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Results of the Indoor Radiological Survey of the Iowa Army Ammunition Plant, Middletown, Iowa

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LIFE SCIENCES DIVISION

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AEC	Atomic Energy Commission
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CPM	counts per minute
DCGL	derived concentration guideline
DOE	Department of Energy
dpm	disintegrations per minute
DQO	data quality objective
DU	depleted uranium
EPA	Environmental Protection Agency
FIDLER	field instrument for detection of low-energy radiation
FS	firing site
GM	Geiger-Mueller
h	hour
IAAAP	Iowa Army Ammunition Plant
L/min	liters/minute
LAP	load, assemble and pack
MARSSIM	*Multi-Agency Radiation Survey and Site Investigation Manual*
MDA	minimum detectable activity
μR/h	microroentgen per hour
NaI	sodium iodide
NaI(Tl)	thallium-activated sodium iodide crystal
ND	not detected
ORNL	Oak Ridge National Laboratory
PIC	pressurized ionization chamber
ROD	Record of Decision
SARA	Superfund Amendments and Reauthorization Act
ZnS	zinc sulfide

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ABSTRACT

At the request of the U.S. Department of Energy (DOE), a team from Oak Ridge National Laboratory conducted an indoor radiological survey of property at the Iowa Army Ammunition Plant (IAAAP), Middletown, Iowa in June 2000. The purpose of the survey was to determine if radioactive residuals resulting from previous Atomic Energy Commission (AEC) activities were present inside selected Line 1 buildings at the IAAAP and conduct sampling in those areas of previous AEC operations that utilized radioactive components at some point during the manufacturing process, in order to evaluate any possible immediate health hazards and to collect sufficient information to determine the next type of survey. The AEC occupied portions of IAAAP from 1947 to 1975 to assemble nuclear weapons. The surveyed areas were identified through interviews with current and former IAAAP employees who had worked at the plant during AEC's tenure, and from AEC records.

The Secretary of Energy committed to perform a radiological survey of Line 1 and Firing Site 12 (FS-12) in response to questions and concerns raised by private citizens in a public forum held in Burlington, Iowa. The questions and concerns related to any immediate threat of public harm resulting from AEC operations at these areas of IAAAP. The Indoor Radiological Survey was performed to partially fulfill the Secretary's commitment made on January 6, 2000. The initial scope of the radiological survey consisted of two phases; the indoor survey of selected buildings at Line 1 and C Yard and, shortly thereafter, the outdoor survey of Line 1 and FS-12. ORNL planned to use information from the indoor survey to show the status indoors as well as to provide insight into transport of contamination to the environment. During the time the survey team spent at IAAAP conducting the indoor survey, the survey team also collected other information to plan the outdoor phase. It was intended that the results of both phases would be combined to provide a comprehensive assessment report on the areas surveyed. However, since this approach was planned, the Formerly Utilized Sites Remedial Action Program (FUSRAP) has, in response to DOE's request, assumed responsibility for former AEC areas at IAAAP. As a result, subsequent surveys will be conducted by FUSRAP.

The indoor survey included a walkover gamma scan, surface alpha/beta scan, fixed-point measurements and exposure rate measurements in designated areas inside selected buildings, and the collection of systematic air samples, in addition to biased debris and smear samples. On-site and subsequent radionuclide analyses were performed on samples. Residual radioactive materials, determined by gamma spectroscopy to be depleted uranium, were found in Buildings 1-11, 1-63-6, 1-12, and 1-61.

Based on historical records and site conditions, the contamination in Building 1-11 is likely results of AEC activities. AEC used the building for shipping and receiving and the location and nature of the contamination found is consistent with AEC activities. Because of the relative newness of the return air filters and radiation protection signs, contamination in building 1-63-6 is most likely due to Army operation at IAAAP. Similarly, the contaminated plastic storage pan found in 1-61 was relatively new, which indicates that the contamination was likely due to Army operations. As both AEC and the Army have conducted operations in Building 1-12, the origin of the contamination found there can not be ascertained with the information currently available.

Results of the Indoor Radiological Survey of the Iowa Army Ammunition Plant, Middletown, Iowa*

INTRODUCTION

Iowa Army Ammunition Plant (IAAAP) is a government facility, owned by the United States Army and operated by a private contractor, American Ordnance Co. It is located in the southeastern part of Iowa, near the town of Middletown, Des Moines County, approximately 10 miles west of the Mississippi River. The IAAAP is a secured facility covering 19,127 acres in a rural setting. Approximately 7,751 acres are leased for agricultural use, 7,500 acres are forested land, and the remaining area is used for administrative and industrial operations.

IAAAP was initially developed in 1941, and it has undergone modernization and expansion since then. Production of supplies for World War II at the facility began in September 1941 and ended in August 1945. Production was resumed in 1949 and has continued to the present. In the 1960s and early 1970s, the IAAAP produced supplies for wars in southeast Asia. During peacetime, activities at the plant continue at a reduced level. Also, from 1946 to 1950, nitrogen fertilizer was produced at Line 8. From about 1947 to 1975, the former Atomic Energy Commission (AEC) operated facilities on the site, which then reverted to Army control in 1975.[1]

IAAAP is currently operating to load, assemble, and pack (LAP) ammunition items, including projectiles, mortar rounds, warheads, demolition charges, anti-tank mines, anti-personnel mines, and the components of these munitions, including primers, detonators, fuses, and boosters. The LAP operations use explosive material and lead-based initiating compounds. Only a few of the production lines are currently in operation.

The AEC operated a portion of Line 1 for several years beginning in 1947. Due to the nature of the AEC operations, less information is available on the activities conducted during AEC's work at Line 1. However, it is known that various components were assembled into a finished nuclear weapon. Radioactive materials used at the line were "received in a sealed configuration" and were swipe tested for leaks before use. Known radioactive materials include depleted uranium (DU), enriched uranium, plutonium, tritium gas, and polonium-210. The AEC announced in 1973 that it was phasing out use of the plant. These facilities reverted back to Army control 1 July 1975.[1]

The firing site area is located in the western portion of the IAAAP and has been in use since the 1940s. Firing Site 12 (FS-12), which is located at the northern end of the firing

*The survey was performed by members of the Measurement Applications and Development Group and the Health Effects Group of the Life Sciences Division at Oak Ridge National Laboratory under DOE contract DE-AC05-00OR22725.

site area, was used for AEC activities. Between 1965 and 1973 FS-12 was used for the destructive testing of 701 shots of DU and high explosives.

Prior to its departure, AEC conducted a radiological survey of the areas it occupied and determined that the only real property which contained residual radioactive contamination was FS-12. Contaminated soil at FS-12 was excavated and transported to a waste disposal facility in Sheffield, Illinois.

The U.S. Environmental Protection Agency (EPA) added IAAAP to the National Priorities List in 1990. The Army, as an agency within the DOD, is the lead agency for implementing the interim remedial action at IAAAP. As the support agency, EPA oversees cleanup activities conducted by the Army to ensure that requirements of the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), the Superfund Amendments and Reauthorization Act (SARA), and the National Contingency Plan have been met. The EPA and the Army signed a Federal Facilities Agreement for site cleanup, which became effective December 10, 1990.[2]

Numerous investigations have been conducted at the site by the Army from 1975 to the present to investigate soil and groundwater contamination. Based on data collected from the site, the Army has initiated response actions to address soil contamination at several areas across the IAAAP. An IAAAP Restoration Advisory Board (RAB) has been established to enable the community and government representatives to meet and exchange information. A Record of Decision (ROD) has been issued for Soils Operable Unit #1, and remediation is ongoing. Separate RODs will be issued for groundwater and installation-wide issues.[2]

In June 2000, a radiological survey was conducted at IAAAP by personnel from ORNL at the request of DOE. The Secretary of Energy committed to perform a radiological survey of areas used by the AEC in response to questions and concerns raised by private citizens in a public forum held in Burlington, Iowa. The questions and concerns related to any immediate threat of public harm resulting from AEC operations at these areas of the IAAAP. This radiological scoping survey of Line 1 and C Yard indoors was performed to partially fulfill the Secretary's commitment made on January 6, 2000. Results of that survey are presented in this report. The general location of the IAAAP is shown in Fig. 1. The general layout of IAAAP including Line 1, the FS Area and C Yard are shown in Fig. 2.

