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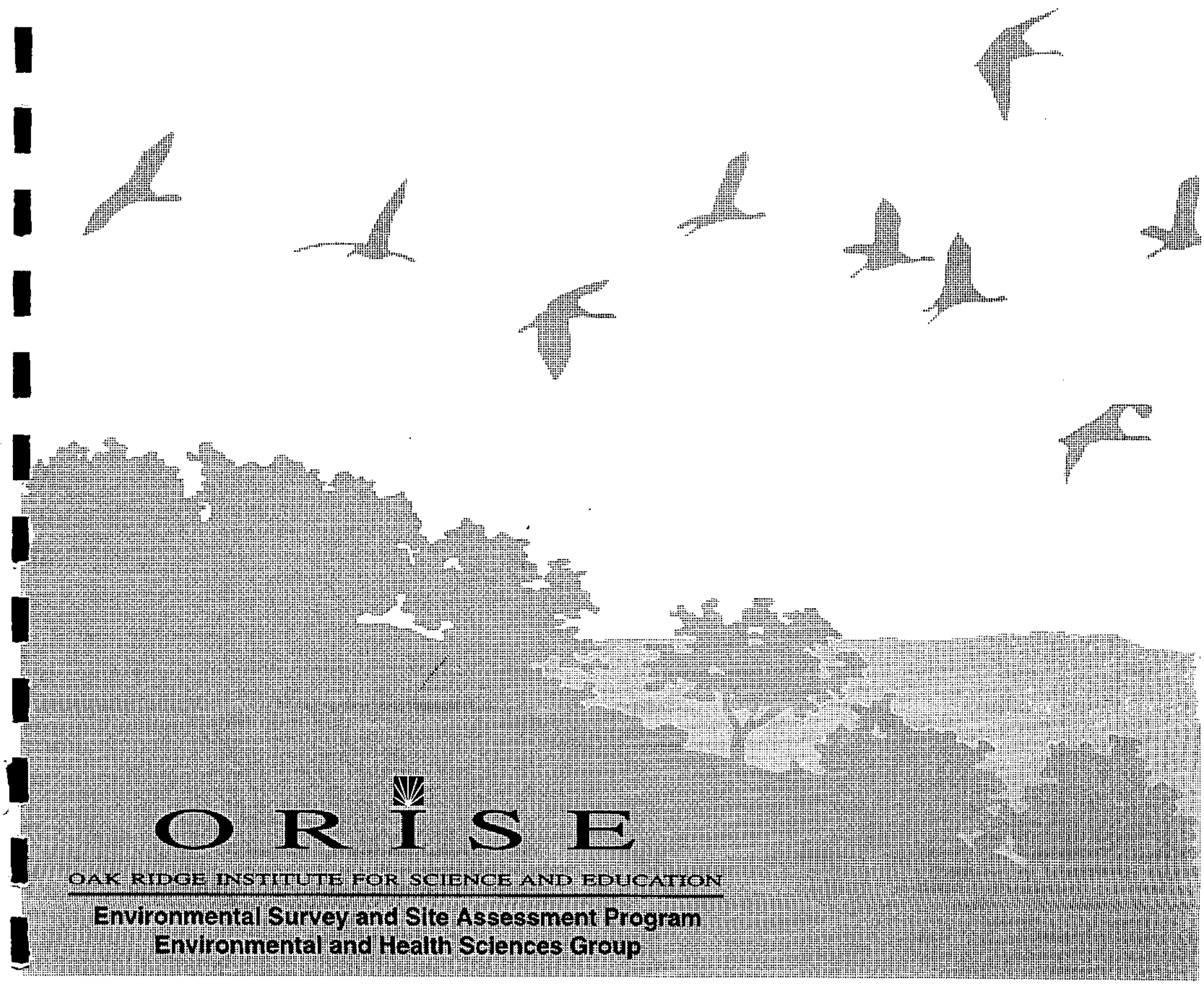
RADIOLOGICAL SURVEY OF THE GUN FORGING MACHINE BUILDING ITHACA GUN COMPANY ITHACA, NEW YORK

T. J. VITKUS AND J. L. PAYNE

Prepared for the Office of Environmental Restoration
U.S. Department of Energy



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NOTICES

RADIOLOGICAL SURVEY OF THE GUN FORGING MACHINE BUILDING ITHACA GUN COMPANY ITHACA, NEW YORK

Prepared by

T. J. Vitkus and J. L. Payne

Environmental Survey and Site Assessment Program
Environmental and Health Sciences Group
Oak Ridge Institute for Science and Education
Oak Ridge, Tennessee 37831-0117

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FINAL REPORT

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RADIOLOGICAL SURVEY
OF THE
GUN FORGING MACHINE BUILDING
ITHACA GUN COMPANY
ITHACA, NEW YORK

Prepared by: Timothy J. Vitkus Date: 10/24/95
T. J. Vitkus, Project Leader
Environmental Survey and Site Assessment Program

Prepared by: James L. Payne Date: 11/1/95
J. L. Payne, Senior Health Physics Technician
Environmental Survey and Site Assessment Program

Reviewed by: Mark Laudeman Date: 11/1/95
M. J. Laudeman, Radiochemistry Laboratory Supervisor
Environmental Survey and Site Assessment Program

Reviewed by: Ann T Payne Date: 11/1/95
A. T. Payne, Administrative Services Manager
Quality Assurance/Health & Safety Manager
Environmental Survey and Site Assessment Program

Reviewed by: W L Beck Date: 11/3/95
W. L. Beck, Program Director
Environmental Survey and Site Assessment Program

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The authors would like to acknowledge the significant contributions of the following staff members:

FIELD STAFF

A. L. Mashburn

LABORATORY STAFF

R. D. Condra
J. S. Cox
M. J. Laudeman
S. T. Shipley

CLERICAL STAFF

T. S. Fox
K. E. Waters

ILLUSTRATIONS

T. D. Herrera

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ABBREVIATIONS AND ACRONYMS

μR/h	microroentgens per hour
AEC	Atomic Energy Commission
ASME	American Society of Mechanical Engineers
BKG	background
cm^2	square centimeter
DOE	U. S. Department of Energy
dpm/100 cm^2	disintegrations per minute per 100 square centimeters
EPA	Environmental Protection Agency
EML	Environmental Measurements Laboratory
ESSAP	Environmental Survey and Site Assessment Program
FUSRAP	Formerly Utilized Sites Remedial Action Program
GM	Geiger-Mueller
IGC	Ithaca Gun Company
kg	kilogram
MDA	minimum detectable activity
mm	millimeter
m^2	square meter
NaI	sodium iodide
NIST	National Institute of Standards and Technology
NLO	National Lead of Ohio
ORISE	Oak Ridge Institute for Science and Education
pCi/g	picocuries per gram

RADIOLOGICAL SURVEY
OF THE
GUN FORGING MACHINE BUILDING
ITHACA GUN COMPANY
ITHACA, NEW YORK

INTRODUCTION AND SITE HISTORY

In 1961 and 1962, the Ithaca Gun Company (IGC) was subcontracted by National Lead of Ohio (NLO) to conduct tests involving the forging of hollow uranium billets into tubes for the Atomic Energy Commission (AEC), predecessor agency of the U. S. Department of Energy (DOE). A series of tests were performed in 1961 to determine the abilities of the Gun Forging Machine's vertical forging unit, used by IGC in the manufacturing of shotgun barrels, to forge hollow uranium billets into tubes for possible use as fuel cores. Additional tests to investigate alternative methods of producing fuel cores were conducted at IGC in 1962. The forging process involved heating the uranium billet to extreme temperatures, followed by mechanical hammering and rapid cooling in quench drums. The process created residual contamination in the form of metal filings and dust. Because of the potential for contamination of equipment and surrounding surfaces, all testing was conducted in an enclosed, secluded building of the plant.

According to information obtained from NLO justification and trip reports, approximately 164 uranium feed stock tubes were used during the period of testing (Workhum 1961; Jansen and Nuckels 1962). NLO controlled most aspects of the work including handling, transporting, and accountability of the uranium and process waste, health and safety, and post-test decontamination efforts. IGC supplied all of the equipment, equipment operators, and special tooling required for the forging process. The site records indicate that NLO exercised considerable effort to minimize contamination during the testing process. Records also indicate that monitoring of equipment, exhaust from dust collectors, and outdoor paved areas was performed routinely and decontamination performed immediately if uranium contamination was detected.

Upon completion of the project in 1962, all uranium shapes, uranium-bearing dust, and contaminated liquid and sludge were returned to NLO. The entire area, including the exterior pavement and grounds adjacent to the testing area, were monitored and only background levels remained after cleanup. However, records do not specify cleanup criteria or guidelines. Due to this uncertainty, further radiological evaluation was needed to determine whether residual uranium contamination was present in excess of DOE guidelines.

