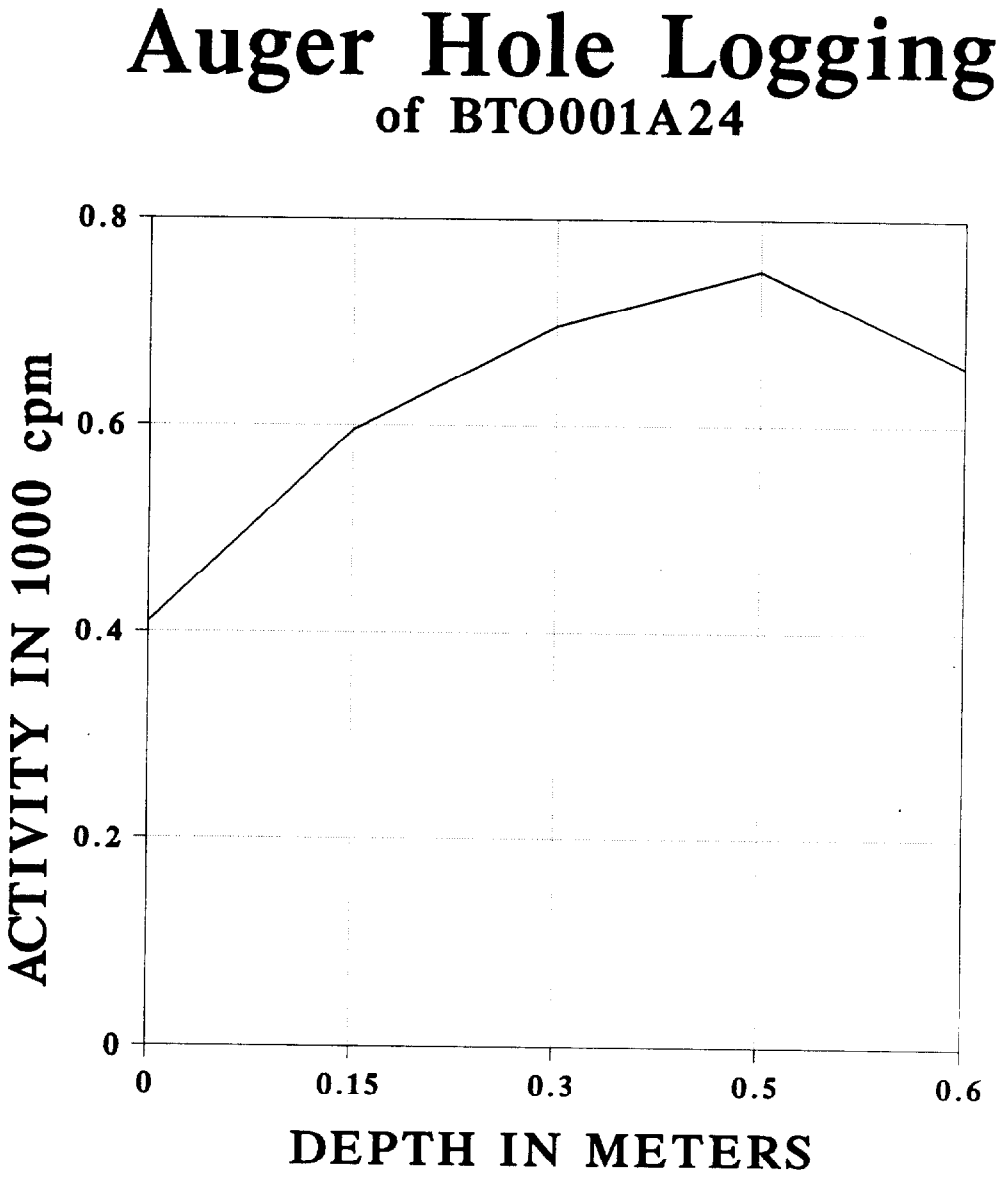

Fig. 52. Gamma profile for auger hole 24 at 2551-2555 Harleau Place, Toledo, Ohio.