SCOPE OF THE SURVEY

The indoor radiological scoping survey of June 2000 included a surface beta-gamma scan of accessible areas inside selected Line 1 and C Yard buildings, a scan of greater than 80% of floor surfaces with a floor monitor probe, a scan of less accessible areas with a beta/gamma pancake probe, and direct measurement of gamma, alpha, and beta-gamma radiation levels inside the surveyed buildings. About 1% of the wall surfaces in each room were scanned for both alpha and beta-gamma radiation using portable instrumentation where areas of floor contamination were found. A small percentage of the overhead structures was also surveyed for both alpha and beta-gamma radiation, depending upon how much contamination was detected in floor areas. Measurements were also made on miscellaneous structures, including air ventilation systems, floor drains, equipment and window sills. Special attention was given to areas where contamination typically collects; i.e., cracks, joints, and corners. Surveyed buildings are listed in Table 1 and shown on Figure 3.

Systematic air samples, in addition to biased debris and smear samples, were collected from some buildings for radionuclide analysis. Systematic samples were collected without regard to radiation level; biased samples were collected at locations of elevated beta-gamma levels. A sampling and analysis plan was approved prior to the survey which detailed the data quality objectives (DQOs) and survey details.

DATA QUALITY OBJECTIVES

The two main objectives of this scoping survey were to 1) collect data to evaluate any possible immediate health hazards, and 2) conduct radiological measurements to plan "Final Status Surveys" and/or "Characterization Surveys" consistent with the *Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM)*.[3]

This scoping survey activity provides input for additional characterization, including a limited amount of surface scanning, surface activity measurements, and sample collection (smears, air samples, building materials, debris). In this case, scans, direct measurements, and samples were used to examine areas likely to contain residual radioactive material. These activities were conducted based on historic site data, preliminary investigation surveys, and professional judgment.

Background activity and radiation levels for the area were determined, including direct radiation levels on building surfaces and radionuclide concentrations in media. Survey locations were referenced to fixed site features. Samples collected as part of this scoping survey were tracked as part of the chain of custody.

The two DQOs included the following actions:

1. Collection of data to evaluate immediate radiological health hazards by:

- Collection of air particulate samples;
- Direct radiation exposure measurements;
- Determining transferrable contamination;
- Determining possible release and migration pathways to plan an outside survey; and
- Data from 2. below.

2. Conducting radiological measurements to plan "Final Status Surveys" and/or "Characterization Surveys" by:

   - using portable radiation survey instrumentation to locate alpha, beta, and gamma emitting nuclides in suspect areas of the buildings. The purpose was to identify any areas where residual contamination exists.

   - investigating suspect areas identified from scans to identify the isotopes and magnitudes; activity per unit area and area size using portable instruments and samples.

   - evaluating survey data and recommending area classifications as

   1. No radiation detected above background, ready for final status survey; or
   2. Contaminated above background, needs further characterization.

The above DQOs were accomplished assuming:

- The likely contaminants of concern were isotopes of uranium and plutonium and that they would tend to be found in the same locations if present. Isotopes of lesser concern were tritium, cobalt-60, radium-226, polonium-210, and cesium-137. These isotopes would be found, if present, during the survey for the primary contaminants, with the exception of tritium and polonium-210. Surveying for tritium was not considered practical because only gaseous tritium should have been present, and it would have most likely dissipated since the last recorded release. The Po-210 was used as part of a neutron generator, has a 138-day half-life, and therefore could not still be detected.
- Estimated derived concentration guidelines (DCGLs) used in the survey were only for the purpose of designing the survey, selecting the appropriate instruments, and evaluating scan rates and minimum detectable activities (MDAs). These DCGLs were not considered to be approved for determining if the building may be released for unrestricted use.

SURVEY METHODS

A comprehensive description of the methods and instrumentation used in this survey and in the laboratory analyses is given in *Measurement Applications and Development Group Guidelines*, ORNL-6782 (January 1995).[4] General guidance for scoping surveys, instrumentation, DQOs, and data evaluation is given in *MARSSIM*.

Drawings were prepared for buildings using the IAAAP grid coordinates. Survey and sample locations were designated by reference to fixed site features.

RADIATION MEASUREMENTS

Gamma radiation levels were determined using portable NaI gamma scintillation meters. Because NaI gamma scintillators are energy dependent, measurements of gamma radiation levels in counts per minute are normalized to pressurized ionization chamber (PIC) measurements to estimate gamma exposure rates in μR/h. Direct exposure measurements were also taken with a PIC in selected buildings and recorded in μR/h.

The FIDLER connected to Ludlum 2221 scaler/ratemeters was used to measure the relative gamma fluence at the interior floor surface with the purpose of detecting gamma-emitting radionuclide contamination beneath floor surfaces. The FIDLER is a NaI(Tl) scintillation probe that is designed to be particularly sensitive to low-energy gamma and x-ray radiation. The sensitive volume is 5 inches in diameter by 0.0063 inches thick, and the instrument is preferentially efficient at measuring gamma fluence rates entering perpendicular to the entrance window. Systematic measurements in counts per minute were taken.

Bicron scaler/ratemeters with Geiger-Mueller (GM) pancake detectors were used to detect beta-gamma radiation. Radiation levels in counts per minute (cpm) were converted to disintegrations per minute (dpm) per 100 cm^2.

Floors were surveyed with the Ludlum Model 239-1F gas flow proportional detector system ("floor monitor"), which includes a Ludlum Model 2221 scaler/ratemeter connected to a Ludlum Model 43-37 detector probe mounted on a roll-around cart. The monitor was set in the "beta" mode, where it is primarily used to detect beta radiation but will detect alpha particles.

Alpha levels on selected surfaces were measured with an ORNL 100 cm^2 ZnS alpha scintillator probe connected to a Bicron Analyst scaler/ratemeter. Air samples were collected using a portable constant flow air sampler (RADeCO AVS-28A).

SAMPLING AND ANALYSES

Systematic air particulate samples, systematic and biased smear samples, and biased debris samples were collected from six buildings for radionuclide analysis. Biased samples were collected in areas exhibiting an anomaly as determined by field instrument measurements, and were analyzed by gamma spectroscopy. Sampling locations for Building 1-11 and Building 1-63-6 are shown on Figs. 4 and 5, respectively. Buildings where air samples were collected are designated on Table 1.

SURVEY RESULTS

RADIATION MEASUREMENTS

Directly measured alpha and beta-gamma radiation levels in each building are list in Table 2. Typical background radiation levels were determined for the surveyed buildin by using survey data from buildings where contamination was not expected and not foun Smear data from selected buildings is summarized in Table 3. Gamma exposure rates insi the buildings on the property generally ranged from 6 to 14 μR/h. Gamma ranges are show in Table 1 for buildings where values were higher than background. A summary of PI measurements is shown in Table 4. The scan of interior areas with a floor monitor prob and beta/gamma pancake probe showed no elevated radiation levels above backgroun levels, with the exception of areas where biased samples were collected.

SAMPLES

Results of analyses of air samples are shown in Table 5. Miscellaneous sample locations for Buildings 1-11, 1-12 and 1-63-6 only are shown on Figs. 4-6, and results of analyses are listed in Table 6.

BUILDING 1-11

The contamination found in Building 1-11 is primarily limited to the northwest corner of the building. One small spot of contamination was found near the south loading dock. Fig. 4 illustrates areas of contamination. As expected, the highest residual contamination was found in the cracks and concrete seams. Samples M1 and M8 were analyzed by gamma spectroscopy to determine the contaminant to be DU. Smear samples T1, T2, and T3 indicated that the contamination is not transferrable under normal use. Soil sample S1 was collected outside the exit door in the northwest corner and contained only DU and a trace amount of cesium-137 consistent with fallout from aboveground weapons tests.

Also within the northwest corner of 1-11 is a pit containing about 18 inches of water and covered with a metal grate. Portions of the grate showed contamination up to 31,000 dpm/100 cm². The gamma exposure rates in the area were not distinguishable from background. Radiological survey results from the 1970s indicated radioactive materials were handled in this area.