DOE reviewed available historical documentation describing the previous AEC activities conducted at the Ithaca Gun Company site and based on the results, requested that the Environmental Survey and Site Assessment Program (ESSAP) of the Oak Ridge Institute for Science and Education (ORISE) perform a radiological survey of the area used for the uranium forging tests. The purpose of the survey was to determine if residual uranium contamination was present on the property for which DOE has authority to require remedial action under the Formerly Utilized Sites Remedial Action Program (FUSRAP). FUSRAP was created in 1974 to identify, investigate, and cleanup or control sites where contamination above today's guidelines remains from the early years of the Nation's atomic energy program.

SITE DESCRIPTION

The former Ithaca Gun Company facility is located at 123 Lake Street in Ithaca, New York, approximately 1.6 kilometers (1 mile) east of state highway 13 (Figure 1). The facility had ceased operations in the late 1980's and is currently unoccupied. A cyclone fence encloses the site. The present owner of the property is State Street Associates L.P.

The building that formerly housed the forging machine used for the uranium tests is located at the north end of the site (Figure 2). The building is constructed with concrete block walls, a sloped wooden roof, and a concrete slab floor. The building dimensions are approximately 18 meters by 11 meters (Figure 3). Exterior areas of the building include concrete drives bordering the north, east, and west, and another building is attached on the southern end of the Gun Forging Machine Building. Drainage from this area of the site flows north and northwest to where the land drops off sharply to a ravine that contains a creek at the base.

OBJECTIVE

The objective of this survey was to obtain sufficient data on the current radiological status, relative to the guidelines, of the Gun Forging Machine Building at the IGC site. The DOE may then use the acquired data to make a determination as to the need for further actions under FUSRAP.

DOCUMENT REVIEW

ESSAP reviewed available historical documentation, relative to radioactive material use at the site. Documentation consisted primarily of NLO trip reports and project justification reports. The information found in the documents was used in the development of the survey plan that was implemented at the site.

PROCEDURES

A survey team from ESSAP visited the IGC site and performed visual inspections and independent measurements and sampling on July 26 and 27, 1995. Survey activities were conducted in accordance with a survey plan submitted to and approved by the DOE (Vitkus 1995). Survey activities included surface scans, direct measurements, smear sampling, exposure rate measurements, and soil and residue sampling. Additional information relative to survey and analytical equipment and procedures may be found in Appendices A and B. A representative from the New York State Department of Environmental Conservation accompanied ESSAP personnel during the course of this survey and provided their findings in a separate correspondence (Merges 1995).

REFERENCE SYSTEM

Measurement and sampling locations were referenced to prominent building or site features.

SURFACE SCANS

Surface scans for gamma and beta activity were performed on 100 percent of the floor, lower walls (up to 2 m), and adjacent exterior surfaces. In addition, approximately 20 percent of overhead surfaces that included I-beams, pipes, ledges, a crane track, and exhaust fans were also scanned, with more concentrated scans in the area above the suspected previous location of the forging machine. Surface scans were performed using NaI scintillation, gas proportional, and/or GM detectors coupled to ratemeters or ratemeter-scalers with audible indicators.

SURFACE ACTIVITY MEASUREMENTS

Processed natural uranium emits both alpha and beta radiation in approximately equal proportions. Because alpha radiation is selectively attenuated by rough, damp, or dirty surfaces, beta radiation measurements provide a more representative indication of residual uranium surface activity levels. Direct measurements for total beta activity were performed at 30 locations on the floor and lower walls. Direct measurements were also performed on equipment surfaces and upper surfaces at 30 locations, and at a total of 10 locations on exterior building and paved surfaces. Smear samples for determining removable gross alpha and gross beta contamination were collected at each direct measurement location. Figures 4 through 6 show measurement and sampling locations.

EXPOSURE RATE MEASUREMENTS

Background interior exposure rate measurements were performed at five locations in the main plant building in an area of similar construction (although no other areas were located that were constructed with the firebrick found in the Gun Forging Machine Building), but without a history of radioactive materials use (Figure 7). Exposure rates were measured at three locations within the Gun Forging Machine Building (Figure 8). Exposure rates were measured at 1 meter above the surface using a pressurized ionization chamber.

SOIL SAMPLING

Probable drainage pathways from the exterior paved surfaces were traced to the point that soil, sediment, or other type of potential contaminant sink was encountered. Surface (0-15 centimeter) soil samples were then collected from three locations (Figure 9). Sample locations included an area on the side of the ravine beneath a drain pipe that appeared to lead from the Gun Forging Machine Building (location # 1), a water settling area at the bottom of the ravine (location # 2), and at a location on top of the ravine where water was channeled from the paved area through a retaining wall and into the ravine (location #3). Exposure rate measurements could not be performed at these locations due to the steep terrain, although direct gamma measurements were made at each sampling location using a NaI scintillation detector coupled to a ratemeter. One composite sample of material (soil, residue, etc.) was collected from a french drain at the interior base of the north wall (Figure 10).

SAMPLE ANALYSIS AND DATA INTERPRETATION

Samples and survey data were returned to ORISE's ESSAP laboratory in Oak Ridge, Tennessee for analysis and interpretation. Soil and trench residue samples were analyzed by solid state gamma spectrometry. Spectra were reviewed for U-235 and U-238 and any other identifiable photopeaks and results reported in picocuries per gram (pCi/g). Smears were analyzed for gross alpha and gross beta activity using a low background proportional counter. Smear data and direct measurement data were converted to units of disintegrations per minute per 100 square centimeters (dpm/100 cm^2). Exposure rates were reported in microroentgens per hour (μR/h). Additional information concerning major instrumentation, sampling equipment , and analytical procedures is provided in Appendices A and B. Results were compared to the DOE guidelines which are provided in Appendix C.

FINDINGS AND RESULTS

SURFACE SCANS

Surface scans for gamma and beta radiation did not identify any locations of elevated direct radiation indicative of residual contamination on surfaces within the Gun Forging Machine Building or on exterior portions of the facility.

SURFACE ACTIVITY LEVELS

The results of total and removable activity levels are summarized in Table 1. Total beta activity ranged from less than 160 to 620 dpm/100 cm^2 on interior building surfaces and were less than 830 dpm/100 cm^2 on the exterior building and paved surfaces. Removable activity levels were all less than the minimum detectable activity levels of the procedure which were 12 dpm/100 cm^2 for gross alpha and 16 dpm/100 cm^2 for gross beta.

EXPOSURE RATES

Interior exposure rates are presented in Table 2. Background exposure rates ranged from 10 to 12 μR/h, and averaged 11 μR/h. Exposure rates measured in the Gun Forging Machine Building ranged from 12 to 14 μR/h. The slight above background increase in exposure rates observed in the Gun Forging Machine Building was the result of the presence of fire brick, which contains naturally occurring elevated levels of gamma emitting radionuclides.

RADIONUCLIDE CONCENTRATIONS IN SOIL SAMPLES

Radionuclide concentrations in the interior composite trench sample and the three exterior surface soil samples are summarized in Table 3. The concentrations of U-235 and U-238, in the trench sample were less than 0.1 pCi/g and less than 1.6 pCi/g, respectively. The concentration of U-235, for the three exterior samples were all less than 0.1 pCi/g, and the concentration of U-238 ranged from less than 1.7 to 2.5 pCi/g. All results are typical of natural background concentrations of uranium.

COMPARISON OF RESULTS WITH GUIDELINES

DOE guidelines for release of facilities for unrestricted use are included as Appendix C. The radionuclide of concern at this site is processed (separated) uranium in its natural isotopic abundances. The DOE surface contamination guideline values for uranium are (DOE 1990):

Total Activity

5,000 α dpm/100 cm^2, averaged over a 1 m^2 area

15,000 α dpm/100 cm^2, maximum in a 100 cm^2 area

Removable Activity

1,000 α dpm/100 cm^2

Processed natural uranium in equilibrium with its short half-life progeny, Th-234, and Pa-234m , emits both alpha and beta radiations at an approximate ratio of 1 : 1. The uranium surface activity guidelines specify alpha activity; however, due to the alpha radiation attenuation, the beta activity measurements provide a more accurate estimation of residual uranium contamination and are used for guideline comparison. All interior and exterior total surface activity levels were less than the 5,000 dpm/100 cm^2 average guideline value for residual contamination. The highest beta activity was 830 dpm/100 cm^2. Removable activity levels were also less than the guideline.

Exposure rate measurements at 1 meter above the surface were well within the guideline value of 20 μR/h above background.

Guidelines for residual uranium concentrations in soil are developed on a site-specific basis only for those sites where above background uranium contamination is present. Uranium concentrations in the composite interior trench sample and the three exterior surface soil samples collected from the site are all typical of background levels of uranium from this region of the country.

SUMMARY

On July 26 and 27, 1995, ESSAP performed a radiological survey of the Gun Forging Machine Building at the former Ithaca Gun Company facility in Ithaca, New York. The survey activities included surface scans, measurements for total and removable surface activity, exposure rate measurements, and interior and exterior soil/residue sampling. No residual surface activity, approaching DOE guidelines, was detected on interior or exterior surfaces. Exposure rates were all within the guideline value, and uranium concentrations in soil/residue samples were all typical of uranium background levels.

