DEPARTMENT OF THE ARMY
US ARMY RESEARCH, DEVELOPMENT AND ENGINEERING COMMAND
ARMY RESEARCH LABORATORY
ABERDEEN PROVING GROUND MD 21005-5066

REPLY TO
ATTENTION OF

07 May 2008

Q-5
MS-16

2008 MAY 15 PM 12: 20
RECEIVED
REGION 1

Experimentation Support Group

Ms. Elizabeth Ullrich
Office of Nuclear Material Safety and Safeguards
U.S. Nuclear Regulatory Commission
Region I
King of Prussia, Pennsylvania 19406

Reference: Docket No. 040-06394
Control No. 141302

Ms. Ullrich,

On March 20, 2008 you requested additional information in support of a request for approval of a Decommissioning Plan (DP) Range 14 (R-14) licensed under SMB-141.

The additional information is attached as two enclosures:

a. Summary Sheets of the Comments and Responses.

b. Eratta Sheets to be replaced in the original document.

The responses were prepared by Cabrera Services, Inc. Cabrera has agreed to meet with you to discuss further details or supply additional information.

Point of Contact for this action is Richard Markland, (410) 278-6354,markland@arl.army.mil.

Sincerely,

Pamela E. Fry
Experimentation Support Manager

Enclosures

141302
NMSS/RGN1 MATERIALS-002

Comment No.	pp/§/¶	Comment	Response
Request for Additional Information from B. Ullrich, NRC, dated 12/28/07			
1	Section 1.0	"Executive Summary" states that non-contaminated debris may be disposed of, and decontaminated materials may be re-used. However, the release criteria was not specified. Please specify the criteria that you intend to use to determine if debris and other materials may be released for unrestricted use. See also items 4, 6, 7, 14 and 16.a. below.	Radiological surface activity limits for unrestricted release of material and equipment, etc. are discussed in Sections 6.1.1, 6.1.3, 6.1.4, 8.1.8, and 12.1 of the *R-14 Range Decommissioning Plan (DP)*. These sections refer to limits in Army Engineer Manual (EM) 385-1-80, *Radiation Protection Manual*, and the CABRERA *Radiation Safety Program*. The tables in EM 385-1-80 (Table 6-4) and the CABRERA RSP (Table I) reflect the average, maximum, and removable surface activity limits in NRC Regulatory Guide 1.86, Table 1.
2	Section 4.1.2 Page 4-3	"Hot line", on page 4-3 refers compares the contaminated water concentration of 3,500 micrograms per liter (ug/L) to the EPA drinking water limit of 30 ug/L. However, the NRC limits for natural uranium in water released to the environment is 3 E-7 microcuries per milliliter (uCi/ml) and to the sewer is 3 E-6 uCi/ml. Using the specific activity for natural uranium of 6.77 E-7 curies per gram, the concentration of 3,500 ug/L is equivalent to 2.4 E-6 mCi/ml, in excess of limits for release to the environment. Other sections of this DP also discuss uranium concentrations in water located in the other tanks, etc. Confirm that you will compare water concentrations to applicable NRC limits, and that any discharges will meet NRC regulations as well as other applicable requirements.	Radiological effluent controls and limits are discussed in Sections 9.0 and 10.2 of the *DP*. Specifically, these sections state that air and liquid effluents during decommissioning activities shall not exceed the applicable limits in 10 CFR 20, Appendix B, Table 2, for releases to the environment. Additionally, Section 9.0 commits to an air effluent ALARA goal of 20% of the applicable Appendix B, Table 2 limit. For uranium, this equates to an ALARA air effluent goal of 5.9E-14 μCi/cc. This assumes Class Y uranium with individual isotopic activity fractions in DU of 0.904 for ^{238}U, 0.012 for ^{235}U, and 0.084 for ^{234}U.
3	Section 4.3	"Surface Soil Contamination" states that the thorium-234 concentration in soil of 511 picocuries per gram (pCi/g) based on gamma spectroscopy, is equivalent to 565 pCi/g depleted uranium (DU). Provide the conversion, including any assumptions needed.	Thorium-234 (^{234}Th) is in secular equilibrium with uranium-238 (^{238}U) approximately 150 days after processing to a metallic form. Therefore, this radionuclide (^{234}Th) is used as a surrogate nuclide for identifying and quantifying ^{238}U based on gamma spectroscopy results. Since the ^{238}U activity fraction in DU at APG is 0.904 (Barg, 1995), the total DU activity determined via gamma

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3 (cont'd)			spectroscopy is equivalent to the ^{234}Th activity divided by the ^{238}U fraction. Actual application of this relationship is shown in the *R-14 Range Characterization Survey Report*, Section 2.5, which provides the following equation: $$DU = \frac{^{234}Th}{0.904}$$ where: DU = Activity concentration of DU (pCi/g) ^{234}Th = Activity concentration of surrogate ^{234}Th (pCi/g) And, for the example in question: $$DU = \frac{^{234}Th}{0.904} = \frac{511\ \text{pCi/g}}{0.904} = 565\ \text{pCi/g}$$
4	Section 5.1	"Unrestricted Release of Structures Using NRC Screening Criteria" used NRC screening values for building surfaces to determine a Derived Concentration Guideline level (DCGL) for the DU of 100 disintegrations per minute (dpm) per 100 square centimeters of surface area (cm$^{2)}$. This is acceptable for building surfaces. However, the NRC screening values have not been approved for items of equipment to be released for unrestricted use. If you have release criteria for equipment approved already in your current license, you may use that release criteria for equipment. Specify the criteria you will use for equipment and items to be released for unrestricted use (re-use or disposal – see also Item 1 above) from any area at Range 14 included in this DP.	See response to Comment No. 1.

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5	Section 5.2	"Unrestricted Release of Surface Soils Using Site-Specific Information" proposes to use a site-specific DCGL of 230 pCi/g, a value originally developed for use at the Transonic Range. Calculations for this value, and changes made in the dose modeling for the R-14 Range, were provided in Appendix C. However, the following information was not provided. Please submit a. the input and output files from the computer code used to determine the site-specific DCGL, with the modeling changes; and b. a discussion of the effect of uncertainty on the results, and the results of any sensitivity analysis performed.	A revised Appendix C, which includes the requested items, is attached.
6	Section 6.1.1	Refers to release limits for steel specified in the Army's EM 385-1-80: Radiation Protection Manual. Section 6.1.4 also refers to release limits in this document. Please submit the criteria; if this criteria has been reviewed and approved for use by the NRC prior to this action, please provide the documentation for that.	See response to Comment No. 1.
7	Section 6.2	"Contaminated Systems and Equipment" discusses scanning to be performed to determine if material is contaminated or not contaminated. Scan surveys are usually not sensitive enough to determine if equipment meets unrestricted release criteria. Describe your scan survey criteria in more detail, including the release criteria based on scans, the scan sensitivity, the instrumentation to be used, and the method of scanning.	Throughout Section 6.2, the term "scanned" is synonymous with "surveyed." All radiological surveys for unrestricted release of materials and equipment will be conducted in accordance with procedure requirements, which include measurements of total and removable activity sufficient to assess surface activity with respect to compliance with the unrestricted release criteria discussed in response to Comment No. 1.

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8	Section 6.3	"Surface Soil", states that the soil is assumed to be contaminated to a depth of six inches. Describe your criteria for deciding when additional actions will be taken to determine if soil contamination extends to a greater depth, and what those actions would be.	Section 3.8.2 of the *DP Appendix D* (Final Status Survey Plan) states that surface and subsurface soil samples will be collected at each sample location within Class 1 land area survey units. This section further states that the surface soil samples will be submitted for analysis and, following review, if any surface soil sample analytical result is greater than the $DCGL_w$, the corresponding subsurface soil sample will then be submitted for analysis to evaluate the potential for soil contamination below the surface soil layer, i.e., below 6 inches. Inherent to this sampling and analysis strategy is the assumption that the only potential source of subsurface contamination is the vertical migration of surface contaminants via storm water infiltration. Historical usage of the R-14 grounds did not include any excavation activities or ground disturbances that would have provided other contaminant pathways to the subsurface soils. Thus, if the surface soils are not contaminated, there is no reason to suspect any impacts to deeper soils.
9	Section 6.3	"Surface Soil", states that the average DU activity in soil to be removed is in the range of 175 to 200 picocuries per gram (pCi/g). Confirm that waste soils will be sampled to verify the concentration to ensure appropriate disposal.	A waste profile will be developed for each R-14 Range decommissioning waste stream intended for off-site disposal. The waste stream profile, including anticipated volumes of waste, will be submitted to the receiving disposal facility for approval prior to shipment of the waste. An appropriate number of samples will be collected and analyzed to facilitate the accurate development of the waste profile and to ensure that the waste conforms to the receiving facility's waste acceptance criteria (WAC).
10	Section 6.3	"Surface Soil", does not describe the methods you plan to use for removal of surface soils during remediation or the radiation protection methods to be used during soil remediation. In addition, it does not specify which	Large area soil removal will be accomplished using industry standard earth moving equipment (e.g., excavator, bobcat, etc.). Small areas of soil contamination (i.e., spot remediation) may be performed manually using shovels or similar tools. All

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10 (cont'd)		methods are currently authorized under your license, and if any new methods are requested for approval. Please provide this information.	decommissioning tasks, including soil removal, will be performed in accordance with the radiation protection requirements specified in the *DP*, which addresses appropriate radiation protection requirements for occupational workers, members of the public, and the environment.
11	Section 7.3	"Decommissioning Task Management", does not address the use of radiation Work Permits (RWP) or equivalent procedures to manage tasks. Please describe: a. how tasks will be managed through the use of the RWP or other procedures; b. how decommissioning tasks are evaluated and the RWP or other procedures developed for the tasks; c. how the RWP or other procedures are issued, maintained, revised, and terminated throughout the decommissioning process; and d. how individuals performing tasks will be informed and/or trained in the use of the applicable RWP or other procedures.	Section 8.0 of the *DP* commits to the use of the decommissioning contractor's NRC-approved radiation safety program. This section further specifies procedures required to implement the radiation safety program for the R-14 Range decommissioning, which includes a standard operating procedure for radiation work permits (RWPs). This procedure describes the RWP life-cycle, from initial generation and any required revisions through RWP termination. Section 7.5 of the *DP* discusses training requirements for visitors to the site and occupational radiation workers. The content of the radiation worker training includes discussion of the radiation safety program, including applicable implementing procedures. Section 7.5.4 also discusses initial site training to include further discussion of applicable decommissioning processes and procedures. In addition to initial briefing of workers on the work area hazards, hazard controls (including administrative and engineering controls), PPE, etc. upon initial RWP use and following any required RWP revision, Section 7.5.6 requires tailgate meetings to be conducted prior to the start of work each day. Topics to be discussed in this meeting include at, a minimum, the work plan for the day, work area hazards, hazard controls, etc.

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12	Section 8.3	"Health Physics Audits, Inspections, and Recordkeeping Program", states that audits will be performed periodically. Specify a minimum frequency for audits to be performed during implementation of your Decommissioning Plan.	Section 11.6 of the *DP* states that audits will be performed quarterly, at a minimum, while decommissioning activities are underway, and that a comprehensive audit of the radiation safety program will be conducted annually. Based on the anticipated duration of decommissioning activities, one quarterly audit will be performed during field work. Quarterly audits collectively address all aspects of decommissioning activities, including the adequacy of the various elements of the radiation safety program and implementation of these requirements.
13	Section 8.0	Confirm that, if assessment of internal dose is required to support Section 8.0, "Health and Safety Program During Decommissioning", you will follow procedures already approved under your license, or will submit new procedures for review and approval.	Occupational exposures due to intakes of radioactive material are not expected to exceed the threshold for internal exposure monitoring as specified in 10 CFR 20.1502(b). To verify that actual conditions support this assumption throughout decommissioning activities that have the potential for personnel exposure to airborne radioactivity, individual and work area air sampling will be performed. Derived air concentration (DAC) - hour tracking will be initiated for each worker with the potential for exposure to 12 DAC-hours in one week or greater, as determined through air sampling. Bioassay (in-vitro or in-vivo) and assessment of internal exposure based on bioassay results will not be required for routine decommissioning activities. If it becomes necessary to use bioassays to assess potential internal exposure due to accidental exposures (inhalation, ingestion or injection) that occur during abnormal events, the bioassay type, frequency, and analysis requirements will be specified by a professional health physicist, with assessment of potential internal exposures in accordance with the specifications of NRC Regulatory Guide 8.9, *Acceptable Concepts, Models, Equations, and Assumptions for a Bioassay Program*, or other similar accepted guidance.

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14	Section 10.1	"Solid Radioactive Waste", states that, if waste is generated that meets the unrestricted release criteria specified in the Cabrera RSP and qualifies for disposal as non-hazardous waste, it will be disposed of in a local landfill. Provide this criteria, describe the surveys that will be done to verify if materials meet this criteria, and explain any assumptions used in determining this criteria. Also, confirm the Army Research Laboratory agrees to use of this criteria.	See response to Comment No. 1.
15	Section 10.1	"Solid Radioactive Waste", does not address management of mixed wastes that may be generated. However, Section 4.0, " Radiological Status of the "Facility", states that some buildings contain asbestos and that other hazardous substances may be present. Please provide the information requested in NUREG-1757, Volume 1, Revision 2, Section 17.5.3, "Mixed Waste".	Asbestos and polychorinated biphenyls (PCBs) are subject to the Toxic Substances Control Act (TSCA) regulations, but are not necessarily regulated as EPA hazardous wastes. Therefore, asbestos and PCB wastes that also contain radioactive contamination are typically accepted at LLRW disposal facilities without classification as "mixed waste," as defined by EPA. Off-site disposal facilities identified in the *DP* for receipt and disposal of decommissioning wastes are permitted to dispose of asbestos and PCB waste under RCRA permits in their chemical landfill facilities, depending on contaminant concentrations. Specific disposal site requirements for waste containing these materials are specified in the applicable WAC. Although hazardous materials may be present within the R-14 facility, they are not collocated with radioactive contamination that is intended for remediation. Decommissioning activities will be planned and executed in a manner that ensures that hazardous chemicals are not introduced into radioactive waste streams, which would require disposal of the waste as mixed waste.