BUILDING 1-12

The areas surveyed in Building 1-12 were the bays designated with double letters (AA through FF). The contamination found was limited to the concrete seam in Bay CC. The maximum measurement was 13,000 dpm/100 cm² beta. Analysis of sample M9 by gamma spectroscopy indicated the contamination to be DU. Figure 6 illustrates areas of contamination.

BUILDING 1-61

The contamination found in Building 1-61 was inside a plastic storage pan located in Bay R. The contamination was identified by gamma spectroscopy as DU and was readily transferrable. Smear sample T4 was removed from the pan, and analysis showed 2500 dpm/100 cm^2. Direct measurements were as high as 1000 dpm/100 cm^2 alpha and 30,000 dpm/100 cm^2 beta. The plastic pan was tagged as contaminated and reported to the IAAAP staff. The pan was subsequently removed from 1-61.

BUILDING 1-63-6

Contamination was found in four locations. It should be noted that just inside the entrance to 1-63-6 is a "Caution Radiation" sign indicating recent work with radioactive materials. Figure 5 details the layout of 1-63-6, the measurements and sample locations. All of the contamination found was identified by gamma spectroscopy as DU. A small spot (<50 cm^2) of loose contamination was found near the entrance; however, smear sample T5 indicated the material was not readily picked up by conventional smear sampling. Sample M2 collected from the debris was analyzed and found to have 39,000 pCi/g DU. Direct measurements revealed 150,000 dpm/100 cm^2 beta, 290 dpm/100 cm^2 alpha, and 14 μR/h gamma at the spot.

Samples were taken from a sump (M5) and floor drain (M6). Sample analysis showed 2.3 pCi/g and 86 pCi/g DU, respectively. The most significant contamination found was on the return air filters in the round process area of 1-63-6. Twelve 24" x 24" filters were mounted in a metal support housing. The filters were generally contaminated at levels of 20,000 to 30,000 dpm/100 cm^2 beta-gamma. Given the poor measurement geometry, the likely radioactivity is reasonably higher. Measurements inside the ductwork and downstream filters showed no additional contamination. A portion of one of the filters was collected as sample M7, and analysis of the sample by gamma spectroscopy showed 2600 pCi/g of DU.

SIGNIFICANCE OF FINDINGS

The indoor radiological survey was conducted at the request of the DOE to document the radiological status of the designated areas of the IAAAP, Middletown, Iowa. No immediate threat to human health was discovered during the survey.

Residual radioactive materials, determined to be DU, were found in Buildings 1-11, 1-63-6, 1-12, and 1-61. The areas identified as containing residual radioactive materials should be marked as such according to applicable regulations. Additional characterization (according to *MARSSIM*) is required, and remediation may be necessary.

Based on historical records and site conditions, the contamination in Building 1-11 is likely the result of AEC activities. AEC used the building for shipping and receiving and the location and nature of the contamination found is consistent with AEC activities. Because of the relative newness of the return air filters and radiation protection signs, contamination in building 1-63-6 is most likely due to Army operation at IAAAP. Similarly, the contaminated plastic storage pan found in 1-61 was relatively new, which indicates that the contamination was likely due to Army operations. As both AEC and the Army have conducted operations in Building 1-12, the origin of the contamination found there can not be ascertained with the information currently available.

Except for the aforementioned, all the other buildings surveyed at Line 1 and C Yard may be classified as Class 3 according to *MARSSIM* and ready for final status survey. Unless otherwise suspected, the contaminant of concern is DU.

REFERENCES

1. *Remedial Investigation/Risk Assessment, Iowa Army Ammunition Plant, Middletown, Iowa.* Revised draft final, May 1996. U.S. Army Environmental Center, Aberdeen Proving Ground, Maryland.

2. *Record of Decision, Iowa Army Ammunition Plant Soils Operable Unit #1, Middletown, Iowa.* Revision No. 1, August 14, 1998. Department of the Army, Corps of Engineers, Omaha District, Omaha, Nebraska.

3. *Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM).* NUREG-1575/EPA 402-R-97-016. December 1997. Department of Defense, Department of Energy, Environmental Protection Agency, Nuclear Regulatory Commission.

4. *Measurement Applications and Development Group Guidelines,* ORNL-6782, Martin Marietta Energy Systems, Inc., Oak Ridge National Laboratory, January 1995.

[illegible]	Building Description	Comments[b]
1-11[c,d]	Shipping/Receiving	General coverage with floor monitor and NaI gamma detector. Static measurements with GM pancake beta-gamma detector and ZnS alpha meter. Random and biased measurements with GM pancake and ZnS alpha meter. Floor monitor coverage: Perimeter, all seams and cracks, meandering of remainder, special attention to scored areas, chips, etc. Beta-gamma scan of rail tracks outside NE entrance. Soil sample S1 taken outside NW corner of building. Bay 1: ~ 500 ft^2 of NW corner around pit generally contaminated. Some concrete low-level contaminated. Seven (out of many) spots characterized. Highest spot ~ 31,000 dpm/100 cm^2 beta. Low alpha, <60 dpm/100 cm^2. Generally contaminated in seams and on steel grate above pit. Samples T1, M8 taken from crack. Sample T2 taken from concrete seam. Approx. 18" of water in pit - inaccessible. Sample T3 taken from steel grate above pit. Another spot ~31,000 dpm/100 cm^2 beta found in concrete seam near loading dock on south side of 1-11. Sample M1 taken here.
1-12 (AA, BB, CC, DD, EE, FF)	Painting	General coverage with floor monitor and NaI gamma detector. Static measurements with GM pancake beta-gamma detector and ZnS alpha meter. Random and biased measurements with GM pancake and ZnS alpha meter. Gamma 7-10 µR/h. Bay CC: Crack running E/W in center of room generally contaminated throughout; 670-13,000 dpm/100 cm^2 beta with GM pancake. No alpha or gamma detected above background. Samples M9 and T6.
1-13 (A, B, C, D, E, F, G)	Development	General coverage with floor monitor and NaI gamma detector. Static measurements with GM pancake beta-gamma detector and ZnS alpha meter. Random and biased measurements with GM pancake and ZnS alpha meter. No anomalies. Gamma 7-13 µR/h.

Table 1 (continued)

Building Number[a]	Building Description	Comments[b]
1-18	Development	General coverage with floor monitor and NaI gamma detector. Static measurements with GM pancake beta-gamma detector and ZnS alpha meter. Random and biased measurements with GM pancake and ZnS alpha meter. No anomalies. Gamma 7-11 μR/h.
1-19-1	Development	General coverage with floor monitor and NaI gamma detector. Static measurements with GM pancake beta-gamma detector and ZnS alpha meter. Random and biased measurements with GM pancake and ZnS alpha meter. No anomalies. Gamma 7 μR/h.
1-19-2	Development	General coverage with floor monitor and NaI gamma detector. Static measurements with GM pancake beta-gamma detector and ZnS alpha meter. Random and biased measurements with GM pancake and ZnS alpha meter. No anomalies. Gamma 7 μR/h.
1-19-3[c]	Development	General coverage with floor monitor and NaI gamma detector. Static measurements with GM pancake beta-gamma detector and ZnS alpha meter. Random and biased measurements with GM pancake and ZnS alpha meter. No anomalies. Gamma 7 μR/h.
1-19-4	Development	General coverage with floor monitor and NaI gamma detector. Static measurements with GM pancake beta-gamma detector and ZnS alpha meter. Random and biased measurements with GM pancake and ZnS alpha meter. No anomalies. Gamma 7 μR/h.
1-19-5	Development	General coverage with floor monitor and NaI gamma detector. Static measurements with GM pancake beta-gamma detector and ZnS alpha meter. Random and biased measurements with GM pancake and ZnS alpha meter. No anomalies. Gamma 5 μR/h.

