RADIOLOGICAL SCOPING SURVEY OF THE HAMMOND DEPOT, HAMMOND, INDIANA

T.J. Vitkus

Prepared for the
Defense National Stockpile Center
Defense Logistics Agency

ORISE
OAK RIDGE INSTITUTE FOR SCIENCE AND EDUCATION
Environmental Survey and Site Assessment Program

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ABBREVIATIONS AND ACRONYMS

ε_i	instrument efficiency
ε_s	surface efficiency
ε_{total}	total efficiency
b_i	number of background counts in the interval
AEC	Atomic Energy Commission
BKG	background
cm	centimeter
cm^2	square centimeter
cpm	counts per minute
d'	index of sensitivity
DCGL	derived concentration guideline level
DLA	Defense Logistics Agency
DNSC	Defense National Stockpile Center
DOE	U.S. Department of Energy
dpm/100 cm^2	disintegrations per minute per 100 square centimeters
ESSAP	Environmental Survey and Site Assessment Program
GSA	General Services Administration
HSA	historical site assessment
ITP	Intercomparison Testing Program
MAPEP	Mixed Analyte Performance Evaluation Program
MDC	minimum detectable concentration
MDCR	minimum detectable count rate
MeV	million electron volts
mg/cm^2	milligram per square centimeter
min	minute
mm	millimeter
NaI	sodium iodide
NIST	National Institute of Standards and Technology
NRC	U.S. Nuclear Regulatory Commission
NRIP	NIST Radiochemistry Intercomparison Program
ORISE	Oak Ridge Institute for Science and Education
pCi/g	picocuries per gram
s	second
TAP	total absorption peak
ThN	thorium nitrate

RADIOLOGICAL SCOPING SURVEY OF THE HAMMOND DEPOT HAMMOND, INDIANA

INTRODUCTION AND SITE HISTORY

In 1946, a National Stockpile program began with the goal of mitigating dependence on foreign sources of vital materials during times of national emergencies. The Hammond Depot in Hammond, Indiana was established as part of this program in 1948. The land area for the Hammond Depot originally consisted of approximately 130.5 acres of land leased from the Indiana Harbor Belt Railroad Company on June 24, 1948. On June 27, 1969 the General Services Administration (GSA) purchased the entire site. The original site had eight warehouses and 80 above ground storage tanks. GSA sold portions of the property, including three warehouses, during the 1970s. The current site consists of 57.3 acres.

The Defense National Stockpile Center (DNSC) used the Hammond Depot to store strategic materials (bulk ores, minerals, and metals). Materials stored in outdoor piles either on the ground or on pads were chrome, ferrochrome, ferromanganese, lead, tin, and others.

Beginning in approximately 1958, additional stored materials included monazite sand comprised of 2.4 to 3.4% thorium dioxide (ThO_2) and bastnesite with 0.01 to 0.11% of ThO_2. Storage of thorium nitrate (reactor grade consisting of 46.0 to 47.15% by weight of ThO_2) began in 1962, followed by sodium sulfate, tantalum pentoxide, and columbium tantalum minerals in the 1980s. These latter materials contained from <0.001 to 0.053% and 0.012 to 0.156% by weight ThO_2 and uranium oxide, respectively. All of these materials were contained in fiber and steel drums and stored in warehouses. Some materials contained radioactive material at concentrations that required a U.S. Atomic Energy Commission (AEC)—predecessor to the U.S. Nuclear Regulatory Commission (NRC)—source material license (License STC-133).

The DNSC of the Defense Logistics Agency (DLA) is now in the process of closing out many of its depots across the country and seeking to terminate its NRC license for those facilities. The initial phase of the cleanup activities has been initiated as the DNSC has removed the remaining source material that has been stored within two of the current site warehouses. Other warehouses

(Warehouses 1, 2, and 3) where source or other materials were stored, were emptied and remediated and surveyed, if contaminated, in the early 1970s. These warehouses were then sold as excess property. In conjunction with site cleanup, at the request of the DLA, the Environmental Survey and Site Assessment Program (ESSAP) of the Oak Ridge Institute for Science and Education (ORISE) performed a historical site assessment (HSA) of the Hammond Depot in order to plan for future site investigations and eventual remediation activities (ORISE 2005a). Additionally, ESSAP has been tasked to conduct scoping surveys of the site to validate the results of the HSA and to provide information for the complete site characterization survey.

SITE DESCRIPTION

The Hammond Depot site is located on the west side of Hammond, Indiana on Sheffield Avenue—about 500 feet east of the Indiana-Illinois state line. The property currently consists of approximately 57 acres with ten structures, mostly in good condition, including the three current warehouses used to store raw materials (Figure 1). The depot is bounded on the east and southeast by the Indiana Harbor Belt railway, the Wolf Lake Industrial Center access road on the east, the Wolf Lake industrial/commercial complex on the north, Wolf Lake on the northern one-third of the western property boundary, and a drainage ditch on the west and southwest property boundary. A security fence encloses the facility. A number of road and railroad tracks provide access on the site. Drainage ditches on site direct surface runoff water to Wolf Lake.

The three current site warehouses are located in the central area of the site and are designated as Buildings 100W, 100E, and 200E. The dimensions of the three warehouses are each 126 feet by 401 feet and are constructed of cinder block walls on a concrete slab floor with steel beams, columns, and roof joists. Building 200E is divided by a cinder block wall into a northern and southern half. The southern half has been used for radioactive material storage and also has an asphalt overlayment covering the building floor where remediation was previously conducted. Building 100W was used for radioactive material storage with no history of any previous remedial activities. Building 100E has no history of radioactive material storage. For storage purposes, the interior of each warehouse was subdivided into 20 bay areas.

OBJECTIVES

The objectives of the radiological scoping survey were to collect adequate field data for use in evaluating the radiological condition of Hammond Depot land areas and warehouses. The data generated are used to validate the results of the HSA regarding classification of areas by radiological contamination potential, validate the radiological contaminants of concern (thorium and uranium or thorium only), determine whether contamination present warrants further evaluation, provide site reconnaissance for site-specific derived concentration guideline level (DCGL) modeling inputs, and provide input information for the development of a complete site characterization plan.

DOCUMENT REVIEW

ESSAP reviewed the HSA during the preparation of the scoping survey plans employed at the site.

PROCEDURES

A survey team from ESSAP visited the Hammond Depot and performed visual inspections, and measurement and sampling activities. Scoping survey activities were conducted in accordance with a site-specific survey plan and with the ORISE/ESSAP Survey Procedures and Quality Assurance Manuals (ORISE 2004 and 2005b and c). Because the warehouses continue to be used for storage, the accessible area available for survey was in some cases less than the proposed percent of each building area discussed below. Therefore, the proposed coverage was modified accordingly.

ESSAP divided the Hammond Depot site into three categories, based on contamination potential, as either Class 1, 2, or 3. A description of each is as follows:

Class 1: Buildings or land areas that have a significant potential for radioactive contamination (based on site operating history) or known contamination (based on previous radiological surveys) that exceeds the expected $DCGL_W$.

Class 2: Buildings or land areas, often contiguous to Class 1 areas, that have a potential for radioactive contamination.

Class 3: Remaining buildings and land areas that are expected to contain little or no residual contamination based on site operating history or previous radiological surveys.

Figure 2 illustrates the site area classifications.

BUILDING SURVEY PROCEDURES: CLASS 1

The following survey procedures were applicable to Class 1 warehouse areas. Specifically, this classification applied to Bays 8 through 18 in Building 100W and Bays 1 through 10 (southern half) of Building 200E. Any additional structures where residual surface contamination was detected during the course of the survey were also surveyed in this manner. Figure 2 illustrates the Class 1 structures.

Reference System

ESSAP prepared to-scale drawings and used a laser tape measure to reference measurement and sampling locations in meters from the southwest corner of each building area. Areas of residual contamination were referenced to the southwest corner and plotted on site drawings. Measurements and samples collected on upper surfaces were referenced to prominent building features and/or to the southwest corner.

Surface Scans

Floors and lower walls were scanned for both alpha plus beta and gamma radiation in the Class 1 portion of Building 100W and for gamma only—due to the asphalt overlayment—of the Building 200E floor. Because the objective of the scoping survey was to validate the results of the HSA and obtain data for the general radiation levels for future characterization survey planning, the scanning percent coverage of surfaces was variable. However, the minimum surface scan coverage was 25% of accessible surfaces. Lower walls were also scanned, with scanning systematically performed over 25% of the lower wall surfaces. Scans of accessible upper surfaces concentrated on horizontal surfaces where material may have accumulated. Up to nine upper surface locations were judgmentally selected for scanning in Class 1 building areas with a minimum area scanned of 1 m^2 at each selected location.