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16	App. B Section 3.4 and 3.5.4	In the Appendix B," R-14 Range Characterization Survey Report" a. Section 3.4, other Structures", states that Building 1150D, the wash rack shed, and housings for the Cartridge and HEPA filter components were expected to be re-used and were not included in the characterization activities or decommissioning activities. If they will be re-used for activities with DU, this is acceptable but if they will be released for unrestricted use, then surveys would be required. Confirm if these structures will be released for unrestricted use, and if necessary, revise the Final Status Surveys to include these structures.	a. Building 1150D, the Wash Rack Shed, and the Cartridge and HEPA Filter housings were excluded from the Characterization Survey but are addressed in the DP to facilitate their reuse and/or unrestricted release. The R-14 Range decommissioning activities discussed in Section 6.1 indicate that equipment and/or material (such as the Cartridge and HEPA Filter housings) may be removed from the range and transported to other locations at APG that are authorized by the Army's NRC license for use or handling of radioactive material, where further processing and radiological surveys may be performed. The Army has the option of re-using the contaminated equipment in other "licensed" areas, decontaminating each item to achieve the unrestricted release criteria for use at any location at the APG, decontaminating equipment and/or material to meet the unrestricted release criteria for disposal, or declaring the material radioactive waste subject to appropriate disposal requirements. As discussed in the *DP Appendix D* (Final Status Survey Plan), the only remaining intact R-14 Range structures following decommissioning will be the Wash Rack Shed and Building 1150D. Both are identified in the Final Status Survey Plan, Sections 3.4 and 3.8, as Class 3 structure survey units due to the low potential for surface contamination. These survey units are also listed in Table 3-4. The justification for the MARSSIM classification of these structures is also provided in Section 3.4.
		b. Section 3.5.4 discusses pavement areas at Range 14. Confirm if the pavement was in place prior to any use of DU; if pavement was installed after use of DU began at Range 14, state if soil underlying the pavement may have been contaminated from previous activities and	b. The majority of the pavement within the boundaries of the R-14 Range (as defined in the *DP*) was installed prior to the commencement of DU activities and, therefore, does not overlie contaminated soils. The only exception to this is a small area of pavement on the south side of the Laydown Yard, which is

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16 (cont'd)		whether or not an assessment will be performed to determine soil containment levels under the pavement.	identified in the Final Status Survey Plan as part of Survey Unit 4a-2. To evaluate the potential for soil contamination in this area, a soil sample will be collected from beneath the asphalt at each designated measurement location within the area that may have been impacted prior to asphalt placement.
17	App. D Section 3.7	In the Appendix D, "R-14 Range Decommissioning Final Status Survey Plan," a. Section 3.7, "Survey Design" uses MARSSIM assumptions for the values of factors such as the LBGR and coefficient of variation, instead of actual data from the characterization surveys. The MARSSIM states that these factors are site-specific values that should be estimated from actual data where available. Explain why the MARSSIM assumptions were used instead of actual data.	a. While MARSSIM does suggest the use of site-specific data when available, this assumes that the data are indicative of conditions likely to be encountered during the Final Status Survey. As indicated in the *DP*, significant remediation will be performed at the R-14 Range, and current conditions, as assessed through site characterization, are not indicative of the final conditions expected during the Final Status Survey. The characterization survey was designed and implemented to assess both soil concentrations and surface activity due to the presence of radionuclides of concern (ROCs) in terms of "nature and extent." Therefore, many of the sampling and survey locations were selected using a biased approach to assess the potential extent of contamination in soil and on structure surfaces, as well as to bound the magnitude of the contamination present. Even though characterization data are available, and estimated standard deviations can be calculated, these standard deviations will be high due to the nature and extent of existing contamination, and will not be representative of expected post-remediation conditions or appropriate use for Final Status Survey design. Thus, MARSSIM assumptions for the LBGR and standard deviation representative of the post-remediation radiological conditions were used in the Final Status Survey design.

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17 (cont'd)	App. D	b. Section 3.7 refers to the alpha DCGL and the beta DCGL. Specify the values for the alpha DCGL and the beta DCGL, and show how these values were determined.	b. The surface activity alpha $DCGL_w$ is discussed in *DP Appendix D* (Final Status Survey Plan), Section 3.2.2. This includes the methodology for determining the single alpha $DCGL_w$ for the mixture of uranium isotopes present in DU. As indicated, the alpha $DCGL_w$ is based on the NRC surface activity screening values provided in NUREG/CR-5512, Volume 3, Table 5.19. A surface activity beta $DCGL_w$ is presented in *DP Appendix D* for performance of surface activity scan measurements only. Given the inherent difficulties in performance of surface alpha activity scans, scans for surface beta activity are more reliable (fewer false positives and more surveyor "friendly"). Additionally, scan surveys are used to assess the potential for elevated areas of activity that may not be identified through systematic sampling. Once an area of potential elevated activity is identified via beta scans, a static or fixed alpha measurement will be performed. It is the static alpha measurement that will be used to determine whether the initial indication of elevated activity is true (i.e., contamination is actually present) and to assess the magnitude of this contamination. Taking into account the total number of beta particles emitted in the two uranium decay chains associated with DU (3 in the ^{238}U decay chain [1 from ^{234}Th, 1 from ^{234m}Pa, and 1 from ^{234}Pa] and 1 in the ^{235}U decay chain from ^{231}Th), the effective gross beta $DCGL_w$ is determined to be 295 dpm/100 cm^2. However, the beta $DCGL_w$ selected for use during scanning is equal to the alpha $DCGL_w$, or 100 dpm/100 cm^2, as a conservative measure. Again, the bases for these values are the NRC screening values in NUREG/CR-5512, Volume 3, Table 5.19.

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17 (cont'd)	App. D	c. Section 3.7 refers to use of area factors. The MARSSIM Tables 5.6 and 5.7 are provided as examples of area factors, based on the assumed concentration and specified dose models and are not intended to be used directly in situations that are different than the assumptions described in MARSSIM. Explain your use of the area factors from these tables. (Please note that Table 8.2, referenced in your plan, is a summary of statistical tests.) You may request alternate area factors if appropriate.	c. Area factors were developed for the Transonic Range (attached), but were limited to areas of 1 to 25 square meters. Area factors were also calculated using the input parameters provided in the *DP Appendix C* (Determination of DCGL for Soil). This was accomplished by changing the area of the contaminated zone to be consistent with each of the areas specified in the table. Additionally, the "length parallel to aquifer flow" was adjusted for each area and assumed to be equal to the square root of the contaminated zone area. These results were very similar to the Transonic Range area factors in the 1 to 25 square meter range. The calculated area factors, with additional area factors in the 300 to 3,000 square meter range, are also attached. This full range of calculated area factors are proposed for use at the R-14 Range in lieu of the MARSSIM land area default area factors previously presented in *DP Appendix D*, Table 6-1. Since there are no changes to the exposure scenario or model input parameters for structure area factors, and the predominant nuclide contributing to surface activity on structures is ^{238}U, the MARSSIM default area factors for structures in Table 5.7 (*DP Appendix D, Table 6-2*) are appropriate for use at the R-14 Range.
		d. Section 3.7 describes surveys to be performed of two Class 3 structures, the Wash Rack Shed and Building 1150D. If these structures were not included in the characterization survey (see also item 11.a above), explain the basis for performing surveys only of certain parts of the interior of these structures.	d. See response to Comment No. 16a.

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17 (cont'd)	App. D	e. Section 6.2.2, "Elevated Measurement Comparison Criteria", uses values from the MARSSIM Tables 5.7 and 5.7. As stated in item 12.c above, these values are based on a specific assumed concentration and certain dose models. Explain why the assumptions in MARRSIM are applicable to your facility, or request different area factors for development of your elevated measurement comparison criteria.	e. See response to Comment No. 17c.

MARSSIM Table 5.6 Default Land Area Factors

Area (m^2)	1	3	10	30	100	300	1,000	3,000	10,000
^{238}U Area Factor	30.6	18.3	11.1	8.4	6.7	4.4	1.3	1.0	1.0

Transonic Range Land Area Factors (Derived using RESRAD Version 5.8.3)

Area (m^2)	1	3	10	30	100	300	1,000	3,000	10,000
Area Factor	10	6	3	2	--	--	--	--	1.0

R-14 Range Calculated Land Area Factors (Derived using RESRAD Version 6.3)

Area (m^2)	1	3	10	30	100	300	1,000	3,000	10,000
Area Factor	10.6	5.4	2.8	2.0	1.5	1.3	1.1	1.1	1.0

R-14 RANGE DECOMMISSIONING PLAN

REV. 0 ADDENDUM

U.S. Army Research Laboratory
Aberdeen Proving Ground, MD

Contract No. DAAA09-02-D-0024
Delivery Order No. 0029

Submitted to:
U. S. Army Joint Munitions Command
1 Rock Island Arsenal
Rock Island, IL 61299-6000

Submitted by:
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CABRERA SERVICES
RADIOLOGICAL • ENVIRONMENTAL • REMEDIATION

April 2008

Responses to Comments from U.S. Nuclear Regulatory Commission on
R-14 Range Decommissioning Plan, Rev. 0 (CABRERA, November 2007, as amended February 2008)

Comment No.	Item	Comment/Response
Request for Additional Information from B. Ullrich, NRC, dated 3/20/07		
1	*Comment*	*Your response to Item 14 of our letter, regarding Solid Radioactive Waste, is acceptable. However, please confirm that you expect only to have surface contamination, and not "volumetric" contamination of materials and equipment. My confusion came from the sometimes-use of the term "solid contamination' to refer to volumetrically-contaminated items.*
1	Response	It is expected that contamination of equipment and material will be limited to surface contamination. The "free release" limits discussed in response to the previous inquiry only apply to surface contamination. These limits do not apply to material with volumetric contamination. Because no volumetrically contaminated material is anticipated to be encountered during decommissioning activities, the Army purposely did not use the term "solid contamination" in the *R-14 Range Decommissioning Plan*. The term "solid surface" is used on numerous occasions throughout the plan, however, to differentiate solid structural surfaces from natural ground surfaces.
2	*Comment*	*You proposed to use the DCGL of 230 pCi/g that was originally developed for use at the Transonic Range for the R-14 Range. Additional information is needed regarding the applicability of the conceptual model used for the Transonic Range to the R-14 Range, such as the physical features important to modeling the transport pathways and the source term, including the configuration and areal variability of the source. In addition, in Appendix C, "Determination of DCGL for R-14 Range Soils", it is stated that the composition of the DU in the R-14 Range consists of U-234, U-235, and U-238 activity fractions of 0.084, 0.012, and 0.904, respectively. However, Appendix C also states that the DCGL for the Transonic Range was generated based on a source term with U-234, U-235, and U-238 activity fractions of 0.190, 0.021, and 0.790. Additional information is needed regarding the applicability of the DCGL from the Transonic Range to the R-14 Range given the different ratio of radionuclides present in the source term.*
2	Response	The Transonic and R-14 Ranges are in the same general geographical location at the Aberdeen Proving Ground (APG), with less than 5 miles separating the 2 locations. In developing the derived concentration guideline level (DCGL) model for the Transonic Range, no site-specific parameters were used except the radionuclides selected, radionuclide input concentrations and the thickness of the contaminated zone. In-lieu of site-specific parameters, RESRAD default values were used in the derivation of the Transonic Range soil DCGLs for the "resident farmer" exposure scenario. The primary purpose of Appendix C, *Determination of Derived Concentration Guideline Level (DCGL) for R-14 Range Soils*, was not to propose a new DCGL for the R-14 Range, but to demonstrate that use of the Transonic Range DCGL for

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2 (cont'd)	Response (cont'd)	application to R-14 Range soils is a conservative decision. Therefore, the DCGL for depleted uranium (DU) derived for the Transonic Range (230 pCi/g) soils is demonstrated to be appropriate for application to the R-14 Range soils. There are some important differences in the derivation of the DCGL for DU in soils presented in Appendix C for the R-14 Range when compared to the Transonic Range DCGL derivation. First, the Transonic Range DCGLs were developed in 1999 using RESRAD Version 5.83, which was published in 1993. Since then, the RESRAD code has been continually refined with subsequent code revisions issued for use. The DCGL derivation presented in Attachment C for the R-14 Range was developed using the currently available version of RESRAD (Version 6.3), which was published in 2005. Therefore, modeling results generated using RESRAD Version 6.3 may not exactly match those generated using earlier versions of RESRAD even when keeping all input parameters the same. Second, since the publication of the Transonic Range DCGL derivation in April 1999, many reference documents have been completed and made available for use in modeling contaminants in soil. These include, for example, NUREG/CR-6697 and NUREG/CR-5512, Volume 3. Although all physical modeling parameters used in the DCGL derivation presented in Appendix C were RESRAD default values, (with the exception of the contaminated zone annual erosion rate), several parameters related to occupancy factors, indoor filtration, gamma shielding, and ingestion rates were derived from recommended values in the NRC NUREGs in lieu of the RESRAD default values. (Note: All RESRAD default and actual input parameter values, if different than the defaults, are presented in Appendix C, Table 3-1.) Before addressing the second portion of the question relating to the DU activity fractions used at the Transonic Range versus the DU activity fractions presented in Appendix C for the R-14 Range, an explanation is needed regarding the Transonic Range DCGL derivation. The selected DCGL for DU in soils at the Transonic Range was based on the analysis results from 100 soil samples collected during characterization of the site between December 1995 and May 1996. These sample results were then reviewed and grouped to establish three DCGL evaluation cases, identified below as Cases 1 through 3. • Case 1 used the mean activity of the analytical results for U-234, U-235 and U-238 in all 100 samples to determine activity fractions for the 3 isotopes of uranium. • Case 2 evaluated all 100 sample results and used only those results with a reported U-235 concentration of greater than 1 pCi/g (35 total samples) to establish the mean activity fractions for the uranium isotopes. • Case 3 excluded the analytical results from 13 sample locations considered to be "hot spots." As a result, 87 of the 100 sample analysis results were used to establish the mean activity fractions for the uranium isotopes.

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Request for Additional Information from B. Ullrich, NRC, dated 3/20/07		
2 (cont'd)	Response (cont'd)	The DU isotope activity fractions for all 3 cases are presented in Table 1.

TABLE 1: TRANSONIC RANGE DU ACTIVITY FRACTIONS

Uranium Isotope	Case 1 Activity Fractions	Case 2 Activity Fractions	Case 3 Activity Fractions	Average Activity Fraction Using All 3 Cases
U-234	0.211	0.138	0.222	0.190
U-235	0.0205	0.0234	0.0193	0.021
U-238	0.768	0.839	0.759	0.788

These activity fractions were then used to evaluate the DCGL for DU in soil independently for each case. The DCGL results are presented in Table 2.

TABLE 2: TRANSONIC RANGE DCGLs

Case Number	DU DCGL (pCi/g)
1	250
2	230
3	250

The Transonic Range DCGL for DU in soil was then selected based on the case result with the lowest (most conservative) value. This is contrary to what has been stated previously. The Transonic Range DCGL for DU in soil is not based on the activity fractions of 0.19, 0.021, and 0.79 for U-234, U-235, and U-238, respectively. It is simply based on the activity fractions that produced the lowest DCGL, which as shown above, were the activity fractions presented for Case 2. In fact, the uranium isotope activity fractions of 0.19, 0.021, and 0.79 are simply the average activity fractions when considering all 3 cases, as shown in Table 1 above.

Based on the above explanation, the pertinent question becomes: "What is the significance, in terms of the resulting DCGL, of the use of uranium isotope activity fractions for the Transonic Range in Case 2 above compared to the uranium isotope activity fractions presented for the R-14 Range, shown in Table 3?"