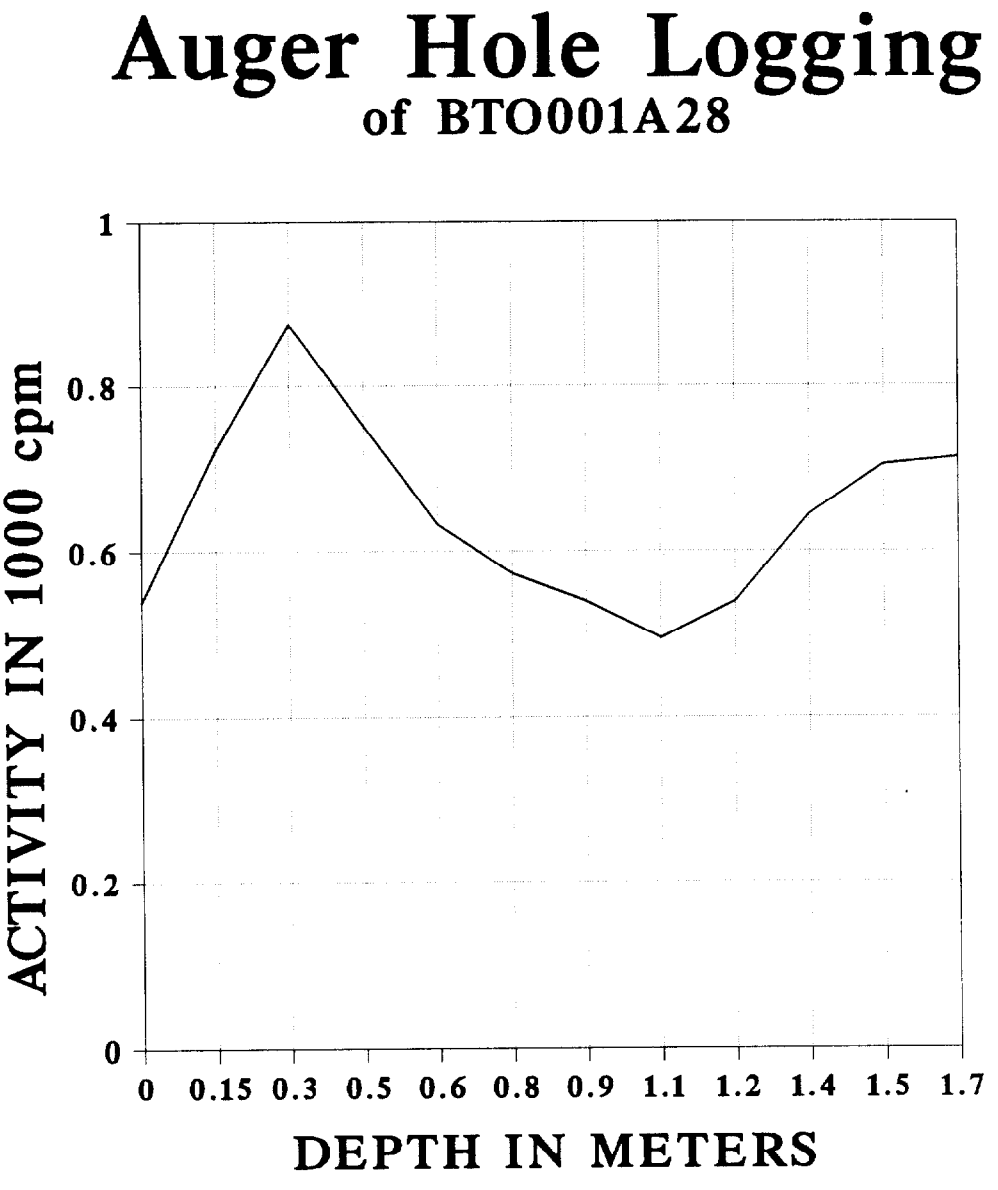

Fig. 53. Gamma profile for auger hole 28 at 2551-2555 Harleau Place, Toledo, Ohio.

Table 1. DOE guidelines for protection against radiation[a]

Mode of exposure	Exposure conditions	Guideline value
Gamma radiation	Indoor gamma radiation level (above background)	20 μR/h[b]
Total residual surface contamination[c]	^{238}U, ^{235}U, U-natural (*alpha emitters*) or Beta-gamma emitters[d]	
	Maximum	15,000 dpm/100 cm^2
	Average	5,000 dpm/100 cm^2
	Removable	1,000 dpm/100 cm^2
	^{232}Th, Th-natural (*alpha emitters*) or ^{90}Sr (*beta-gamma emitter*)	
	Maximum	3,000 dpm/100 cm^2
	Average	1,000 dpm/100 cm^2
	Removable	200 dpm/100 cm^2
	^{226}Ra, ^{230}Th, tranuranics	
	Maximum	300 dpm/100 cm^2
	Average	100 dpm/100 cm^2
	Removable	20 dpm/100 cm^2
Beta-gamma dose rates	Surface dose rate averaged over not more than 1 m^2	0.20 mrad/h
	Maximum dose rate in any 100-cm^2 area	1.00 mrad/h
Radionuclide concentrations in soil (generic)	Maximum permissible concentration of the following radionuclides in the soil above background levels averaged over 100-m^2 area ^{226}Ra ^{230}Th ^{232}Th	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.
Derived concentrations	^{238}U	Site specific[e]