Additional areas were scanned, as necessary to delineate contamination boundaries, when residual contamination was detected. Particular attention was given to cracks and joints in the floor and walls, ledges, and other horizontal surfaces where material may have accumulated. Scans were performed using NaI scintillation detectors for direct gamma radiation and gas proportional detectors for direct alpha plus beta radiation, coupled to ratemeters or ratemeter-scalers with audible indicators. Locations of elevated direct radiation were marked for further investigation. Identification of areas requiring additional investigation was based on instrument count rate action levels established at the site.

Surface Activity Measurements

Initially, construction material-specific backgrounds were determined in areas of similar construction but without a history of radioactive material use. Direct measurements to quantify total beta activity levels, with supplementary measurements of total alpha activity, were performed within areas of residual contamination identified by surface scans and also at 14 random start/systematic locations in the Class 1 area of Building 100W and at 10 randomly selected locations beneath the asphalt overlayment in the southern half of Building 200E. For the Building 200E floor measurement locations, a jackhammer was used to separate an approximately 150 cm^2 area of the asphalt thereby exposing the underlying, original concrete surface. There were seven judgmental measurements made on the lower walls of the southern half of Building 200E. On upper surfaces, direct measurements were performed within each of the areas that were selected for judgmental scanning—nine locations in Building 200E and five locations in the Class 1 portion of Building 100W. Direct measurements were made using gas proportional detectors coupled to ratemeter-scalers. A smear sample, to determine removable gross alpha and gross beta activity levels, was collected from each direct measurement location. Figures 3 and 4 show measurement and smear sampling locations.

BUILDING SURVEY PROCEDURES: CLASS 2

The following procedures were used for the survey of Class 2 warehouse areas. Specifically, these areas were Bays 1 through 7, small portions of 8 through 18, 19, and 20 in Building 100W and Bays 11 through 20 in Building 200E.

Reference Grid

Class 2 areas were not gridded. Measurements and samples collected in Class 2 areas were referenced to either the southwest corner of the building or prominent features and then documented on site drawings.

Surface Scans

Floors and lower walls were scanned for alpha plus beta and gamma radiation. Twenty-five to 50% of accessible surfaces were systematically scanned. Results of these scans as the survey progressed also resulted in the identification of additional areas for judgmental scanning. Upper walls, ceilings, and overhead structures were scanned with emphasis on horizontal surfaces where residual contamination may have settled and accumulated at the same general frequency as described above for Class 1 structures. Scans were performed using NaI scintillation detectors for direct gamma radiation and gas proportional detectors for alpha plus beta radiation, coupled to ratemeters or ratemeter-scalers with audible indicators. Locations of elevated direct radiation were marked for further investigation and reevaluation of the structure to determine the need for area reclassification.

Surface Activity Measurements

Direct measurements of total beta surface activity were made at 50 random start/systematic locations on the floor and lower walls of the north half of Building 200E, at two judgmental locations on the lower walls, and at 10 random upper wall/ceiling locations. In Building 100W, the area outside of the former ThN storage bays was divided into two survey units along the north/south centerline. Fourteen random start/systematic direct measurements were made on the floors and lower walls in each area and six and five overhead measurements were made in the north and south sides, respectively. Measurements were made using gas proportional detectors coupled to ratemeter-scalers. A smear sample, to determine removable gross alpha and gross beta activity levels, was collected from each direct measurement location. Figures 3 and 4 show measurement and smear sampling locations.

BUILDING SURVEY PROCEDURES: CLASS 3

The following procedures were used for the survey of Building 100E.

Reference Grid

Measurements and samples collected were referenced to prominent building features and documented on site drawings.

Surface Scans

Floors and lower walls were judgmentally scanned for alpha plus beta and gamma radiation. Up to 25% of the accessible floor surfaces were scanned for direct gamma and alpha plus beta radiation. Scans were performed using NaI scintillation detectors for direct gamma radiation and gas proportional detectors for direct alpha plus beta radiation, coupled to ratemeters or ratemeter-scalers with audible indicators. Locations of elevated direct radiation distinguishable from background were marked for further investigation.

Surface Activity Measurements

Direct measurements were made at 14 floor and lower wall locations within Building 100E at randomly generated locations. Additional measurements were made at four overhead locations and one elevated radiation investigation location. Figure 5 shows measurement locations. Measurements were made using gas proportional detectors coupled to ratemeter-scalers. A smear sample for determining removable surface activity levels was collected from each direct measurement location.

Exterior Survey Procedures: Class 1

There were no Class 1 land areas identified during the HSA.

Exterior Survey Procedures: Class 2

The following survey procedures were applicable to accessible, exterior land areas identified in the HSA as Class 2 (Figure 2). Specifically, this included the perimeters of the warehouses, roadways and current and former railroad lines that cross the site, and the burn cage area.

Reference System

ESSAP referenced survey results to prominent site features and recorded the results on site maps.

Surface Scans

Scans for gamma radiation were performed judgmentally around the warehouse perimeters, along center lines and edges of roadways and railroad lines, and at judgmental locations of remaining Class 2 land areas. Scans were performed using NaI scintillation detectors coupled to ratemeters with audible indicators. Locations of elevated direct gamma radiation were marked for further investigation.

Soil Sampling

Surface (0 to 15 cm) soil samples were collected from 10 judgmental locations where direct gamma radiation levels were detected above background. One subsurface sample was collected from one surface sampling location within the former burn cage area. Figure 6 shows sampling locations.

Exterior Survey Procedures: Class 3

The remaining portions of the site that were not designated as Class 2 per the HSA and illustrated in Figure 2, were considered as Class 3 areas.

Reference System

ESSAP referenced survey results to prominent site features and recorded results on site maps.

Surface Scans

Gamma surface scans were performed judgmentally around these land areas using NaI scintillation detectors. Scans concentrated on areas such as surface drainage paths, near transport routes, and other judgmental areas determined at the time of the scoping survey.

Soil Sampling

Surface soil samples were collected from three locations judgmentally selected based on surface scan results.

SAMPLE ANALYSIS AND DATA INTERPRETATION

Samples and data were returned to the ORISE/ESSAP laboratory in Oak Ridge, Tennessee for analysis and interpretation. Sample analyses were performed in accordance with the ORISE/ESSAP Laboratory Procedures Manual (ORISE 2005d). Smear samples were analyzed using a low-background proportional counter. Smear sample and direct measurement results were reported in units of disintegrations per minute per one-hundred square centimeters (dpm/100 cm^2). Soil samples were analyzed by gamma spectroscopy for thorium and uranium and the results reported in units of picocuries per gram (pCi/g).

Site-specific DCGLs for building surfaces and soils had not been developed at the time of the scoping survey. However, preliminary DCGL modeling using default parameters provided in the RESRAD and RESRAD-BUILD computer codes had been performed. The scoping survey thorium surface activity and Th-232 soil sample results were compared with a resultant action level of 350 dpm/100 cm^2 for surface activity and 2 pCi/g for Th-232 in soil.

FINDINGS AND RESULTS

BUILDING SURFACE SCANS

Surface scans for specific areas of Buildings 100E, 200E, and 100W are described below under the respective survey classification sections.

Class 1 Areas

Gamma scans of the asphalt overlayment covering the floor of Bays 1 through 10 in Building 200E identified numerous areas of elevated direct gamma radiation over primarily the western half of the area. Investigations that consisted of removing the asphalt overlayment to expose the original floor surface determined that the contamination was predominantly associated with floor cracks and expansion joints; although contamination was also present on the ordinary concrete floor.

Alpha plus beta scans of the Class 1 floor area in Building 100W were affected by the increased ambient gamma background associated with the stored drums of tungsten and aluminum oxide. However, one location of elevated alpha plus beta activity was confirmed in the southwest quadrant of the survey area.

Class 2 Areas

Surface scans of Bays 11 through 20 in Building 200E identified elevated gamma activity associated with the northwest corner wall. Further investigation identified the presence of three small jars of unknown source material—assumed by DLA personnel to be ThN—within a locker room closet located on the opposite side of the wall. Scans of Bays 1 through 7, those portions of Bays 8 through 18 outside of the former ThN storage area, and Bays 19 and 20 of Building 100W did not identify any elevated direct gamma or alpha plus beta radiation with the exception of elevated gamma radiation in the vicinity of the stored materials.

Class 3 Areas

Surface scans of Building 100E identified elevated direct gamma radiation on several pallets stored in the north end of the building. Investigations noted that the elevated radiation levels were associated with a distinct stain on a number of pallets that was likely from ThN leaks. In addition, an open drum was also noted with elevated gamma radiation. The drum was stored near the central part of the building. It is believed that the elevated radiation levels may have been the result of the presence of tungsten material within the drum.

SURFACE ACTIVITY LEVELS

Surface activity levels are provided in Table 1 and are summarized below for each building according to classification.

