104-02

SENECA ARMY DEPOT ACTIVITY
LICENSE TERMINATION AND LICENSE RELEASE PLAN

January 2003

NRC FORM 374

U.S. NUCLEAR REGULATORY COMMISSION

Amendment No. 13

MATERIALS LICENSE

Pursuant to the Atomic Energy Act of 1954, as amended, the Energy Reorganization Act of 1974 (Public Law 93-438), and Title 10, Code of Federal Regulations, Chapter I, Parts 30, 31, 32, 33, 34, 35, 36, 39, 40, and 70, and in reliance on statements and representations heretofore made by the licensee, a license is hereby issued authorizing the licensee to receive, acquire, possess, and transfer byproduct, source, and special nuclear material designated below; to use such material for the purpose(s) and at the place(s) designated below; to deliver or transfer such material to persons authorized to receive it in accordance with the regulations of the applicable Part(s). This license shall be deemed to contain the conditions specified in Section 183 of the Atomic Energy Act of 1954, as amended, and is subject to all applicable rules, regulations, and orders of the Nuclear Regulatory Commission now or hereafter in effect and to any conditions specified below.

Licensee	In accordance with the letter dated February 11, 2003,
1. Department of the Army Commander, Seneca Army Depot Activity ATTN: SDSSE-CO	3. License number SUC-1275 is amended in its entirety to read as follows:
2.	4. Expiration date February 28, 2005
Romulus, New York 14541-5001	5. Docket No. 040-08526 Reference No.

6. Byproduct, source, and/or special nuclear material	7. Chemical and/or physical form	8. Maximum amount that licensee may possess at any one time under this license
A. Uranium (depleted in the isotope uranium 235)	A. Solid metal alloy	A. 5,000,000 kilograms
B. Uranium (depleted in the isotope uranium 235)	B. Solid metal alloy	B. 5,000,000 kilograms

9. Authorized use:

A. For receipt, possession, storage, transportation, inspection and disposal incident to the demilitarization of munitions.
B. For receipt, possession, storage, transportation, inspection, and disposal incident to demilitarization of munitions from other licensed U.S. Army and U.S. Navy installations.

CONDITIONS

10. Licensed material may be used only at the licensee's facilities located at the Seneca Army Depot, Romulus, New York.

11. A. Licensed material shall be used by, or under the supervision of John F. Cleary, Michael R. Lewis, or Thomas E. Reynolds.

B. The Radiation Safety Officer for this license is John Cleary.

MATERIALS LICENSE
SUPPLEMENTARY SHEET

License Number
SUC-1275

Docket or Reference Number
040-08526

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12. The licensee is authorized to transport licensed material in accordance with the provisions of 10 CFR Part 71, "Packaging and Transportation of Radioactive Material."

13. Radioactive waste generated shall be stored in accordance with the statements, representations, and procedures included with the waste storage plan described in the licensee's letter dated January 27, 1995.

14. The licensee may use the Derived Concentration Guideline Level (DCGL) values described in the Seneca Army Depot Activity License Termination and License Release Plan for decommissioning of the facilities at the Seneca Army Depot Activity, Romulus, New York, with the intention of release of the facilities for unrestricted use.

License Number
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MATERIALS LICENSE
SUPPLEMENTARY SHEET

15. Except as specifically provided otherwise in this license, the licensee shall conduct its program in accordance with the statements, representations, and procedures contained in the documents, including any enclosures, listed below, except for minor changes in the medical use radiation safety procedures as provided in 10 CFR 35.31. The U.S. Nuclear Regulatory Commission's regulations shall govern unless the statements, representations, and procedures in the licensee's application and correspondence are more restrictive than the regulations.

    A. Letter dated January 17, 1992
    B. Letter dated March 31, 1992
    C. Application dated October 30, 1992
    D. Letter dated November 2, 1992
    E. Letter dated December 21, 1992
    F. Letter dated September 2, 1993
    G. Letter dated September 27, 1993
    H. Letter dated December 15, 1993
    I. Letter dated January 27, 1995
    J. Letter dated December 5, 1996
    K. Letter dated August 13, 1997
    L. Letter dated February 11, 2003 with the Seneca Army Depot Activity License Termination and License Release Plan
    M. Letter dated April 3, 2003

For the U.S. Nuclear Regulatory Commission

Date June 11, 2003

By *__Original signed by Elizabeth Ullrich__*

Elizabeth Ullrich
Nuclear Materials Safety Branch 2
Division of Nuclear Materials Safety
Region I
King of Prussia, Pennsylvania 19406

UNITED STATES
NUCLEAR REGULATORY COMMISSION
REGION I
475 ALLENDALE ROAD
KING OF PRUSSIA, PENNSYLVANIA 19406-1415

June 11, 2003

Docket No. 04008526 License No. SUC-1275
Control No. 132746

Stephen M. Absolom
Commander's Representative
Department of the Army
Seneca Army Depot Activity
5786 State Route 96
P. O. Box 9
Romulus, NY 14541-009

SUBJECT: DEPARTMENT OF THE ARMY, ISSUANCE OF LICENSE AMENDMENT, CONTROL NO. 132746

Dear Mr. Absolom:

This refers to your license amendment request. Enclosed with this letter is the Amendment 13 of the license.