Table 1. (continued)

Mode of exposure	Exposure conditions	Guideline value
Guideline for nonhomo geneous contamination (used in addition to the 100-m^2 guideline)[f]	Applicable to locations with an area ≤ 25 m^2 with significantly elevated concentrations of radionuclides ("hot spots")	$G_A = G_i\,(100/A)^{½}$ *where* G_A = guideline for "hot spot" of area (A) G_i = guideline averaged over a 100-m^2 area

[a]References 5 and 6.

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

[c]DOE surface contamination guidelines are consistent with the Nuclear Regulatory Commission guidelines found in Reference 7.

[d]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, ^{129}I, ^{126}I, ^{125}I.

[e]DOE guidelines for uranium are derived on a site-specific basis. Guidelines of 35-40 pCi/g have been applied at various FUSRAP sites. *Sources*: J. L. Marley and R. F. Carrier, *Results of the Radiological Survey at 4 Elmhurst Avenue, Colonie, New York (AL219)*, ORNL/RASA-87/117, Martin Marietta Energy Systems, Inc., Oak Ridge Natl. Lab., February 1988; B. A. Berven et al., *Radiological Survey of the Former Kellex Research Facility, Jersey City, New Jersey*, DOE/EV-0005/29, ORNL-5734, Martin Marietta Energy Systems, Inc., Oak Ridge Natl. Lab., February 1982.

[f]DOE guidelines specify that every reasonable effort shall be made to identify and remove any source which has a concentration exceeding 30 times the guideline value, irrespective of area. *Source*: Adapted from *Revised Guidelines for Residual Radioactive Material at FUSRAP and Remote SFMP Site*, April 1987. *Sources*: Adapted from *U.S. Department of Energy*, DOE Order 5400.5, April 1990.

Table 2. Average background radiation levels for the Ohio area[a]

Type of radiation measurement or sample	Radiation level or radionuclide concentration
Gamma exposure at 1 m above ground surface	μR/h 8
Concentration of radionuclides in soil	pCi/g[b]
^{226}Ra	1.5
^{232}Th	1.0
^{238}U	1.4

[a]Reference 8.

[b]These values represent an average of normal radionuclide concentrations in this state.

Table 3. Concentrations of radionuclides in outdoor soil samples at 2551-2555 Harleau Place, Toledo, Ohio (BTO001)

Sample[a]	Depth (cm)	Radionuclide concentration (pCi/g)[b]		
		^{226}Ra	^{232}Th	^{238}U
		Biased samples[c]		
B1	5-25	2.92±0.05	1.74±0.08	2.91± 1.58
B2[d]	0-15	[e]	[e]	160000 ± 540
B3A	0-15	0.92±0.65	0.66±0.09	360 ± 5
B3B	15-30	0.97±0.09	0.56±0.12	200 ± 6
B4A	0-15	1.36±0.57	<1.27	9900 ± 80
B4B	15-30	0.78±0.24	0.79±0.35	1000 ± 32
B4C	30-45[f]	0.88±0.19	0.97±0.29	920 ± 30
B5	0-8[f]	<1.55	<2.17	5500 ± 210
B6A	0-15	0.82±0.30	<0.68	790 ± 58
B6B	15-25	0.95±0.14	0.75±0.21	130 ± 6
B7A	0-15	0.82±0.37	<0.97	2100 ± 59
B7B	15-30	0.66±0.09	0.64±0.13	310 ± 10
B7C	30-45	0.46±0.04	0.35±0.05	26 ± 0.84
B7D	45-60	0.48±0.04	0.39±0.04	43 ± 3.20
B8A	0-15	0.65±0.07	0.57±0.12	160 ± 7
B8B	15-30	0.73±0.02	0.65±0.03	27 ± 1.28
B9A	0-15	1.06±0.14	0.82±0.24	1300 ± 21
B9B	15-30	0.92±0.23	0.69±0.28	440 ± 10
B10A	0-15	<12	<17	38000 ±1600
B10B	15-30	0.82±0.17	0.88±0.30	2400 ± 25
B10C	30-45	0.70±0.15	<0.37	1300 ± 32
B11A	0-15	<1.43	<2.16	11000 ± 180
B11B	15-30	0.73±0.10	0.66±0.17	320 ± 13
B12A	0-15	<0.45	0.83±0.39	4100 ± 63
B12C[g]	30-45	0.91±0.10	0.88±0.14	160 ± 11

