

**Lake City Army Ammunition Plant  
Dose Assessment for the  
600-Yard Bullet Catcher Area and Buildings 3A and 12A**

Dose assessment analyses were conducted in support of the removal of contaminated areas and facilities, located at the Lake City Army Ammunition Plant, from the SDMP list (Status of Decommissioning Program, SECY-00-0094, 4/25/00). The facilities include the 600-Yard Bullet Catcher and Buildings 3A and 12A. For the Bullet Catcher, contaminated sand and soils will be removed and the area will be decontaminated to levels not exceeding 35 pCi/g, in accordance with the Commission-approved unrestricted release limit for depleted uranium (DU) in the SDMP Action Plan. For Building 3A, residual levels of contamination will be decontaminated and the building will be demolished, while Building 12A has been decontaminated successfully to the cleanup limit of 5,000 dpm/100 cm<sup>2</sup> limit, also addressed by the SDMP Action Plan. The analyses assess future potential doses in anticipation of the remediation of these areas and their subsequent use.

The analyses were conducted using the DandD code (Ver. 2.1.0). Using the guidance of NMSS Decommissioning Standard Review Plan (NUREG-1727, App. C), a modified site-specific dose screening analysis approach was used with doses expressed as the peak of the mean rather than at the 90<sup>th</sup> percentile. This approach was used because of the conservative assumptions built into the DandD code, the concern that applying doses derived at the 90<sup>th</sup> percentile would result in doses that would be unrealistically high given the known radiological status of the areas considered in this evaluation, and the fact that the site is being remediated under SDMP criteria which are based on soil concentration and surface contamination levels rather than dose limits.

**I. 600-Yard Bullet Catcher**

The Bullet Catcher is located on the Firing Range and near Area 10. The 600-Yard Bullet Catcher was used for the demilitarization of ammunition containing DU. The demilitarization process involved shooting live rounds into a sand-filled catch box. About 44,000 rounds were disposed of in this manner, resulting in the contamination of the sand present in the Bullet Catcher and surrounding grounds. Under prior interim remediation efforts, some of the contaminated sands have been relocated to Area 10 and only a small fraction of the initial amount of contaminated sands remains in the area. The resulting DU contamination has been estimated to be present in an area of about 10,000 ft<sup>2</sup> (~929 m<sup>2</sup>) and containing about 40,000 ft<sup>3</sup> (~1,130 m<sup>3</sup>) of contaminated sand and soil.

Because the Bullet Catcher has not yet been remediated, the dose assessment makes several assumptions about the residual DU radiological source term remaining in the area following remediation. The radiological source term assumes that:

- a. the distribution of radionuclides and radionuclide concentrations following remediation are the same as that characterizing initial DU contamination levels before remediation.
- b. the maximum post-remediation DU concentration is capped at 35 pCi/g, based on the decommissioning plan approved for the area.

- c. an isotopic uranium (U) distribution of 0.832 for U-238, 0.1496 for U-234, and 0.0184 for U-235, based on the results of U-isotopic analyses using a site sample.
- d. DU decay products are present after 1,000 years of ingrowth, given the U-isotopic distribution noted above and ingrowth fractions given in NUREG-1717 (Table 3.1.4), with concentrations assigned to each decay product.
- e. the dose is contributed by U-238, thorium-234 (Th-234), protactinium-234 (Pa-234); U-234, Th-230, radium-226 (Ra-226), lead-210 (Pb-210), polonium-210 (Po-210); and U-235, Th-231, Pa-231, Ac-227, Th-227, and Ra-223.

The derived DU concentrations and distributions are based on existing contamination levels. As noted earlier, post-remediation distributions are assumed to follow the profile of the original contamination, but is capped at 35 pCi/g. The resulting post-remediation U-238 contamination levels are estimated to range from 0.0673 to 35 pCi/g, with an average of 2.9±6.1 pCi/g. At the 90<sup>th</sup>, 95<sup>th</sup>, and 99<sup>th</sup> percentiles, the U-238 concentrations are assumed to be 9.2, 16.8, and 23.8 pCi/g, respectively. The DU concentrations used in the dose assessment, corrected for the noted isotopic distributions, are 3.5 pCi/g for the average level, 11.1 pCi/g for the 90<sup>th</sup> percentile concentration, and 35 pCi/g for the maximum concentration.