	Description	Comments[b]
1-19-6	Development	General coverage with floor monitor and NaI gamma detector. Static measurements with GM pancake beta-gamma detector and ZnS alpha meter. Random and biased measurements with GM pancake and ZnS alpha meter. No anomalies. Gamma 6 μR/h.
1-19-7	Development	General coverage with floor monitor and NaI gamma detector. Static measurements with GM pancake beta-gamma detector and ZnS alpha meter. Random and biased measurements with GM pancake and ZnS alpha meter. No anomalies. Gamma 6 μR/h.
1-40 (G[c], H, J, Q, S)	Machining	General coverage with floor monitor and NaI gamma detector. Static measurements with GM pancake beta-gamma detector and ZnS alpha meter. Random and biased measurements with GM pancake and ZnS alpha meter. No anomalies.
1-61[d]	Assembly	Surveyed upstairs floor and basement. General coverage with floor monitor and NaI gamma detector. Static measurements with GM pancake beta-gamma detector and ZnS alpha meter. Random and biased measurements with GM pancake and ZnS alpha meter. Bay R: Inside bottom of plastic pan ~ 30,000 dpm/100 cm^2 beta, 1,000 dpm/100 cm^2 transferable. Outside appeared clean. Sample T4. No other anomalies in building.
1-63-1	Assembly	General coverage with floor monitor and NaI gamma detector. Static measurements with GM pancake beta-gamma detector and ZnS alpha meter. Random and biased measurements with GM pancake and ZnS alpha meter. No anomalies.

Table 1 (continued)

Building Number[a]	Building Description	Comments[b]
1-63-2	Assembly	General coverage with floor monitor and NaI gamma detector. Static measurements with GM pancake beta-gamma detector and ZnS alpha meter. Random and biased measurements with GM pancake and ZnS alpha meter. No anomalies.
1-63-3[c]	Assembly	General coverage with floor monitor and NaI gamma detector. Static measurements with GM pancake beta-gamma detector and ZnS alpha meter. Random and biased measurements with GM pancake and ZnS alpha meter. No anomalies. Samples M3 (sump), M4 (drain).
1-63-4	Assembly	General coverage with floor monitor and NaI gamma detector. Static measurements with GM pancake beta-gamma detector and ZnS alpha meter. Random and biased measurements with GM pancake and ZnS alpha meter. No anomalies.
1-63-5	Assembly	General coverage with floor monitor and NaI gamma detector. Static measurements with GM pancake beta-gamma detector and ZnS alpha meter. Random and biased measurements with GM pancake and ZnS alpha meter. No anomalies.

Building Number	Building Description	Comments[b]
1-63-6[d]	Assembly	General coverage with floor monitor and NaI gamma detector. Static measurements with GM pancake beta-gamma detector and ZnS alpha meter. Random and biased measurements with GM pancake and ZnS alpha meter. Radiation sign in entrance. Access to outside entrance of manway blocked. Spot found near end of manway; ~150,000 dpm/100 cm^2 beta, ~290 dpm/100 cm^2 alpha. Gamma 14 μR/h at spot. Background gamma 9 μR/h. Samples M2 and T5 taken from manway. Sump and rectangular drain near assembly area had slightly contaminated sediment. Samples M5 (sump), M6 (drain). Complete resurvey of 1-63-6: Floor monitor, FIDLER, GM pancake beta-gamma detector, alpha spot checks with ZnS alpha meter. Return air filters in assembly area generally contaminated. The filter rack housed 12 2' x 2' filters, generally reading 20,000 to 30,000 dpm/100 cm^2. Otherwise, the assembly area was remarkably clean. Filters appeared relatively new. Sample M7 (return air filter).
1-63-7	Assembly	General coverage with floor monitor and NaI gamma detector. Static measurements with GM pancake beta-gamma detector and ZnS alpha meter. Random and biased measurements with GM pancake and ZnS alpha meter. No anomalies. Gamma 10-14 μR/h.
1-64-1	Assembly	General coverage with floor monitor and NaI gamma detector. Static measurements with GM pancake beta-gamma detector and ZnS alpha meter. Random and biased measurements with GM pancake and ZnS alpha meter. No anomalies.

Table 1 (continued)

Building Number[a]	Building Description	Comments[b]
1-64-2	Assembly	General coverage with floor monitor and NaI gamma detector. Static measurements with GM pancake beta-gamma detector and ZnS alpha meter. Random and biased measurements with GM pancake and ZnS alpha meter. No anomalies.
1-64-3	Assembly	General coverage with floor monitor and NaI gamma detector. Static measurements with GM pancake beta-gamma detector and ZnS alpha meter. Random and biased measurements with GM pancake and ZnS alpha meter. No anomalies.
1-64-4[c, d]	Assembly	General coverage with floor monitor and NaI gamma detector. Static measurements with GM pancake beta-gamma detector and ZnS alpha meter. Random and biased measurements with GM pancake and ZnS alpha meter. No anomalies.
1-64-5	Assembly	General coverage with floor monitor and NaI gamma detector. Static measurements with GM pancake beta-gamma detector and ZnS alpha meter. Random and biased measurements with GM pancake and ZnS alpha meter. No anomalies.
1-65-1[d]	Storage	General coverage with floor monitor and NaI gamma detector. Static measurements with GM pancake beta-gamma detector and ZnS alpha meter. Random and biased measurements with GM pancake and ZnS alpha meter. No anomalies. Gamma 9 μR/h.
1-65-2	Storage	General coverage with floor monitor and NaI gamma detector. Static measurements with GM pancake beta-gamma detector and ZnS alpha meter. Random and biased measurements with GM pancake and ZnS alpha meter. No anomalies. Gamma 9 μR/h.

Building Number[a]	Building Description	Comments[b]
1-65-3	Storage	General coverage with floor monitor and NaI gamma detector. Static measurements with GM pancake beta-gamma detector and ZnS alpha meter. Random and biased measurements with GM pancake and ZnS alpha meter. No anomalies. Gamma 6 µR/h.
1-65-4	Storage	General coverage with floor monitor and NaI gamma detector. Static measurements with GM pancake beta-gamma detector and ZnS alpha meter. Random and biased measurements with GM pancake and ZnS alpha meter. No anomalies. Gamma 7 µR/h.
1-65-5	Storage	General coverage with floor monitor and NaI gamma detector. Static measurements with GM pancake beta-gamma detector and ZnS alpha meter. Random and biased measurements with GM pancake and ZnS alpha meter. No anomalies. Gamma 6 µR/h.
1-65-6	Inaccessible	Inaccessible
1-65-7	Storage	General coverage with floor monitor and NaI gamma detector. Static measurements with GM pancake beta-gamma detector and ZnS alpha meter. Random and biased measurements with GM pancake and ZnS alpha meter. No anomalies. Gamma 6 µR/h.
1-66-1	Development	General coverage with floor monitor and NaI gamma detector. Static measurements with GM pancake beta-gamma detector and ZnS alpha meter. Random and biased measurements with GM pancake and ZnS alpha meter. No anomalies. Gamma 21 µR/h.
1-66-2	Development	General coverage with floor monitor and NaI gamma detector. Static measurements with GM pancake beta-gamma detector and ZnS alpha meter. Random and biased measurements with GM pancake and ZnS alpha meter. No anomalies. Gamma 8 µR/h.

Table 1 (continued)

Building Number[a]	Building Description	Comments[b]
1-67-1	Assembly	General coverage with floor monitor and NaI gamma detector. Static measurements with GM pancake beta-gamma detector and ZnS alpha meter. Random and biased measurements with GM pancake and ZnS alpha meter. No anomalies.
1-67-2	Assembly	General coverage with floor monitor and NaI gamma detector. Static measurements with GM pancake beta-gamma detector and ZnS alpha meter. Random and biased measurements with GM pancake and ZnS alpha meter. No anomalies.
1-67-3	Assembly	General coverage with floor monitor and NaI gamma detector. Static measurements with GM pancake beta-gamma detector and ZnS alpha meter. Random and biased measurements with GM pancake and ZnS alpha meter. No anomalies.
1-77[d]	Shipping/Receiving	General coverage with floor monitor and NaI gamma detector. Static measurements with GM pancake beta-gamma detector and ZnS alpha meter. Random and biased measurements with GM pancake and ZnS alpha meter. Floor monitor coverage: Perimeter, all cracks and seams. S-pattern remainder. Beta-gamma pancake corners and walls. No anomalies.
1-100-1[d]	X-Ray Facility	General coverage with floor monitor and NaI gamma detector. Static measurements with GM pancake beta-gamma detector and ZnS alpha meter. Random and biased measurements with GM pancake and ZnS alpha meter. No anomalies. Gamma 6 μR/h.
1-100-2	X-Ray Facility	General coverage with floor monitor and NaI gamma detector. Static measurements with GM pancake beta-gamma detector and ZnS alpha meter. Random and biased measurements with GM pancake and ZnS alpha meter. No anomalies. Gamma 7 μR/h.