Table 3. (continued)

Sample[a, b]	Depth (cm)	Radionuclide concentration (pCi/g)[b]		
		^{226}Ra	^{232}Th	^{238}U
		Auger samples[h]		
A1A	0-15	3.14±0.04	1.18±0.05	3.42± 1.11
A1C[g]	30-45	1.94±0.02	1.26±0.03	2.02± 0.48
A1D	45-60	1.44±0.04	0.91±0.06	2.19± 1.16
A1E	60-75	1.13±0.03	0.73±0.03	1.11± 0.79
A1F	75-90	0.76±0.02	0.50±0.03	1.06± 0.42
A1G	90-105	0.63±0.02	0.44±0.02	1.69± 0.71
A1H	105-120	0.61±0.02	0.36±0.04	0.97± 0.51
A1I	120-135	0.65±0.02	0.43±0.02	1.26± 0.68
A1J	135-150	0.91±0.02	0.61±0.03	0.92± 0.76
A1K	150-165	1.51±0.03	1.08±0.04	1.65± 1.12
A1L	165-180	1.09±0.02	0.70±0.04	1.38± 0.82
A1M	180-195	1.18±0.04	0.78±0.07	3.81± 1.87
A1N	195-210	1.02±0.03	0.72±0.06	1.95± 0.79
A1O	210-225	1.13±0.02	0.77±0.03	1.90± 0.74
A2A	0-15	1.03±0.09	0.49±0.11	180 ± 6.95
A2B	15-30	1.18±0.09	0.89±0.16	130 ± 7.02
A2C	30-45	1.30±0.04	0.91±0.06	74 ± 1.89
A2D	45-60	1.43±0.06	0.87±0.10	31 ± 3.61
A2E	60-75	1.45±0.04	0.92±0.05	14 ± 1.78
A2F	75-90	1.40±0.04	0.95±0.05	12 ± 1.14
A3A	0-15	0.97±0.07	0.65±0.11	570 ±11.5
A3B	15-30	0.84±0.08	0.57±0.12	380 ±11.92
A3C	30-45	0.98±0.09	0.56±0.13	150 ± 9.20
A3D	45-60	0.94±0.03	0.61±0.06	33 ± 1.11
A3E	60-75	0.74±0.09	0.42±0.11	140 ± 6.02
A3F	75-90	0.61±0.02	0.39±0.04	8.72± 1.39
A3G	90-105	0.61±0.02	0.37±0.02	0.86± 0.82
A3H	105-120	1.27±0.02	0.85±0.03	1.76± 0.81
A4A	0-15	0.88±0.02	0.56±0.03	5.48± 0.85
A4B	15-30	1.01±0.02	0.63±0.03	3.78± 0.49
A4C	30-45	0.95±0.03	0.54±0.05	3.31± 1.10
A4D	45-60	0.94±0.02	0.59±0.04	2.06± 0.76
A4E	60-75	0.93±0.02	0.51±0.03	0.88± 0.71
A4F	75-90	0.75±0.02	0.50±0.04	0.63± 0.52
A4G	90-105	0.84±0.02	0.51±0.02	0.58± 0.59
A4H	105-120	0.96±0.02	0.67±0.03	1.69± 1.13
A5A	0-15	1.04±0.04	0.63±0.05	4.88± 1.40
A5B	15-30	1.08±0.03	0.61±0.05	3.12± 0.76
A5C	30-45	0.99±0.02	0.63±0.02	1.30± 0.46

Table 3. (continued)