The DandD code was used to conduct three analyses. The first case is based on all default assumptions of the DandD code for the residential scenario, using an average DU concentration of 3.5 pCi/g and all exposure pathways, including external radiation, inhalation, secondary ingestion, and all agricultural and water pathways, and the “unlimited area” option for all pathways. The second case applies the 90<sup>th</sup> percentile DU concentration (11.1 pCi/g) with all exposure pathways noted earlier turned on, but limits the size of the contaminated area to 10,000 ft<sup>2</sup> (~929 m<sup>2</sup>). The third case, also a residential scenario, uses a maximum DU concentration of 35 pCi/g, but confines the residual contamination levels only within the contaminated area using the “limited area” option. This scenario typifies a site occupancy scenario by turning off all agricultural and water pathways, where the total dose is due only to the external radiation, inhalation, and secondary ingestion pathways. The results of the analyses are tabulated below:

600-Yard Bullet Catcher Case Conditions				Annual Doses (mrem)
Case No.	Scenario	DU Conc. (pCi/g)	Model Assumptions	Peak of the Mean
1	Residential	3.5	All code defaults and average DU concentration	5
2	Residential	11.1	All code defaults, area confined to 929 m <sup>2</sup> , and DU concentration at the 90th-percentile	20
3	Residential	35.0	Agricultural and water pathways turned off, area confined to 929 m <sup>2</sup> and maximum DU concentration	3

The results indicate that DU concentrations of 3.5 and 11.1 pCi/g yield annual doses that are well within 25 mrem, assuming exposures associated with residential scenarios. The third case

represents a full time site occupancy scenario without any of the agricultural pathways, assuming that the entire area of the decontaminated portions of the Bullet Catcher had post-remediation levels at the maximum of the limit (35 pCi/g). The resulting annual dose (peak of the mean) is about 3 mrem, where the total dose is due the external radiation, inhalation, and secondary ingestion pathways. For the cases constructed above, peak doses occur at 20, 4, and 2 years, respectively.

## II. Building 3A

Building 3A is located in Area 21 along Owens School House Road. The building was used for the machining of DU rounds and final assembly of ammunition. Also, the building was used to store ammunition. The building consist of 14 bays opening on a center hallway, with a total surface area of about 15,760 ft<sup>2</sup> (1,464 m<sup>2</sup>). The building has been decontaminated once, but there are still a few small isolated spots on concrete surfaces with contamination levels exceeding the limit, estimated to vary from 12,000 to 200,000 dpm/100 cm<sup>2</sup>, based on an NRC inspection<sup>1</sup>. The building is slated for additional decontamination and demolition to meet the SDMP cleanup level of 5,000 dpm/100 cm<sup>2</sup>. Given that the building will be demolished, the dose assessment is based on the residual presence of DU contaminants in soil within the footprint of the building, rather than on building surfaces. Lacking specific information, post-remediation DU soil concentrations are assumed to be similarly distributed as that of original contamination levels present on building surfaces before remediation. As a result, the dose assessment assumes that the area comprising the former footprint of the building may be occupied by future residents.

Since Building 3A has not yet been remediated, the dose assessment makes several assumptions about the residual radiological source term for DU remaining in the building after remediation and demolition. The radiological source term assumes that:

- a. the distributions of radionuclides and radionuclide concentrations in soil following remediation are the same as that characterizing initial building DU surface contamination levels before remediation.
- b. the maximum post-remediation DU concentration is capped at 35 pCi/g, based on the approved site decommissioning plan.
- c. an isotopic U distribution of 0.832 for U-238, 0.1496 for U-234, and 0.0184 for U-235, based on the results of U-isotopic analyses from a site sample.
- d. DU decay products are present after 1,000 years of ingrowth, given the U-isotopic distribution noted above and ingrowth fractions given in NUREG-1717 (Table 3.1.4), with concentrations assigned to each decay product.
- e. the dose is contributed by U-238, Th-234, Pa-234; U-234, Th-230, Ra-226, Pb-210, Po-210; and U-235, Th-231, Pa-231, Ac-227, Th-227, and Ra-223.