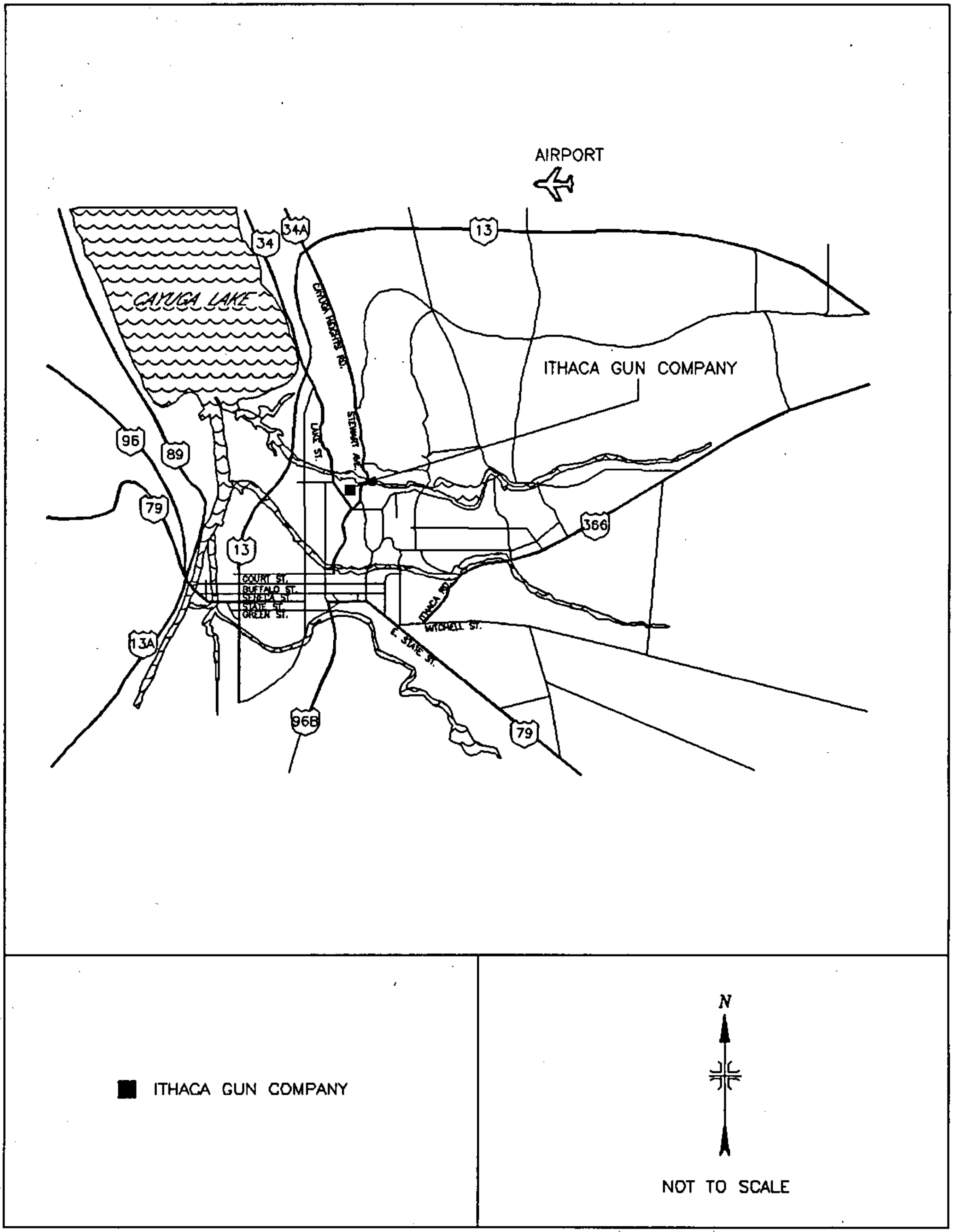

FIGURE 1: Location of the Ithaca Gun Company, Ithaca, New York

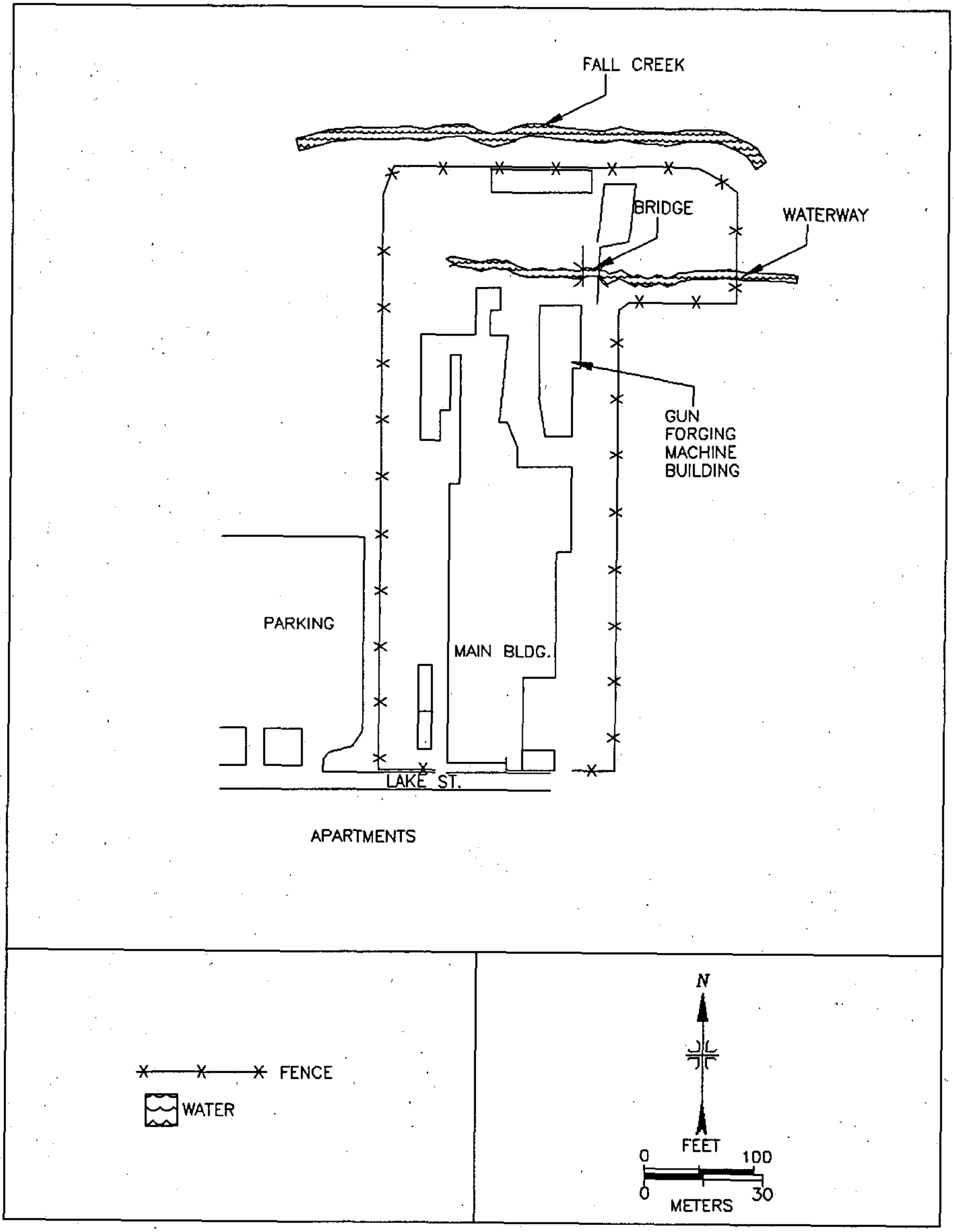

FIGURE 2: Ithaca Gun Company Site, Plot Plan — Location of the Gun Forging Machine Building