	Description	Comments[a]
1-137-4	Change House	General coverage with floor monitor and NaI gamma detector. Static measurements with GM pancake beta-gamma detector and ZnS alpha meter. Random and biased measurements with GM pancake and ZnS alpha meter. No anomalies. Naturally-occurring radioactive materials in the ceramic tile floors caused the background to be elevated. Gamma 6-10 μR/h.
1-148	Machining	General coverage with floor monitor and NaI gamma detector. Static measurements with GM pancake beta-gamma detector and ZnS alpha meter. Random and biased measurements with GM pancake and ZnS alpha meter. No anomalies. Gamma 7-9 μR/h.
C Yard, 23-53[c]	Shipping and Receiving	General coverage with floor monitor and NaI gamma detector. Static measurements with GM pancake beta-gamma detector and ZnS alpha meter. Random and biased measurements with GM pancake and ZnS alpha meter. No anomalies. Gamma 7-10 μR/h.
C Yard, Igloo 23-1	Storage	General coverage with floor monitor and NaI gamma detector. Static measurements with GM pancake beta-gamma detector and ZnS alpha meter. Random and biased measurements with GM pancake and ZnS alpha meter. Sample T7. No anomalies.
C Yard, Igloo 23-2	Storage	General coverage with floor monitor and NaI gamma detector. Static measurements with GM pancake beta-gamma detector and ZnS alpha meter. Random and biased measurements with GM pancake and ZnS alpha meter. No anomalies.
C Yard, Igloo 23-3	Storage	General coverage with floor monitor and NaI gamma detector. Static measurements with GM pancake beta-gamma detector and ZnS alpha meter. Random and biased measurements with GM pancake and ZnS alpha meter. No anomalies.

Table 1 (continued)

Building Number[a]	Building Description	Comments[b]
Ramps	Transportation	Ramps were surveyed in the immediate vicinity of the buildings being surveyed, and in route to survey the various buildings connected by ramps. No anomalies.

[a]Line 1 building numbers are coded as follows: A-B-C where: "A" is the IAAAP line number, "B" is an operational function identifier, such as 61 for machining operations, and "C" (if used) is a sequential identifier within an operational grouping.

[b]If no direct gamma reading is given in a building without anomalies, the walkover gamma scan found no radiation distinguishable from instrument background of 5.7 μR/h. Gamma readings were taken at 1 meter above the ground for 1 minute.

[c]Air samples were collected from these buildings. See Table 5.

[d]PIC measurements were made in these buildings. See Table 4.

Table 2. Directly measured radiation levels in buildings, Iowa Army Ammunition Plant

Location Description	Measurement ID	Alpha[a]	Beta-gamma
		(dpm/100 cm², 1-minute count)	
1-11, SW corner	FP1	7	1300
1-11, NW corner	FP2	14	900
1-11, center	FP3	ND	720
1-11, NE corner	FP4	14	780
1-11, SE corner	FP5	14	780
1-11, Bay 1. Crack. Samples T1, M8	BP1	49	7500
1-11, Bay 1. Concrete seam. Sample [illegible]2	BP2	35	4400
[illegible]11, Bay 1. Top of steel grate. Bad [illegible]ometry. Sample T3	BP3	42	31,000
[illegible]11, Bay 1. No seam. Flat area on [illegible]ncrete	BP4	35	3200
[illegible]11, Bay 1. Seam at foot of pier	BP5	28	1300
[illegible]11, Bay 1. Seam at edge of pit	BP6	7	3300
[illegible]11, Bay 1	BP7	ND	1400
[illegible]11, Sample M1 location before [illegible]llection	BP8		31,000
[illegible]1, Sample M1 location after [illegible]llection	BP8		14,000
[illegible]12, center of Bay AA	FP1	ND	540
[illegible]12, center of Bay BB	FP2	7	1400
[illegible]12, center of Bay CC	FP3	ND	1600
[illegible]2, center of Bay DD	FP4	ND	780
[illegible]2, center of Bay EE	FP5	ND	1400
[illegible]2, center of Bay FF	FP6	ND	1700
[illegible]2, Bay CC. Seam. Samples M9, T6	BP1	7	13,000

Table 2 (continued)

Location Description	Measurement ID	Alpha[a]	Beta-gamma
		(dpm/100 cm², 1-minute count)	
1-13, center of Bay G	FP1	ND	720
1-13, center of Bay F	FP2	ND	720
1-13, center of Bay E	FP3	7	1700
1-13, center of Bay D	FP4	7	780
1-13, center of Bay C	FP5	ND	840
1-13, center of Bay A	FP6	ND	1200
1-13, center of Bay B	FP7	ND	1500
1-18, center of northernmost room	FP1	7	540
1-18, center of next room SW of FP1 location	FP2	7	780
1-18, center of next room SE of FP2 location	FP3	ND	ND
1-18, center of hallway	FP4	ND	840
1-18, center of southernmost room	FP5	ND	720
1-19-1, center	FP1	21	360
1-19-2, center	FP1	7	180
1-19-3, center	FP1	7	240
1-19-4, center	FP1	42	60
1-19-5	FP1	14	660
1-19-6, center	FP1	14	360
1-19-7, center	FP1	21	660
1-40, center of Bay Q	FP1	35	ND
1-40, center of Bay S	FP2	7	ND
1-40, center of Bay J	FP3	14	ND
1-40, center of Bay H	FP4	14	720
1-40, center of Bay G	FP5	35	720

Table 2 (continued)

Location Description	Measurement ID	Alpha[a]	Beta-gamma
		(dpm/100 cm^2, 1-minute count)	
1-61, basement, western side	FP1	14	ND
1-61, basement, eastern side	FP2	28	1100
1-61, basement, center of Bay 1	FP3	49	420
1-61, upstairs, east side of large room	FP4	7	600
1-61, upstairs, west side of large room	FP5	21	540
1-61, upstairs, center of Bay R	FP6	28	360
1-63-1, entrance	FP1	14	2000
1-63-1, SE side of building. Damp floor	FP2	ND	1800
1-63-1, center of circular room	FP3	21	660
1-63-2, entrance	FP1	14	1100
1-63-2, SE side of building	FP2	28	1000
1-63-2, center of circular room	FP3	28	660
1-63-3, entrance	FP1	42	660
1-63-3, SE side of building	FP2	28	ND
1-63-3, center of circular room	FP3	14	840
1-63-4, entrance	FP1	7	360
1-63-4, SE side of building	FP2	ND	ND
1-63-4, center of circular room	FP3	7	360
1-63-5, entrance	FP1	21	1400
1-63-5, northern area of building. Damp vinyl	FP2	ND	240
1-63-5, center of circular room	FP3	ND	ND
1-63-6, entrance	FP1	14	720
1-63-6, northern area of building	FP2	ND	60
1-63-6, center of circular room	FP3	ND	300

Table 2 (continued)

Location Description	Measurement ID	Alpha[a]	Beta-gamma
		(dpm/100 cm², 1-minute count)	
1-63-6, southern end of manway. Samples M2, T5	BP1	290	150,000
1-63-7, center of circular room	FP1	ND	720
1-63-7, center	FP2	ND	420
1-63-7, entrance. ~ 30 ft. from 120-mm DU rounds	FP3	14	1100
1-64-1, center	FP1	7	1900
1-64-2, center	FP1	7	960
1-64-3, center	FP1	14	180
1-64-4, center. Door not locked	FP1	ND	120
1-64-5, center	FP1	ND	300
1-65-1, center	FP1	7	480
1-65-2, center	FP1	ND	180
1-65-3, center	FP1	14	720
1-65-4, center	FP1	28	1000
1-65-5, center	FP1	ND	180
1-65-7, center	FP1	35	540
1-66-1, center. ~10 ft. from DU ammunition	FP1	14	180
1-66-2, center	FP1	7	900
1-67-1, center	FP1	21	120
1-67-2, center	FP1	ND	120
1-67-3, center	FP1	7	1100
1-77, SW corner	FP1	7	900
1-77, NW corner. Tile floor	FP2	ND	ND
1-77, center	FP3	7	360