Sample[a, b]	Depth (cm)	Radionuclide concentration (pCi/g)[b]		
		^{226}Ra	^{232}Th	^{238}U
A5D	45-60	0.83±0.02	0.59±0.04	1.88± 0.64
A5E	60-75	0.59±0.01	0.40±0.02	0.81± 0.35
A5F	75-90	0.50±0.02	0.30±0.03	1.99± 0.71
A5G	90-105	0.61±0.02	0.42±0.02	1.07± 0.73
A5H	105-120	1.54±0.02	0.93±0.03	1.58± 0.77
A6A	0-15	0.84±0.02	0.56±0.03	2.20± 0.73
A6B	15-30	0.88±0.02	0.59±0.03	1.72± 0.43
A6C	30-45	0.97±0.02	0.57±0.02	1.38± 0.73
A6D	45-60	0.77±0.02	0.50±0.02	1.26± 0.64
A6E	60-75	0.68±0.02	0.45±0.02	1.22± 0.58
A6F	75-90	0.51±0.02	0.36±0.02	0.66± 0.61
A6G	90-105	0.65±0.02	0.35±0.02	0.86± 0.62
A6H	105-120	1.11±0.02	0.72±0.03	1.70± 0.75
A7A	0-15	1.28±0.08	0.76±0.12	140 ± 8.19
A7B	15-30	1.35±0.06	0.95±0.09	110 ± 5.01
A7C	30-45	1.24±0.09	0.73±0.12	70 ± 5.52
A7D	45-60	1.45±0.04	0.95±0.06	42 ± 2.18
A7E	60-75	1.46±0.04	0.94±0.07	13 ± 2.06
A7F	75-90	1.40±0.04	0.94±0.07	6.51± 1.56
A8A	0-15	1.78±0.02	1.03±0.03	2.16± 0.37
A8B	15-30	1.10±0.02	1.82±0.04	2.16± 1.00
A8C	30-45	0.90±0.02	0.75±0.04	1.17± 0.67
A8D	45-60	1.00±0.02	0.84±0.03	1.16± 0.40
A8E	60-75	1.08±0.03	0.85±0.04	0.93± 0.70
A8F	75-90	1.02±0.02	0.79±0.03	1.70± 0.37
A8G	90-105	1.15±0.02	0.77±0.02	1.14± 0.40
A8H	105-120	1.12±0.02	0.74±0.03	1.51± 0.78
A8I	120-135	1.00±0.02	0.64±0.02	1.18± 0.58
A9A	0-15	1.68±0.03	0.61±0.03	2.08± 0.82
A9B	15-30	1.38±0.03	0.83±0.03	1.31± 0.83
A9C	30-45	1.24±0.03	0.80±0.03	1.88± 1.65
A9D	45-60	1.75±0.03	0.96±0.04	1.77± 0.79
A9E	60-75	1.33±0.03	0.92±0.05	1.94± 0.83
A9F	75-90	1.47±0.03	0.88±0.04	1.24± 0.54
A10A	0–15	3.59±0.15	2.30±0.23	1600 ±20
A10B	15–30	1.93±0.08	1.50±0.12	52 ± 2.61
A10C	30–45	1.57±0.04	1.17±0.06	20 ± 2.21
A10D	45–60	0.94±0.05	0.77±0.08	45 ± 2.29
A10E	60–75	1.16±0.09	0.76±0.12	220 ± 8.14
A10F	75–90	1.01±0.08	0.81±0.11	40 ± 1.54

Table 3. (continued)