Class 1 Areas

Total and removable beta activity ranges are summarized in the table below. Individual measurement location results are provided in Table 1.

Area	Total Activity Range (dpm/100 cm^2)		Removable Activity Range (dpm/100 cm^2)	
	Alpha	Beta	Alpha	Beta
Building 200E South Side, Bays 1 through 10	-15 to 19,000	-190 to 100,000	0 to 26	-5 to 15
Building 100W Bays 8 through 18 (ThN storage area)	---[a]	21 to 3,100	0 to 3	-2 to 15

[a]Measurements not performed.

These results clearly show the presence of ThN contamination on the floors and to a lesser extent on the overheads of the southern half of Building 200E. One measurement location within the former ThN storage area of Building 100W had elevated activity present and three locations were identified as suspect elevated, but may only be a result of ambient gamma radiation interference.

Class 2 Areas

Total and removable beta activity ranges are summarized in the table below. Individual measurement location results are provided in Table 1.

Area	Total Activity Range ($dpm/100\ cm^2$)		Removable Activity Range ($dpm/100\ cm^2$)	
	Alpha	Beta	Alpha	Beta
Building 200E North Side, Bays 11 through 20	---[a]	-340 to 13,000	0 to 7	-4 to 20
Building 100W Bays 1 through 20 (excludes ThN storage area)	---	-290 to 380	0 to 3	-5 to 19

[a]Measurements not performed.

The results shown above and in Table 1 indicate one location with contamination. However, this measurement location was on the wall on the opposite side of where the small jars of source material were later discovered. The maximum beta activity measurement in Building 200E on the north side, once this location is removed from the data set, was 210 $dpm/100\ cm^2$.

Class 3 Areas

Total and removable beta activity ranges for Building 100E are summarized in the table below. Individual measurement location results are provided in Table 1.

Area	Total Activity Range ($dpm/100\ cm^2$)		Removable Activity Range ($dpm/100\ cm^2$)	
	Alpha	Beta	Alpha	Beta
Building 100E	0 to 4,900	-310 to 26,000	0 to 89	-4 to 35

The results shown above and in Table 1 indicate one location with contamination. However, this measurement was taken on the contaminated pallets that were identified in the north end of the building. The maximum beta activity measurement in Building 100E, once this location is removed from the data set, was 250 dpm/100 cm^2.

EXTERIOR SURFACE SCANS

Surface scan results for exterior areas are described below under the respective survey classification sections.

Class 2 Areas

Surface scans in the vicinity of the warehouses, the former burn cage area, and along roadways and railroads identified gamma radiation levels that ranged from 4 to 20 times the background levels that were adjacent to the exterior west wall of Building 200E and in the area of the burn cage. The results of the field investigations conducted at these locations are provided in the Discussion of Results section below. Several other less distinct locations were marked along roads and railroad tracks. These locations represented the maximum observed gamma radiation levels that were considered distinguishable from background.

Class 3 Areas

Surface scans of the remaining land areas did not identify any distinct areas of elevated direct gamma radiation. There were three locations—determined to be the maximum levels of direct gamma radiation observed—that were marked for sampling.

RADIONUCLIDE CONCENTRATIONS IN SOIL SAMPLES

The concentrations of Th-232 and U-238 for individual soil samples are provided in Table 2. The table below provides a summary of the range of activities.

Area	Radionuclide Concentration (pCi/g)	
	Th-232	U-238
Class 2 Samples	0.96 to 2.47	1.44 to 4.20
Class 3 Samples	0.84 to 1.20	1.34 to 2.89

DISCUSSION OF RESULTS

The contaminant of concern for the Hammond Depot is primarily thorium with the potential for lesser quantities of uranium. The results of the scoping survey identified extensive contamination on the floors of the south end of Building 200E where containers of ThN were stored and known to have leaked. The contamination was on the original concrete floor of the building, beneath the asphalt overlayment. However, it was determined during investigations that pieces of asphalt that were removed to gain access to the concrete floor had elevated levels of contamination that had been transferred to and adhered to the underside of the overlayment. Of particular interest was that only one of the random measurement locations (20A) had activity (520 dpm/100 cm^2) in excess of the 350 dpm/100 cm^2 action level that was established for the site in lieu of a site-specific DCGL. All other non-random locations selected for direct measurements were identified by gamma scans. As noted earlier, most of these elevated locations were associated with floor cracks and expansion joints. One lower wall location (24A) exceeded the 350 dpm/100 cm^2 action level and may have been the result of elevated ambient gamma radiation levels from the stored materials. Elevated activity levels were also noted on the horizontal overhead I-beam surfaces at the north end of this area (locations 37A through 39A). Figure 3 provides color-coded activity levels that provide a visual indication of the general contamination distribution. The area is recommended for further characterization surveys of floors and overheads and reinvestigation of portions of the lower walls once the drums of tungsten are removed. The survey should also include sub-slab soil investigations to determine if contamination may have migrated through expansion joints.

One area of elevated direct radiation was identified on a northwest wall of the north half of Building 200E. Investigations determined that the activity noted was a result of gamma radiation penetrating the wall from the jars of source material stored on the opposite side. The rooms where these jars were found, consisting of storage rooms and locker areas, could not be adequately surveyed to determine if the material was contained to the jars or had potentially spread (one jar was noted to be leaking) due to the high gamma levels encountered. All remaining activity levels in the north half of Building 200E did not indicate the presence of any contamination and supported the Class 2 designation. Future characterization surveys at the site should include an evaluation of the storage/locker room area.

The survey of Building 100E identified contaminated pallets stored on the north end and a drum with elevated activity. There were no indications of contamination on the building surfaces which in general supported the Class 3 designation, excluding now the north end. Once the pallets have been surveyed and removed, a survey of the pallet storage area is recommended.

The Building 100W scoping survey results overall supported the initial classification of the structure. One area of elevated beta activity was identified within the former ThN storage area. Three additional suspect areas were identified in the Class 1 area and two were identified in the northern Class 2 survey area. Removal of the tungsten and aluminum oxide stored in the area is recommended, to eliminate the interfering gamma radiation emitted by these materials, followed by a thorough survey.

The exterior field investigations performed, coupled with the analytical results for soil samples, determined the following information. The elevated gamma radiation noted adjacent to the exterior west wall of Building 200E was not due to the presence of contaminated soil. Rather, the radiation levels noted were the result of high levels of gamma emitting contamination noted at the corresponding interior floor/wall interface. Within the former burn cage area, sample analyses indicated slightly elevated concentrations of Th-232 and U-238. However, it is believed, based on gamma readings obtained from the sample holes, that contamination may be present beneath the initial 15 to 30 cm of soil that was sampled. Therefore, the possibility of subsurface contamination should be investigated further within the burn cage area during future characterization surveys. Elevated U-238 concentrations, relative to expected background concentrations, were also noted in most samples where railroad ballast or industrial slag was present. Confirmation that the U-238 activity levels noted are the result of these materials and not from licensed activities is also recommended during future characterization activities. These actions will be necessary before a final determination can be made as to whether uranium is a contaminant of concern.

SUMMARY

At the request of the Defense Logistics Agency, the Environmental Survey and Site Assessment Program of the Oak Ridge Institute for Science and Education conducted radiological scoping surveys of the Hammond Depot during the period September 12 to 16, 2005. The scoping survey included visual inspections and limited radiological surveys performed in accordance with area classification that included surface scans, total and removable activity measurements, and soil sampling.

The results of the scoping survey overall validated the initial findings reported in the historical site assessment. Extensive contamination was confirmed beneath the asphalt overlayment in the Class 1 portion of Building 200E and isolated contamination was noted in the Class 1 area of Building 100W. Two unexpected findings were noted, the contaminated pallets that were identified in Building 100E (a Class 3 structure) and the jars of source material found in the northwest corner storage room of the Class 2 section of Building 200E. Low-level concentrations of Th-232 that were approximately twice background were identified in soil samples from the burn cage area, although additional subsurface contamination may be present.

Recommendations for further site characterization include extensive surveys of the southern portion of Building 200E, the northwest corner room of Building 200E, the former ThN storage area in Building 100W, the floor of the pallet storage area in Building 100E, and subsurface investigations in the burn cage area. DNSC has initiated activities to prepare the site for complete characterization that includes removing the jars of source material and relocating stored materials to provide complete area access. The scoping survey building data were collected to fulfill the requirements for final status survey data quantity and quality for those building areas where no further action is required. The applicable data will be evaluated further once a site-specific DCGL is approved.