Table 2 (continued)

Location Description	Measurement ID	Alpha[a]	Beta-gamma
		(dpm/100 cm², 1-minute count)	
1-77, NE corner	FP4	28	720
1-77, SE corner	FP5	7	1400
100-1, center	FP1	28	540
1-100-2, center	FP1	35	1200
137-4, locker room north	FP1	14	2500[b]
137-4, locker room south. Floor tile	FP2	14	3400[b]
137-4, ramp	FP3	ND	1300
137-4, lunch room north	FP4	ND	ND
137-4, kitchen	FP5	ND	3200[b]
137-4, hallway from kitchen to ference room	FP6	7	2200[b]
137-4, lunch room south	FP7	ND	1300
48	FP1	ND	1300
48	FP2	7	1600
01. Thorium used in welding and lding area adjacent to 1-148	FP3	14	1300
48	FP4	ND	ND
48, center	FP5	ND	480
48	FP6	ND	600
Yard, 23-53	FP1	7	1200
Yard, 23-53, Bay A	FP2	ND	780
Yard, 23-53, Bay B	FP3	14	1400
Yard, 23-53	FP4	7	1500
Yard, 23-53	FP5	14	480
Yard, Igloo C1, center	FP1	42	2500
Yard, Igloo C2, center	FP1	ND	1900

Table 2 (continued)

Location Description	Measurement ID	Alpha[a]	Beta-gamma
		(dpm/100 cm², 1-minute count)	
C Yard, Igloo C3, center	FP1	ND	1000

[a]The average background (+2 sigma) for alpha and beta measurements are 43 and 1800 dpm/100 cm², respectively.

[b]Naturally-occurring radioactive materials in the ceramic tile floors caused the background to be elevated.

Table 3. Smear data from buildings at Iowa Army Ammunition Plant

Smear number	Location	Directly measured radiation levels		Removable radioactivity	
		Alpha	Beta-gamma	Alpha	Beta-gamma
		(dpm/100 cm²)		(dpm/100 cm²)	
T1	1-11, Bay 1, crack	49	7500	ND	17
T2	1-11, Bay 1, concrete seam	35	4400	ND	ND
T3	1-11, Bay 1, steel grate	42	31,000	ND	17
T4	1-61, Bay R, pan	1000	30,000	630	2500
T5	1-63-6, manway	290	150,000	21	ND
T6	1-12, Bay CC, crack	7	13,000	ND	29
T7	Yard C, Igloo 23-1, floor	NM	NM	ND	ND

ND = Not detected.
NM = Not measured.

Table 4. Summary of pressurized ionization chamber (PIC) measurements at the Iowa Army Ammunition Plant

Building location	Direct exposure measurements (µR/h)
1-11 (Center of building)	8
1-11 (Center of area with elevated radiation levels)	8
1-61	7
1-63-6	9
1-64-4	9
1-65-1	9
1-77	8
1-100-1	7

Table 5. Air particulate sample data from buildings at Iowa Army Ammunition Plant[a]

Sample number	Building location	Start date	Start time	Total time	Gross alpha (µCi/cc)[b]	Percent of U-238 DCG[c]
[illegible]	1-11	6-12-00	3:30 p.m.	16 h 40 min	3.8E-15	4
[illegible]	1-63-3, center of press room	6-13-00	4:50 p.m.	16 h 17 min	5.3E-15	5
[illegible]	1-64-4	6-14-00	3:55 p.m.	16 h 55 min	1.1E-14	11
[illegible]	1-40, Bay G	6-15-00	3:20 p.m.	18 h	4.5E-14	45
[illegible]	1-19-3	6-19-00	4:07 p.m.	15 h 34 min	2.0E-14	20
[illegible]	Yard C, 23-53	6-20-00	9:05 a.m.	6 h 30 min	*ND*	---

[a] Air samples were collected using a portable constant flow air sampler (RADeCO AVS-28A). [illegible] pump ID number was 349002AS. Starting and ending flow rates were 20 L/min. Sampling [illegible] was approximately 1.5 m.

[b] Background ambient air radioactivity has not been subtracted.

[c] The non-occupational Derived Concentration Guide (DCG) is 1.0E-13 µCi/cc.

Table 6. Concentrations of radionuclides in samples from Line 1, Iowa Army Ammunition Plant, Middletown, Iowa

Sample ID[a]	Building	Location description	Radionuclide concentrations (pCi/g)[b,c]					
			^{235}U	^{238}U	^{226}Ra	^{137}Cs	^{232}Th	^{40}K
S1	1-11	Soil outside NW corner	*ND*[d]	3.9 ± 0.7	0.7 ± 0.3	0.7 ± 0.2	0.8 ± 0.2	13 ± 4
M1	1-11	Floor crack, south side of building	400 ± 50	19,000 ± 1000	*ND*	*ND*	*ND*	*ND*
M2	1-63-6	Manway	570 ± 100	39,000 ± 3000	*ND*	*ND*	*ND*	*ND*
M3	1-63-3	Sump	*ND*	0.5 ± 0.1	0.3 ± 0.1	*ND*	0.5 ± 0.1	7 ± 3
M4	1-63-3	Floor drain	*ND*	1.0 ± 1	0.5 ± 0.2	*ND*	0.3 ± 0.2	6 ± 3
M5	1-63-6	Sump	0.6 ± 0.3	10 ± 4	1.9 ± 0.5	*ND*	1.9 ± 0.3	6.4 ± 1.4
M6	1-63-6	Floor drain	1.3 ± 0.8	86 ± 2	1.2 ± 0.6	*ND*	0.5 ± 0.2	8 ± 5
M7	1-63-6	Air filter	36 ± 10	2600 ± 200	3 ± 4	*ND*	*ND*	*ND*
M8	1-11	NW corner of building	2.4 ± 0.2	130 ± 30	0.4 ± 0.1	*ND*	0.5 ± 0.1	14 ± 2
M9	1-12, Bay CC	Center floor crack	7.0 ± 0.7	180 ± 20	0.5 ± 0.2	0.2 ± 0.2	0.7 ± 0.2	12 ± 2
T4	1-61, Bay R	Plastic pan	37 ± 12	2700 ± 300	*ND*	*ND*	*ND*	*ND*
Typical *a priori* MDA for radionuclide:			0.5	0.7	0.3	0.04	0.4	0.5

[a]Debris samples (M#) and smear (T#) were taken from locations with elevated beta-gamma radiation levels. Sample locations are shown on Figs. 4 and 5.

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

[c]A typical cleanup guideline for total uranium (U-238 + U-235 + U-234) is 60 pCi/g.

[d]*ND* = Not detected above the MDA for the radionuclide. Am-241 was not identified in any sample at an MDA of 0.02 pCi/g.

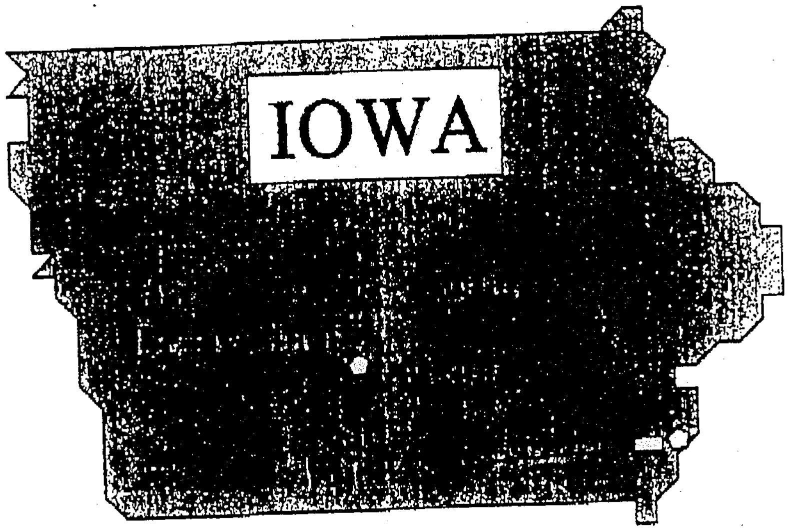

Fig. 1. Map of Iowa showing the general location of the Iowa Army Ammunition Plant (IAAAP), Middletown, Iowa.