Sample[a, b]	Depth (cm)	Radionuclide concentration (pCi/g)[b]		
		^{226}Ra	^{232}Th	^{238}U
A10G	90–105	0.75±0.02	0.52±0.03	4.37± 0.90
A10H	105–120	1.19±0.02	0.74±0.03	1.98± 0.81
A10I	120–135	1.13±0.06	0.65±0.08	680 ± 9.47
A10J	135–150	1.16±0.05	0.70±0.07	130 ± 5.85
A10K	150–165	1.18±0.02	0.85±0.03	3.61± 1.09
A10L	165–180	1.28±0.02	0.71±0.04	2.44± 1.02
A11A	0–15	4.46±0.05	2.63±0.07	41 ± 1.57
A11B	15–30	1.58±0.02	1.16±0.11	14 ± 1.09
A11C	30–45	1.60±0.07	1.31±0.12	47 ± 3.30
A11D	45–60	1.63±0.03	1.28±0.05	6.39± 1.39
A11E	60–75	0.99±0.02	0.59±0.03	4.15± 0.71
A11F	75–90	0.92±0.02	0.62±0.03	2.11± 0.79
A11G	90–105	1.39±0.03	0.81±0.03	1.50± 0.80
A11H	105–120	1.14±0.02	0.92±0.03	3.42± 1.30
A11I	120–135	2.29±0.05	1.50±0.06	39 ± 1.62
A11J	135–150	1.94±0.05	1.21±0.06	33 ± 3.13
A11K	150–165	0.99±0.02	0.75±0.03	1.55± 0.77
A11L	165–180	1.29±0.02	0.73±0.03	1.20± 0.66
A12A	0–15	1.59±0.05	1.04±0.08	49 ± 3.20
A12B	15–30	1.26±0.05	1.01±0.07	17 ± 2.48
A12C	30–45	0.89±0.03	0.66±0.04	18 ± 1.71
A12D	45–60	1.45±0.05	1.01±0.07	21 ± 2.54
A12F[g]	75–90	1.48±0.04	0.94±0.06	23 ± 1.14
A12G	90–105	0.99±0.02	0.70±0.03	4.61± 0.44
A12H	105–120	1.14±0.03	0.72±0.03	1.85± 0.89
A13A[d]	0–15	1.96±0.03	1.19±0.04	3.94± 0.90
A13B	15–30	1.69±0.02	1.28±0.03	8.56± 0.88
A13C	30–45	0.93±0.02	0.77±0.03	15 ± 1.18
A13D	45–60	0.67±0.02	0.47±0.03	14 ± 1.02
A13E	60–75	0.90±0.04	0.58±0.06	33 ± 3.13
A13F	75–90	0.92±0.03	0.58±0.04	5.42± 0.77
A13G	90–105	0.99±0.02	0.69±0.03	2.03± 0.55
A13H	105–120	1.24±0.02	0.86±0.03	1.60± 0.79
A13I	120-135	1.18±0.02	0.77±0.03	2.23± 0.47
A13J	135-150	1.17±0.02	0.69±0.03	1.37± 0.43
A13K	150-165	0.96±0.02	0.68±0.02	1.27± 0.38
A13L	165-180	1.19±0.02	0.72±0.03	1.41± 0.86
A14A	0-15	3.03±0.04	1.89±0.06	21 ± 1.71
A14B	15-30	1.94±0.05	1.41±0.07	7.27± 2.11
A14C	30-45	1.44±0.03	1.09±0.04	15 ± 1.51

Table 3. (continued)

Sample[a, b]	Depth (cm)	Radionuclide concentration (pCi/g)[b]		
		^{226}Ra	^{232}Th	^{238}U
A14D	45-65	1.25±0.06	0.97±0.08	20 ± 2.46
A14E	60-75	1.30±0.03	0.92±0.04	2.29± 1.24
A14F	75-90	1.13±0.02	0.71±0.03	1.50± 0.76
A14G	90-105	0.87±0.02	0.57±0.03	0.99± 0.37
A14H	105-120	1.21±0.02	0.76±0.04	0.50± 0.50
A15A	0-15	2.53±0.05	1.63±0.06	5.20± 1.12
A15B	15-30	1.82±0.03	1.17±0.04	3.55± 0.86
A15C	30-45	1.34±0.02	0.97±0.03	3.27± 0.78
A15D	45-60	1.86±0.03	1.53±0.05	5.32± 1.01
A16A	0-15	0.70±0.01	0.10±0.01	1.94± 0.28
A16B	15-30	1.71±0.02	1.20±0.03	1.68± 0.79
A16C	30-45	1.06±0.02	0.70±0.02	0.88± 0.56
A16D	45-60	1.12±0.02	0.79±0.04	0.85± 0.75
A17A	0-15	2.49±0.03	1.54±0.03	3.15± 0.78
A17B	15-30	2.60±0.05	1.58±0.06	2.98± 1.64
A17C	30-45	1.28±0.02	0.82±0.03	0.96± 0.63
A17D	45-60	0.87±0.02	0.48±0.03	0.85± 0.44
A18A	0-5	1.77±0.03	0.93±0.03	3.78± 0.98
A18B	5-15	1.43±0.02	1.00±0.04	9.14± 1.85
A18C	15-30	1.33±0.02	1.12±0.04	2.76± 0.68
A18D	30-45	0.92±0.02	0.73±0.03	4.52± 0.80
A18F	60-75	0.89±0.02	0.57±0.03	7.92± 0.59
A18G	75-90	0.99±0.02	0.61±0.03	0.71± 0.40
A19A	0-15	1.66±0.02	1.13±0.03	1.71± 0.76
A19B[g]	30-45	1.42±0.03	0.88±0.04	1.50± 0.80
A19C	45-60	2.47±0.03	1.43±0.04	3.42± 0.99
A19D	60-75	1.45±0.03	0.87±0.04	1.37± 0.85
A21A[g]	0-15	1.85±0.02	0.95±0.03	2.32± 0.84
A21B	15-30	0.93±0.02	0.62±0.03	1.42± 0.88
A21C	30-45	1.01±0.02	0.64±0.03	2.69± 0.88
A22A	0-15	0.49±0.02	0.36±0.03	0.94± 0.55
A22B	15-30	0.92±0.02	0.61±0.03	0.77± 0.77
A22C	30-45	1.16±0.02	0.81±0.04	2.12± 1.02
A22D[g]	60-75	0.82±0.02	0.57±0.04	0.79± 0.78
A22E	75-90	0.85±0.02	0.62±0.04	1.16± 0.95
A22F	90-105	1.26±0.03	0.83±0.04	1.38± 0.91
A22G	105-120	1.41±0.02	1.01±0.03	1.40± 0.80
A23A	0-15	0.81±0.02	0.08±0.02	1.37± 0.71