The derived DU concentrations and distributions are based on existing contamination levels. As noted earlier, post-remediation distributions follow that of original surface contamination levels, but are capped at 35 pCi/g. The resulting post-remediation U-238 contamination levels are estimated to range from 0.192 to 35 pCi/g, with an average of 2.4±6.2 pCi/g. At the 90<sup>th</sup>,

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<sup>1</sup>Lake City Army Ammunition Plant Inspection, report No. 040-08767/2000002(DNMS), dated Sept. 25-27, 2000.

95<sup>th</sup>, and 99<sup>th</sup> percentiles, the U-238 concentrations are assumed to be 7.1, 12.2, and 29.0 pCi/g, respectively. The DU concentrations used in the dose assessment, corrected for the noted isotopic distributions, are 2.9 pCi/g for the average level, 8.5 pCi/g for the 90<sup>th</sup> percentile concentration, and 35 pCi/g for the maximum concentration.

The DandD code was used to conduct the analysis using three cases. The first case is based on all default assumptions of the DandD code for the residential scenario, using an average DU concentration of 2.9 pCi/g and all exposure pathways, including external radiation, inhalation, secondary ingestion, and all agricultural and water pathways, using the “unlimited area” option for all pathways. The second case applies the 90<sup>th</sup> percentile DU concentration (8.5 pCi/g) and all exposure pathways noted earlier, but limits the size of the contaminated area to 15,760 ft<sup>2</sup> (1,464 m<sup>2</sup>). The third case, also a residential scenario, uses a maximum DU concentration of 35 pCi/g, but confines the residual contamination levels only within the contaminated area using the “limited area” option, mimicking a site occupancy scenario by turning off all agricultural and water pathways. In this scenario, the total dose is due only to the external radiation, inhalation, and secondary ingestion pathways. The results of the analyses are tabulated below:

Building 3A Case Conditions				Annual Doses (mrem)
Case No.	Scenario	DU Conc. (pCi/g)	Model Assumptions	Peak of the Mean
1	Residential	2.9	All code defaults and average DU concentration	5
2	Residential	8.5	All code defaults, area confined to 1,464 m <sup>2</sup> , and DU concentration at the 90th-percentile	16
3	Residential	35.0	Agricultural and water pathways turned off, area confined to 1,464 m <sup>2</sup> and maximum DU concentration	3

The results indicate that DU concentrations of 2.9 and 8.5 pCi/g yield annual doses that are well within 25 mrem, assuming exposures associated with residential scenarios. The third case represents a full time site occupancy scenario without any of the agricultural pathways, assuming that the entire footprint area of the decontaminated portions of Building 3A had post-remediation levels at the maximum of the limit (35 pCi/g). The resulting annual dose (peak of the mean) is about 3 mrem, where the total dose is due the external radiation, inhalation, and secondary ingestion pathways. For the cases noted above, the peak doses occur at 20, 2, and 2 years, respectively.