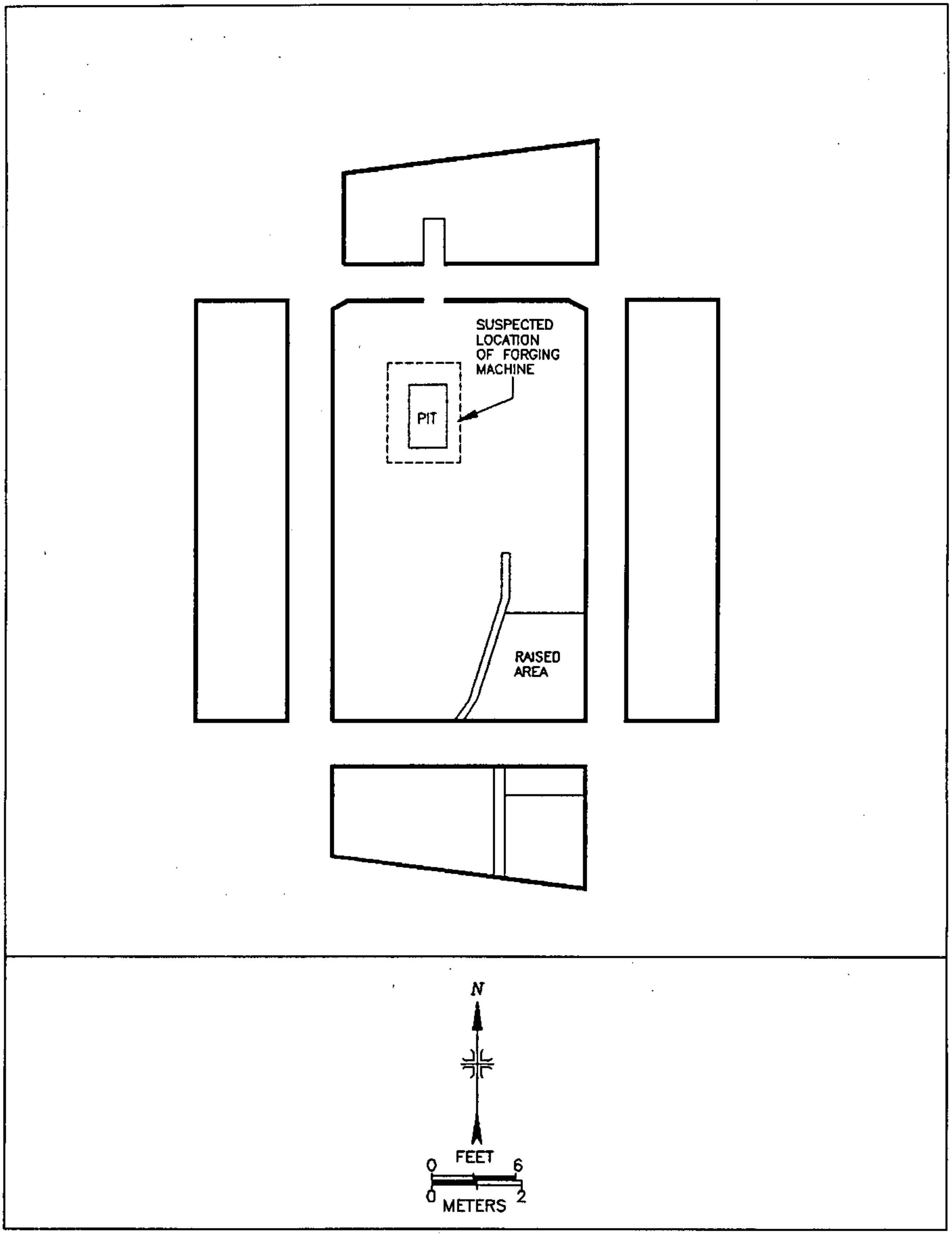

FIGURE 3: Gun Forging Machine Building – Floor Plan

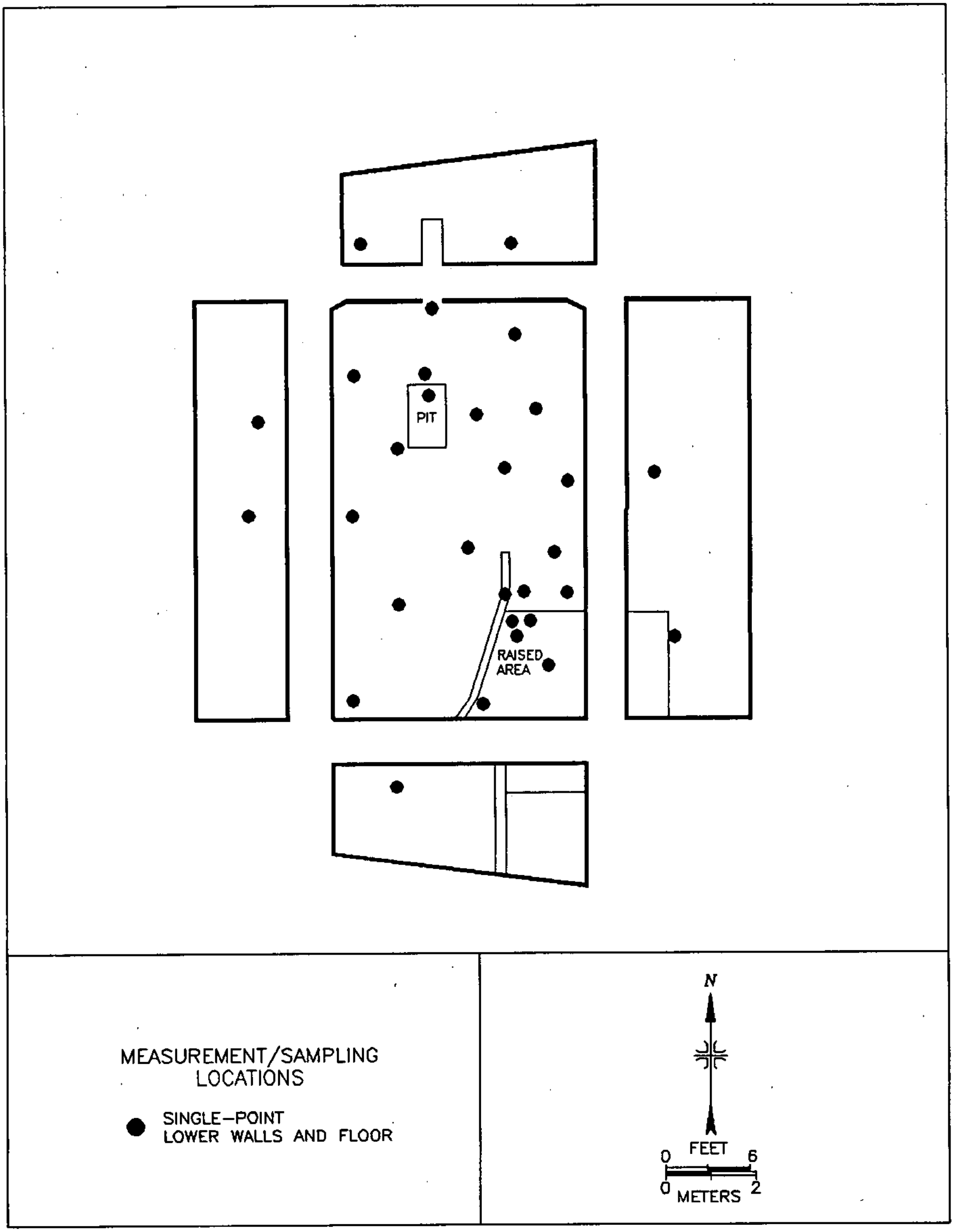

FIGURE 4: Gun Forging Machine Building — Floor and Lower Wall Measurement and Sampling Locations