FIGURES

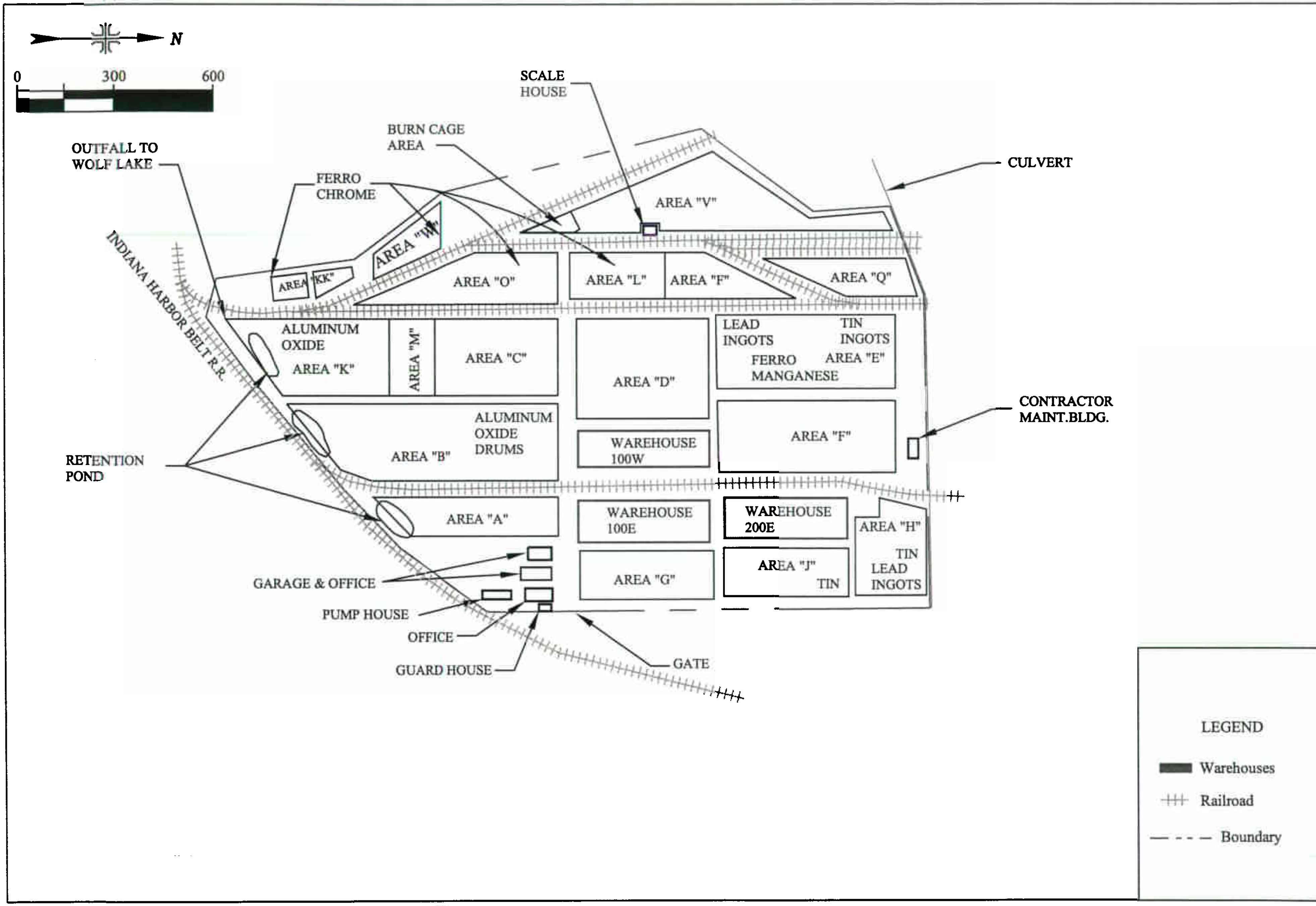

FIGURE 1: Hammond Depot, Hammond, Indiana - Plot Plan

432-002 (6)

