FINAL

CHARACTERIZATION SURVEY REPORT
BUILDING 210

NEW HAVEN DEPOT
DEFENSE NATIONAL STOCKPILE CENTER

NEW HAVEN, INDIANA

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Prepared for:

ARMY JOINT MUNITIONS COMMAND

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List of Acronyms

CABRERA	Cabrera Services, Inc.
DCGL or $DCGL_W$	derived concentration guideline level
Depot	New Haven Depot
DLA	Defense Logistics Agency
DNSC	Defense National Stockpile Center
dpm/100 cm^2	disintegrations per minute per 100 square centimeters
GSA	General Services Administration
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
MDC	minimum detectable concentration
NORM	naturally occurring radioactive materials
NRC	U.S. Nuclear Regulatory Commission
ROCs	radionuclides of concern
^{232}Th	thorium-232
^{235}U	uranium-235
^{238}U	uranium-238
ZnS	zinc sulfide

EXECUTIVE SUMMARY

This Characterization Survey Report documents the findings of the characterization survey of Building (warehouse) 210 at the Defense National Stockpile Center (DNSC), New Haven Depot (Depot). Building 210 characterization was performed as part of a comprehensive effort to complete characterization of the remainder of the Depot, including impacted structures. Results from the characterization surveys will be used to complete the final status survey of impacted areas at the Depot and develop appropriate remediation work plans, as necessary, to support unrestricted release of the property in accordance with U.S. Nuclear Regulatory Commission (NRC) regulations and guidance.

Characterization surveys in Building 210, Sections 1, 3 and 4 indicated these portions of the structure do not contain surface activity above 50 percent of the derived concentration guideline level ($DCGL_w$). However, activity found in several bays in Section 2 indicate that at least the northwest corner, which includes the locations with elevated activity, should be *Multi-Agency Radiation Survey and Site Investigation Manual* (MARSSIM) (NRC 2000) Class 1. Additionally, the upper walls and ceiling in the northwest corner of Building 210, Section 2, should also be MARSSIM Class 2. Remediation will be required in portions of Section 2 prior to performing the final status survey in this area.

1.0 INTRODUCTION

This Characterization Survey Report documents the findings of the characterization survey in Building 210 at the New Haven Depot.

1.1 Background

The Defense National Stockpile Center (DNSC) Depot is located on 268 acres 3 miles east of New Haven, Indiana. It is currently owned by the General Services Administration (GSA), and operated by the Department of Defense under the Defense Logistics Agency (DLA). Historically, the Depot's primary mission has been storage of metallurgical ores and materials necessary for manufacturing defense and/or strategic materials. Throughout the system of warehouses and outdoor areas at the Depot, the DNSC has stored columbium/tantalum ores and concentrates, tungsten ores and concentrates, zirconium ore, rare earth sodium sulfate, monazite, tungsten metal scrap, and bastnasite, all containing sufficient amounts of natural uranium and thorium to require licensing under NRC rules. The DNSC stored these materials under the authority of NRC License STC-133.

Zirconium ore (baddeleyite ore) is a natural zirconium oxide found in Brazil and Ceylon. The ore contains naturally occurring radioactive materials (NORM) in the form of uranium and thorium. The zirconium ore at the Depot was stored in two piles designated 111 and 111A in open area 7A in the northwest corner of the Depot, as presented in Figure 1-1. Pile 111 contained 31,981,402 pounds of the ore. Pile 111A contained soil contaminated with the ore from the transfer of 2,783,706 pounds of zirconium ore from other DNSC depots. Pile 111 stood 28 feet high with a length of 296 feet and a width of 60 feet. Pile 111A was 28 feet high by 104 feet long and 50 feet wide. Approximately half of the zirconium ore in Pile 111 was shipped to the Depot in 1988 from the DNSC depots at Jeffersonville, Indiana and Columbus, Ohio. The contaminated soils at the base of the piles at these depots comprised the contents of Pile 111A. Both ore piles were removed from the Depot in 2004.

Six storage buildings (Warehouses 210 through 215) are present at the Depot, as presented in Figure 1-1. Each building is 180 feet wide by 960 feet long and has wood, concrete, or concrete block structural framing supporting wood roof decks and an aggregate floor space capacity of approximately 1,037,000 square feet. The warehouses are subdivided into four equal 180-foot by 240-foot sections. Each section is accessed through four overhead roll-up metal doors. Each section is divided into 79 storage bays (each approximately 20 feet by 20 feet). The materials containing licensable quantities of thorium and uranium were packaged (in either wooden boxes or drums) and stacked in various bays throughout the warehouse series.