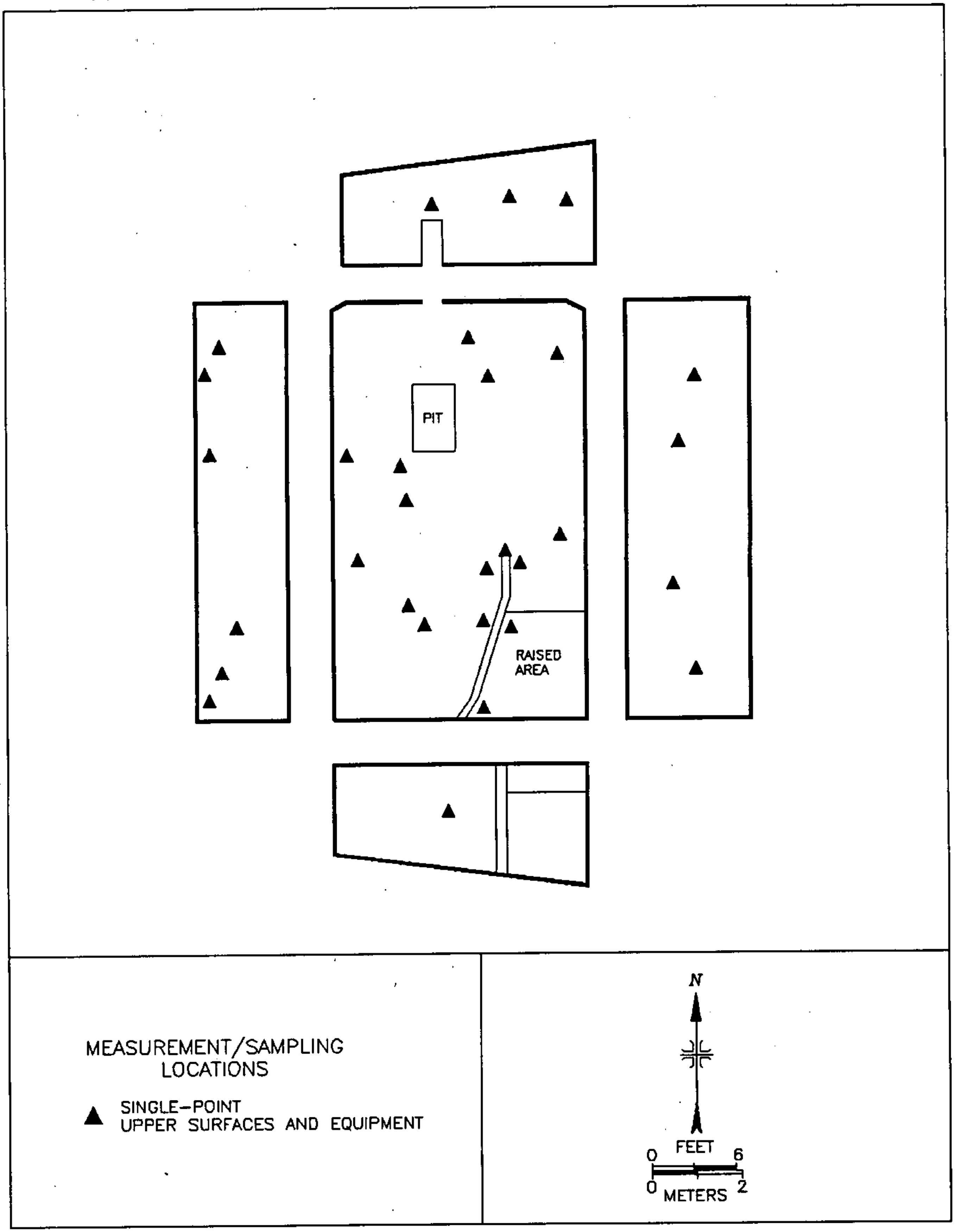

FIGURE 5: Gun Forging Machine Building – Upper Surfaces and Equipment Measurement and Sampling Locations

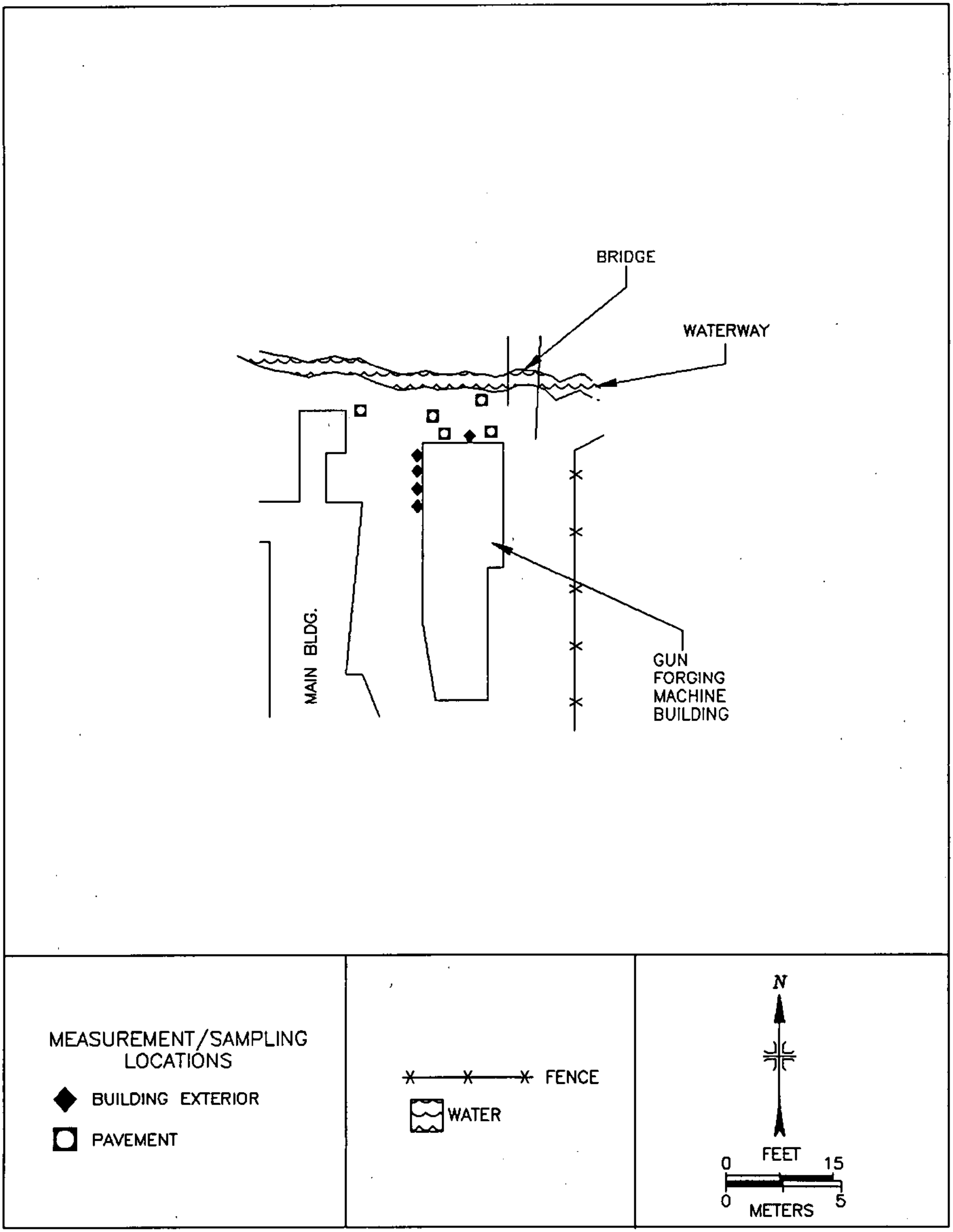

FIGURE 6: Gun Forging Machine Building — Exterior Measurement Locations

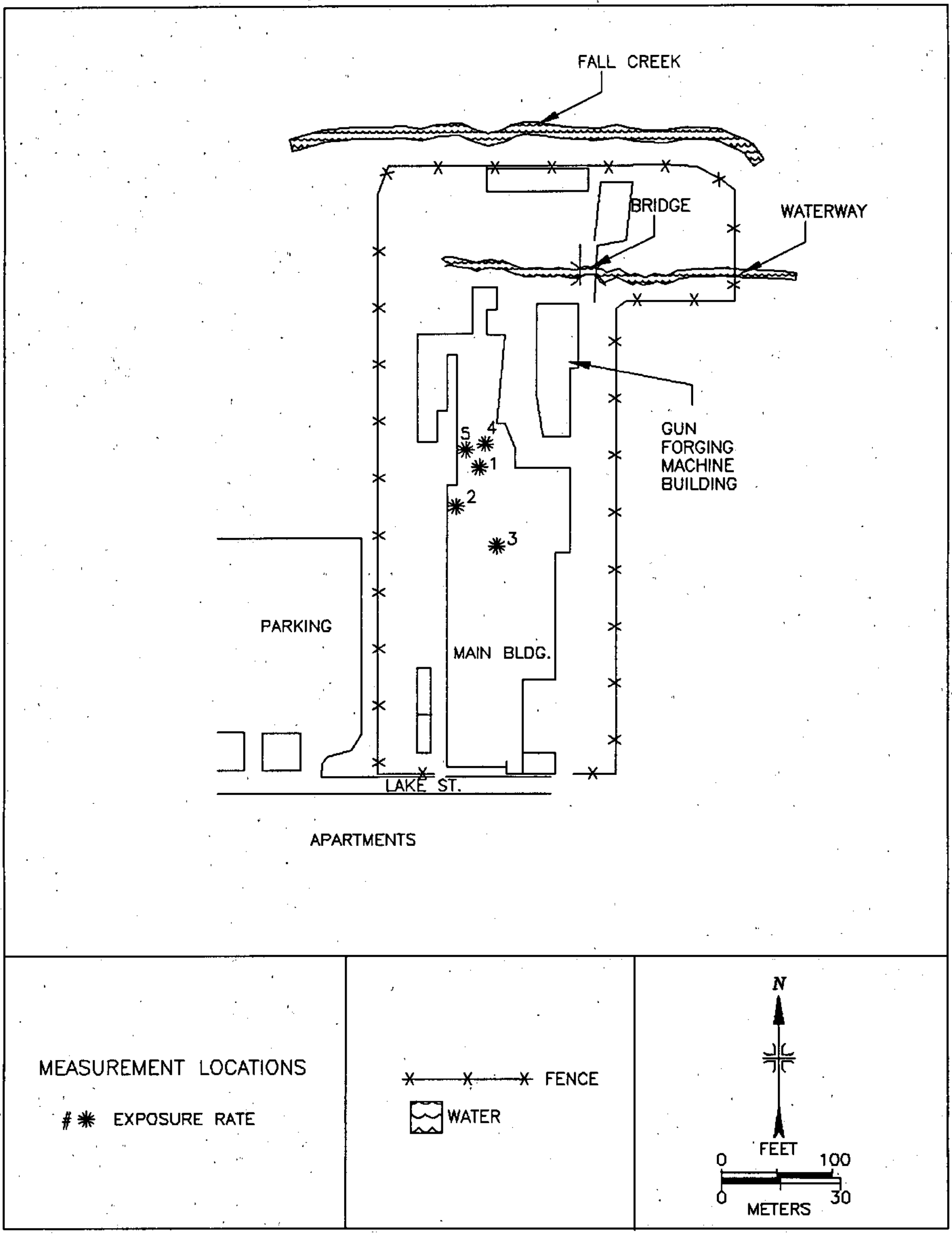

FIGURE 7: Ithaca Gun Company Site — Background Exposure Rate Measurement Locations