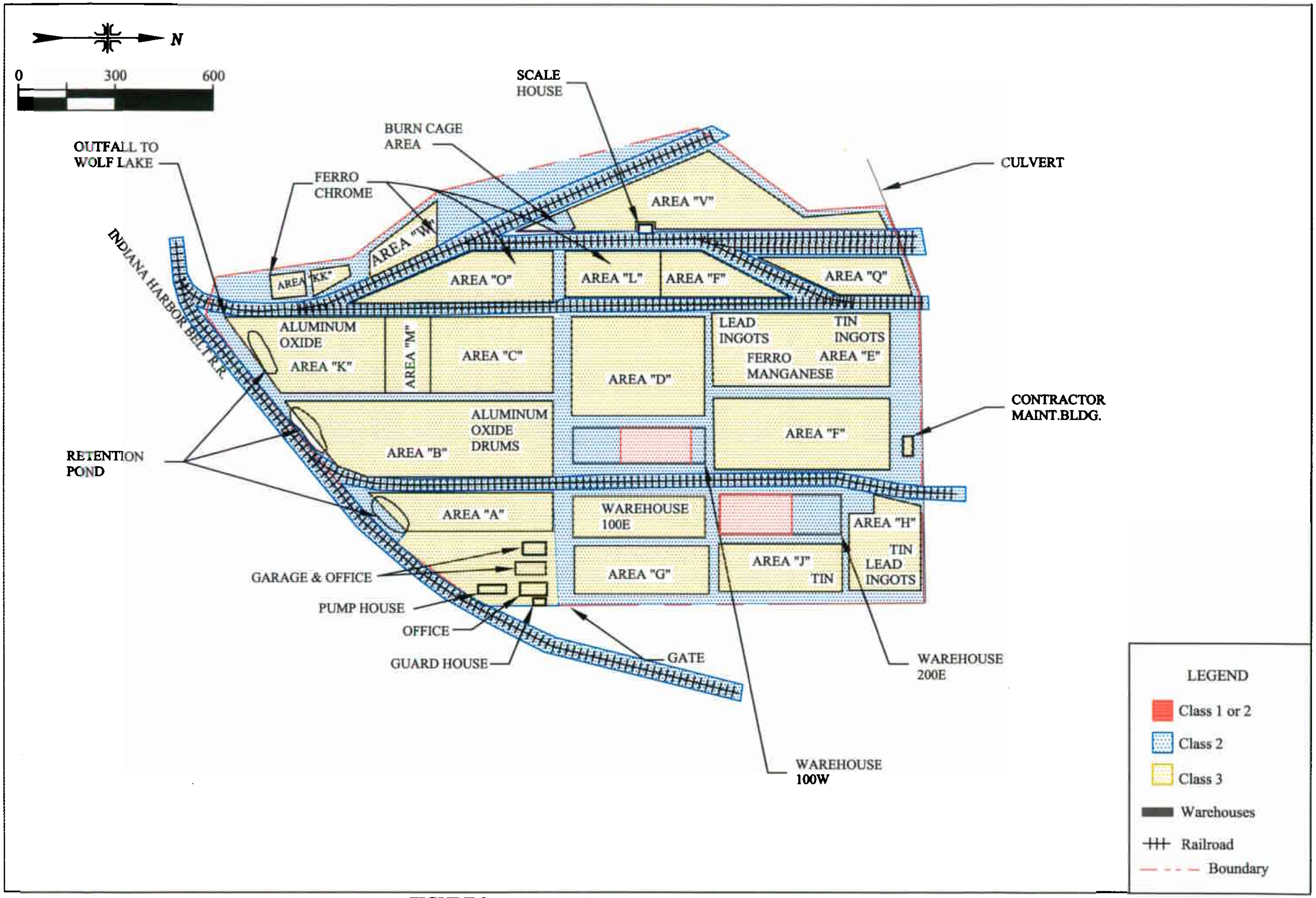

FIGURE 2: Hammond Depot - Conceptual Model

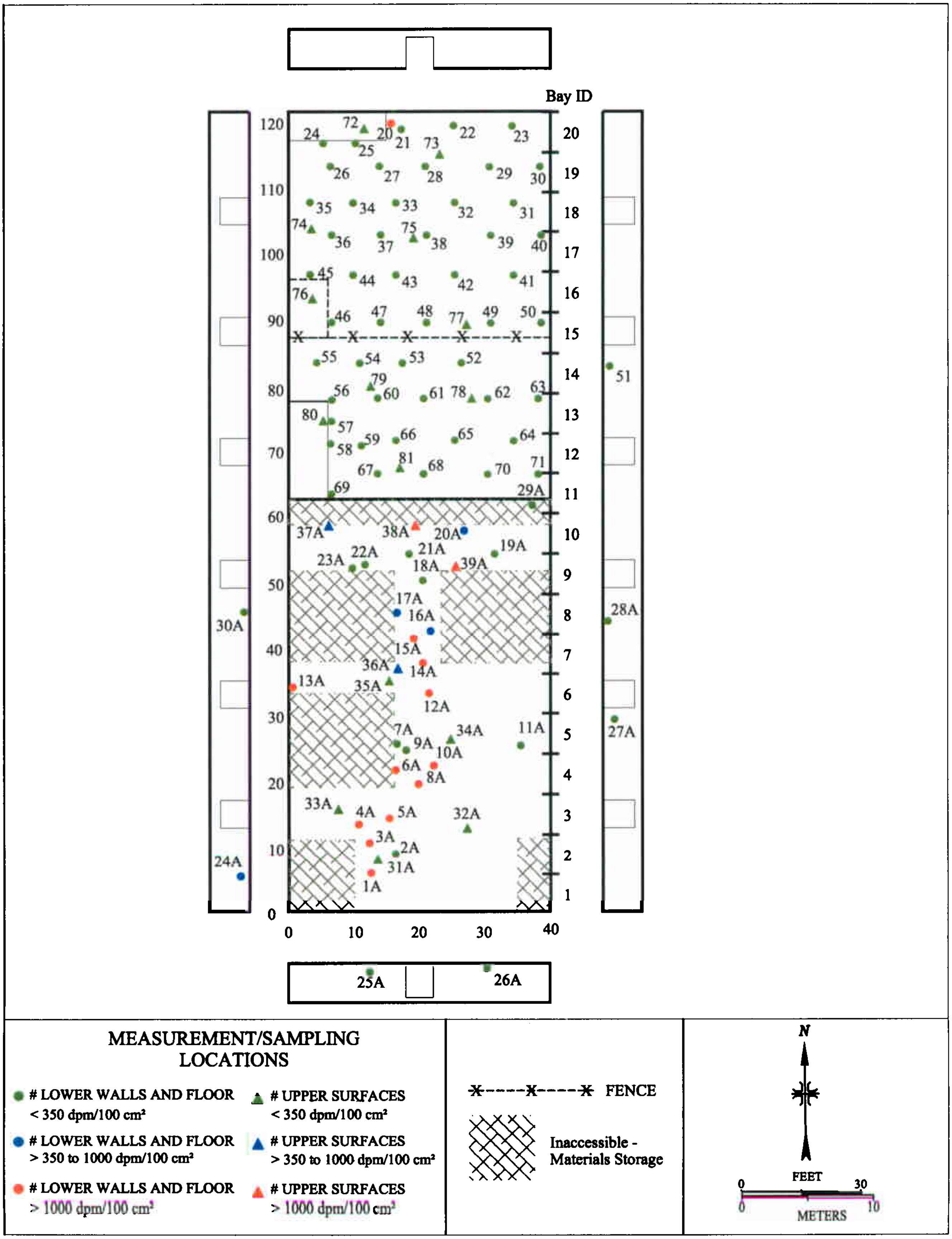

FIGURE 3: Building 200E - Direct Measurement and Sampling Locations

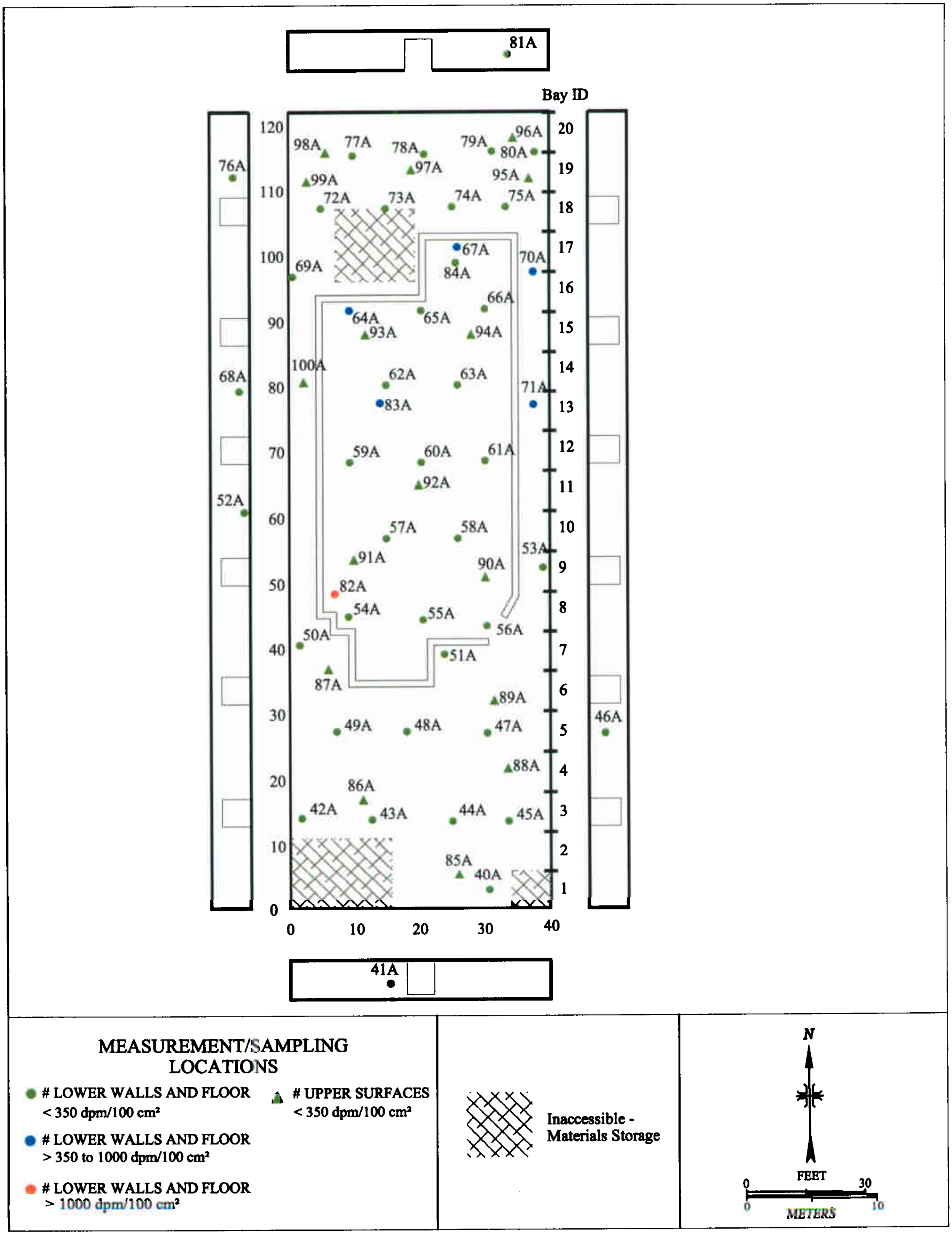

FIGURE 4: Building 100W - Direct Measurement and Sampling Locations

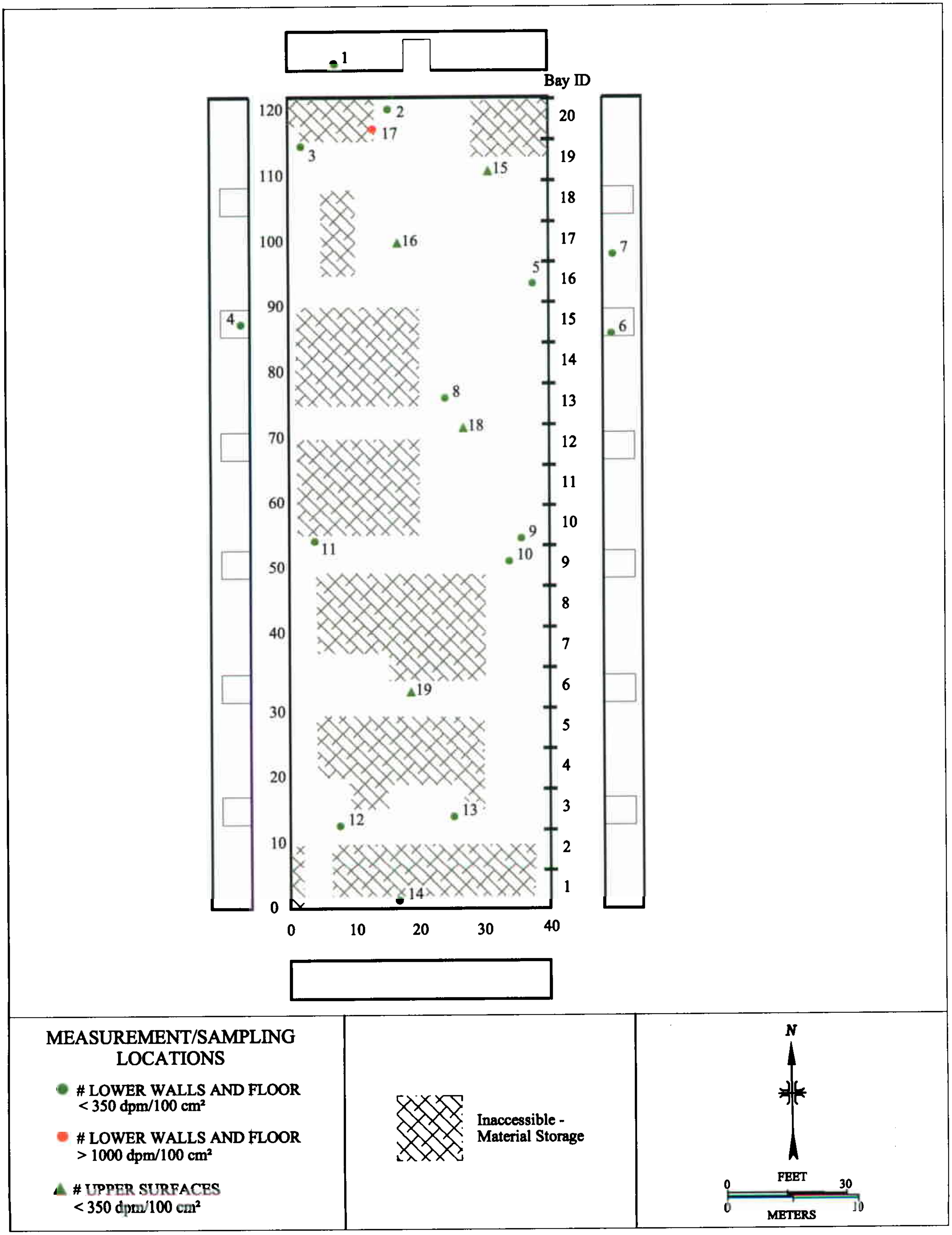

FIGURE 5: Building 100E - Direct Measurement and Sampling Locations

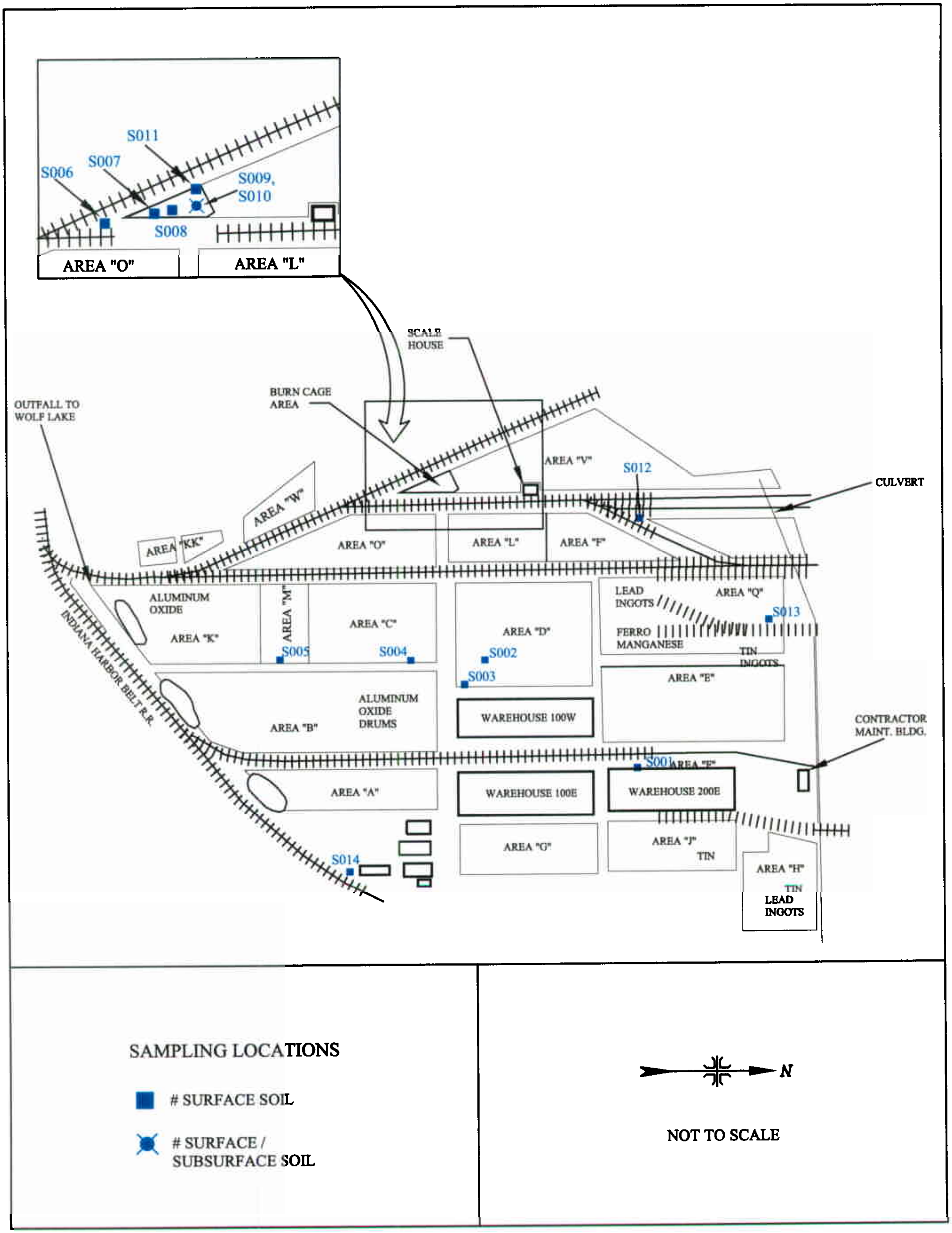

FIGURE 6: Hammond Depot, Hammond, Indiana - Sampling Locations

TABLES

TABLE 1

SURFACE ACTIVITY LEVELS
HAMMOND DEPOT
HAMMOND, INDIANA

Location (Smear No.)[a]	Surface[b]	Total Activity (dpm/100 cm^2)		Removable Activity (dpm/100 cm^2)	
		Alpha [c]	Beta	Alpha	Beta
Building 100E					
1	LW	10	-310	1	2
2	F	0	28	1	-2
3	F	0	250	0	4
4	LW	1	-52	0	4
5	F	10	65	1	-2
6	LW	0	16	0	-4
7	LW	3	140	0	1
8	F	4	62	0	-1
9	F	4	100	0	-2
10	F	9	-44	1	2
11	F	12	-58	5	-2
12	F	1	12	0	7
13	F	1	6	1	1
14	F	4	-30	0	3
15	US	6	81	0	10
16	US	0	110	1	-3
17	Pallets	4,900	26,000	89	35
18	US	0	-28	1	-1
19	US	--[c]	-65	0	3
Building 200E (North)					