Table 3. (continued)

Sample[a, b]	Depth (cm)	Radionuclide concentration (pCi/g)[b]		
		^{226}Ra	^{232}Th	^{238}U
A23B	15-30	0.85±0.02	0.27±0.02	1.88± 0.45
A23C	30-45	0.83±0.02	0.55±0.04	3.05± 0.99
A23D	45-60	0.69±0.02	0.65±0.04	1.75± 0.93
A23E	60-75	1.07±0.02	0.69±0.04	0.88± 0.81
A23F	75-90	1.12±0.02	0.75±0.03	1.44± 0.79
A23G	90-105	1.05±0.02	0.71±0.03	1.57± 0.47
A24A	0-15	1.05±0.02	0.69±0.02	2.06± 0.67
A24B	15-30	1.79±0.02	1.15±0.03	3.64± 0.94
A25C[i]	30-45	0.68±0.02	0.49±0.03	1.88± 0.49
A25D	45-60	1.31±0.02	1.07±0.03	2.42± 0.71
A27A[g]	0-15[f]	1.71±0.02	0.94±0.03	2.04± 0.76
A28C[i]	30-45	1.99±0.03	1.28±0.04	1.78± 0.96

[a]Locations of soil samples are shown on Fig. 25.

[b]Indicated counting error is at the 95% confidence level ($\pm 2\sigma$).

[c]Biased samples are taken from areas with elevated gamma exposure rates.

[d]Biased sample B2 and auger sample A13 were taken from the same location.

[e]Sample was not analyzed for this radionuclide.

[f]Refusal at this depth.

[g]Preceding sample(s) not taken due to soil conditions.

[h]Auger samples are taken from holes drilled to further define the depth and extent of radioactive material. Holes are drilled where the surface may or may not be contaminated.

[i]Preceding samples were not analyzed.

Table 4. Concentrations of radionuclides from roof and indoor dust and debris samples at 2551-2555 Harleau Place, Toledo, Ohio (BTO001)

Sample[b]	Depth (cm)	Radionuclide concentration (pCi/g)[a]		
		^{226}Ra	^{232}Th	^{238}U
		Systematic samples[c]		
D1	0-5	0.22±0.03	0.22±0.03	1.05± 0.37
D2	0-5	[d]	[d]	5400 ±1600
D3	0-5	0.29±0.02	0.42±0.04	2.12± 0.81
D4	0-5	[d]	[d]	[d]
D5	0-5	[d]	[d]	<5 .4
D6	0-5	0.30±0.02	0.20±0.02	1.09± 0.40
D7	0-5	0.65±0.03	0.39±0.04	1.31± 0.87
D11	0-5	[d]	[d]	[d]
D12	0-5	[d]	[d]	<1.08
D13	0-5	0.80±0.02	0.46±0.03	1.49± 0.52
D14	0-5	0.38±0.03	0.46±0.05	<1.65
D15	0-5	0.48±0.02	0.41±0.03	0.75± 0.39
D20	0-5	0.60±0.03	0.49±0.05	0.81± 0.97

[a]Indicated counting error is at the 95% confidence level ($\pm 2\sigma$).
[b]Locations of dust and debris samples are shown on Figs. 24, 30, and 31.
[c]Systematic samples are taken at locations irrespective of gamma exposure rates.
[d]Sample could not be analyzed for this radionuclide.