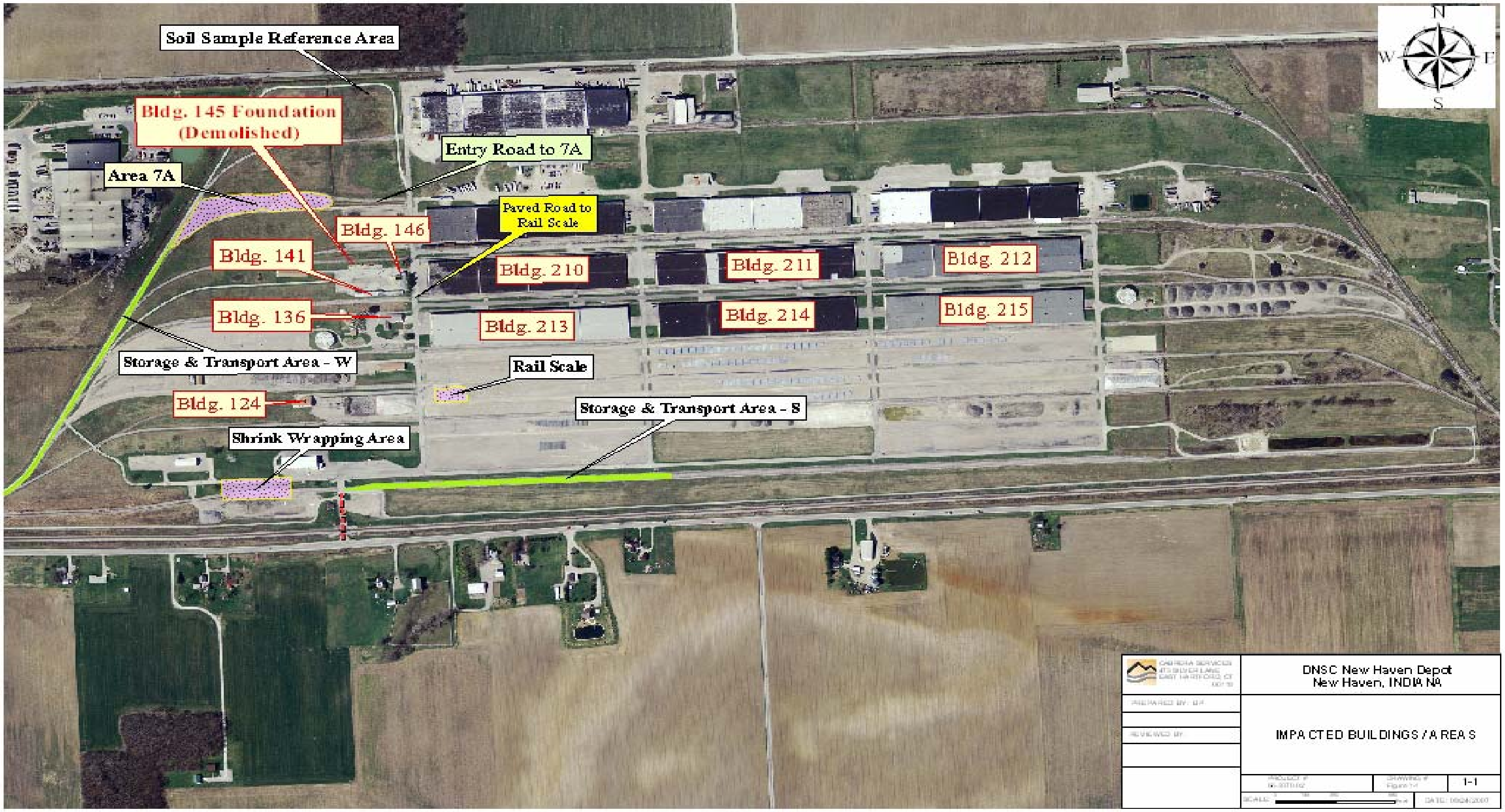

Figure 1-1, Overview of New Haven Depot

1.2 Radionuclides of Concern

Based on the composition of the metallurgical ores stored at the Depot, the radionuclides of concern (ROCs) are natural thorium and natural uranium. Since the ores containing these ROCs were simply stored at the Depot and never processed, the radioactive decay products in both the natural thorium and natural uranium chains remain in secular equilibrium with the parent radionuclide, as they were in nature.