20	LW	--	13,000	0	-2
21	F	--	26	0	3
22	F	--	4	1	3
23	F	--	-12	0	-2
24	LW	--	-120	0	-2
25	LW	--	65	1	1
26	F	--	22	0	-2
27	F	--	-16	0	1
28	F	--	-46	1	-1
29	F	--	-26	1	-2
30	F	--	-32	5	-2
31	F	--	38	1	-3
32	F	--	32	0	-2
33	F	--	-4	1	-3
34	F	--	42	0	1

TABLE 1 (Continued)

SURFACE ACTIVITY LEVELS
HAMMOND DEPOT
HAMMOND, INDIANA

Location (Smear No.)[a]	Surface[b]	Total Activity (dpm/100 cm^2)		Removable Activity (dpm/100 cm^2)	
		Alpha[c]	Beta	Alpha	Beta
Building 200E (North) (continued)					
35	F	--	-40	0	3
36	F	--	-81	0	-1
37	F	--	-89	7	9
38	F	--	71	0	2
39	F	--	-6	0	3
40	F	--	-20	1	-3
41	F	--	-38	0	-1
42	F	--	-48	1	3
43	F	--	-87	0	4
44	F	--	-20	0	-4
45	F	--	-24	0	-3
46	F	--	-77	0	-3
47	F	--	-16	0	2
48	F	--	-62	0	-1
49	F	--	-12	0	5
50	F	--	4	1	18
51	LW	--	-290	0	-2
52	F	--	-71	0	2
53	F	--	-22	5	-2
54	F	--	-2	1	8
55	F	--	2	1	5
56	LW	--	-340	1	-1
57	LW	--	200	0	2
58	F	--	-97	1	2
59	F	--	24	0	5
60	F	--	-87	0	5
61	F	--	-56	0	3
62	F	--	-52	1	2
63	F	--	67	0	20
64	F	--	-85	0	3
65	F	--	-91	1	1
66	F	--	60	0	2
67	F	--	200	3	-1
68	F	--	-16	0	1

TABLE 1 (Continued)