Comment No.	Item	Comment/Response
Request for Additional Information from B. Ullrich, NRC, dated 3/20/07		
2 (cont'd)	Response (cont'd)	**TABLE 3: TRANSONIC RANGE CASE 2 AND R-14 RANGE URANIUM ISOTOPE ACTIVITY FRACTIONS IN DU**

Uranium Isotope	Transonic Range Case 2 Activity Fractions	R-14 Range Activity Fractions
U-234	0.138	0.084
U-235	0.0234	0.012
U-238	0.839	0.904

To determine the significance resulting from the 2 sets of activity fractions presented in Table 3, each set was used to develop RESRAD input values, with the activity fractions used as input concentrations for the 3 uranium isotopes. Other than changing the thickness of the contaminated zone from the RESRAD default of 2 meters to 0.15 meters, no other changes were made to the RESRAD default parameters. RESRAD Version 6.3 was used for both evaluations. The resulting dose-to-source ratio (DSR) for the DU mix for the 2 sets of activity fractions in Table 3 are shown in Table 4 (obtained from page 10 of the RESRAD report for each of the 2 input fractions).

TABLE 4: TRANSONIC RANGE AND R-14 RANGE DOSE-TO-SOURCE RATIOS

Activity Fraction Input Source	Dose-to-Source Ratio or DSR (mrem/yr per pCi/g DU)
Transonic Range Case 2	1.048E-1
R-14 Range	1.050E-1

The DCGL is then determined using the following formula:

DCGL (pCi/g) = 25 mrem per year / DSR (mrem/yr per pCi/g)

Applying this equation to the DSR values in Table 4 results in the DCGLs presented in Table 5.

Comment No.	Item	Comment/Response
Request for Additional Information from B. Ullrich, NRC, dated 3/20/07		
2 (cont'd)	Response (cont'd)	**TABLE 5: TRANSONIC RANGE AND R-14 RANGE DCGL** **Activity Fraction Input Source** — **DCGL (pCi/g DU)** Transonic Range Case 2 — 238.55 R-14 Range — 238.10 In each case, the maximum DSR (and dose) occurs at time (t) = 0 years. During the time period of 0 to 300 years, the "water independent pathways" are the only contributors to the DSR and dose, with direct exposure to external radiation being the greatest contributor. As expected, U-238 (and decay products built up during this period) contributes greatest to external exposure. At approximately 300 years, "water dependent pathways" begin contributing to the DSR and dose, with the maximum contribution occurring after approximately 1,000 years. In this instance, U-234 and decay products are the greatest contributors. However, at no time does the DSR or dose exceed the DSR or dose at t = 0 years. As indicated in the evaluation results presented, the differences in the uranium isotope activity fractions used to generate the Transonic Range DCGL compared to the R-14 Range activity fractions have no impact on the calculated DSR or DCGL.
3	*Comment*	*Table 5 in the document "Determination of the Derived Concentration Guideline Level for R-14 Range Soils" showed the results of individual uranium isotope and the depleted uranium (DU) DCGLs. However, the calculation method used to determine the final DU DCGL for the R-14 Range differs from the methodology used to calculate the DU DCGL for the Transonic Range (ANL, 1999). While the dose limit and the total dose/source concentration ratios for uranium at the depleted uranium study area of the Transonic Range were used to calculate the DU DCGL for the Transonic Range, the DU DCGL for the R-14 Range in Table 5 was calculated by simply multiplying the respective activity fractions of each of the uranium isotopes in DU with the DCGL calculated for that individual uranium isotope and adding the products. Since you are seeking to use the approved Transonic DCGL at the R-14 Range site, the same methodology should be used for the R-14 Range calculations as were used for the DU DCGL calculations for the Transonic Range. These calculations should be provided for review. (Reference: ANL, 1999. Derived Uranium Guidelines for the Depleted Uranium Study Area of the Transonic Range, Aberdeen Proving Ground, Maryland. M. Picel and S. Kamboj, Argonne National Laboratory, Argonne, IL. April 1999.)*

Comment No.	Item	Comment/Response
Request for Additional Information from B. Ullrich, NRC, dated 3/20/07		
3	Response	To address this comment, the examples from the previous question/comment response are used. For the Transonic Range and R-14 Range DSR and DCGL evaluations, the DCGLs determined using the "conventional" approach are 238.55 and 238.10 pCi/g, respectively (refer to Table 5).

Individual uranium isotope "soil guidelines," in pCi/g, are obtained from page 19 of the RESRAD output report. These values are based on the summed DSR per radionuclide for each of the time periods evaluated. Since the DSR is reported in units of mrem/yr per pCi/g, the resulting DSR for each radionuclide and the individual "soil guideline" in pCi/g for each radionuclide will not change regardless of input concentrations, provided all other parameters are held constant. As an example of this, the DSR and individual radionuclide "soil guideline" or DCGL for the 2 examples evaluated in response to the previous question, Transonic Range Case 2 and R-14 Range, are provided in Table 6.

TABLE 6: TRANSONIC AND R-14 RANGE URANIUM ISOTOPE DSR AND DCGL

Uranium Isotope	Transonic Range Case 2		R-14 Range	
	DSR (mrem/yr per pCi/g)	DCGL (pCi/g)	DSR (mrem/yr per pCi/g)	DCGL (pCi/g)
U-234	3.162E-2	790.8	3.162E-2	790.8
U-235	4.454E-1	56.14	4.454E-1	56.14
U-238	1.073E-1	233.0	1.073E-1	233.0

In determining a DCGL in this manner for a mixture of radionuclides (or isotopes), such as the case for DU, the appropriate formula is:

$$\text{DU Mixture DCGL} = \frac{1}{\left(\frac{f_{U-234}}{DCGL_{U-234}}\right) + \left(\frac{f_{U-235}}{DCGL_{U-235}}\right) + \left(\frac{f_{U-238}}{DCGL_{U-238}}\right)}$$

Where:

f = activity fraction for the uranium isotope
DCGL = DCGL for the uranium isotope

Comment No.	Item	Comment/Response
Request for Additional Information from B. Ullrich, NRC, dated 3/20/07		
3 (cont'd)	Response (cont'd)	Using the above equation, the individual radionuclide DCGL values from Table 6 for each of the mixtures evaluated, and the activity fractions for each of these mixtures from Table 3, the DU mixture DCGL for each are calculated as shown in Table 7.

TABLE 7: TRANSONIC RANGE AND R-14 RANGE CALCULATED MIXTURE DCGL

Activity Fraction Input Source	DCGL (pCi/g DU)
Transonic Range Case 2	238.54
R-14 Range	238.11

When comparing the results provided in Table 7 (based on a calculated mixture DCGL) with the results presented in Table 5 (determined using the mixture DSR), the results are the same with the exception of minor differences due to rounding.

This analysis demonstrates that the formula provided as a footnote to Appendix C, Table 4-1, is incorrect and must be revised. Using the above method of determining the DCGL for a mixture of radionuclides or isotopes, the R-14 Range DU activity fractions, and the DCGL for each individual uranium isotope for the time period resulting in the maximum dose for the mixture of uranium isotopes in DU (0 years) in Appendix C, Table 4-1, the correct DCGL for the R-14 Range DU mixture should be 253.5 pCi/g (conservatively rounded down to 253 pCi/g).

From a practical standpoint, the different DU isotope fractions used for the Transonic Range and the R-14 Range have no significant impact on the calculated soil DCGL. The R-14 Range DCGL evaluation in Appendix C used several RESRAD input parameters based on recommendations published in NRC references that were issued subsequent to the derivation and publication of the Transonic Range DCGL. These input parameters are discussed in detail in Appendix C and are limited to input parameters associated with "receptor" occupancy and dietary ingestion relative to the resident farmer exposure scenario. R-14 Range site-specific input parameters were not proposed or used in this evaluation. The sole purpose for using these different parameters was to evaluate the impact on the calculated DCGL. As shown in Appendix C, the DCGL for DU in soil is higher when using these modified occupancy and dietary ingestion input parameters. Therefore, continued use of the previously applied Transonic Range DCGL of 230 pCi/g is demonstrated to be reasonable and conservative.

R-14 RANGE DECOMMISSIONING PLAN

REV. 0 ADDENDUM
APRIL 2008

This addendum consists of replacement pages for the R-14 Range Decommissioning Plan (DP) Rev. 0, which was submitted to NRC in November 2007, and amended in February 2008. The pages in this addendum supersede previous versions of the following sections of the DP:

- **Section 4.0: Radiological Status of the Facility (pp. 4-1 to 4-9)**
- **Section 6.0: Planned Decommissioning Activities (pp. 6-1 to 6-7)**
- **Section 10.0: Radioactive Waste Management Program (pp. 10-1 to 10-3)**
- **Appendix C: Determination of DCGLS For the R-14 Range Soils (pp. 1 to 24)**

4.0 RADIOLOGICAL STATUS OF THE FACILITY

A characterization survey of the R-14 Range was completed in December 2006. The survey results confirmed that historical activities involving DU have resulted in radiological contamination of the some of the structures and grounds, as described below. Details regarding the survey results are presented in the *R-14 Range Characterization Survey Report* (CABRERA, 2007), which is included as Appendix B.

4.1 Contaminated Structures

The scope of the characterization survey conducted at the R-14 Range included the interior and exterior surfaces of the following structures: the Blast Chamber, Hot Line, Firing Tube (with access shed), Muffler, and Water Treatment Shed. The gross DU surface screening limit (100 disintegrations per minute [dpm] per 100 square centimeters [cm^2]) and transferable activity screening limit (10 dpm/100 cm^2) used during the survey were derived in accordance with *NUREG 1757: Consolidated Decommissioning Guidance* (NRC, 2006). Based on the nature of historical activities conducted at the range and on the time period during which the structures were built, the characterization survey not only addressed DU contamination, but also included any hazardous substances suspected of being present in the building materials. This included asbestos, polychlorinated biphenyl compounds (PCBs), and *Resource Conservation and Recovery Act* (RCRA) metals.

4.1.1 Blast Chamber

Inside the Blast Chamber, static measurements and gross alpha smear data indicate widespread contamination on the walls, ceiling, and floor. Every interior location surveyed exceeded the building surface and/or transferable activity screening limits. Consistent with the nature of historical activities conducted at the range, the interior walls and ceiling of the Blast Chamber exhibited the highest levels of alpha contamination measured during the range characterization effort, with integrated direct measurements of up to 8,175 dpm/100 cm^2 and smear count rates of up to 1,071 dpm/100 cm^2.

On the exterior surfaces of the Blast Chamber, static measurements recorded at survey locations on the roof all exceeded the building surface screening limit, although none of the smear data exceeded the transferable activity screening limit. With respect to the exterior walls, only the north and west walls were surveyed due to accessibility issues on the other walls. While there was only one exceedance each of the building surface and transferable activity screening limits, the survey data indicated the likely presence of additional contamination in crevices and on horizontal surfaces (i.e., I-beams) where radioactive dust may have accumulated. Other likely areas of potential contamination include the entrance ramp on the west side of the building and the grooved sliding door track at the top of the ramp.

Because the Blast Chamber structure consists predominantly of steel, no volumetric sampling was conducted other than asbestos sampling of weather stripping around the two doors. Analytical results indicated that neither sample contained any detectable asbestos.

Based on the conclusions of the Blast Chamber characterization survey, the following assumptions were made regarding the radiological status of this structure:

- All interior surfaces are assumed to be contaminated with fixed, as well as transferable contamination.
- The roof is assumed to be contaminated with fixed contamination.
- Exterior walls exhibit limited areas of contamination that should be further delineated to identify discrete areas that may potentially be decontaminated and reused rather than disposed.

4.1.2 Hot Line

Inside the Hot Line, static measurements and gross alpha smear data indicated widespread contamination in the X-Ray Room, Cassette Room, and Hallway. Every location surveyed on the floors and walls of these areas exceeded the building surface screening limit, and approximately one-third of the locations also exceeded the transferable activity limit. Integrated direct measurements of up to 1,331 dpm/100 cm^2 and smear count rates of up to 146 dpm/100 cm^2.were recorded during the survey of floors and walls in these areas. In addition, surveys of the furniture and other large items in the X-Ray and Cassette Rooms (i.e., table, metal cabinet, toolbox, shelf, and platform) indicate multiple exceedances of one or both screening limits. Although not all of the planned ceiling locations were able to be surveyed due to accessibility issues, those that were surveyed did not indicate any exceedances of the screening limits.

There are only a few exceedances of the screening limits in the Changing/Wash Room and the Ramp leading from this room to the X-Ray Room hallway. One interior wall location in the Changing/Wash Room exceeds the transferable activity screening limit, and two floor locations on the Ramp exceed the building surface screening limit. None of the ceiling survey locations in these areas exceed the radiological screening limits. Survey results for the furniture, appliances, and sink drain do not indicate any exceedances of the screening limits. However, based on the high concentration of uranium in the Water Treatment Shed evaporator tank (see Section 4.1.5), which collects contaminated water from the Hot Line drains, it would be prudent to consider all drain lines used to transport water from the Hot Line to the evaporator tank contaminated.

Analytical data for samples of wallboard, ceiling tile, and flooring material collected from the Hot Line indicate no exceedance of a chemical action level or asbestos screening limit.[1]

Analysis of the water pumped from the floors in the Hallway and X-Ray Room prior to the survey of this building indicate a concentration of total uranium of 3,500 micrograms per liter [μg/L], with isotopic ratios indicative of DU. (Note: As a comparison, the EPA drinking water standard for total uranium is 30 μg/L [EPA, 2000].) Although technically no longer part of the Hot Line building, the 50 gallons of water that were removed from the floor is noticeably contaminated and must be appropriately treated and discharged (i.e., in accordance with the Army's existing National Pollutant Discharge Elimination System [NPDES] permit) or solidified and disposed.

Based on the conclusions of the Hot Line characterization survey, the following assumptions were made regarding the radiological status of this structure:

- The walls, floors, furniture, and other items in the X-Ray Room, Cassette Room, and Hallway are assumed to be contaminated and require disposal as radioactive waste.
- The floor of the Ramp is assumed to be contaminated and requires disposal as radioactive waste.

[1] The *Characterization Survey Report* in Appendix B incorrectly states that the ceiling tile in the Changing/Wash Room was found to contain greater than 1% friable asbestos and, thus, is considered asbestos-containing material (ACM). However, closer examination of the *Asbestos Inspection Report* indicates that this statement was based on a misinterpretation of the field data. The friable material in the tile sample was mineral wool, not asbestos.

- The wall in the Changing/Wash Room, which was the only location in the room where the transferable activity screening limit was exceeded, should be further evaluated to determine whether it can be decontaminated and disposed as non-radioactive waste.

- Based on historical use, and on data collected previously by ARL, the drain lines transporting water from the sink and washing machine in the Changing/Wash Room to the Water Treatment Shed should be considered contaminated and require disposal as radioactive waste. This assumption also applies to internal drain lines and pumps that are integral to the washing machine.

- Exterior building surfaces require further evaluation prior to disposal. However, based on results of other exterior surface surveys conducted during this effort, it is assumed that few, if any, of the exterior Hot Line areas exceed either the building surface or transferable activity screening limit.