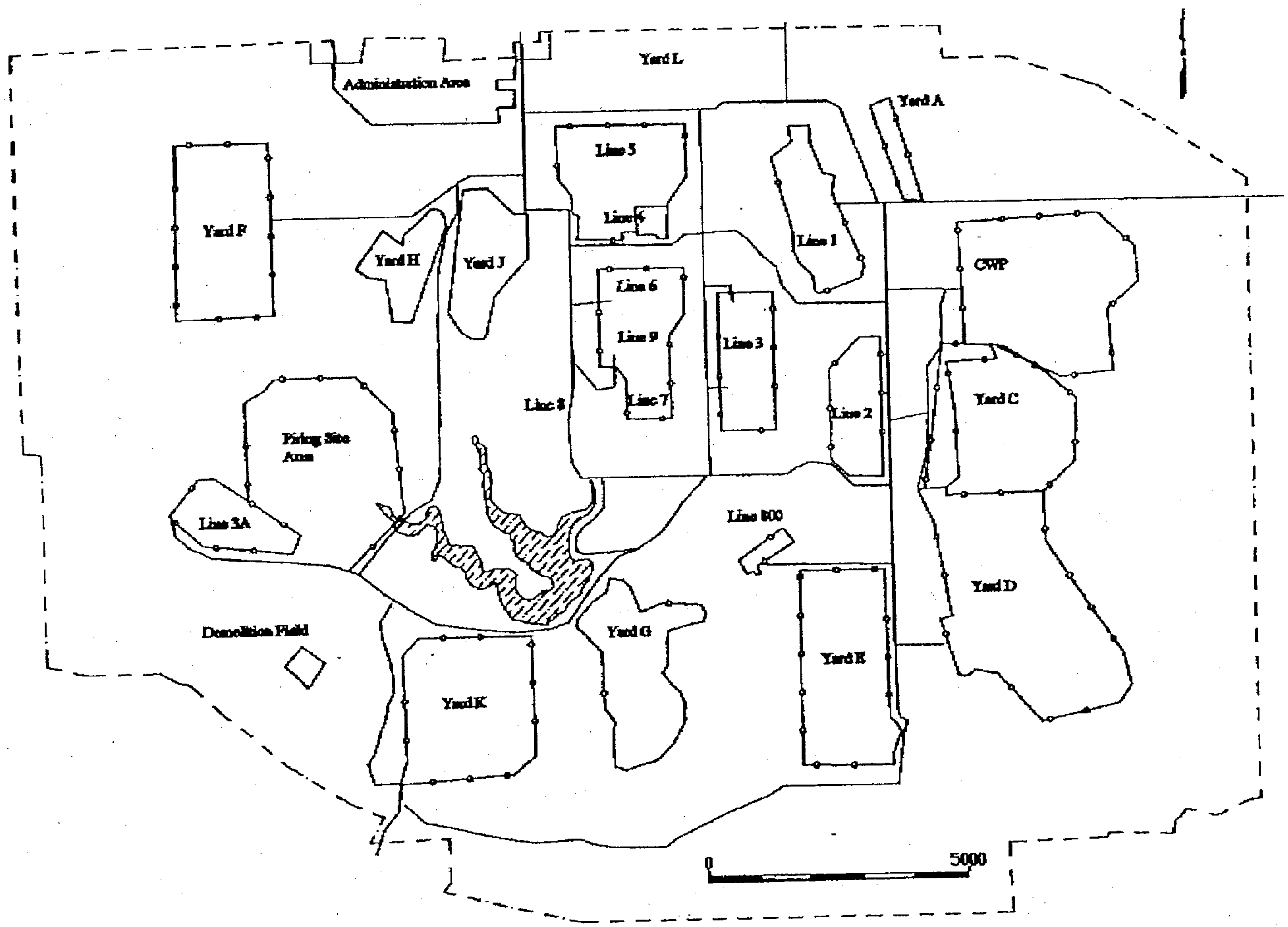

Fig. 2. Map of IAAAP showing Line 1 and C Yard.

Fig. 2. Map of IAAAP showing Line 1 and C Yard.

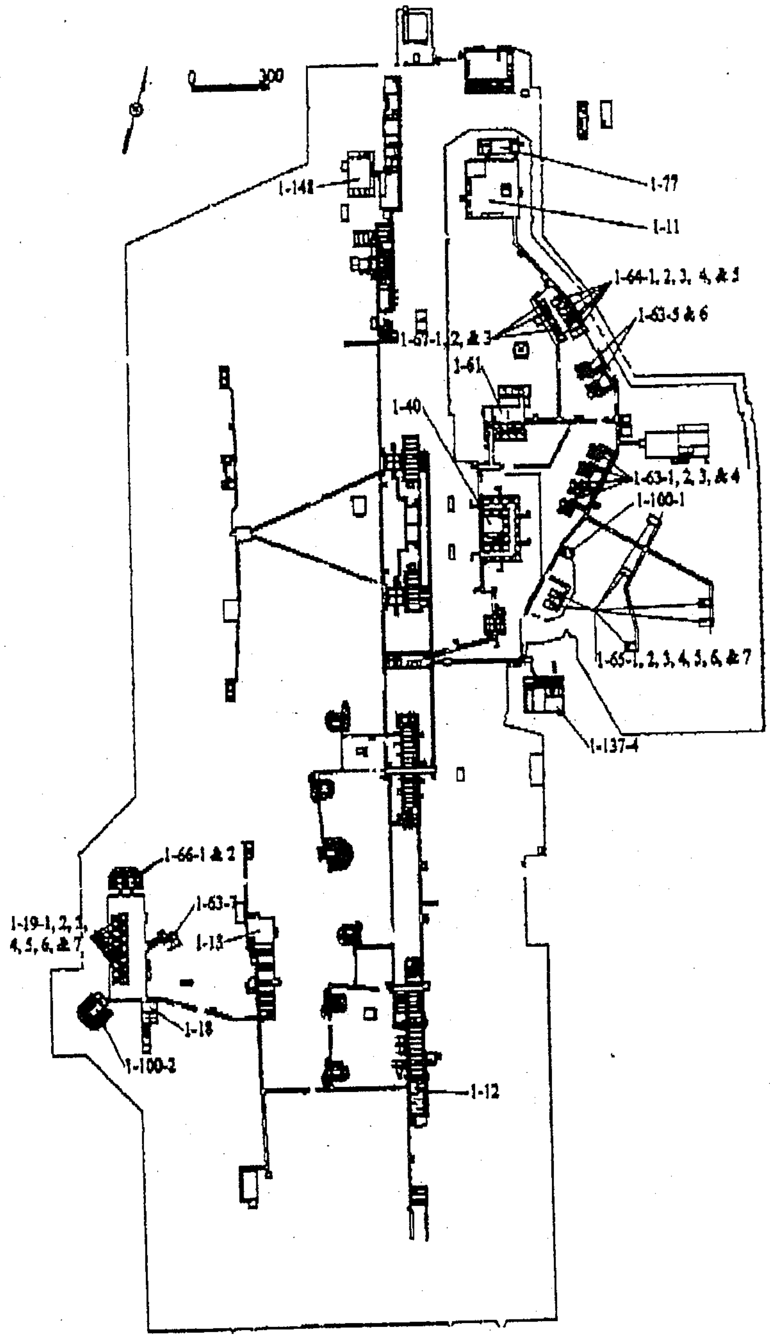

Fig. 3. Diagram showing surveyed buildings at Line 1, IAAAP.