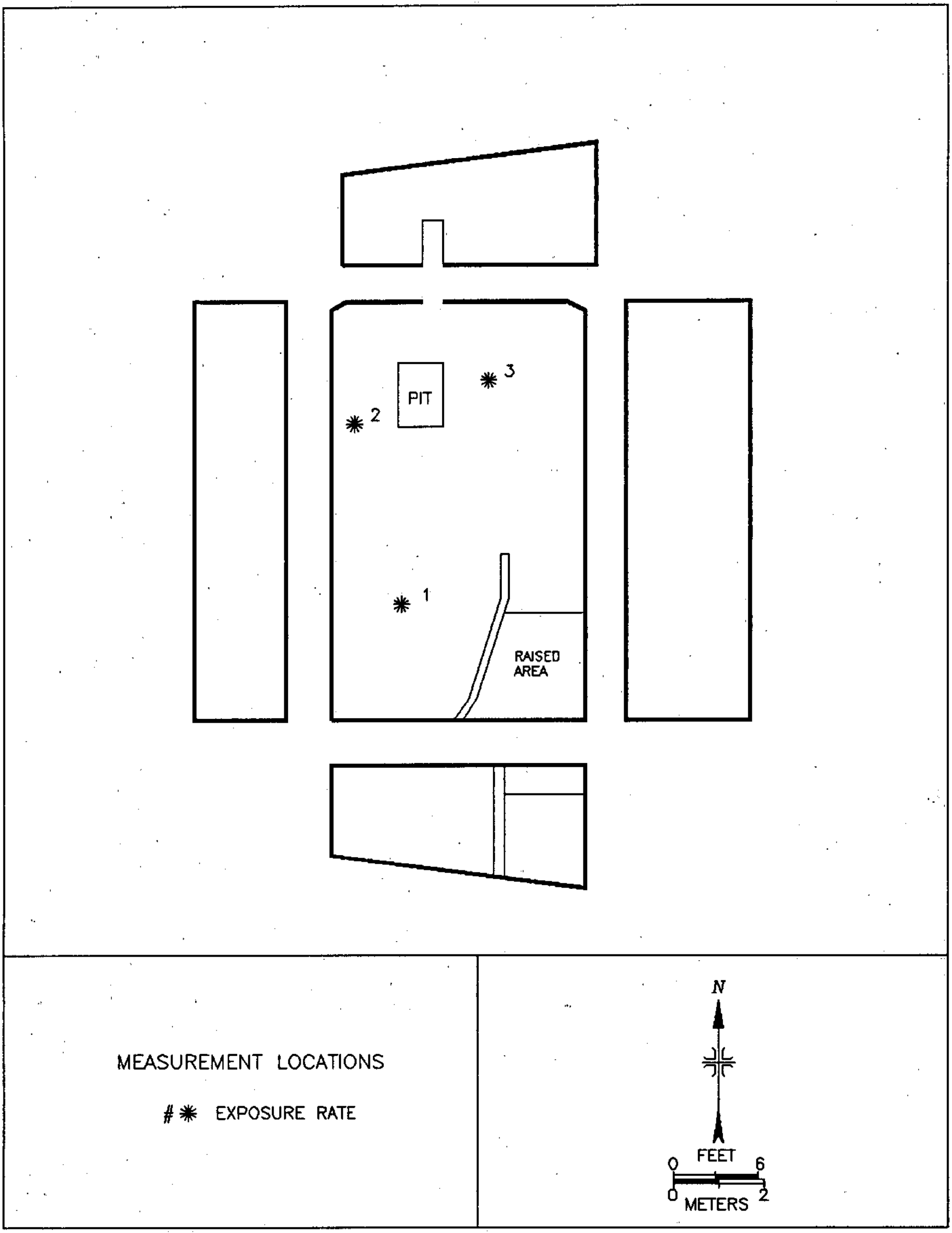

FIGURE 8: Gun Forging Machine Building – Exposure Rate Measurement Locations

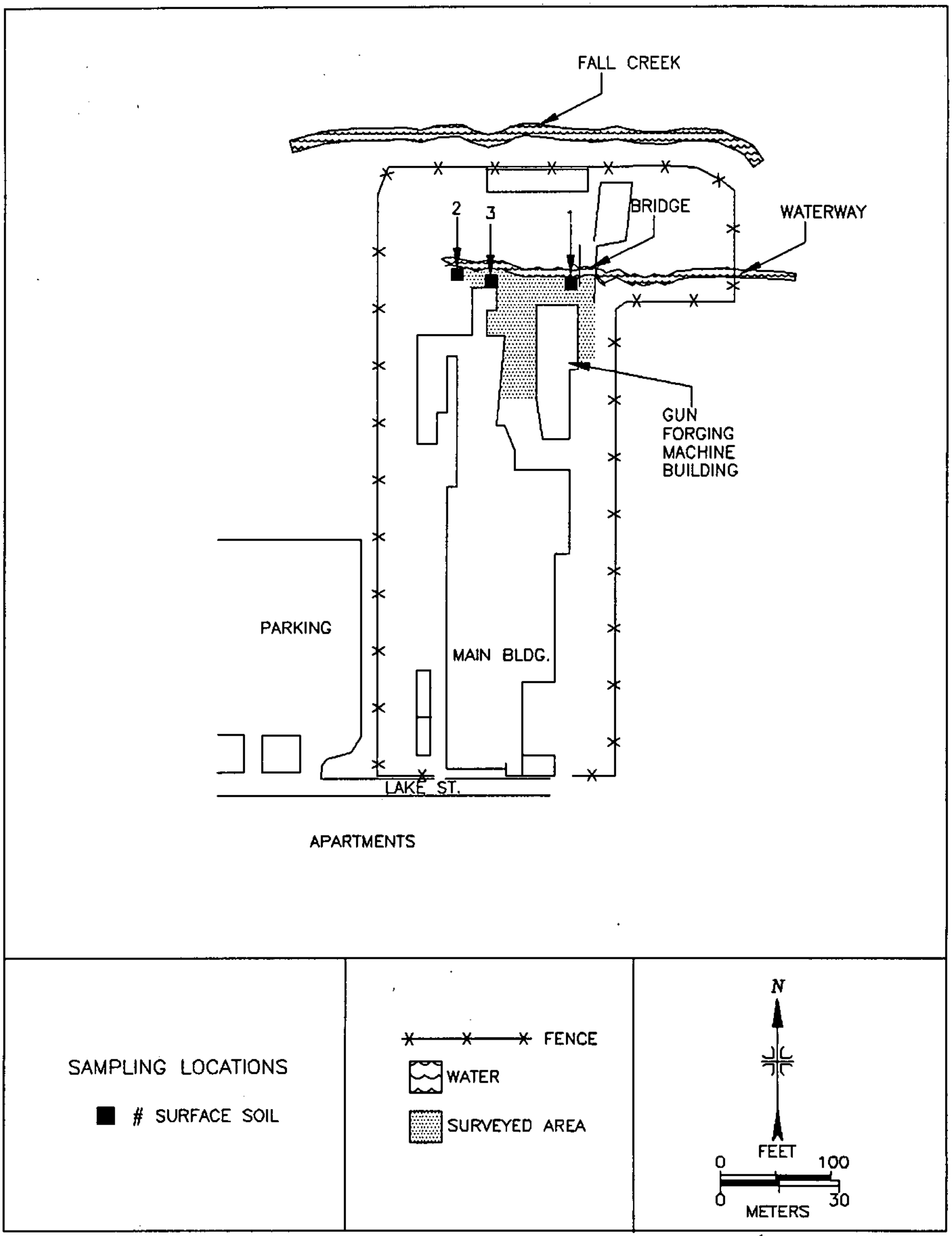

FIGURE 9: Ithaca Gun Company Site – Soil Sampling Locations

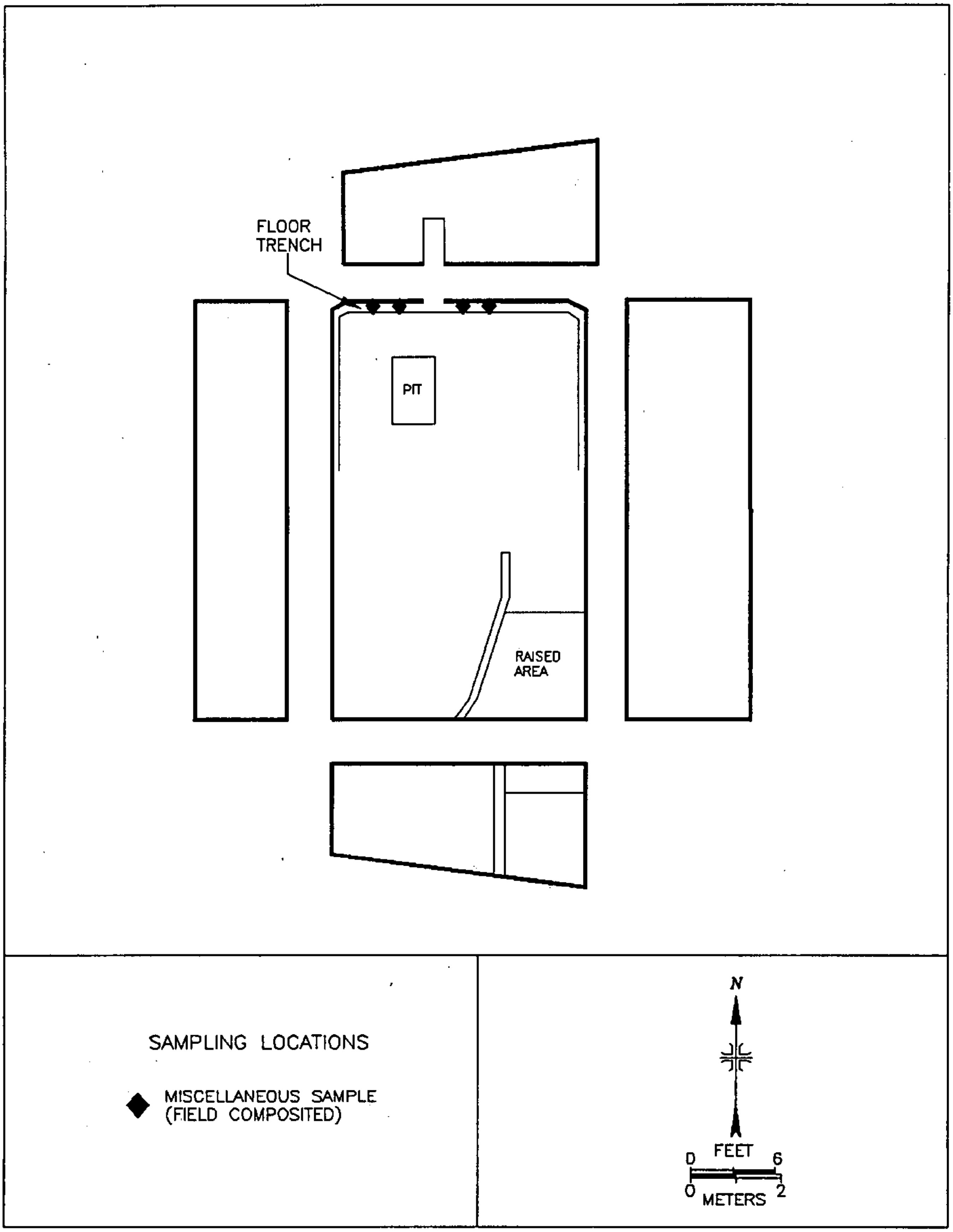

FIGURE 10: Gun Forging Machine Building — Miscellaneous Composite Sample Locations

TABLE 1

SUMMARY OF SURFACE ACTIVITY MEASUREMENTS
GUN FORGING MACHINE BUILDING
ITHACA GUN COMPANY
ITHACA, NEW YORK

Location	Number of Direct Measurements	Direct Measurement Total Activity dpm/100 cm²	Removable Activity dpm/100 cm²	
		Beta	Alpha	Beta
Interior				
Floor[a]	21	<210 to 430	<12	<16
Lowerwall[a]	9	<210 to 530	<12	<16
Upperwall[b]	15	<210 to 620	<12	<16
Equipment[b]	15	<160 to 380	<12	<16
Exterior[c]				
Building	6	<830	<12	<16
Pavement	4	<830	<12	<16

[a]Refer to Figure 4
[b]Refer to Figure 5
[c]Refer to Figure 6

TABLE 2

EXPOSURE RATE MEASUREMENTS
GUN FORGING MACHINE BUILDING
ITHACA GUN COMPANY
ITHACA, NEW YORK

Location	Exposure Rate at 1 meter (μR/h)
Background[a]	
1	11
2	11
3	10
4	11
5	12
Gun Forging Machine Building[b]	
1	14
2	12
3	14

[a]Refer to Figure 7
[b]Refer to Figure 8

TABLE 3

RADIONUCLIDE CONCENTRATIONS
IN SOIL SAMPLES
GUN FORGING MACHINE BUILDING
ITHACA GUN COMPANY
ITHACA, NEW YORK

Location	Radionuclide Concentrations (pCi/g)	
	U-235	U-238
Exterior[a] - Location 1	<0.1	<1.7
Exterior - Location 2	<0.1	2.5 ± 1.5[c]
Exterior - Location 3	<0.1	0.9 ± 1.1
Interior[b] - Trench Composite	<0.1	<1.6

[a]Refer to Figure 9
[b]Refer to Figure 10
[c]Uncertainties represent the 95% confidence level, based only on counting statistics.

REFERENCES

DOE, 1990. DOE Order 5400.5, *Radiation Protection of the Public and Environment*. June 5, 1990.

Jansen, R.J. and Nuckels, J.G., 1962. Trip Report to the Ithaca Gun Company, Ithaca, New York, on May 21 through June 8, 1962. Memorandum to S. Marshall, National Lead of Ohio. July 26, 1962.

Merges, P.J. (NYDEC) 1995. Letter to M. Finklestein (State Street Associates L.P. II). September 8, 1995.

Vitkus, T. J., (ORISE) 1995. Letter to W. Alexander Williams (DOE/HQ). July 24, 1995.

Workhum, A.D., 1961. Trip Report to the Ithaca Gun Company, Ithaca, New York, June 19-30 and July 4-7, 1961. Memorandum to J.A. Quigley, MD, National Lead of Ohio. July 28, 1961.

APPENDIX A

MAJOR INSTRUMENTATION

APPENDIX A

MAJOR INSTRUMENTATION

The display of a specific product is not to be construed as an endorsement of the product or its manufacturer by the authors or their employers.