4.1.3 Firing Tube

The interior of the Firing Tube exhibited large areas of contamination, with integrated direct measurements of up to 209 disintegrations per minute (dpm) per 100 square centimeters (100 cm^2) and smear count rates of up to 71 dpm/100 cm^2 recorded during the survey. Numerous locations on the interior floor of the Firing Tube exceeded both direct and transferable screening limits, especially at the south end where the tube adjoins the Blast Chamber and radioactive dust dispersed by overpressure from the blast would be most likely to settle. Although the walls and ceiling of the Firing Tube were not scanned, it is assumed that they are similarly contaminated, with the highest radioactivity being near the south end of the tube.

On the exterior surfaces of the Firing Tube, two locations exceeded the building surface screening limit, with integrated direct measurements of up to 367 dpm/100 cm^2. Both locations were on the south end of the tube, with the highest measurement recorded on top of the tube where the tube adjoins the Blast Chamber. None of the locations surveyed exceeded the transferable activity screening limit of 10 dpm/100 cm^2.

The Firing Tube Shed survey results indicated one location of surface contamination, which was in the middle section of the interior south wall of the shed. The transferable activity screening limit was exceeded at this location, with a smear count rate of 14 dpm/100 cm^2. The building surface screening limit of 100 dpm/100 cm^2 was met.

Because the Firing Tube consists predominantly of steel, no volumetric sampling was conducted other than the asbestos sampling of the Firing Tube Shed roof. Analytical results indicated that the asphalt shingle sample collected from this location did not contain any detectable asbestos.

Based on the conclusions of the Firing Tube characterization survey, the following assumptions were made regarding the radiological status of this structure:

- Interior surfaces (including shredder mounts and other appurtenances) throughout the length of the tube are assumed to be contaminated with fixed and removable contamination.
- Exterior surfaces exhibit limited regions of contamination that should be further delineated to identify discrete areas that may potentially be decontaminated and reused rather than disposed.

4.1.4 Muffler

Results of the Muffler survey indicated a few areas of exterior surface contamination, which appear to be limited to the south end of the structure where the access door is located. Both the building surface and transferable activity screening limits were exceeded on the exterior wall underneath the access door on this end of the Muffler. Integrated direct measurements of 164 dpm/100 cm^2 and a smear count rates of 192 dpm/100 cm^2 were recorded at this location during the survey. Scan survey data indicate similar levels of contamination on the door itself.

The floor of the Muffler contains a mixture of water and fine particulate that must be removed prior to decommissioning and/or reuse of this structure as an air handling device. Although no volumetric samples of this material were able to be collected during the characterization effort, it is assumed that the DU concentration in the Muffler water is at least as high as that reported for the water pumped from the floor of the Hot Line. This assumption is based on the similar nature of contamination (i.e., standing flood water containing radioactive dust that originated within the Blast Chamber as a result of testing operations). Assuming the water in the Muffler is one foot deep, it is estimated that approximately 2,200 gallons of contaminated water and sludge need to be removed from the structure and appropriately treated and discharged or solidified and disposed.

Volumetric samples of asphalt shingle and underlying roofing material were collected from the Muffler roof and analyzed for asbestos. Analytical results indicate that neither of the samples contained any detectable asbestos.

Based on the conclusions of the Muffler characterization survey, the following assumptions were made regarding the radiological status of this structure:

- All interior surfaces are assumed to be contaminated based on historical use of this structure.
- The water/sludge mixture contained in the Muffler is assumed to be contaminated and must be removed and treated.
- Only one exterior surface location (i.e., the south end of the Muffler, near the access door) exhibits contamination that should be further delineated to identify discrete areas that could be decontaminated rather than disposed.

4.1.5 Water Treatment Shed

Results of the Water Treatment Shed survey indicated no exceedances of either the building surface or transferable activity screening limit on the structure itself. Analysis of the water in the evaporator tank inside the shed, however, indicated a concentration of total uranium of 1,200 μg/L, with isotopic ratios indicative of DU. This is higher than the EPA drinking water standard of 30 μg/L (EPA, 2000); thus, any water remaining in the tank at the time of decommissioning will need to be treated and discharged or solidified and disposed. Once the water is removed and the shed is dismantled, the evaporator tank and associated piping can be surveyed to determine the extent to which contamination is present. Considering their historical use, it is assumed that these items will be significantly contaminated.

A volumetric sample of asphalt shingle was collected from the roof of the Water Treatment Shed and analyzed for asbestos. Analytical results indicate that this sample did not contain any detectable asbestos.

Based on the conclusions of the Water Treatment Shed characterization survey, the following assumptions were made regarding the radiological status of this structure:

- Contamination levels on the Water Treatment Shed walls and roof are below project screening limits.

- The water in the evaporator tank is assumed to be contaminated and must be removed and treated.

- Based on historical use, the evaporator tank and associated piping are assumed to be contaminated, but should be further evaluated to confirm this assumption prior to disposal. This assumption also applies to the floor and other low-lying components of the shed where contaminated water may have splashed or settled.

4.2 Contaminated Systems and Equipment

The following systems and equipment associated with the structures discussed in Section 4.1 are assumed to be contaminated unless otherwise demonstrated during building demolition: any exposed electrical, ventilation, and plumbing systems located within contaminated portions of the structures; and any sewer drains and/or piping through which contaminated water was historically conveyed; and any tanks, pumps, or other appurtenances used in the treatment of contaminated water. Similarly, any culvert or basin used in the management of storm water in contaminated portions of the grounds, such as the Sediment Trap discussed in Section 4.3, is assumed to be contaminated unless demonstrated otherwise upon removal of the associated water and sediment

4.3 Surface Soil Contamination

Results of the R-14 Range Grounds sampling and analysis indicated that, of all the areas evaluated, only the Laydown Yard contained regions exceeding the DU soil screening limit of 102 picocuries per gram (pCi/g). Two-thirds of the surface soil samples (i.e., from 0 to 6 in. below ground surface [bgs]) collected from this area contained DU at concentrations that exceeded the soil screening limit. The highest reported ^{234}Th activity concentration, which is used as a surrogate measure of ^{238}U when performing gamma spectroscopy analysis, was 511 pCi/g. This equates to a DU activity concentration of 565 pCi/g.[2] Alpha spectrometry data confirm that isotopic ratios of uranium in the soil are indicative of DU. Analytical results of a subsurface soil sample (i.e., from 6 to 12 in. bgs), collected from one of the surface sampling locations that exceeded the screening limit, were less than the soil screening limit of 102 pCi/g, suggesting that contamination is likely limited to the top 6 inches of soil.

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[2] See *R-14 Range Characterization Survey Report* in Appendix B for details regarding the conversion of activity concentrations of ^{234}Th to DU.

The storm water Sediment Trap located on the west side of the Laydown Yard contained sediment with a ^{238}U activity concentration of 620 pCi/g, which is well in excess of the soil screening limit. However, the water in the Sediment Trap contained total uranium at a concentration of 20 μg/L, which is less than the EPA drinking water standard of 30 μg/L (EPA, 2000). Alpha spectrometry data confirmed that the isotopic ratios in both the sediment and water samples were indicative of DU. Neither the sediment nor the water in the trap contained metals at concentrations exceeding hazardous waste limits.

While none of the soil samples collected from the Firing Fan, Sediment Trap, Pavement, or Grassy Field contained DU in concentrations exceeding the soil screening limit, gamma walkover survey (GWS) results indicated a few suspect regions of elevated radioactivity in these areas. The Firing Fan contained a region of elevated radioactivity along the east edge of the firing line, approximately 50 to 80 feet north of the north end of the Firing Tube. Other regions of elevated activity included a small grassy area downgradient of the Sediment Trap; several Pavement areas (i.e., at the junction of the Muffler and the Blast Chamber exhaust vent, the south entrance to the laydown yard, the low point in the road south of the buildings, and next to the Firing Tube approximately 40 ft north of the Blast Chamber); and the center portion of the north edge of the Grassy Field.

Based on the conclusions of the Grounds characterization survey, it is recommended that the following considerations be incorporated in the remediation approach for this portion of the R-14 Range:

- Surface soil in the Laydown Yard is assumed to be contaminated and should be remediated to a depth of 6 inches.
- The Sediment Trap, including the concrete basin, baffles, sediment, and water, is assumed to be contaminated and should be remediated. Based on the concentration of DU in the sediment, it is assumed that the entire trap is contaminated and that the water in the trap will become contaminated with suspended solids once the sediment is disturbed.
- Additional areas of the Grounds where GWS data indicate discrete regions of elevated radioactivity should be considered potentially contaminated and either investigated further or remediated to a depth of 6 inches.

4.4 Subsurface Soil Contamination

No subsurface soil contamination was observed during the characterization survey. Based on the nature of the DU contamination at the range (i.e., insoluble metal particles) and the low potential for downward migration through the surface soil, there is no reason to suspect any subsurface soil contamination at the site.

4.5 Surface Water

There are no natural surface water features within the boundaries of the R-14 Range. The only surface water observed during the characterization survey was in the Sediment Trap used in the management of storm water from the Laydown Yard, as discussed in Section 4.3.

4.6 Groundwater

Based on the lack of subsurface contamination, there is no reason to suspect any radioactive contamination in the groundwater at the site. This assumption is supported by Army well monitoring data, which does not indicate any radioactive contamination in the groundwater in the vicinity of the range.

6.0 PLANNED DECOMMISSIONING ACTIVITIES

Decommissioning activities planned for the R-14 Range include the demolition and removal of contaminated structures, systems, and equipment; decontamination of remaining concrete slabs; excavation and removal of contaminated soil; and MARSSIM (NRC, 2000) FSS of the remaining structures and soils. Decommissioning activities will be performed in accordance with the radiation safety and H&S programs discussed in later sections of this DP. Appropriate precautions will be specified in the Site Safety and Health Plan (SSHP) and task-specific radiation work permits (RWPs) to minimize the generation of airborne radioactivity and control the spread of contamination during each activity.

6.1 Contaminated Structures

The following above-ground structures will be demolished or dismantled and removed from the Site during decommissioning: Blast Chamber, Hot Line, Firing Tube and associated shed, Air Handling System (i.e., Muffler, Cartridge House, and HEPA Filter), and Water Treatment Shed. The concrete slabs remaining after building demolition will be spot-surveyed and decontaminated, as necessary, to meet building surface FSS release requirements. The waste generated during building demolition and dismantlement activities will be carefully segregated to minimize the total volume of material requiring disposal as radioactive waste.

6.1.1 Blast Chamber

The Blast Chamber will be dismantled in a manner that allows for the possible reuse or recycling of a large portion of the structural steel and/or steel plates. Building components (e.g., walls, stairs, roof, etc.) will be dismantled, re-sized as necessary, loaded onto trucks, and transported to another part of the installation for further processing by the Army. The Army intends to survey, decontaminate if possible, and reuse or recycle any steel that meets the release limits specified in the Army's EM 385-1-80: *Radiation Protection Manual* (Army, 1997). Steel that does not meet the release criteria and cannot be decontaminated will be loaded into shipping containers and transported off-site to an NRC-licensed facility for disposal. It is estimated that approximately half of the steel from the interior of the Blast Chamber may need to be disposed as radioactive waste due to the significant amounts of contamination observed during the characterization survey.

6.1.2 Hot Line

The Hot Line building will be dismantled in a manner that allows for non-contaminated materials to be disposed as standard industrial waste. Spot surveys will be conducted to confirm the results of the characterization survey, which indicate that the Clean Room and its contents (i.e., walls, floors, cabinets, benches, etc.), as well as the walls and ceiling of the Ramp, are generally not contaminated. Efforts will be made to decontaminate small areas of surface contamination that may be identified during the surveys to optimize the volume of waste that is eligible for disposal without regard to radiation. The exterior walls and roof of the Hot Line building, which are also expected to be non-contaminated, will be similarly surveyed and decontaminated, as necessary.

Materials from the Changing Room, Ramp, and exterior of the Hot Line that are verified as being non-contaminated will be removed from the building, containerized, and transported to a local industrial waste disposal facility, with one exception. The drains and drain lines on the washing machine and sink, as well as the pump and internal drain lines on the washing machine, will be disposed as radioactive waste based on their historical use in the conveyance of contaminated wash water.

The rest of the Hot Line, including the X-Ray Room, Cassette Room, Hallway, and floor of the Ramp are assumed to be contaminated based on the results of the characterization survey. These rooms and their contents will be dismantled, removed, containerized, transported, and disposed as radioactive waste.

6.1.3 Firing Tube

The Firing Tube will be dismantled in a manner that allows for the possible reuse or recycling of a large portion of the structural steel and/or steel appurtenances. Firing Tube sections will be dismantled, re-sized as necessary, loaded onto trucks, and transported to another part of the installation for further processing by the Army. As with the Blast Chamber, the Army intends to survey, decontaminate if possible, and reuse or recycle any steel from the Firing Tube that meets the EM 385-1-80 release limits (Army, 1997). Steel that does not meet the release criteria and cannot be decontaminated will be loaded into shipping containers and transported off-site to an NRC-licensed facility for disposal. Based on the results of the characterization survey, it is estimated that less than 5% of the Firing Tube steel will require disposal as radioactive waste.

The Firing Tube shed will be spot-surveyed to confirm the results of the characterization survey, which indicate that this structure and its contents (i.e., walls, floors, shelves, benches, etc.) are generally not contaminated. Efforts will be made to decontaminate small areas of surface contamination that may be identified during the spot surveys to optimize the volume of waste that is eligible for disposal without regard to radiation. Materials that are verified as being non-contaminated will be removed, containerized, and transported to a local industrial waste disposal facility. Contaminated materials that cannot be sufficiently decontaminated will be disposed as radioactive waste.

6.1.4 Air Handling System

The three components of the Air Handling System (i.e., Muffler, Cartridge House, and HEPA Filter) will be dismantled, loaded onto trucks, and transported to another part of the installation for further processing by the Army. The Army intends to survey these items to verify that they meet the EM 385-1-80 release limits (Army, 1997), decontaminate them as necessary to meet the limits, and reuse the entire system elsewhere on base.

The only part of the Air Handling System unit expected to be contaminated is the Muffler, which is directly downstream of the Blast Chamber exhaust vent. As noted during the characterization survey, the Muffler contains a mixture of water and sludge that is assumed to be contaminated based on historical use. It is estimated that 2,200 gallons of waste need to be removed from the Muffler prior to its dismantlement and removal from the Site. Contaminated waste will be pumped from the Muffler into a storage tank and transported to another location on base for treatment. Treated water that meets the applicable discharge limits will be discharged, and the residual sludge will be dried, sampled for radioactivity, and disposed appropriately, based on the analytical results.

6.1.5 Water Treatment Shed

The Water Treatment shed will be spot-surveyed to confirm the results of the characterization survey, which indicate that the walls and roof of this structure are generally not contaminated. Efforts will be made to decontaminate small areas of surface contamination that may be identified during the spot surveys to optimize the volume of waste that is eligible for disposal without regard to radiation. Materials that are verified as being non-contaminated will be removed, containerized, and shipped to a local industrial waste disposal facility.

Contaminated materials that cannot be sufficiently decontaminated will be disposed as radioactive waste.