Table 5. Alpha and beta-gamma activity levels measured on the roof and indoors at 2551-2555 Harleau Place, Toledo, Ohio (BTO001)

	Directly measured contamination		Removable contamination[a]	
Smear Sample[b]	Alpha[c] (dpm/100 cm^2)	Beta-gamma[d] (mrad/h)	Alpha[e] (dpm/100 cm^2)	Beta-gamma[f] (dpm/100 cm^2)
	Second floor indoors			
1	0	0.02	0	0
2	18	0.01	0	0
3	27	0.03	3	0
4	36	0.02	0	0
5	9	0.02	6	0
6	36	0.03	0	16
7	9	0.03	0	0
8	27	0.03	0	0
9	9	0.02	0	32
10	9	0.02	0	0
11	36	0.02	0	0
28	1900	2.25	3	16
29	5400	0.03	6	0
30	[g]	7	15	0
31	0	0.02	0	0
32	0	0.02	0	98
33	0	0.03	3	49
34	0	0.03	3	0
35	0	0.03	3	0
36	0	0.03	0	0
37	0	0.03	0	0
38	0	0.03	0	98
48	[g]	2-5	1600	2900

Table 5 (continued)

Smear Sample[b]	Directly measured contamination		Removable contamination[a]	
	Alpha[c] (dpm/100 cm^2)	Beta-gamma[d] (mrad/h)	Alpha[e] (dpm/100 cm^2)	Beta-gamma[f] (dpm/100 cm^2)
65	45	0.04	0	0
92	18	0.02	0	0
		First floor indoors		
12	0	0.02	0	0
13	36	0.02	0	0
14	9	0.01	0	0
15	0	0.02	0	98
16	27	0.02	0	0
17	36	0.02	0	16
18	18	0.02	9	0
19	18	0.03	0	33
20	36	0.03	0	0
21	0	0.02	0	0
22	27	0.03	0	82
39	18	0.04	3	0
40	9	0.02	0	16
41	36	0.03	0	213
42	9	0.03	0	197
43	18	0.04	0	16
44	18	0.03	0	0
45	0	0.03	0	0
46	27	0.02	3	16
47	0	0.02	0	0
48	0	0.02	0	128
49	0	0.02	0	0
50	0	0.02	0	0

Table 5 (continued)

Smear Sample[b]	Directly measured contamination		Removable contamination[a]	
	Alpha[c] (dpm/100 cm^2)	Beta-gamma[d] (mrad/h)	Alpha[e] (dpm/100 cm^2)	Beta-gamma[f] (dpm/100 cm^2)
51	0	0.02	6	48
52	9	0.03	0	0
53	9	0.02	0	0
54	0	0.02	0	0
55	18	0.02	0	0
56	9	0.02	0	16
57	72	0.02	0	112
58	18	0.02	0	112
59	54	0.04	0	0
60	27	0.02	3	0
61	9	0.03	3	82
62	9	0.02	0	0
63	18	0.03	0	0
64	27	0.03	3	16
81	[g]	0.02	0	112
82	[g]	0.02	0	64
83	[g]	0.03	0	94
84	[g]	0.02	3	0
85	[g]	0.03	0	0
86	[g]	0.03	0	0
87	[g]	0.03	0	0
88	[g]	0.03	0	0
89	[g]	0.02	0	0
90	0	0.02	0	0
91	36	0.02	0	16

Table 5 (continued)

Smear Sample[b]	Directly measured contamination		Removable contamination[a]	
	Alpha[c] (dpm/100 cm^2)	Beta-gamma[d] (mrad/h)	Alpha[e] (dpm/100 cm^2)	Beta-gamma[f] (dpm/100 cm^2)
		Roof data		
35	171	0.04	0	64
36	9	0.03	0	0
37	36	0.03	0	0
38	36	0.03	0	0
39	261	0.05	0	0
40	135	0.03	0	0
41	36	0.02	0	48
42	27	0.02	0	33
43	9	0.02	0	0

[a]Measurements of removable radioactivity are net disintegration rates. Background radiation levels have been subtracted.
[b]Locations of smear samples are shown on Figs. 24, 30, and 31.
[c]Minimum detectable activity (MDA) level = 25 dpm/100 cm^2.
[d]MDA = 0.01 mrad/h.
[e]MDA = 10 dpm/100 cm^2.
[f]MDA = 200 dpm/100 cm^2.
[g]Measurement not taken.

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