The parent radionuclides in the natural thorium and natural uranium decay chains, thorium-232 (^{232}Th) in the natural thorium decay chain, uranium-238 (^{238}U) and uranium-235 (^{235}U) in the natural uranium decay chain, emit alpha particles. The daughter products in both chains decay by emission of alpha or beta particles, some with accompanying emission of gamma rays. The decay schemes for both the natural thorium and natural uranium chains are very well documented, and this knowledge was used in the performance of characterization surveys, as well as the selection of appropriate survey instruments and analysis methods.

2.0 DERIVED CONCENTRATION GUIDELINE LEVEL (DCGL)

The natural thorium and natural uranium surface activity $DCGL_w$s are based on the surface activity screening values published in NUREG/CR-5512, Volume 3, Table 5.19 (P_{crit} = 0.90) (NRC 1999). The primary method of surface activity measurements for both total and removable activity required use of alpha monitoring instrumentation. Therefore, the surface activity screening values have been calculated based on the total number of alphas emitted in each of the applicable radioactive decay chains, and for natural uranium, the percent contribution from the applicable decay chain, as shown in Table 2-1.

TABLE 2-1: SURFACE ACTIVITY $DCGL_w$

ROC		NUREG/CR-5512 Screening Level[1]	Total Alphas per Decay	Alpha Based Screening Level[1]	ROC Alpha $DCGL_w$[1]
Natural thorium (^{232}Th+C)		6.03	6	36.2	36.2
Natural uranium	97.8% ^{238}U+C	19.5	8	156.0	119.2
	2.2% ^{235}U+C	1.48	7	10.4	

[1] disintegrations per minute per 100 square centimeters (dpm/100 cm^2)

As indicated previously, various licensed radioactive materials were stored at the New Haven Depot. To determine the appropriate surface alpha activity $DCGL_w$ for each impacted outdoor surface or interior structure surface, the type of licensed radioactive material previously stored or present in the area was considered. In general, this licensed material was of 2 types: material predominated by natural uranium and material predominated by natural thorium. These radioactive materials and the average natural uranium and natural thorium activity fractions are presented in Table 2-2.

TABLE 2-2: LICENSED MATERIAL RADIOACTIVITY FRACTIONS

Material	Natural Uranium Fraction	Natural Thorium Fraction
Columbium	0.94	0.06
Tantalum	0.95	0.05
Baddelyite (zirconium ore)	0.91	0.09
Tungsten ore (Wolframite and Ferberite)	0.08[1]	0.92[1]
Monazite	0.11	0.89
Bastnasite	0.16	0.84

[1] Mixture based on the average fractions for Wolframite and Ferberite

The surface activity $DCGL_w$ for the mixtures of natural uranium and natural thorium in the material presented in Table 2-2 was then determined using the following formula:

$$\text{Mixture DCGL}_w = \frac{1}{\left(\frac{f_{U-nat}}{DCGL_{U-nat}}\right) + \left(\frac{f_{Th-nat}}{DCGL_{Th-nat}}\right)}$$

Where:

f = activity fraction from Table 2-2

DCGL = DCGL from Table 2-1

Applying the above formula to the natural uranium and natural thorium fractions in Table 2-2 results in the mixture $DCGL_w$ presented in Table 2-3.

TABLE 2-3: MATERIAL MIXTURE ALPHA $DCGL_W$

Material	Mixture Alpha $DCGL_w$ (dpm/100 cm^2)
Columbium	105
Tantalum	107
Baddelyite (zirconium ore)	99
Tungsten ore (Wolframite and Ferberite)	38
Monazite	39
Bastnasite	41

To simplify the application of the mixture $DCGL_w$ for the various licensed radioactive material previously stored within structures, the values in Table 2-4 were applied for the characterization surveys.

TABLE 2-4: CHARACTERIZATION SURVEY MATERIAL ALPHA $DCGL_W$

Material	Material Alpha $DCGL_w$ (dpm/100 cm^2)
Material predominated by natural uranium (columbium, tantalum and baddelyite)	100
Material predominated by natural thorium (tungsten ore, monazite and bastnasite)	38

To apply the material alpha $DCGL_w$ in Table 2-4, the following logic was used:

- If the only material stored or used in an area or within a structure was predominated by natural uranium or natural thorium, the applicable Table 2-4 material alpha $DCGL_w$ will be used.
- If two different materials were stored or used in an area or within a structure and one was predominated by natural uranium and the other natural thorium, the material is assumed equally distributed with 50% contribution from each. The resultant material alpha $DCGL_w$ in this instance is 55 dpm/100 cm^2.
- If more than two different materials were stored or used in an area or within a structure and the majority are predominated by natural uranium or natural thorium, the material alpha $DCGL_w$ for the predominant material will be used.