DIRECT RADIATION MEASUREMENT

Instruments

Eberline Pulse Ratemeter
Model PRM-6
(Eberline, Santa Fe, NM)

Ludlum Floor Monitor
Model 239-1
(Ludlum Measurements, Inc.,
Sweetwater, TX)

Ludlum Ratemeter-Scaler
Model 2221
(Ludlum Measurements, Inc.,
Sweetwater, TX)

Detectors

Eberline GM Detector
Model HP-260
Effective Area, 20 cm^2
(Eberline, Santa Fe, NM)

Ludlum Gas Proportional Detector
Model 43-37
Effective Area, 550 cm^2
(Ludlum Measurements, Inc.,
Sweetwater, TX)

Ludlum Gas Proportional Detector
Model 43-68
Effective Area, 126 cm^2
(Ludlum Measurements, Inc.,
Sweetwater, TX)

Reuter-Stokes Pressurized Ion Chamber
Model RSS-111
(Reuter-Stokes, Cleveland, OH)

Victoreen NaI Scintillation Detector
Model 489-55
3.2 cm x 3.8 cm Crystal
(Victoreen, Cleveland, OH)

LABORATORY ANALYTICAL INSTRUMENTATION

High Purity Extended Range Intrinsic Detectors
Model No: ERVDS30-25195
(Tennelec, Oak Ridge, TN)
Used in conjunction with:
Lead Shield Model G-11
(Nuclear Lead, Oak Ridge, TN) and
Multichannel Analyzer
3100 Vax Workstation
(Canberra, Meriden, CT)

Low Background Gas Proportional Counter
Model LB-5100-W
(Oxford, Oak Ridge, TN)

APPENDIX B

SURVEY AND ANALYTICAL PROCEDURES

APPENDIX B

SURVEY AND ANALYTICAL PROCEDURES

SURVEY PROCEDURES

Surface Scans

Surface scans were performed by passing the probes slowly over the surface; the distance between the probe and the surface was maintained at a minimum - nominally about 1 cm. A large surface area, gas proportional floor monitor was used to scan the floors of the surveyed areas. Other surfaces were scanned using small area (20 cm^2, 126 cm^2) hand-held detectors. Identification of elevated levels was based on increases in the audible signal from the recording and/or indicating instrument. Combinations of detectors and instruments used for the scans were:

Alpha-Beta	-	gas proportional detector with ratemeter-scaler
Beta	-	gas proportional detector with ratemeter-scaler
	-	pancake GM detector with ratemeter-scaler
Gamma	-	NaI scintillation detector with ratemeter

Surface Activity Measurements

Measurements of total beta activity levels were primarily performed using gas proportional detectors with portable ratemeter-scalers. Beta activity measurements were performed on upper room surfaces, some equipment, and exterior surfaces, using gas proportional and/or GM detectors with ratemeter-scalers.