6.1.6 Remaining Solid Surfaces

As estimated 4,000 ft^2 of solid surfaces (i.e., concrete slab, steel floor, and/or asphalt pad) will remain onsite following completion of building demolition and dismantlement. It is assumed that approximately half of this surface area will require decontamination by an abrasive process, such as scabbling, to meet the FSS surface release criteria. Contaminated portions of these solid surfaces (to include the surfaces within the building area footprint and the foundation of the Water Treatment Shed) will be decontaminated, as necessary, and the additional waste generated during decontamination will be collected disposed as radioactive waste.

6.2 Contaminated Systems and Equipment

The following systems and equipment associated with the structures discussed in Section 6.1 will be removed and disposed prior to building demolition: electrical, ventilation, and/or plumbing systems; sewer drains and piping used to convey contaminated water from the structures to Water Treatment Shed; and any tanks, pumps, or other appurtenances used in the treatment of contaminated water. In addition, the Sediment Trap and any other culvert or basin used in the management of storm water in contaminated areas of the Site will be removed and disposed prior to excavation of contaminated soils.

6.2.1 Electrical, Ventilation, and Plumbing Systems

Contaminated electrical, ventilation, and/or plumbing systems will be removed from the buildings prior to the initiation of any structural dismantlement or demolition activities. The following will be considered when removing these systems:

- Electrical components (e.g., transformers, switch gear, control boxes, etc.), which may contain PCBs, will be removed, scanned, and disposed appropriately as hazardous or mixed waste. Conduit and wiring will be removed, scanned, and disposed as either industrial or radioactive waste. Metals recycling may be considered for conduit and wiring removed from non-contaminated areas (i.e., Changing Room), depending on the amount of material and the degree to which it can be confirmed non-radioactive.

Materials will be considered eligible for recycling or disposal as standard industrial waste only if it meets the unrestricted release criteria discussed in Section 12.1.

- Ventilation systems (e.g., vents, filters, fans, ducts, stacks, room air conditioners, etc.) will be removed, scanned, and disposed appropriately as industrial or radioactive waste. It is noted that even non-contaminated areas may contain ventilation system components with internal contamination, especially if they are in-line with ducts conveying exhaust air from the contaminated portions of the building. Thus, ventilation system components for which it is not practical to survey all interior surfaces will be disposed as radioactive waste.
- Plumbing systems (e.g., water supply piping, pumps, valves, faucets, etc.) will be removed, scanned, and disposed appropriately as industrial or radioactive waste. It is assumed that most plumbing system components will require disposal as radioactive waste. Any system components that appear to be suitable for disposal as industrial waste will be thoroughly evaluated to ensure that the unrestricted release criteria discussed in Section 12.1are met.

6.2.2 Sewer Drains and Piping

Contaminated sewer drains and piping will be removed during demolition. This includes the buried metal sewer line between the Hot Line building and the Wastewater Treatment Shed (approximately 50 ft long), as well as the buried double-cased line (i.e., polyvinyl chloride [PVC] pipe inside a larger metal conduit) between the Wastewater Treatment Shed and the Evaporator Building east of the R-14 Range (approximately 100 ft long). Residual water will be flushed from the system prior to removing the lines, and the wastewater will be transported to another location on base for treatment. Due to the historical use of these pipes in conveying contaminated wastewater, it is assumed that the drains and primary piping are contaminated and require disposal as radioactive waste. The secondary pipe (i.e., outer metal conduit), which is expected to be non-contaminated, will be removed, surveyed, and disposed appropriately.

6.2.3 Wastewater Treatment System

Contaminated components of the wastewater treatment system will be removed during demolition of the Wastewater Treatment Shed. Residual water will be flushed from the system prior to removing the equipment, and the wastewater will be transported to another location on base for treatment. Due to the historical use of this system in treating contaminated wastewater from the R-14 structures, and on data collected during the characterization survey, it is assumed that most components of this system are contaminated to some extent and require disposal as radioactive waste. Depending on their mechanical condition and degree of contamination, the Army may elect to transport these components to another part of the base for decontamination and possible reuse rather than disposing of them.

6.2.4 Storm Water Management System

Contaminated components of the storm water management system, such as the Sediment Trap, will be removed during Site remediation. Residual standing water in these structures will be pumped into a storage tank and transported to another location on base for treatment. Accumulated sludge remaining in the bottom of these structures will be allowed to dry, then removed and disposed as contaminated soil, based on data collected during the characterization survey. The concrete and metal components of the structure will be removed, scanned, and disposed appropriately. For the Sediment Trap structure, it is assumed that these materials will require disposal as radioactive waste due to their semi-porous nature and the length of time during which they were in direct contact with contaminated sediment.

6.3 Surface Soil

Contaminated surface soil will be excavated from the Laydown Yard as part of the decommissioning process. This soil is assumed to be contaminated to a depth of six inches across the entire surface within the existing Laydown Yard fence, which is approximately 10,000 square feet (ft^2) in area. A small, additional area of contamination will be excavated from outside the western Laydown Yard fence, in the vicinity of the Sediment Trap. Upon remediation of the Sediment Trap structure, the underlying and adjacent surface soil will be excavated to a depth of 6 inches over the area surrounding the trap, up to 6 feet in all directions. This will involve the removal of soil from an area of approximately 100 ft^2 that lies outside the existing fence.

The total estimated volume of contaminated soil from the Site to be excavated and disposed, accounting for bulk growth, is approximately 250 cubic yards (yd^3). Based on analytical data collected during the characterization survey, it is assumed that the average DU activity in this waste stream will be 175 to 200 pCi/g. As such, this soil may be disposed at a permitted facility as special waste with unimportant quantities of radioactivity.

6.4 Schedule

The proposed schedule for the R-14 Range decommissioning is presented in Table 6-1. This schedule allows for the completion of decommissioning activities by June 2008, and the submittal of FSS documentation to NRC by October 2008.

Table 6-1: Schedule for R-14 Range Decommissioning

Activity	Estimated Date
Receive NRC Approval of DP	Feb 2008
Structural Assessment of Buildings	Mar 2008
Finalization of Work Plans	Apr 2008
Field Activities	May to Jul 2008
Submittal of FSS Report to NRC	Oct 2008

10.0 RADIOACTIVE WASTE MANAGEMENT PROGRAM

The solid and liquid radioactive waste generated during decommissioning of the R-14 Range will be managed as described in this section.

10.1 Solid Radioactive Waste

It is estimated that approximately 39,000 cf (1,440 cubic yards [yd^3]) of solid waste will be generated during decommissioning activities. This includes scrap metal, reinforced concrete, piping (metal, PVC, and/or clay), miscellaneous demolition debris, and soil. Descriptions and estimated volumes of waste materials are presented in Table 10-1. (Note: These volumes include the waste volume requiring disposal, as well as the steel components of the Blast Chamber and Firing Tube expected to be decontaminated and re-used elsewhere on base.)

Waste materials from decommissioning activities will be segregated and re-sized, as necessary, to meet packaging requirements and the disposal facility's acceptance criteria. Sized waste will be staged at the site and placed in hard-top intermodal containers to await transport. Contamination containment devices such as intermodal liners and tarps, in conjunction with sound health physics practice, will be used to prevent loose contamination from becoming dispersed during waste handling and loading activities.

Low-level radioactive waste meeting the proper acceptance criteria will be transported to EnergySolutions of Utah, in Clive, UT, for disposal. Contaminated soil and ACM will be transported to U.S. Ecology in Grandview, ID, for disposal. These waste streams will be properly profiled, as required by the disposal facility; and will be characterized, packaged, labeled, marked, placarded (if necessary), manifested, and transported in accordance with applicable regulations in 10 CFR 20 and 49 CFR.

If any waste is generated that meets the unrestricted release criteria specified in the CABRERA RSP and qualifies for disposal as non-hazardous waste, it will be hauled to a local industrial waste landfill facility, such as the Honeygo Run Rubble Landfill in Perry Hall, MD.

Table 10-1: Types and Estimated Volumes of Solid Waste

Source of Waste	Estimated Volume[1] (cf)	Potential Hazard	Description
Blast Chamber Demolition	2,600 5,200 250	Rad Rad Rad	Steel plates, targets, and backstop Structural steel and misc. debris Concrete scabbling waste
Hot Line Demolition	4, 750 3,600	Rad NA	Contaminated building debris General (non-contaminated) debris
Firing Tube and Shed	12,200 90 350	Rad Rad NA	Steel tube sections Steel appurtenances General (non-contaminated) debris
Wastewater Treatment Shed	150 20 750	Rad Rad NA	Treatment system components Concrete scabbling waste General (non-contaminated) debris
Sediment Trap	90 40	Rad Rad	Concrete demo debris Steel appurtenances
Sewer Pipe	230	Rad	Sewer pipe demo debris
Contaminated Soil Removal	8,400	Rad	Contaminated surface soils
TOTAL	**39,000**		

[1]Estimated volumes assume the following bulking factors: 25% for flat steel plate, 50% for general demolition and scabbling debris, and 30% for ex situ soil. Volume of firing tube assumes steel tube cross-sections remain intact.

10.2 Liquid Radioactive Waste

It is estimated that approximately 4,000 gal of liquid waste will be encountered or generated during decommissioning activities. This includes contaminated water removed from the Hot Line, Muffler, Sediment Trap, and Wastewater Treatment System, as well as water flushed from the sewer lines to be removed and general decontamination fluids, as indicated in Table 10-2. Contaminated liquid waste will be collected and transported to another location on base for treatment. The Army intends to treat, sample, and discharge this wastewater in accordance with its existing NPDES permit.

No additional sources of contaminated water currently exist at the Site, and groundwater is not expected to be encountered during demolition and excavation activities. Mitigative measures will be implemented during excavation activities (e.g., covering the excavated areas with tarps to keep rain water from collecting, installing straw bale barriers, etc.), as necessary, to prevent the uncontrolled release of contaminated liquids. If rain water does accumulate within open excavations prior to the completion of final status surveys, the water will be sampled and analyzed prior to release.

Table 10-2: Estimated Volumes of Liquid Waste

Source of Waste	Estimated Volume (gal)	Estimated Total Uranium Concentration (µg/L)
Hot Line	50	3,500
Muffler	2,200	3,500
Sediment Trap	480	20
Wastewater Treatment System	100	1,200
Sewer Lines	100	1,200
Decontamination Fluids	1,000	1,200
TOTAL	**3,930**	**2,373**[1]

[1] Weighted average

APPENDIX C

DETERMINATION OF DCGL FOR R-14 RANGE SOILS

DETERMINATION OF DERIVED CONCENTRATION GUIDELINE LEVEL (DCGL) FOR R-14 RANGE SOILS

1.0 INTRODUCTION

This appendix presents an evaluation of the Transonic Range derived concentration guideline level (DCGL) calculation for depleted uranium (DU) in soils with respect to its applicability to the R-14 Range. Both ranges are part of the U.S. Army Research Laboratory (ARL) located at Aberdeen Proving Ground (APG) in Aberdeen, Maryland. This DCGL evaluation was performed based on the resident farmer receptor scenario, which is the limiting dose scenario at both sites.

The DCGLs presented in this document are based on the *Radiological Criteria for Unrestricted Use* requirements set forth by the U.S. Nuclear Regulatory Commission (NRC) in 10 CFR Part 20.1402. In accordance with these requirements, a site is considered acceptable for unrestricted use if the residual radioactivity that is distinguishable from background radiation results in a Total Effective Dose Equivalent (TEDE) to an average member of the critical group that does not exceed 25 mrem (0.25 mSv) per year (mrem/yr), and the residual radioactivity has been reduced to levels that are as low as reasonably achievable (ALARA).

The results of this evaluation verify that the soils DCGL used previously at the Transonic Range is applicable and protective for use at the R-14 Range Site. Thus, the DCGL value of 230 pCi/g will be used as the soil action level for remediation and final status survey of the R-14 Range Site.

2.0 BACKGROUND INFORMATION

The *Transonic Range Decommissioning Plan* (DP; ATG, 2000) utilized the DCGL report developed by Argonne National Laboratory (ANL) for DU-contaminated soils at the Transonic Range of APG (ANL, 1999). The DP was approved by NRC, and the site was remediated and released in accordance with the specified DCGLs. The DCGLs for the DU Study Area of the Transonic Range were based on site-specific uranium guidelines derived for a 50-year TEDE to a hypothetical individual not exceeding 25 mrem in any one year, and evaluated over a 1,000 year time interval. The *Residual Radioactivity* (RESRAD) computer code, Version 5.82, was used to develop DCGLs for the Transonic Range (ANL, 1999). The RESRAD code parameters and pathways used in the Transonic Range evaluation were set up to consider nine exposure pathways:

1) Direct exposure from contaminated soil,
2) Internal dose from inhalation of contaminated dust,
3) Internal radiation from the inhalation of emanating radon-222,
4) Internal radiation from the ingestion of plant foodstuffs grown in contaminated soil and irrigated with groundwater drawn from a well located within the decontaminated area,
5) Internal radiation from the ingestion of meat from livestock fed fodder grown in the decontaminated area and irrigated with groundwater from the decontaminated area,

6) Ingestion of milk from milk animals raised with fodder and irrigation groundwater drawn from the decontaminated area,
7) Internal radiation from ingestion of fish from a pond drawing water from the decontaminated area,
8) Internal dose from the ingestion of onsite soil, and
9) Internal radiation from drinking water drawn from an onsite well.

Two potential exposure scenarios - the industrial worker scenario and the resident farmer scenario - were considered for the Transonic Range using combinations of the above pathways. Based on uranium-234 (^{234}U), uranium-235 (^{235}U), and uranium-238 (^{238}U) activity fractions of 0.138, 0.023, and 0.839, a DCGL of 230 picocuries per gram (pCi/g) was determined for DU in soils under the more restrictive resident farmer scenario.

A similar evaluation was performed to develop the DCGL for DU in soils at the Aberdeen Test Center (ATC) Bomb Throwing Device (BTD) Site by utilizing the same procedure as that for the Transonic Site (CABRERA, 2003). The results of the BTD evaluation showed that:

> *"The DCGL developed at the Transonic Range is considered applicable to and adequately protective for the BTD Site on the basis of comparable site-specific RESRAD parameter/pathways, the similarity of both locations, and the equivalence of the radiological isotopic DU mixes. Use of the approved Transonic DCGL at the BTD Site will ensure that the potential dose to a hypothetical individual will not exceed 25 mrem in any one year over a 1,000-year period. The DCGL for the BTD Site soil is 230 pCi/g total DU (resident farmer scenario)."*

3.0 METHODOLOGY

The following sections of this evaluation summarize the methodology used for determining the soil DCGL for DU under the standard resident farmer receptor scenario at the R-14 Range Site and compare the result with that obtained for Transonic Range Site. The results of the more conservative DCGL derivation will be utilized as the DCGL for the R-14 Range Site.

3.1 Dose Assessment Model

RESRAD, Version 6.3 (ANL, 2005), was used to derive the DCGL for DU. RESRAD is a computer code developed by ANL for the U.S. Department of Energy (DOE) to determine site-specific residual radiation guidelines and dose to a future hypothetical onsite receptor at sites that are contaminated with residual radioactive materials.