SURFACE ACTIVITY LEVELS
HAMMOND DEPOT
HAMMOND, INDIANA

Location (Smear No.)[a]	Surface[b]	Total Activity (dpm/100 cm^2)		Removable Activity (dpm/100 cm^2)	
		Alpha[c]	Beta	Alpha	Beta
Building 200E (North) (continued)					
69	LW	--	93	0	5
70	F	--	-6	0	-3
71	F	--	28	0	5
72	US	--	52	0	8
73	US	--	-34	3	2
74	US	--	65	0	2
75	US	--	4	0	3
76	US	--	-10	0	-2
77	US	--	-210	1	6
78	US	--	16	1	5
79	US	--	28	0	2
80	US	--	110	1	10
81	US	--	60	1	-1
Building 200E (South)					
1A	F	240	8,000	0	-2
2A	F	-15	16	0	-1
3A	F	180	3,700	3	-1
4A	F	19,000	100,000	26	12
5A	F	7,800	37,000	7	6
6A	F	8,400	53,000	3	2
7A	F	-3	32	1	-5
8A	F	3,300	6,300	5	3
9A	F	30	250	1	1
10A	F	67	4,400	0	1
11A	F	-3	69	0	4
12A	F	6,100	18,000	0	3
13A	F	5	24,000	1	-4
14A	F	2,800	22,000	18	4
15A	F	2,200	4,800	0	15
16A	F	7	600	0	1
17A	F	42	560	1	5
18A	F	-4	230	0	3
19A	F	12	170	3	-3
20A	F	-14	520	1	4

TABLE 1 (Continued)

SURFACE ACTIVITY LEVELS
HAMMOND DEPOT
HAMMOND, INDIANA

Location (Smear No.)[a]	Surface[b]	Total Activity (dpm/100 cm²)		Removable Activity (dpm/100 cm²)	
		Alpha[c]	Beta	Alpha	Beta
Building 200E (South) (continued)					
21A	F	5	200	0	-4
22A	F	0	79	7	1
23A	F	-4	100	1	4
24A	LW	--	430	3	-2
25A	LW	--	300	0	6
26A	LW	--	-190	1	3
27A	LW	--	140	0	4
28A	LW	--	230	1	4
29A	LW	--	130	0	4
30A	LW	--	120	5	-1
31A	US	--	100	0	5
32A	US	--	220	3	4
33A	US	--	-18	0	5
34A	US	--	200	1	4
35A	US	--	340	5	2
36A	US	--	420	5	-1
37A	US	--	440	5	7
38A	US	--	1,400	5	-2
39A	US	--	1,900	16	3
Building 100W					
Class 1 Survey Area					
54A	F	--	300	0	15
55A	F	--	21	1	4
56A	F	--	300	1	4
57A	F	--	52	0	6
58A	F	--	74	0	1
59A	F	--	250	1	1
60A	F	--	29	3	2
61A	F	--	85	3	2
62A	F	--	140	1	4
63A	F	--	54	0	14
64A	F	--	470	0	-1
65A	F	--	140	0	6
66A	F	--	190	0	8
67A	F	--	450	0	8

TABLE 1 (Continued)

SURFACE ACTIVITY LEVELS
HAMMOND DEPOT
HAMMOND, INDIANA

Location (Smear No.)[a]	Surface[b]	Total Activity (dpm/100 cm²)		Removable Activity (dpm/100 cm²)	
		Alpha [c]	Beta	Alpha	Beta
Building 100W (continued)					
Class 1 Survey Area					
82A	F	--	3,100	0	8
83A	F	--	370	3	1
84A	F	--	250	0	-2
90A	US	--	52	0	-1
91A	US	--	160	1	5
92A	US	--	66	1	3
93A	US	--	120	1	-1
94A	US	--	160	0	7
Class 2 Survey Area 1					
40A	F	--	-99	0	9
41A	LW	--	87	0	2
42A	F	--	-2	0	3
43A	F	--	-72	0	-2
44A	F	--	6	0	2
45A	F	--	14	0	1
46A	LW	--	190	1	-2
47A	F	--	35	3	-5
48A	F	--	52	1	1
49A	F	--	19	1	9
50A	F	--	110	1	10
51A	F	--	110	0	2
52A	LW	--	200	1	6
53A	F	--	6	0	-2
85A	US	--	-110	0	3
86A	US	--	37	0	6
87A	US	--	-91	0	2
88A	US	--	48	1	6
89A	US	--	15	0	-2
Class 2 Survey Area 2					
68A	LW	--	250	1	3
69A	F	--	120	0	-3
70A	F	--	380	1	-1
71A	F	--	350	0	-4

TABLE 1 (Continued)

SURFACE ACTIVITY LEVELS
HAMMOND DEPOT
HAMMOND, INDIANA

Location (Smear No.)[a]	Surface[b]	Total Activity (dpm/100 cm^2)		Removable Activity (dpm/100 cm^2)	
		Alpha[c]	Beta	Alpha	Beta
Building 100W (continued)					
Class 2 Survey Area 2 (continued)					
72A	F	--	31	3	3
73A	F	--	74	1	5
74A	F	--	170	0	1
75A	F	--	120	0	2
76A	LW	--	150	0	-2
77A	F	--	52	0	7
78A	F	--	8	0	4
79A	F	--	62	0	1
80A	F	--	17	1	-1
81A	LW	--	-290	0	2
95A	US	--	130	0	19
96A	US	--	-35	0	3
97A	US	--	-56	0	-1
98A	US	--	-12	0	2
99A	US	--	68	0	-2
100A	US	--	230	0	1

[a]Refer to Figures 3 through 5.
[b]F=floor, LW=lower wall, US=upper surface.
[c]-- = No measurement taken.

TABLE 2

RADIONUCLIDE CONCENTRATIONS IN SOIL SAMPLES
HAMMOND DEPOT
HAMMOND, INDIANA

Sample Location[a]	Area Class	Radionuclide Concentrations (pCi/g)	
		Th-232	U-238
1/Building 200E West Side	2	0.96 ± 0.18[b]	1.95 ± 0.65
2/Area D	3	0.89 ± 0.18	2.24 ± 0.73
3/Area D	3	1.20 ± 0.18	2.89 ± 0.60
4/Area C	3	0.84 ± 0.15	2.03 ± 0.53
5/Area M	3	0.88 ± 0.14	1.34 ± 0.47
6/Burn Cage Area at RR Track	2	2.05 ± 0.33	4.0 ± 1.2
7/Burn Cage Area	2	2.47 ± 0.28	3.92 ± 0.72
8/Rubble Pile Area	2	1.35 ± 0.19	2.35 ± 0.50
9/Rubble Pile Area	2	1.41 ± 0.23	2.48 ± 0.78
10/Rubble Pile Area Location 9, (15 to 30 cm)	2	1.56 ± 0.26	1.44 ± 0.89
11/Rubble Pile	2	1.34 ± 0.22	2.77 ± 0.75
12/RR Track North	2	1.09 ± 0.16	4.20 ± 0.86
13/Area Q	2	1.10 ± 0.17	2.90 ± 0.63
14/Pump House	3	0.96 ± 0.16	2.61 ± 0.70

[a]Refer to Figure 6.
[b]Uncertainties are total propagated uncertainties at the 95% confidence interval.

REFERENCES

Oak Ridge Institute for Science and Education (ORISE). Survey Procedures Manual for the Environmental Survey and Site Assessment Program. Oak Ridge, TN; September 2, 2004.

Oak Ridge Institute for Science and Education. Final Report—Historical Site Assessment of the Hammond Depot, Hammond, Indiana. Oak Ridge, TN; August 2005a.

Oak Ridge Institute for Science and Education. Radiological Scoping Survey Plan for the Hammond Depot, Hammond, Indiana. Oak Ridge, TN; August 25, 2005b.

Oak Ridge Institute for Science and Education. Quality Assurance Manual for the Environmental Survey and Site Assessment Program. Oak Ridge, TN; July 29, 2005c.

Oak Ridge Institute for Science and Education. Laboratory Procedures Manual for the Environmental Survey and Site Assessment Program. Oak Ridge, TN; June 20, 2005d.

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 author or his employer.