### III. Building 12A

Building 12A is located in Area 7, south of Building 1 and off Lake City-Buckner Road. The building was used for machining DU rounds and packing of ammunition. Also, the building was used to store raw materials and machine parts and tools. The building consists of two major

wings, east and west, with a total surface area of about 10,590 ft<sup>2</sup> (984 m<sup>2</sup>). The East Wing of the building was used for non-production support, including office, locker room, lunch room, and conference room spaces. The formerly contaminated portion of the building, confined to the West Wing, is estimated to be about 4,400 ft<sup>2</sup> (410 m<sup>2</sup>). The building has been successfully decontaminated in 1987 below the SDMP cleanup level of 5,000 dpm/100 cm<sup>2</sup>, with the results confirmed by an independent NRC survey<sup>2 3</sup>. The post-remediation residual U-238 contamination levels vary from 163 to 696 dpm/100 cm<sup>2</sup>, with an average of 322±83 dpm/100 cm<sup>2</sup> based on a review of 826 survey measurement results. The results represent total average residual levels (fixed and loose) within survey grids. On average loose or removable surface contamination levels were typically less than 4% of the total fixed, based on a review of 62 matched data pairs (total fixed vs loose using beta measurement results). Given that the building will be used for other uses, the dose assessment is based on the residual presence of DU (actual post-remediation levels) on building surfaces, assuming a building occupancy scenario.

Since Building 12A has been remediated, the dose assessment makes several assumptions about the residual radiological source term for DU remaining in the building after remediation and subsequent use. The radiological source term assumes that:

- a. the distributions of radionuclides and residual contamination levels are based on post-remediation results.
- b. the average post-remediation residual DU surface contamination level is present throughout the West Wing.
- c. an isotopic U distribution of 0.832 for U-238, 0.1496 for U-234, and 0.0184 for U-235, based on the results of U-isotopic analyses using a site sample.
- d. DU decay products are present after 1,000 years of ingrowth, given the U-isotopic distribution noted above and ingrowth fractions given in NUREG-1717 (Table 3.1.4), with concentrations assigned to each decay product.
- e. the dose is contributed by U-238, Th-234, Pa-234; U-234, Th-230, Ra-226, Pb-210, Po-210; and U-235, Th-231, Pa-231, Ac-227, Th-227, and Ra-223.

The derived residual surface DU levels and distributions are based on post-remediation conditions. The average DU level used in the dose assessment is 387 dpm/100cm<sup>2</sup>, corrected for the noted isotopic distributions.

The DandD code was used to conduct the analysis, based on the default assumptions of the code for the building occupancy scenario with two modifications. The first one relied on applying the "limited area" option by setting the area to 4,400 ft<sup>2</sup> (410 m<sup>2</sup>), which is the area that was once contaminated. The second modification applied an adjustment for the fact that actual removable surface contamination levels (4%) are less than the default value (10%) of the code.

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<sup>2</sup>Final Activity Report on Decontamination Project at Lake City Army Ammunition Plant of Building 12A and 3A East Wing, Chem-Nuclear Systems, Inc., May 1987.

<sup>3</sup>Confirmatory Survey of Building 12A and 3A at Lake City Army Ammunition Plant, Inspection Report No. 040-08767/95001(DNMS), March 7, 1996, U.S. NRC, Region III.

In this scenario, the total dose is due to the external radiation, inhalation, and secondary ingestion pathways.

The results of the analyses are tabulated below:

<b>Building 12A Case Conditions</b>				<b>Annual Dose (mrem)</b>
<b>Case No.</b>	<b>Scenario</b>	<b>DU Surface Cont. (dpm/100 cm<sup>2</sup>)</b>	<b>Model Assumptions</b>	<b>Peak of the Mean</b>
1	Building occupancy	387	All code defaults and average DU surface levels confined to 410 m <sup>2</sup>	22

The results indicate that an average residual DU surface level of 387 dpm/100 cm<sup>2</sup> yields an annual dose of 22 mrem, assuming exposures associated with a building occupancy scenario. Essentially, all of the dose (peak of the mean within the first year) is associated with the inhalation pathway, while the external and secondary ingestion pathways contribute only minimally to the total dose. The inhalation dose is driven by the resuspension factor, which models the redistribution of residual loose surface radioactivity (as respirable material) due to various work activities, ranging from walking to vigorous sweeping. The use of conservative resuspension factors is due to the lack of empirical data to support the development of more realistic estimates. The staff has found that this feature, among others, is an inherent part of the conservatism built into the DandD code and tends to yield unrealistic high dose results.