3.2 Source Term

Radionuclides of concern (ROCs) known to be present in the R-14 Range area are limited to DU isotopes (i.e., ^{234}U, ^{235}U, and ^{238}U) and their short-lived decay progeny. The activity fractions are calculated from the weight ratios and specific activities of each uranium isotope. The resulting composition consists of ^{234}U, ^{235}U, and ^{238}U activity fractions of 0.084, 0.012, and 0.904, respectively. These fractional source terms were used as inputs to RESRAD model.

3.3 Receptor

NRC guidance recommends analysis of a residential farmer scenario as the basis for the DCGLs for residual contamination in site-wide surface soil (NUREG/CR-1549). As with the Transonic and BTD sites, the resident farmer scenario was confirmed to be the most restrictive scenario evaluated during the determination of the DU soils DCGL for the R-14 Range Site. Under this scenario, the receptor was assumed to be exposed to radioactive contamination in soil through various pathways.

The residential farmer receptor is assumed to live onsite for 350 days per year for 30 years (EPA, 2000). Under a resident farmer scenario, a family is assumed to move onto the site after it has been released for use without radiological restrictions, builds a home, and raises crops and livestock for family consumption. Based on a 24-hour occupancy scenario, the resident is assumed to spend 240 days/yr indoors, 40.2 days/yr outdoors, and 2.92 days/yr for gardening activities (NUREG/CR-5512).

3.4 Exposure Scenarios

The resident farmer is exposed through various exposure pathways to radioactive contamination present in the site soil. Members of the critical group can incur a radiation dose by:

(1) Direct radiation from radionuclides in the soil,
(2) Inhalation of re-suspended dust (if the contaminated area is exposed at the ground surface),
(3) Ingestion of food from crops grown in contaminated soil,
(4) Ingestion of milk from livestock raised in the contaminated area,
(5) Ingestion of meat from livestock raised in the contaminated area,
(6) Ingestion of fish from a nearby pond contaminated by water that has percolated through the contaminated area,
(7) Ingestion of water from a well contaminated by water that has percolated through the contaminated zone, and
(8) Ingestion of contaminated soil.

Unlike the Transonic Range and BTD Sites, the radon pathway was suppressed during this evaluation due to its inapplicability. As radium-226 is not an ROC for this site, neither is its daughter radon an ROC for the site. In addition, in a Federal Register Notice (NRC, 1994), issued as a result of comments received from a radon workshop, the NRC noted that "radon would not be evaluated when developing release criteria due to: the ubiquitous nature of radon in the general environment, the large uncertainties in the models used to predict radon concentrations; and the inability to distinguish between naturally occurring radon and that which occurs due to licensed activities."

3.5 Recommended Values for RESRAD Parameters

3.5.1 Selection Process for Recommended Values

Site-specific information is the first preference for selection of values to use as RESRAD input parameters. When site-specific data is not available, the default values assigned in NRC documents are used. Between the three NRC documents, Volume 4 of NUREG/CR-5512 defines the residential farmer scenario, hence was given first preference. The remaining documents define the values for residential scenario.

a) *Comparison of the Models and Assumptions used in DandD 1.0, RESRAD 5.61, and RESRAD-Build 1.50 Computer Codes with Respect to the Residual Farmer and Industrial Occupant Scenarios* Provided in NUREG/CR-5512 (NUREG/CR-5512, Vol.4)
b) *Residual Radioactive Contamination From Decommissioning - Parameter Analysis, Draft Report for Comments* (NUREG/CR-5512, Vol. 3)
c) *Residual Radioactive Contamination From Decommissioning: Technical Basis for Translating Contamination Levels to Annual Total Effective Dose Equivalent*, Volume 1) PNL-7994 (NUREG/CR-5512)
d) *Development of Probabilistic RESRAD 6.0 and RESRAD-Build 3.0 Computer Codes* (NUREG/CR-6697, 2000)

US EPA guidance documents were given the third preference. The following EPA documents were mainly used for comparison purposes and for selection of conservative values for intake parameters.

a) *Soil Screening Guidance Document for Radionuclides: User's Guide* (EPA, 2000)
b) *Exposure Factors Handbook* (EPA, 1997)

When no site-specific, NRC, and EPA values for the RESRAD parameters is available, *Data Collection Handbook to Support Modeling Impacts of Radioactive Material in Soil,* Environmental Assessment and Information Sciences Division, Argonne National Laboratory (ANL, 1993) was used for selection of RESRAD default values.

However, there is one exception. EPA's assigned value of 36.5 g/yr was selected instead of NUREG/CR-5512 value of 18.3 g/yr for the resident adult soil ingestion rate. This was done due to the fact that NUREG/CR-5512 assigned value is equivalent to the soil ingestion rate for an industrial worker scenario under the EPA's guidance document.

3.5.2 Recommended Values for RESRAD Input Parameters

Table 3-1 presents the default value and the selected recommended value associated with each RESRAD input parameter. The recommended values were used in the derivation of soil DCGLs for the resident farmer scenario.

TABLE 3-1: DEFAULT AND RECOMMENDED VALUES FOR RESRAD INPUT PARAMETERS

RESRAD			Recommendations			
Parameter	**Code**	**Default Value**	**Value**	**Units**	**Justification**	**Reference**
Area of contaminated zone	AREA	10,000	10,000	m^2	RESRAD-default value is used. Site-specific area is higher than the default value. However, dose is insensitive to an area greater than 10000 m^2.	ANL, 1993
Thickness of contaminated zone	THICK0	2	0.15	m	No site-specific data is available. NRC assumed surface contamination of 0.15 m;	NUREG/CR 5512
Length parallel to aquifer flow	LCZPAQ	100	100	m	RESRAD default value was assumed.	ANL, 1993
Time since placement of material	TI	0	1,3,10,30, 100, 300, 1000	yr	This is RESRAD model-related parameter. No NRC and EPA value could be located.	ANL, 1993
Cover depth	COVER0	0	0	m	No site-specific data is available. The project assumed no cover as a conservative approach.	NA
Density of cover material	DENSCV	1.5	NA	g/m^3	No value is assigned due to no soil cover.	NA
Cover depth erosion rate	VCV	0.001	NA	m/yr	No value is assigned due to no soil cover.	NA
Density of contaminated zone	DENSCZ	1.5	1.5	g/m^3	RESRAD default value was assumed.	ANL, 1993
Contaminated zone erosion rate	VCZ	0.001	0.0006	m/yr	No site-specific data is available. Assuming 2% slope and significant farming and gardening activities at the site, 0.0006 m/yr was assigned.	ANL, 1993
Contaminated zone total porosity	TPCZ	0.4	0.4	unitless	RESRAD default value was assumed.	ANL, 1993
Contaminated zone field capacity	FCCZ	0.2	0.2	unitless	RESRAD default value was assumed.	ANL, 1993
Contaminated zone hydraulic conductivity	HCCZ	10	10	m/yr	RESRAD default value was assumed.	ANL, 1993
Contaminated zone b parameter	BCZ	5.3	5.3	unitless	RESRAD default value was assumed.	ANL, 1993

TABLE 3-1: DEFAULT AND RECOMMENDED VALUES FOR RESRAD INPUT PARAMETERS (CONT'D)

RESRAD			Recommendations			
Parameter	**Code**	**Default Value**	**Value**	**Units**	**Justification**	**Reference**
Average annual wind speed	WIND	2	2	m/sec	RESRAD default value was assumed.	ANL, 1993
Humidity in air	HUMID	8	NA	g/m^3	No value was assigned, as Tritium is not a radionuclide of interest for this site. Humidity input only required if Tritium is present.	NA
Evapotranspiration coefficient	EVAPTR	0.5	0.5	unitless	No site-specific data is available. NRC and EPA value could not be located. Hence, RESRAD default value was assigned for this parameter.	ANL, 1993
Precipitation	PRECIP	1	1	m/yr	RESRAD default value was assumed.	ANL, 1993
Irrigation	RI	0.2	0.2	m/yr	No site-specific data is available. NRC and EPA value could not be located. Hence, RESRAD default value was assigned for this parameter.	ANL, 1993
Irrigation mode	IDITCH	Overhead	Overhead	unitless	RESRAD default value was assumed.	ANL, 1993
Runoff coefficient	RUNOFF	0.2	0.2	unitless	RESRAD default value was assumed.	ANL, 1993
Watershed area for nearby stream or pond	WAREA	1.00E+06	1.00E+06	m^2	RESRAD default value was assumed.	ANL, 1993
Accuracy for water/soil computations	EPS	0.001	0.001	unitless	This is RESRAD model-related parameter. No NRC and EPA value could be located.	ANL, 1993
Saturated zone density	DENSAQ	1.5	1.5	g/m^3	RESRAD default value was assumed.	ANL, 1993
Saturated zone total porosity	TPSZ	0.4	0.4	unitless	RESRAD default value was assumed.	ANL, 1993
Saturated zone effective porosity	EPSZ	0.2	0.2	unitless	RESRAD default value was assumed.	ANL, 1993
Saturated zone field capacity	FCSZ	0.2	0.2	unitless	RESRAD default value was assumed.	ANL, 1993
Saturated zone hydraulic conductivity	HCSZ	100	100	m/yr	RESRAD default value was assumed.	ANL, 1993

TABLE 3-1: DEFAULT AND RECOMMENDED VALUES FOR RESRAD INPUT PARAMETERS (CONT'D)

RESRAD			Recommendations			
Parameter	**Code**	**Default Value**	**Value**	**Units**	**Justification**	**Reference**
Saturated zone hydraulic gradient	HGWT	0.02	0.02	unitless	This is RESRAD model-related parameter. No NRC and EPA value could be located.	ANL, 1993
Saturated zone b parameter	BSZ	5.3	5.3	unitless	RESRAD default value was assumed.	ANL, 1993
Water table drop rate	VWT	0.001	0.001	m/yr	No site-specific data, NRC and EPA value could be located. Hence, RESRAD default value was assumed.	ANL, 1993
Well pump intake depth (m below water table)	DWIBWT	10	10	m	RESRAD default value was assumed.	ANL, 1993
Model: Nondispersion (ND) or Mass-Balance (MB)	MODEL	ND	ND	unitless	Area of contamination is greater than 1000 m^2, hence non-dispersion model was assumed.	ANL, 1993
Well pumping rate	UW	250	250	m^3/yr	RESRAD default value was assumed.	ANL, 1993
Number of unsaturated zone strata #	NS	1	1	unitless	No site-specific data is available. Both NRC & RESRAD default used the same value.	ANL, 1993 NUREG/CR-5512
Unsaturated zone thickness	H(1)	4	4	m	RESRAD default value was assumed.	ANL, 1993
Unsaturated zone density	DENSUZ(1)	1.5	1.5	g/m^3	RESRAD default value was assumed.	ANL, 1993
Unsaturated zone total porosity	TPUZ(1)	0.4	0.4	unitless	RESRAD default value was assumed.	ANL, 1993
Unsaturated zone effective porosity	EPUZ(1)	0.2	0.2	unitless	RESRAD default value was assumed.	ANL, 1993
Unsaturated zone field capacity	FCUZ(1)	0.2	0.2	unitless	RESRAD default value was assumed.	ANL, 1993
Unsaturated zone hydraulic conductivity	HCUZ(1)	100	100	m/yr	RESRAD default value was assumed.	ANL, 1993
Unsaturated zone b parameter	BUZ(1)	5.3	5.3	unitless	RESRAD default value was assumed.	ANL, 1993

TABLE 3-1: DEFAULT AND RECOMMENDED VALUES FOR RESRAD INPUT PARAMETERS (CONT'D)

RESRAD			Recommendations			
Parameter	**Code**	**Default Value**	**Value**	**Units**	**Justification**	**Reference**
Distribution coefficients						
Uranium	D-1	50	50	cm^3/g	In absence of soil type, RESRAD default value was assumed.	ANL 1993
Inhalation rate	INHALR	8,400	6650 (footnote)	m^3/yr	Site-specific value for this parameter is not available. Hence, time-weighted inhalation rate was calculated based on NRC defined inhalation rates for different activities, and the time, receptor will spend for each activity. Indoor = 0.9; Outdoor = 1.4 ; Gardening = 1.7 (m^3/hr)	NUREG/CR-5512
Mass loading for inhalation	MLINH	0.0001	4.6E-6 (footnote)	g/m^3	Site-specific value for this parameter is not available. Hence, time-weighted mass loading for inhalation rate was calculated based on NRC defined mass loading factor for different activities, and the time, receptor will spend for each activity. Indoor = 1.4E-6; Outdoor=3.14E-6; Gardening = 4E-4; (g/m^3)	NUREG/CR-5512
Exposure duration	ED	30	30	yr	No site-specific value is available. As conservative approach, EPA's defined value was assigned for this parameter.	EPA, 2000
Indoor Dust Filtration Factor	SHF3	0.4	0.2448	unitless	No site-specific value is available. Hence, NRC value was assigned.	NUREG/CR-5512
External gamma shielding factor	SHF1	0.7	0.5512	unitless	No site-specific value is available. Hence, NRC value was assigned.	NUREG/CR-5512
Fraction of time spent indoors	FIND	0.5	0.658	unitless	NRC value was assigned.	NUREG/CR 5512

TABLE 3-1: DEFAULT AND RECOMMENDED VALUES FOR RESRAD INPUT PARAMETERS (CONT'D)

RESRAD			Recommendations			
Parameter	Code	Default Value	Value	Units	Justification	Reference
Fraction of time spent outdoors (onsite)	FOTD	0.25	0.118	unitless	NRC value was assigned based on combining outdoor and gardening activities.	ANL, 1993
Shape of the contaminated zone: Circular; Non-Circular	FS	Circular	Circular	unitless	No site-specific, NRC and EPA value for this parameter could be located; hence, RESRAD default was assigned.	ANL, 1993
Fruits, vegetables and grain consumption	DIET(1)	160	166	kg/yr	No site-specific value is available. NUREG/CR-5512 default value was chosen for this parameter. The value is almost equal to the most likely value defined in NUREG/CR-6697. This value is more conservative than EPA value. (Fruits = 51; Grains = 69; Vegetables = 51; kg/yr)	NUREG/CR-5512
Leafy vegetable consumption	DIET(2)	14	11	kg/yr	No site-specific value is available. Hence, NRC value was used for this parameter. This value is more conservative than EPA value.	NUREG/CR-5512
Milk consumption	DIET(3)	92	100	L/yr	No site-specific value is available. NUREG/CR-5512 default value was chosen for this parameter. The value is almost equal to the most likely value defined in NUREG/CR-6697. This value is more conservative than EPA value.	NUREG/CR-5512
Meat and poultry consumption	DIET(4)	63	65.1	kg/yr	No site-specific value is available. NRC value was used. (Beef = 59; Poultry = 6; kg./yr)	NUREG/CR-5512
Fish consumption	DIET(5)	5.4	10	kg/yr	No site-specific value is available. Hence, NRC value was used.	NUREG/CR-5512
Other seafood consumption	DIET(6)	0.9	0.9	kg/yr	No site-specific value, NRC and EPA value could be located. Hence, RESRAD default value was assigned.	ANL, 1993