SCANNING INSTRUMENT/DETECTOR COMBINATIONS

Alpha plus Beta

Ludlum Floor Monitor Model 239-1
combined with
Ludlum Ratemeter-Scaler Model 2221
coupled to
Ludlum Gas Proportional Detector Model 43-37, Physical Area: 550 cm^2
(Ludlum Measurements, Inc., Sweetwater, TX)

Beta

Ludlum Ratemeter-Scaler Model 2221
coupled to
Ludlum Gas Proportional Detector Model 43-68, Physical Area: 126 cm^2
(Ludlum Measurements, Inc., Sweetwater, TX)

Gamma

Ludlum Pulse Ratemeter Model 12
(Ludlum Measurements, Inc., Sweetwater, TX)
coupled to
Victoreen NaI Scintillation Detector Model 489-55, Crystal: 3.2 cm x 3.8 cm
(Victoreen, Cleveland, OH)

DIRECT MEASUREMENT INSTRUMENT/DETECTOR COMBINATIONS

Alpha and Beta

Ludlum Ratemeter-Scaler Model 2221
coupled to
Ludlum Gas Proportional Detector Model 43-68, Physical Area: 126 cm^2
(Ludlum Measurements, Inc., Sweetwater, TX)

LABORATORY ANALYTICAL INSTRUMENTATION

Low Background Gas Proportional Counter
Model LB-5100-W
(Tennelec/Canberra, Meriden, CT)

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

High Purity Extended Range Intrinsic Detector
Model No. GMX-45200-5
(AMETEK/ORTEC, Oak Ridge, TN)
used in conjunction with:
Lead Shield Model SPG-16-K8
(Nuclear Data)
Multichannel Analyzer
DEC ALPHA Workstation
(Canberra, Meriden, CT)

High-Purity Germanium Detector
Model GMX-30-P4, 30% Eff.
(AMETEK/ORTEC, Oak Ridge, TN)
Used in conjunction with:
Lead Shield Model G-16
(Gamma Products, Palos Hills, IL) and
Multichannel Analyzer
DEC ALPHA Workstation
(Canberra, Meriden, CT)

APPENDIX B

SURVEY AND ANALYTICAL PROCEDURES

APPENDIX B

SURVEY AND ANALYTICAL PROCEDURES

PROJECT HEALTH AND SAFETY

The proposed survey and sampling procedures were evaluated to ensure that any hazards inherent to the procedures themselves were addressed in current job hazard analyses. Additionally, upon arrival on site, a walk-down of the site was performed to identify hazards present and a pre-job integrated safety management checklist was completed and discussed with field personnel. All survey and laboratory activities were conducted in accordance with ORISE health and safety and radiation protection procedures.

CALIBRATION AND QUALITY ASSURANCE

Calibration of all field and laboratory instrumentation was based on standards/sources, traceable to NIST.

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, (September 2004)
- Laboratory Procedures Manual, (June 2005)
- Quality Assurance Manual, (July 2005)

The procedures contained in these manuals were developed to meet the requirements of Department of Energy (DOE) Order 414.1C and the U.S. Nuclear Regulatory Commission *Quality Assurance Manual for the Office of Nuclear Material Safety and Safeguards* 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 MAPEP, NRIP, and ITP Laboratory Quality Assurance Programs.
- Training and certification of all individuals performing procedures.

- Periodic internal and external audits.

Detectors used for assessing surface activity were calibrated in accordance with ISO-7503[1] recommendations. Total alpha and beta efficiencies (ε_{total}) were determined for each instrument/detector combination and consisted of the product of the 2π instrument efficiency (ε_i) and surface efficiency (ε_s): $\varepsilon_{total} = \varepsilon_i \times \varepsilon_s$. Beta total efficiencies were determined based on a beta energy multi-point calibration, development of an instrument efficiency to beta energy calibration curve, and the calculation of the weighted efficiency representing the Th-232 decay series. Included in the weighted efficiency was an empirically determined correction for a disequilibrium in the decay series that results from Rn-220 loss. A 3.8 mg/cm^2 density thickness mylar window was used on the beta detectors to block detector response contributions from alpha radiation.

Th-230 was selected as the alpha calibration source. The 2π alpha instrument efficiency (ε_i) factors were 0.41 and 0.42 for the gas proportional detectors. C-14, Tc-99, Tl-204, and Sr/Y-90 were selected as the beta calibration sources to represent the energy distribution of the detectable beta-emitters in the Th-232 decay series. The 2π interpolated ε_i factors for the detectable beta-emitters ranged from 0.19 to 0.59 for the gas proportional detectors. ISO-7503 recommends an ε_s of 0.25 for alpha emitters and also beta emitters with a maximum energy of less than 0.4 MeV and an ε_s of 0.5 for maximum beta energies greater than 0.4 MeV. The total alpha efficiency weighted to represent the Th-232 alpha component of the decay series ranged from 0.53 to 0.58. The total weighted beta efficiency for the beta detectors ranged from 0.40 to 0.41.

SURVEY PROCEDURES

Surface Scans

Structural surface scans were performed by passing the detectors slowly over the surface; the distance between the detector and the surface was maintained at a minimum—nominally about 1 cm. Building surfaces were scanned using either a floor monitor or small area (126 cm^2) hand-held gas proportional detectors. A NaI scintillation detector was used to scan for elevated

[1]International Standard. ISO 7503-1, Evaluation of Surface Contamination - Part 1: Beta-emitters (maximum beta energy greater than 0.15 MeV) and alpha-emitters. August 1, 1988.

gamma radiation throughout the buildings and the exterior grounds. Identification of elevated radiation levels was based on increases in the audible signal from the recording and/or indicating instrument.

Beta surface scan minimum detectable concentrations (MDCs) were estimated using the calculational approach described in NUREG-1507.[2] The scan MDC is a function of many variables, including the background level. Additional parameters selected for the calculation of scan MDCs included a two-second observation interval, a specified level of performance at the first scanning stage of 95% true positive rate and 25% false positive rate, which yields a *d'* value of 2.32 (NUREG-1507, Table 6.1), and a surveyor efficiency of 0.5. The scanning instrument total efficiency (ε_{total}) for the hand-held gas proportional detectors was approximately 0.45.

The construction material-specific background levels ranged from 290 to 700 cpm for the gas proportional detectors. To illustrate an example for a hand-held gas proportional detector using a concrete background of 340 cpm, the minimum detectable count rate (MDCR) and scan MDC can be calculated as follows:

b_i = (340 cpm)(2 s)(1 min/60 s) = 11.3 counts,
MDCR = (2.32)(11.3 counts)$^{1/2}$ [(60 s/min)/(2 s)] = 234 cpm,
$MDCR_{surveyor}$ = 234/(0.5)$^{1/2}$ = 331 cpm

The scan MDC is calculated assuming a total efficiency (ε_{total}) of 0.41:

$$ScanMDC = \frac{MDCR_{surveyor}}{(\varepsilon_s)(\varepsilon_i)} dpm/100\,cm^2$$

For the given background, the estimated scan MDC was 810 dpm/100 cm^2 for the hand-held gas proportional detector.

The scan MDC for the NaI scintillation detector for Th-232 in soil was 2.8 pCi/g as provided in NUREG-1507.

[2]NUREG-1507. Minimum Detectable Concentrations With Typical Radiation Survey Instruments for Various Contaminants and Field Conditions. US Nuclear Regulatory Commission. Washington, DC; June 1998.

Surface Activity Measurements

Measurements of total alpha and beta surface activity levels were performed using hand-held gas proportional detectors coupled to portable ratemeter-scalers. Count rates (cpm), which were integrated over one minute with the detector held in a static position, were converted to activity levels (dpm/100 cm^2) by dividing the count rate by the total static efficiency ($\varepsilon_i \times \varepsilon_s$) and correcting for the physical area of the detector. Construction material-specific background corrections were made for each surface type encountered for determining net count rates.

Surface activity measurements were performed on concrete, brick, terra cotta block, metal, and wood. The static beta MDC ranged from 120 to 220 dpm/100 cm^2 for the gas proportional detector. The physical surface area assessed by the gas proportional detector used was 126 cm^2.

Removable Activity Measurements

Smear samples for removable gross alpha and gross beta contamination were obtained from most measurement locations. Removable activity samples were collected 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.

RADIOLOGICAL ANALYSIS

Gross Alpha/Beta

Smears were counted on a low-background gas proportional system for gross alpha and beta activity. The MDCs of the procedure were 9 dpm/100 cm^2 and 15 dpm/100 cm^2 for a 2-minute count time for gross alpha and gross beta, respectively.

Gamma Spectroscopy

Samples of soil were dried, mixed, crushed, and/or homogenized as necessary, and a portion sealed in a 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 total absorption peaks (TAP) associated with the radionuclides of concern were reviewed for consistency of activity. TAPs used for determining the activities of radionuclides of concern and the typical associated MDCs for a one-hour count time were:

Radionuclide	TAP (MeV)	MDC (pCi/g)
Th-232	0.911 from Ac-228*	0.11
U-238	0.063 from Th-234*	0.70

*Secular equilibrium assumed.

Spectra were also reviewed for other identifiable TAPs.

Detection Limits

Detection limits, referred to as minimum detectable concentration (MDC), were based on 3 plus 4.65 times the standard deviation of the background count $[3 + (4.65\ (BKG)^{1/2})]$. 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.