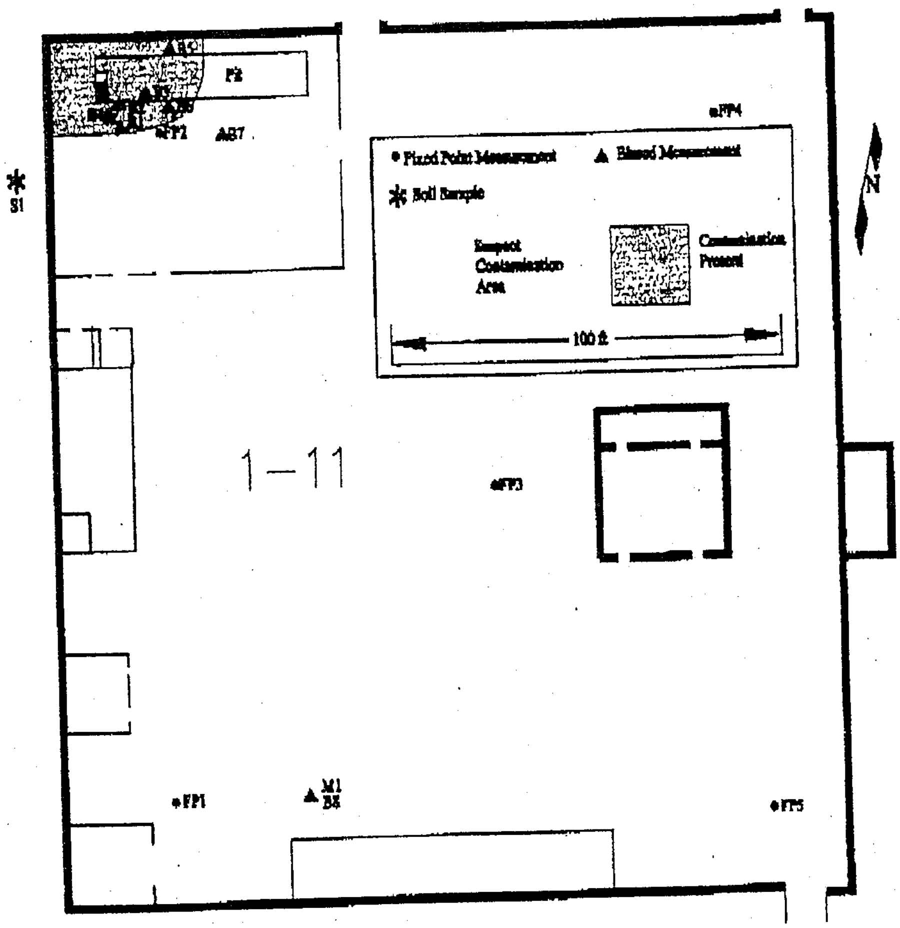

Fig. 4. Diagram of Building 1-11 showing results of radiation survey and a view of sample collection.

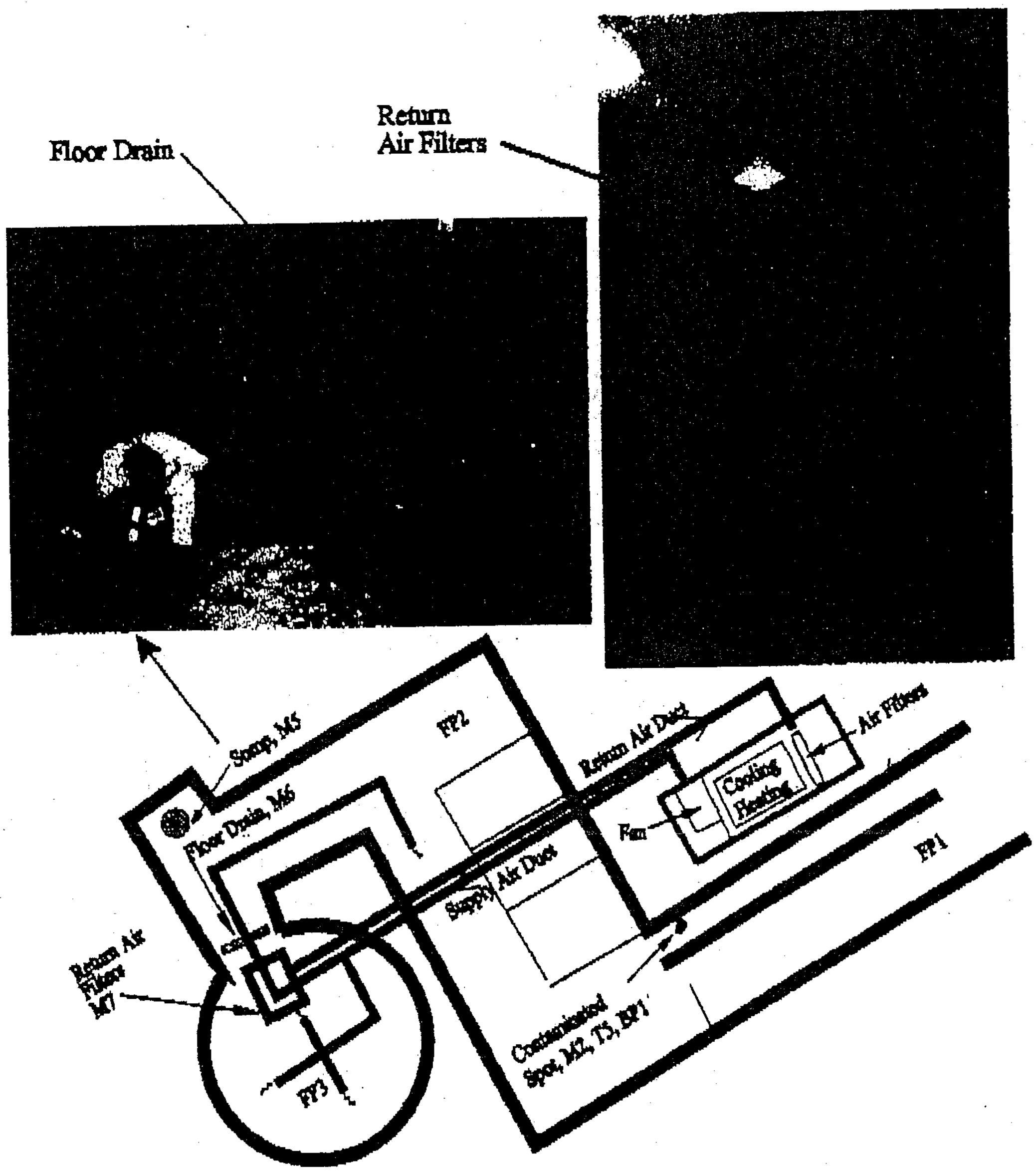

Fig. 5. Diagram of Building 1-63-6 showing results of radiation survey and views of return air filters and sample collection.

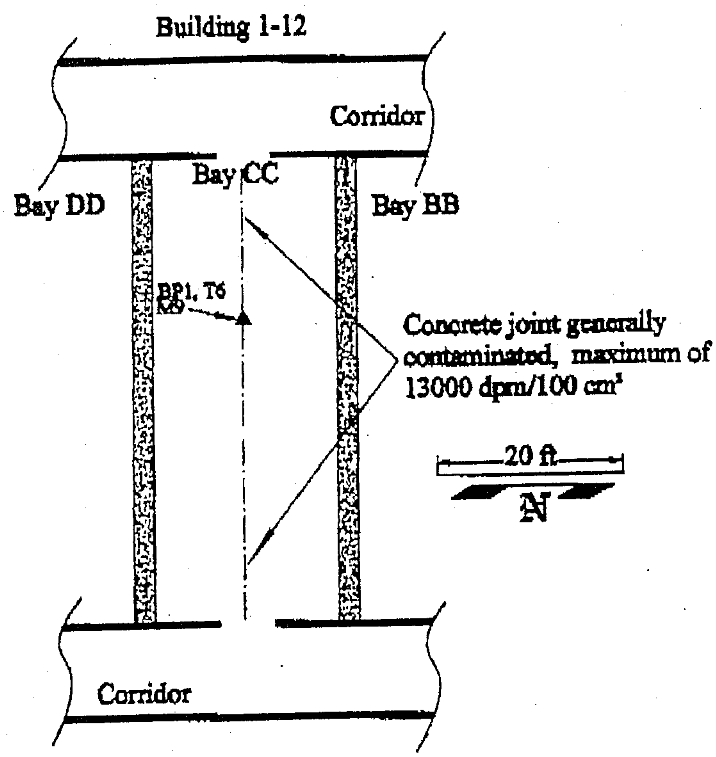

Fig. 6. Diagram of Building 1-12 showing results of radiation survey.

Project file

DEPARTMENT OF ENERGY/ALBUQUERQUE OPERATIONS
ENVIRONMENTAL RESTORATION DIVISION

Total Pages (Including Cover) 40

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