TABLE 3-1: DEFAULT AND RECOMMENDED VALUES FOR RESRAD INPUT PARAMETERS (CONT'D)

RESRAD			Recommendations			
Parameter	**Code**	**Default Value**	**Value**	**Units**	**Justification**	**Reference**
Soil ingestion rate	SOIL	36.5	36.5	g/yr	Soil ingestion rate Both RESRAD default and EPA use the same value for this parameter for adult receptor. Adult = 100 mg/day	EPA, 1997
Drinking water intake	DWI	510	478.5	L/yr	No site-specific value is available. Hence, NRC value was used. (1.3 L/d)	NUREG/CR-5512
Contamination fraction of drinking water	FDW	1	1	unitless	No site-specific value is available. Hence, the maximum NRC value was used for this parameter.	NUREG/CR-6697
Contamination fraction of household water	FHHW	1	NA	unitless	Radon pathway is not selected; hence this parameter is not applicable	NA
Contamination fraction of livestock water	FLW	1	1	unitless	No site-specific value is available. Hence, maximum NRC value was used.	NUREG/CR-6697
Contamination fraction of irrigation water	FIRW	1	1	unitless	No site-specific value is available. Hence, the maximum NRC value was used.	NUREG/CR-6697
Contamination fraction of aquatic food	FR9	0.5	1	unitless	No site-specific value is available. Hence, the maximum NRC value was used for this parameter.	NUREG/CR-6697
Contamination fraction of plant food	FPLANT	-1 **	1	unitless	No site-specific value is available. Hence, NRC value was used for this parameter.	NUREG/CR-6697
Contamination fraction of meat	FMEAT	-1 **	1	unitless	No site-specific value is available. Hence, NRC value was used for this parameter.	NUREG/CR-6697
Contamination fraction of milk	FMILK	-1**	1	unitless	No site-specific value is available. Hence, the maximum NRC value was used for this parameter.	NUREG/CR-6697
Livestock fodder intake for meat	LFI5	68	26.85	kg/day	No site-specific value is available. Hence, NRC value was used for this parameter.	NUREG/CR-6697
Livestock fodder intake for milk	LFI6	55	63.25	kg/day	No site-specific value is available. Hence, NRC value was used for this parameter.	NUREG/CR-6697

TABLE 3-1: DEFAULT AND RECOMMENDED VALUES FOR RESRAD INPUT PARAMETERS (CONT'D)

RESRAD			Recommendations			
Parameter	**Code**	**Default Value**	**Value**	**Units**	**Justification**	**Reference**
Livestock water intake for meat	LWI5	50	50	L/day	No site-specific value is available. Hence, NRC value was used for this parameter.	NUREG/CR-6697
Livestock water intake for milk	LWI6	160	60	L/day	No site-specific value is available. Hence, NRC value was used for this parameter.	NUREG/CR-6697
Livestock soil intake	LSI	0.5	0.5	kg/day	Both NRC and RESRAD values are the same; hence that value was assigned for this parameter.	ANL, 1993 NUREG/CR-5512
Mass loading for foliar deposition	MLFD	0.0001	0.0001	g/m^3	No site-specific value, NRC and EPA value could be located. Hence RESRAD default value is assigned.	ANL, 1993
Depth of soil mixing layer	DM	0.15	0.15	m	No site-specific value, NRC and EPA value could be located. Hence RESRAD default value is assigned for this parameter.	ANL, 1993
Depth of roots	DROOT	0.9	0.9	m	No site-specific value, EPA value could be located. Hence RESRAD default value is assigned.	ANL, 1993
Drinking water fraction from ground water	FGWDW	1	1	unitless	Both NRC and RESRAD values for this parameter are the same; hence that value was assigned.	ANL, 1993 NUREG/CR-5512
Household water fraction from ground water	FGWHH	1	NA	unitless	Radon pathway is not selected; hence this parameter is not applicable	NA
Livestock fraction from ground water	FGWLW	1	1	unitless	Both NRC and RESRAD values for this parameter are the same; hence that value was assigned.	ANL, 1993 NUREG/CR-5512
Irrigation fraction from ground water	FGWIR	1	1	unitless	Both NRC and RESRAD values for this parameter are the same; hence that value was assigned.	ANL, 1993 NUREG/CR-5512
Wet weight crop yield for non-leafy vegetables	YV(1)	0.7	0.7	kg/m2	No site-specific, NRC and EPA value could be located. RESRAD default value was assigned.	ANL, 1993

TABLE 3-1: DEFAULT AND RECOMMENDED VALUES FOR RESRAD INPUT PARAMETERS (CONT'D)

RESRAD			Recommendations			
Parameter	**Code**	**Default Value**	**Value**	**Units**	**Justification**	**Reference**
Wet weight crop yield for leafy	YV(2)	1.5	1.5	kg/m^2	No site-specific, NRC and EPA value could be located. Hence RESRAD default value was assigned.	ANL, 1993
Wet weight crop yield for fodder	YV(3)	1.1	1.1	kg/m^2	No site-specific, NRC and EPA value could be located. Hence RESRAD default value was assigned.	ANL, 1993
Growing season for non-leafy	TE(1)	0.17	0.17	years	No site-specific, NRC and EPA value could be located. Hence RESRAD default value was assigned.	ANL, 1993
Growing season for leafy	TE(2)	0.25	0.25	years	No site-specific, NRC and EPA value could be located. Hence RESRAD default value was assigned.	ANL, 1993
Growing season for fodder	TE(3)	0.08	0.08	years	No site-specific, NRC and EPA value could be located. Hence RESRAD default value was assigned.	ANL, 1993
Translocation factor for non-leafy	TIV(1)	0.1	0.1	unitless	Both NRC and RESRAD values for this parameter are the same; hence that value was assigned.	ANL, 1993 NUREG/CR-5512
Translocation factor for leafy	TIV(2)	1	1	unitless	Both NRC and RESRAD values for this parameter are the same; hence that value was assigned	ANL, 1993 NUREG/CR-5512
Translocation factor for fodder	TIV(3)	0.1	0.1	unitless	Both NRC and RESRAD values for this parameter are the same; hence that value was assigned.	ANL, 1993 NUREG/CR-5512
Dry foliar interception fraction for non-leafy vegetables	RDRY(1)	0.25	0.25	unitless	No site-specific, NRC and EPA value could be located. RESRAD default value was assigned.	ANL, 1993
Dry foliar interception fraction for leafy vegetables	RDRY(2)	0.25	0.25	unitless	No site-specific, NRC and EPA value could be located. RESRAD default value was assigned.	ANL, 1993
Dry foliar interception fraction for fodder	RDRY(3)	0.25	0.25	unitless	No site-specific, NRC and EPA value could be located. RESRAD default value was assigned.	ANL, 1993

TABLE 3-1: DEFAULT AND RECOMMENDED VALUES FOR RESRAD INPUT PARAMETERS (CONT'D)

RESRAD			Recommendations			
Parameter	**Code**	**Default Value**	**Value**	**Units**	**Justification**	**Reference**
Wet foliar interception fraction for non-leafy vegetables	RWET(1)	0.25	0.25	unitless	No site-specific, NRC and EPA value could be located. RESRAD default value was assigned.	ANL, 1993
Wet foliar interception fraction for leafy	RWET(2)	0.25	0.25	unitless	Site-specific value is not available. Most likely value defined in NUREG/CR was assigned.	ANL, 1993
Wet foliar interception fraction for fodder	RWET(3)	0.25	0.25	unitless	Site-specific value is not available. Most likely value defined in NUREG/CR was assigned.	ANL, 1993
Weathering removal constant for vegetation	WLAM	20	18	unitless	Site-specific value is not available. Most likely value defined in NUREG/CR was assigned.	NUREG/CR 6697
Storage time: fruits, non-leafy vegetables, and grain	STOR_T(1)	14	14	days	Both NRC and RESRAD values for this parameter are the same; hence that value was assigned.	ANL, 1993 NUREG/CR-5512
Storage time: leafy vegetables	STOR_T(2)	1	1	days	Both NRC and RESRAD values for this parameter are the same; hence that value was assigned	ANL, 1993 NUREG/CR-5512
Storage time: milk	STOR_T(3)	1	1	days	Both NRC and RESRAD values for this parameter are the same; hence that value was assigned	ANL, 1993 NUREG/CR-5512
Storage time: meat and poultry	STOR_T(4)	20	20	days	Both NRC and RESRAD values for this parameter are the same; hence that value was assigned.	ANL, 1993 NUREG/CR-5512
Storage time: fish	STOR_T(5)	7	7	days	Both NRC and RESRAD values for this parameter are the same; hence that value was assigned	ANL, 1993 NUREG/CR-5512
Storage time: crustacea and mollusks	STOR_T(6)	7	7	days	Both NRC and RESRAD values for this parameter are the same; hence that value was assigned	ANL, 1993 NUREG/CR-5512
Storage time: well water	STOR_T(7)	1	1	days	Both NRC and RESRAD values for this parameter are the same; hence that value was assigned.	ANL, 1993 NUREG/CR-5512
Storage time: surface water	STOR_T(8)	1	1	days	Both NRC and RESRAD values for this parameter are the same; hence that value was assigned.	ANL, 1993 NUREG/CR-5512

TABLE 3-1: DEFAULT AND RECOMMENDED VALUES FOR RESRAD INPUT PARAMETERS (CONT'D)

RESRAD			Recommendations			
Parameter	**Code**	**Default Value**	**Value**	**Units**	**Justification**	**Reference**
Storage time: livestock fodder	STOR_T(9)	45	45	days	Both NRC and RESRAD values for this parameter are the same; hence that value was assigned.	ANL, 1993 NUREG/CR-5512
Thickness of building foundation	FLOOR1	0.15	NA	m	No Radon pathway, hence this parameter is not applicable.	NA
Bulk density of building foundation	DENSFL	2.4	NA	g/cm^3	No Radon pathway, hence this parameter is not applicable.	NA
Total porosity of the cover material	TPCV	0.4	NA	unitless	No Radon pathway, hence this parameter is not applicable.	NA
Total porosity of the building foundation	TPFL	0.1	NA	unitless	No Radon pathway, hence this parameter is not applicable.	NA
Volumetric water constant of the cover material	PH2OCV	0.05	NA	unitless	No Radon pathway, hence this parameter is not applicable.	NA
Volumetric water constant of the foundation	PH2OFL	0.03	NA	unitless	No Radon pathway, hence this parameter is not applicable.	NA
Diffusion coefficient for radon gas in cover material	DIFCV	2.00E+06	NA	m/sec	No Radon pathway, hence this parameter is not applicable.	NA
Diffusion coefficient for radon gas in foundation material	DIFFL	3.00E-07	NA	m/sec	No Radon pathway, hence this parameter is not applicable.	NA
Diffusion coefficient for radon gas in contaminated zone soil	DIFCZ	2.00E-06	NA	m/sec	No Radon pathway, hence this parameter is not applicable.	NA
Radon vertical dimension of mixing	HMIX	2	NA	m	No Radon pathway, hence this parameter is not applicable.	NA
Average building air exchange rate	REXG	0.5	NA	1/hour	No Radon pathway, hence this parameter is not applicable.	NA
Height of the building (room)	HRM	2.5	NA	m	No Radon pathway, hence this parameter is not applicable.	NA

TABLE 3-1: DEFAULT AND RECOMMENDED VALUES FOR RESRAD INPUT PARAMETERS (CONT'D)

RESRAD			Recommendations			
Parameter	Code	Default Value	Value	Units	Justification	Reference
Building interior area factor	FAI	0	NA	unitless	No Radon pathway, hence this parameter is not applicable.	NA
Building depth below ground surface	DMFL	-1	NA	m	No Radon pathway, hence this parameter is not applicable.	NA
Emanating power of Rn-222 gas	EMANA(1)	0.25	NA	unitless	No Radon pathway, hence this parameter is not applicable.	NA
Emanating power of Rn-220 gas	EMANA(2)	0.15	NA	unitless	No Radon pathway, hence this parameter is not applicable.	NA
Pathway – external gamma	NA	active	active	unitless	NA	NA
Pathway – inhalation (w/o radon)	NA	active	active	unitless	NA	NA
Pathway – plant ingestion	NA	active	active	unitless	NA	NA
Pathway – meat ingestion	NA	active	active	unitless	NA	NA
Pathway – milk ingestion	NA	active	active	unitless	NA	NA
Pathway – aquatic foods	NA	active	active	unitless	NA	NA
Pathway – drinking water	NA	active	active	unitless	NA	NA
Pathway – soil ingestion	NA	active	active	unitless	NA	NA
Pathway – radon	NA	active	inactive	unitless	NA	NA

NA = Not Applicable
N/A = Not Available
** specifies that the contaminated fraction will be calculated from the appropriate area factor in RESRAD.
Inhalation Rate = ((0.9 m^3/hr x 15.77 hrs/day) + (1.4 m^3/hr x 2.64 hrs/day) + (1.7 m^3/hr x 0.20 hrs/day)) x 8760 hrs/yr / (24 hrs/day) = 6650 m^3/yr, where 15.77, 2.64, and 0.2 hrs/day are indoor, outdoor, and gardening activities for the receptor
Mass loading for inhalation = ((1.4 E-6 g/m^3 x 15.77 hrs/day) + (3.14E-06 g/m^3 x 2.64 hrs/day) + (4E-04 g/m^3 x 0.20 hrs/day)) /24 hrs/day = 4.6E-06 g/m^3

4.0 SOIL DCGL RESULTS FOR DU

RESRAD, Version 6.3 (ANL, 2005), was used to perform the dose assessments for contaminated soil present at the R-14 Range Site. The concentrations for DU isotopes presented in Section 4-2 were inputted into the model along with the RESRAD input parameters presented in Table 3-1 during the dose assessments. The dose resulting from a unit concentration for a given radionuclide is defined as the dose-to-source ratio (DSR). The maximum DSR (in units mrem/yr per pCi/g) over the 1,000-year evaluation period for each radionuclide of concern was then divided into the 25 mrem/yr primary limit to determine the soil DCGLs. Attachment 1 presents the results of the surface soil RESRAD "run" for depleted uranium isotopes. Table 4-1 lists the surface soil DCGL results for individual radionuclides. All individual uranium isotopes except ^{234}U produce a maximum dose at year zero. ^{234}U produces a maximum dose at year 1000 due to the water dependent pathways (drinking water and plant ingestion). However, when considering the mix of uranium isotopes in DU, the maximum dose due to all occurs at year zero.

TABLE 4-1: DETERMINATION OF DCGLS FOR INDIVIDUAL URANIUM ISOTOPES AND DU

U Isotopes	DSR (mrem/yr)/(pCi/g)	DCGL (pCi/g)
^{234}U	4.03E-02	620
^{235}U	3.71E-01	67
^{238}U	1.01E-01	249

To determine the DCGL for a mixture of radionuclides (or isotopes) as in DU, the following equation is used:

$$\text{DU Mixture DCGL} = \frac{1}{\left(\frac{f_{U-234}}{DCGL_{U-234}}\right)+\left(\frac{f_{U-235}}{DCGL_{U-235}}\right)+\left(\frac{f_{U-238}}{DCGL_{U-238}}\right)}$$

Where:

f = activity fraction for the uranium isotope
DCGL = DCGL for the uranium isotope

Using the R-14 uranium isotope activity fractions in DU, the individual uranium isotope DCGL values in Table 4-1 (which are rounded to the nearest whole number) and the above equation, the DCGL for the mixture is 253 pCi/g (rounded down to the nearest whole number).