As indicated in the *Historical Site Assessment of the Defense National Stockpile Center New Haven Depot* (Cabrera 2007), the primary commodities stored in Building 210, Sections 1, 2 and 3 were columbium tantalum, monazite and tungsten ore, while only columbium tantalum was stored in Section 4. Based on the logic previously presented, the alpha $DCGL_w$ applicable to Building 210 is presented in Table 2-5.

TABLE 2-5: STRUCTURE ALPHA $DCGL_w$

Building	**Impacted Structure Area**	**Alpha $DCGL_w$ (dpm/100 cm^2)**
210	Sections 1, 2 and 3: All locations	38
	Section 4: Bays 2-5, 8, 9, 12-14, 32-33, 35, 43, 45, 46, 48, 52-54, 56, 58, and 76 only	100

Removable alpha contamination limits are 10% of the alpha $DCGL_w$ values in Table 2-5.

3.0 INSTRUMENTATION AND CALIBRATION

Field and laboratory instrument calibrations were performed using NIST traceable radioactive standards (sources). Specific field and laboratory instrumentation are discussed in the following sections.

3.1 Field Instrumentation

The following survey instrumentation was used during the characterization of Building 210.

3.1.1 Scanning Instrumentation

Alpha Scans

Alpha surface activity scans were performed with the Ludlum Model 43-37 gas proportional detector (physical area of 582 cm^2) and the Ludlum Model 43-68 gas proportional detector (physical area of 126 cm^2), both coupled to a Ludlum ratemeter-scaler, such as the Ludlum Model 2221. The probability of observing one or more counts, scan speed in centimeters per second (cm/s) and pause times in seconds (s) for the two detectors and the three surface activity $DCGL_w$ values in Table 4-7 are provided in Table 3-1.

TABLE 3-1: ALPHA SCAN PARAMETERS

Detector	Probability	Scan Speed (cm/s)	Pause Time (s)
Surface Activity Alpha $DCGL_w$ = 38 dpm/100 cm^2			
43-68	0.69	1	18
43-37	0.79	4	4
Surface Activity Alpha $DCGL_w$ = 100 dpm/100 cm^2			
43-68	0.96	1	7
43-37	0.99	4[1]	2

[1] Scan speed may be increased to 6 cm/s, with a probability of 0.93.

3.1.2 Direct Surface Activity Measurement Instrumentation

Direct measurements for surface alpha activity were performed on structure surfaces using a Ludlum Model 43-37 gas proportional detector (physical area of 582 cm^2) or Ludlum Model 43-68 gas proportional detector (physical area of 126 cm^2), both coupled to a Ludlum ratemeter-scaler, such as the Ludlum Model 2221. With a background and sample count time of 1 minute with the Ludlum Model 43-37, the alpha MDC is 18 dpm/100 cm^2. With a 10 minute background count time and 3 minute sample count time for the Ludlum Model 43-68, the alpha MDC is 15 dpm/100 cm^2.

Note: Shorter background and sample count times with the Ludlum Model 43-68 were acceptable for areas with a surface alpha $DCGL_w$ greater than 38 dpm/100 cm^2. A 1 minute background and sample count time results in an alpha MDC of 37 dpm/100 cm^2, which is acceptable for surface areas with an alpha $DCGL_w$ of 55 dpm/100 cm^2 or 100 dpm/100 cm^2.

3.2 On-Site Laboratory Instrumentation

Smears for removable alpha activity on outdoor solid surfaces and structure surfaces were analyzed with a Ludlum Model 2929 scaler or Tennelec gas flow proportional counter. The Ludlum Model 2929 employs a zinc sulfide (ZnS) scintillation detector, while the Tennelec utilizes a gas proportional detector, both capable of simultaneous analysis of alpha and beta radioactivity on media such as smears. A 20 minute background count time and 5 minute sample count time results in an alpha MDC of 3 dpm/100 cm^2 or less for both instruments.

4.0 CHARACTERIZATION SURVEY

All sections within Building 210 were initially MARSSIM Class 3. Characterization survey activities consisted of:

- Alpha scan surveys of approximately 20 percent of the interior floor and lower wall surfaces within Building 210 (single survey unit for floors and single survey unit for lower walls).

- Direct alpha integrated measurements at 17 randomly selected systematic locations in each survey unit (floor survey unit and lower wall survey unit), as well as biased locations based on alpha scan survey results.

- Direct alpha integrated measurements at randomly selected locations on upper walls and beams.

- Smear survey collection and analysis in systematic and biased locations.

These surveys were designed and performed to provide results of sufficient quality and quantity to meet final status survey requirements.