Count rates (cpm), which were integrated over 1 minute in a static position, were converted to activity levels (dpm/100 cm^2) by dividing the net rate by the 4 π efficiency and correcting for the active area of the detector. Because different building materials (poured concrete, concrete block, steel, etc.) can have very different background levels, average background counts were determined for each material encountered in the surveyed area at a location of similar construction and having no known radiological history. The beta activity background count rates for the proportional detectors and the GM detectors averaged 249 cpm and 64 cpm for wood, and 413 cpm and 70 cpm for poured concrete, respectively. Beta background count rates for the proportional detector on concrete block and steel, averaged 384 cpm and 234 cpm, respectively. Net count rates were determined by subtracting the appropriate material background from the gross count rate for each measurement location. Beta efficiency factors were 0.36 for the gas proportional detector and 0.25 for the GM detector calibrated to T1-204. The beta minimum detectable activities (MDA) for the gas proportional and the GM detectors varied by material and ranged from 171 dpm/100cm^2 to 225 dpm/100cm^2 and 800 dpm/100cm^2 to 834 dpm/100cm^2, respectively. The effective window for the gas proportional and the GM detector were 126 cm^2 and 20 cm^2, respectively.

Removable Activity Measurements

Removable activity levels were determined using numbered filter paper disks, 47 mm in diameter. Moderate pressure was applied to the smear and approximately 100 cm^2 of the surface was wiped. Smears were placed in labeled envelopes with the location and other pertinent information recorded.

Exposure Rate Measurements

Measurements of gamma exposure rates were performed using a pressurized ionization chamber (PIC). The instrument is adjusted to one meter (3.3 ft) above the surface and allowed to stabilize. The measurement is read directly in μR/h.

Soil Sampling

Approximately 1 kg of soil was collected at each sample location. Collected samples were placed in a plastic bag, sealed, and labeled in accordance with ESSAP survey procedures.

ANALYTICAL PROCEDURES

Gross Alpha/Beta

Smears were counted on a low background gas proportional system for gross alpha, and gross beta activity.

Gamma Spectrometry

Samples of solid materials (soil, residues) were dried, mixed, crushed, and/or homogenized as necessary, and a portion sealed in 0.5-liter Marinelli beaker or other appropriate container. The quantity placed in the beaker was chosen to reproduce the calibrated counting geometry. Net material weights were determined and the samples counted using intrinsic germanium detectors coupled to a pulse height analyzer system. Background and Compton stripping, peak search, peak identification, and concentration calculations were performed using the computer capabilities inherent in the analyzer system.

All photopeaks associated with the radionuclides of concern were reviewed for consistency of activity. Energy peaks used for determining the activities of radionuclides of concerns were:

U-235	0.143 or 0.186 MeV
U-238	0.063 MeV and/or 0.093 MeV from Th-234*

*Secular equilibrium assumed.

Spectra were also reviewed for other identifiable photopeaks.

UNCERTAINTIES AND DETECTION LIMITS

The uncertainties associated with the analytical data presented in the tables of this report represent the 95% confidence level for that data. These uncertainties were calculated based on both the gross sample count levels and the associated background count levels. Additional uncertainties, associated with sampling and measurement procedures, have not been propagated into the data presented in this report.

Detection limits, referred to as minimum detectable activity (MDA), were based on 2.71 plus 4.65 times the standard deviation of the background count [$2.71 + 4.65\sqrt{BKG}$]. When the activity was determined to be less than the MDA of the measurement procedure, the result was reported as less than MDA. Because of variations in background levels, measurement efficiencies, and contributions from other radionuclides in samples, the detection limits differ from sample to sample and instrument to instrument.

CALIBRATION AND QUALITY ASSURANCE

Calibration of all field and laboratory instrumentation was based on standards/sources, traceable to NIST, when such standard/sources were available. In cases where they were not available, standards of an industry recognized organization were used. Calibration of pressurized ionization chambers was performed by the manufacturer.

Analytical and field survey activities were conducted in accordance with procedures from the following documents of the Environmental Survey and Site Assessment Program:

- Survey Procedures Manual, Revision 9 (April 1995)
- Laboratory Procedures Manual, Revision 9 (January 1995)
- Quality Assurance Manful, Revision 7 (January 1995)

The procedures contained in these manuals were developed to meet the requirements of DOE Order 5700.6C and ASME NQA-1 for Quality Assurance and contain measures to assess processes during their performance.

Quality control procedures include:

- Daily instrument background and check-source measurements to confirm that equipment operation is within acceptable statistical fluctuations.
- Participation in EPA and EML laboratory Quality Assurance Programs.
- Training and certification of all individuals performing procedures.
- Periodic internal and external audits.

APPENDIX C

RESIDUAL RADIOACTIVE MATERIAL GUIDELINES
SUMMARIZED FROM DOE ORDER 5400.5

APPENDIX C

RESIDUAL RADIOACTIVE MATERIAL GUIDELINES SUMMARIZED FROM DOE ORDER 5400.5

BASIC DOSE LIMITS

The basic limit for the annual radiation dose (excluding radon) received by an individual member of the general public is 100 mrem/yr. In implementing this limit, DOE applies as low as reasonable achievable principles to set site-specific guidelines.

STRUCTURE GUIDELINES

Indoor/Outdoor Structure Surface Contamination

Allowable Total Residual Surface Contamination

($dpm/100\ cm^2$)[b]

Radionuclides[a]	Average[c,d]	Maximum[d,e]	Removable[f]
Transuranics, Ra-226, Ra-228, Th-230 Th-228, Pa-231, Ac-227, I-125, I-129 [g]	100	300	20
Th-Natural, Th-232, Sr-90, Ra-223, Ra-224, U-232, I-126, I-131, I-133	1,000	3,000	200
U-Natural, U-235, U-238, and associated decay products	5,000α	15,000α	1,000α
Beta-gamma emitters (radionuclides with decay modes other than alpha emission or spontaneous fission) except Sr-90 and others noted above [h]	5,000β-γ	15,000β-γ	1,000β-γ

External Gamma Radiation

The average level of gamma radiation inside a building or habitable structure on a site that has no radiological restriction on its use shall not exceed the background level by more than 20 μR/h and will comply with the basic dose limits when an appropriate-use scenario is considered.

SOIL GUIDELINES

Radionuclides	Soil Concentration (pCi/g) Above Background[i,j,k]
Uranium	Soil guidelines are calculated on a site-specific basis, using the DOE manual developed for this use.

[a] Where surface contamination by both alpha- and beta-gamma-emitting radionuclides exists, the limits established for alpha- and beta-gamma-emitting radionuclides should apply independently.

[b] As used in this table, dpm (disintegrations per minute) means the rate of emission by radioactive material as determined by correcting the counts per minute measured by an appropriate detector for background, efficiency, and geometric factors associated with the instrumentation.

[c] Measurements of average contamination should not be averaged over an area of more than 1 m^2. For objects of less surface area, the average should be derived for each such object.

[d] The average and maximum dose rates associated with surface contamination resulting from beta-gamma emitters should not exceed 0.2 mrad/h and 1.0 mrad/h, respectively, at a depth of 1 cm.

[e] The maximum contamination level applies to an area of not more than 100 cm^2.

[f] The amount of removable radioactive material per 100 cm^2 of surface area should be determined by wiping an area of that size with dry filter or soft absorbent paper, applying moderate pressure, and measuring the amount of radioactive material on the wipe with an appropriate instrument of known efficiency. When removable contamination on objects of surface area less than 100 cm^2

is determined, the activity per unit area should be based on the actual area and the entire surface should be wiped. It is not necessary to use wiping techniques to measure removable contamination levels, if direct scan surveys indicate that total residual surface contamination levels are within the limits for removable contamination.

g Guidelines for these radionuclides are not given in DOE Order 5400.5; however, these guidelines are considered applicable until guidance is provided.

h This category of radionuclides includes mixed fission products, including the Sr-90 which is present in them. It does not apply to Sr-90, which has been separated from the other fission products, or mixtures where the Sr-90 has been enriched.

I These guidelines take into account ingrowth of radium-226 from thorium-230 or thorium-232 and radium-228 and assume secular equilibrium. If either Th-230 and Ra-226 or Th-232 and Ra-228 are both present, not in secular equilibrium, the guidelines apply to the higher concentration. If other mixtures of radionuclides occur, the concentrations of individual radionuclides shall be reduced so that (1) the dose for the mixtures will not exceed the basic dose limit, or (2) the sum of ratios of the soil concentration of each radionuclide to the allowable limit for that radionuclide will not exceed 1 ("unity").

j These guidelines represent allowable residual concentrations above background averaged across any 15-cm-thick layer to any depth and over any contiguous 100 m^2 surface area.

k If the average concentration in any surface or below-surface area, less than or equal to 25^2m , exceeds the authorized limit of guideline by a factor of $(100/A)^{1/2}$, where A is the area or the elevated region in square meters, limits for "hot spots" shall also be applicable. Procedures for calculating these hot spot limits, which depend on the extent of the elevated local concentrations, are given in the DOE Manual for Implementing Residual Radioactive Materials Guidelines, DOE/CH/8901. In addition, every reasonable effort shall be made to remove any source of radionuclide that exceeds 30 times the appropriate limit for soil, irrespective of the average concentration in the soil.

REFERENCES

"U.S. Department of Energy Guidelines for Residual Radioactive Material at Formerly Utilized Sites Remedial Action Program and Remote Surplus Facilities Management Program Sites," Revision 2, March 1987.

"DOE Order 5400.5, Radiation Protection of the Public and the Environment," February 1990.