The same resident farmer scenario was used for both the Transonic Range and BTD Sites, and the DCGL for DU was determined to be 230 pCi/g. The DCGL results for the other two sites at APG are more conservative than that for R-14 Range Site. Thus, as a conservative approach, a DCGL of 230 pCi/g will be used for DU at the R-14 Range Site.

Page 10 of Attachment 1 presents the maximum dose resulting from the three uranium isotopes. The results showed that the maximum dose occurs at year 0. Table 4-2 presents the contribution of doses to total dose for year 0 by different exposure pathways. According to the table, the external gamma pathways is the most significant dose contributor for the site, followed by plant ingestion, milk ingestion, soil ingestion, and meat ingestion. The table also showed that the contribution of doses by inhalation and fish ingestion pathways are negligible.

TABLE 4-2: CONTRIBUTION OF TOTAL DOSE BY EACH EXPOSURE PATHWAY

DU Isotopes	External Gamma	Inhalation	Plant	Meat	Milk	Soil	All Pathways
^{234}U	1.5E-05	1.6E-05	1.7E-03	2.6E-04	7.3E-04	6.4E-04	3.4E-03
^{235}U	4.0E-03	2.1E-06	2.3E-04	3.6E-05	9.9E-05	8.7E-05	4.5E-03
^{238}U	5.6E-02	1.5E-04	1.8E-02	2.7E-03	7.5E-03	6.6E-03	9.1E-02
Total	6.0E-02	1.7E-04	2.0E-02	3.0E-03	8.3E-03	7.3E-03	9.9E-02
% Contribution	61%	0.2%	20%	3%	8%	7%	

5.0 SENSITIVITY ANALYSIS

Sensitivity analyses were performed for the site using the RESRAD sensitivity graphic utility on input parameters related to intake assumptions for the receptors. Based on the results presented in Table 4-2, pathways that contributed more than 15% of total dose are considered significant dose contributors. The following intake parameters related to significant dose contributors were selected for the sensitivity analyses. Those include:

(1) External Gamma Shielding Factor

(2) Fraction of Time Spent Indoor

(3) Fraction of Time Spent Outdoor

(4) Fruits, Vegetables, and Grains Consumption; and

(5) Leafy Vegetables Consumption

The RESRAD sensitivity utility operates by both reducing and increasing the selected input parameter by a common factor. During the sensitivity analyses, the common factor was selected in such a way that the maximum and minimum values related to the parameter included the uncertainty range associated with the parameter. For parameters for which there was no uncertainty range, a common factor of two was used.

Doses were calculated for each perturbed parameter value. The output, including dose with the parameter unperturbed, dose with parameter reduced, and dose with parameter increased, was graphically displayed, with time as the independent variable.

A sensitivity index (SI) was calculated to determine which parameters have the greatest influence on the calculated DCGLs by using the following formula.

$$SI = 1 - (f(p)_{min} / f(p)_{max}),$$

where the f(p) values are the minimum and maximum doses resulting from the increased and reduced values related to certain intake parameters.

Table 5-1 presents the results of the sensitivity analysis for radionuclide-specific intake parameters. The table presents the average sensitivity index, as determined based on the dose results examined over a 1000-year period. A positive value of the sensitivity index indicates that the DCGL is directly proportional to the parameter of interest, whereas a negative value indicates that the DCGL is inversely proportional to the parameter of interest. The higher the value of SI, the more sensitive is the intake value. A SI value of greater than 15% was used to identify the most sensitive parameters.

The results of the sensitivity analysis summarized in Table 5-1 shows that the external gamma shielding factor is the most sensitive intake parameter for DU. However, leafy vegetable consumption is the least sensitive intake parameters for all radionuclides. <u>Conservative values were assigned for the intake parameters that are most sensitive to the radionuclides of concern under current site conditions</u>.

TABLE 5-1: SENSITIVITY INDICES FOR RESRAD INTAKE PARAMETERS

RESRAD Input Parameter	Sensitivity Index (unitless)	
	Average	Maximum
External Gamma Shielding Factor	0.33	0.48
Fraction of Time Spent Outdoor	0.16	0.23
Fraction of Time Spent Indoor	0.28	0.39
Fruits, Vegetables, and Grains Consumption	0.19	0.23
Leafy Vegetables Consumption	0.02	0.05

6.0 UNCERTAINTY ANALYSIS

Uncertainty is inherent in all dose and risk assessment calculations and should be considered in determining whether a selected DCGL concentration will satisfy the regulatory decision-making criteria.

6.1 Types of Uncertainty

In general, there are three primary sources of uncertainty in a dose/risk assessment (Bonano et.al., 1988, and Kozak et al., 1991). The following paragraphs explain each of these sources of uncertainty and summarize how this project handled the associated uncertainties.

(1) Uncertainty in the models;
(2) Uncertainty in scenarios; and
(3) Uncertainty in the parameters.

(1) <u>Uncertainty in the models</u>: A number of computer software models are available to characterize the site-specific fate and transport mechanisms of the contaminants in the environment, and to assess dose and risk present at the site. Models are simplifications of reality, and in general, are not able to fully characterize the physical condition of the site. During this project, the RESRAD code is used for estimating the carcinogenic risk to human receptors from exposure to soil contaminated with residual radioactivity. DOE and NRC have approved the use of RESRAD for dose evaluation and waste disposal at licensed nuclear facilities. EPA

also used the code in rule making for sites contaminated with radioactivity. Therefore, the uncertainty associated with the RESRAD model is considered to be acceptable.

(2) Uncertainty in the scenario: Uncertainty in scenarios is the result of lack of absolute knowledge about the future uses of the Site. Hence, DCGLs were determined based on the most conservative receptor scenario. Based on NRC regulatory guidance and recommendations, a residential farmer scenario was chosen for determining the soil DCGLs at the site. However, it is important to recognize that the outlook evaluation time criterion (1000 years) is not intended to predict future scenarios for the next 1000 years. It is intended to evaluate the continued protectiveness of a given DCGL for 1000 years into the future given the reasonable and plausible future uses of the Site in today's social and economic conditions. Since the residential farmer scenario is considered the most conservative scenario, the uncertainty associated with this scenario is considered to be acceptable.

(3) Uncertainty in the parameters: Uncertainty in parameters was limited by using, whenever possible, site-specific values. However, there are no site-specific values for many of the parameters; thus, conservative NRC/EPA reference values were used to ensure that doses would be over- rather than under-estimated. The selection of prudently conservative parameters was conducted based on the hierarchy presented in Section 3.5 and was designed to utilize broadly accepted values. Because of the established hierarchy and the tendency toward prudently conservative parameters values that tend to overestimate doses, the uncertainties associated with parameter selection is considered to be acceptable.

RESRAD allows users to consider parameters as point estimates (deterministic) or as distributions (probabilistic). A sensitivity analysis on point estimate values may be used to determine which parameters have the largest impact on dose results. This analysis was performed as described above. Knowledge of sensitivity analysis results helps modelers limit uncertainty by focusing on the most sensitive parameters, if possible. When the probabilistic module is used, modelers can represent parameters as distributions (e.g., with a mean and standard deviation) to limit the conservatism in using NRC/EPA reference values. In some cases, there is sufficient site-specific data to utilize the probabilistic module, or NRC default definitions can be used. In either case, the selection of probabilistic inputs can limit uncertainty assuming those inputs are representative of site conditions. If a probabilistic module is populated with default distributions the uncertainty may or may not be reduced depending on the overlap of modeled versus actual conditions.

6.2 Selection of Uncertainty Range for RESRAD Input Parameters

DCGLs for the R-14 Range site were calculated using the deterministic and not the probabilistic approach. However, Table 6-1 presents probabilistic parameters along with the selected deterministic values for non-default RESRAD input exposure parameters. NUREG/CR-6697-assigned values were used as uncertainty ranges for most of the RESRAD parameters under a residential scenario. When site-specific values were not available, values defined in NUREG/CR-6697 were used. NUREG/CR-5512-assigned values were used for parameters that are directly proportional to dose.

TABLE 6-1: RECOMMENDED VALUES AND UNCERTAINTY RANGES FOR THE NON-DEFAULT RESRAD EXPOSURE PARAMETERS

RESRAD Parameter	Recommended Value	Units	Uncertainty Range			
			Value	Statistics	Distribution	NUREG/CR-6697
Inhalation rate	6650	m³/yr	4,380	Minimum	Triangular	Section 5
			13,100	Maximum		
			8,400	Most likely		
Mass loading for inhalation	4.6E-06	g/m³	2.00E-04	Indoor and outdoor time fraction	Empirical	RESRAD
Indoor Dust Filtration Factor	0.2448	unitless	0.15	Minimum	Uniform	Section 7.1
			0.95	Maximum		
External gamma shielding factor	0.5512	unitless	-1.3	Mean	Bounded lognormal-n	Section 7.10
			0.59	Std. Dev		
			0.044	Lower value		
			1	Upper value		
Fraction of time spent indoors	0.6571	unitless	NA	NA	NA	NA
Fraction of time spent outdoors	0.1181	unitless	NA	NA	NA	NA
Fruits, vegetables and grain consumption	166	kg/yr	135	Minimum	Triangular	Section 5.4
			318	Maximum		
			178	Most likely		
Leafy vegetable consumption	10	kg/yr	NA	NA	NA	NA
Milk consumption	100	L/yr	60	Minimum	Triangular	Section 5.3
			200	Maximum		
			102	Most likely		
Meat and poultry consumption	65.1	kg/yr	NA	NA	NA	NA
Fish consumption	10	kg/yr	NA	NA	NA	NA
Other seafood consumption	0.9	kg/yr	NA	NA	NA	NA
Soil ingestion rate	36.5	g/yr	0	Minimum	Triangular	Section 5.6
			36.5	Maximum		
			18.3	Most likely		
Drinking water intake	478.5	L/yr	510	Mean	Truncated lognormal-n	Table 5.2-2 (Adult) (EPA, 1997)
			478.5	50th Percentile		
			840	90th Percentile		

NA = Not Available

6.3 Selection of Recommended Value Based On Uncertainty

This section summarizes the process regarding the selection of the recommended values based on the uncertainty associated with the RESRAD input parameters.

6.3.1 Inhalation Rate

The time-weighted inhalation rate was determined by multiplying the inhalation rates for each activity (i.e., indoor, outdoor, and gardening) with the fraction of time the resident farmer will spend for each activity. The calculated inhalation rate (6,650 m^3/yr) falls within the minimum and maximum values of 4,380 and 13,100 m^3/yr, respectively, of the uncertainty range. The inhalation pathway is sensitive to this parameter; however, the total annual dose is not, because the inhalation pathway is not a significant contributor to total annual dose.

6.3.2 Mass Loading for Inhalation

The site-specific mass-loading factor for the inhalation was calculated based on time- weighted-average activity-specific mass loading inhalation factor and fraction of the time being spent for each activity (i.e., indoor, outdoor, and gardening). The site-specific mass loading for inhalation factor is 4.6E-06 g/m^3 for the site and is less than the RESRAD default value of 0.0002 g/m^3. The inhalation pathway is sensitive to this parameter; however, total annual dose is not because the inhalation pathway is not a significant contributor to total annual dose.

6.3.3 External Gamma Shielding Factor

The external gamma shielding factor is used to calculate the dose from the external penetrating gamma radiation pathway. The external gamma pathway and the overall dose (particularly the dose from a byproduct source term for which the dominant pathway is external gamma radiation) are sensitive to this parameter. The total annual dose from the external gamma pathway is 63%. This is the most sensitive parameter among all exposure parameters. EPA's *Soil Screening Guidance Document for Radionuclides: User's Guide* (EPA, 2000) assigned a value of 0.4 for this parameter. The recommended value of 0.5512 is higher than that for EPA's recommended value and falls within the upper and lower values of 1 and 0.044 of the uncertainty range.

6.3.4 Indoor Dust Filtration Factor

NUREG/CR-5512 lists the value for the indoor dust filtration factor as 0.2448 (unitless) under the residential farmer scenario. The inhalation pathway is relatively sensitive to this parameter but the overall dose is insensitive to variation in this factor as the inhalation pathway is not a significant contributor to overall dose. The indoor dust filtration factor is represented with a uniform distribution ranging from 0.15 to 0.95, and the recommended value falls within that uncertainty range.

6.3.5 Indoor & Outdoor Time Fractions

Under NUREG/CR-5512, the indoor & outdoor time fractions are 0.658 and 0.1181, respectively. The results of the sensitivity analyses using the NRC values showed that both parameters are sensitive to the total dose.

6.3.6 Fruits, Vegetable, and Grains Consumption

This parameter is relevant for resident farmer scenario. The recommended value of 166 kg/yr is almost equal to the most likely value of 178 kg/yr as defined in NUREG/CR-6697 and falls within the minimum and maximum values of 135 and 318 kg/yr, respectively, of the uncertainty range. The sensitivity analysis shows that the plant ingestion pathway is sensitive to this parameter. The plant ingestion pathway is a significant contributor of total overall dose.

6.3.7 Milk Consumption

The recommended value of 100 L/yr for milk consumption is equivalent to the most likely value of 102 L/yr, as defined in NUREG/CR-6697, and falls within the minimum and maximum values of 60 and 200 L/yr, respectively, of the uncertainty range. The milk ingestion pathway is not a significant contributor of total overall dose.

6.3.8 Soil Ingestion Rate

The recommended value of 36.5 g/yr for this parameter is based on adult resident farmer and the value is equal to the maximum value of the uncertainty range. The soil ingestion pathway does not contribute significantly to the total dose for the Site.

6.3.9 Drinking Water Intake

The recommended value of 478.5 L/yr for this parameter is equal to the 50^{th} percentile value of the uncertainty range. The results of the soil dose assessment indicated that the drinking water ingestion pathway is not a significant contributor to the total dose.

7.0 CONCLUSION

Surface soil DCGLs were derived for DU present at the R-14 Range Site using the residential farmer exposure scenario. The NRC dose limit of 25 mrem in any year in excess of natural background radiation was used as the basis for each derivation. Table 4-1 presents the DCGL results for individual uranium isotopes and for DU. The resulting DCGL for DU was calculated to be 253 pCi/g, which is higher than the 230-pCi/g value used for the Transonic Range and BTD Sites. This evaluation demonstrates that the DCGL used previously at the Transonic Range and BTD Sites is applicable and protective for use at the R-14 Range Site. Thus, the DCGL value of 230 pCi/g will be used as the soil action level for remediation at the R-14 Range Site, and as the concentration limit for evaluating the final status survey results with respect to the NRC criteria for unrestricted release.

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