Prior to performance of characterization surveys in Building 210 survey units, background measurements were obtained from a non-impacted location with similar building materials. A total of 5 direct integrated alpha material background measurements were obtained for each material type expected within the actual survey unit. This included concrete (floors) and wood (walls). The average of these material background measurements were subtracted from each gross direct alpha measurement and the result converted to dpm/100 cm^2 for comparison to the $DCGL_w$ and performance of the Sign test.

5.0 RESULTS

Systematic direct alpha integrated measurements were performed at 17 randomly selected locations in each survey unit (floor and lower wall). The results are summarized in Table 5-1.

TABLE 5-1: BUILDING 210 SYSTEMATIC DIRECT ALPHA SURVEY SUMMARY

Building	Survey Unit	Average[1,2]	Standard Deviation[1,2]	Maximum[1,2]
210	Floor	1.2	3.9	10.7
	Wall	0.8	4.0	6.8

1 dpm/100 cm^2

2 Corrected for material background.

None of the individual direct alpha surveys in either survey unit exceeded 50% of the surface activity $DCGL_w$ in Building 210, Sections 1, 2, 3 and 4. Although the $DCGL_w$ for Section 4 is higher, the lower $DCGL_w$ (38 dpm/100 cm^2) was applied as a conservative measure for initial data evaluation.

Since the average and individual direct alpha measurements were less than the surface activity $DCGL_w$ in each of the survey units, performance of the Sign test was not necessary and it was concluded the survey units pass (reject the null hypothesis).

All surface activity smear results were less than 10 percent of the surface activity $DCGL_w$. There were no elevated surface activity locations identified in Building 210, Sections 1, 3, and 4. However, alpha scan surveys did identify several areas of elevated surface activity in Section 2. These locations were found in three bays (7, 8 and 19) and floor areas adjacent to bays 7 and 8 (designated 7E and 8E) in the northwest corner of this section of the building. Follow-up direct integrated alpha measurements indicated surface activity is present above the $DCGL_w$ over a majority of the floor surfaces in 4 locations (bays 7, 8, 7E and 8E) and a localized area of surface activity above the $DCGL_w$ on the floor in bay 19. The results of the direct alpha measurements are summarized in Table 5-2.

TABLE 5-2: BUILDING 210, SECTION 2 BIASED DIRECT ALPHA SURVEY SUMMARY

Building	Location	Average[1,2]	Standard Deviation[1,2]	Maximum[1,2]
210, Section 2	Bays 7, 8, 7E and 8E[3]	195	48	256
	Bay 19	351	67	398

1 dpm/100 cm^2

2 Corrected for material background.

3 Locations 7E and 8E are not actual bays, but designators assigned to these spaces which are between contaminated bays 7 and 8 and bays 17 and 18.

As a result of these biased direct alpha measurements, it is clear this portion of Building 210, Section 2 was incorrectly classified initially and should be MARSSIM Class 1.

6.0 SUMMARY OF RESULTS AND CONCLUSION

6.1 Summary of Results

Characterization surveys performed in Building 210 were sufficient to conclude Sections 1, 3 and 4 are MARSSIM Class 3 and surface activity measurements did not identify activity in these sections above 50 percent of the $DCGL_w$. Alpha scan surveys did not identify elevated surface activity in these sections that would warrant further investigation. Although all systematic direct alpha measurements in all sections of Building 210 were less than the $DCGL_w$, alpha scans in Section 2 indicated several bays contained surface activity above the $DCGL_w$. Follow-up direct alpha measurements indicated the elevated surface activity covered a majority of the floor surfaces in 4 locations (bays 7, 8, 7E and 8E); elevated surface activity in bay 19 was limited to a small area of the floor surface.

6.2 Conclusions

Characterization surveys in Building 210, Sections 1, 3 and 4 indicated these locations do not contain surface activity above 50 percent of the $DCGL_w$. However, activity found in several bays in Section 2 indicate that at least the northwest corner, which includes the locations with elevated activity identified in Table 2-2, should be MARSSIM Class 1. Additionally, the upper walls and ceiling in the northwest corner of Building 210, Section 2, should also be MARSSIM Class 2. Remediation will be required in the 5 locations in Section 2, refer to Table 5-2, prior to performing the final status survey in this area.

7.0 REFERENCES

(Cabrera 2007) Historical Site Assessment of the Defense National Stockpile Center New Haven Depot, New Haven, Indiana, Cabrera Services, Inc., 2007.

(NRC, 1999) NUREG/CR-5512, Volume 3, October 1999.

(NRC, 2000) NUREG-1575, *Multi-Agency Radiation Survey and Site Investigation Manual* (MARSSIM), U.S. Nuclear Regulatory Commission, dated August, 2000.