Please note that Condition 14 of Amendment 12 of this license was removed. That condition was added to Amendment 10 of the license, after you notified us of the planned closure of the facility in August 1996. Because you did not begin decommissioning immediately at that time, you were required to submit a decommissioning plan within 12 months of the notification. Amendments 11 and 12 extended the date for submission of the plan. A plan was submitted by the date as required and the condition is no longer applicable. Several revisions of the plan have been reviewed because of the site-specific derived concentration guideline levels (DCGL) used as criteria for release. The approved criteria is listed in Condition 14 of Amendment 13 (enclosed).

Please review the enclosed document carefully and be sure that you understand and fully implement all the conditions incorporated into the amended license. If there are any errors or questions, please notify the U.S. Nuclear Regulatory Commission, Region I Office, Licensing Assistance Team, (610) 337-5239, so that we can provide appropriate corrections and answers.

An environmental assessment for this action is not required, since this action is categorically excluded under 10 CFR 51.22(c)(14).

In accordance with 10 CFR 2.790, a copy of this letter will be placed in the NRC Public Document Room and will be accessible from the NRC Web site at http://www.nrc.gov/reading-rm.html.

Thank you for your cooperation.

Sincerely,

Original signed by Elizabeth Ullrich

Betsy Ullrich
Senior Health Physicist
Nuclear Materials Safety Branch 2
Division of Nuclear Materials Safety

Enclosure:
Amendment No. 13

cc:
John F. Cleary, Radiation Safety Officer

Seneca Army Depot Activity
License Termination and License Release Plan

U.S. Department of the Army,
Seneca Army Depot Activity, New York

prepared by
Argonne National Laboratory
Environmental Assessment Division
Argonne, Illinois

January 2003

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TABLES

FIGURES

Notation

The following is a list of the acronyms, abbreviations, and units of measure used in this report:

Acronyms and Abbreviations

AEC	U.S. Atomic Energy Agency
ALARA	as low as reasonably achievable
Am	americium
AMCCOM	Armament, Munitions and Chemical Command (U.S. Army)
BRAC	Base Realignment and Closure
CFR	*Code of Federal Regulations*
D&D	decontamination and decommissioning
DCGL	derived concentration guideline level
DOA	U.S. Department of the Army
DOD	U.S. Department of Defense
DOE	U.S. Department of Energy
DQI	data quality indicator
DQO	data quality objective
DSR	dose-to-source (concentration) ratio
DU	depleted uranium
EPA	U.S. Environmental Protection Agency
H-3	tritium
LTC	Lieutenant Colonel (U.S. Army)
LTP	License Termination Plan
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
MDA	minimum detection activity level
NaI	sodium iodide
NRC	U.S. Nuclear Regulatory Commission
Pm	promethium
Pu	plutonium
QA	quality assurance
QAPP	Quality Assurance Project Plan
QC	quality control

Ra	radium
SEDA	Seneca Army Depot Activity
Sm	samarium
Tc	technetium
TEDE	total effective dose equivalent
Th	thorium
U	uranium

Units of Measure

cm	centimeter(s)
cm^2	square centimeter(s)
cm^3	cubic centimeter(s)
cpm	count(s) per minute
d	day(s)
dpm	disintegration(s) per minute
g	gram(s)
h	hour(s)
keV	kiloelectron volt(s)
kg	kilogram(s)
L	liter(s)
m	meter(s)
m^2	square meter(s)
mm	millimeter(s)
mrem	millirem(s)
pCi	picocurie(s)
s	second(s)
yr	year(s)

1 GENERAL INFORMATION

The purpose of this License Termination Plan (LTP) is to successfully terminate Nuclear Regulatory Commission (NRC) license #SUC-1275 (Docket No. 040-08526) held by the Department of the Army (Seneca Army Depot Activity, 5786 State Route 96, Romulus, New York 14541-5001) and to amend, gain release from, or otherwise close out the following licenses and permits:

- SUC-1380, Possession and Storage of depleted uranium as 25 mm, 105 mm, and 120 mm cartridge penetrators, issued to U.S. Army, Operations Support Command (OSC).

- 45-16023-01NA issued to US Navy for 20 mm and 25 mm cartridges.

- SUB-834 held by U.S. Army Combat Systems Test Activity for 7.62 mm and 0.50 caliber cartridges

- BML 12-00722-07, possession of promethium-147 in the light anti-tank rocket system

- STC-133, to store Columbite and tantalum (thorium) ore, managed by Defense Logistic Agency

Seneca Army Depot Activity (SEDA) is located about 40 miles south of Lake Ontario, near Romulus, New York. The 10,587-acre SEDA facility was constructed in 1941 and has been owned by the U.S. Government and operated by the Department of the Army (DOA) since that date. From its inception in 1941 until 1995, SEDA's primary mission was the receipt, storage, maintenance, and supply of military items, including munitions and equipment. The Depot's mission changed in 1995 when the Department of Defense (DOD) recommended closure of the SEDA under its Base Realignment and Closure (BRAC) process. The above NRC license-related activities occurred in the following buildings/structures:

- Building 612

- Building 5

- Building 306

- Building S-2084

- Building 2073

- Warehouse 356
- Total of 121 ammunition storage bunkers

In addition to the buildings covered directly under the license, and in accordance with NRC's July 26, 2000 letter to this effect, the entire site will be evaluated to determine that it meets Radiological Criteria for License Termination specified in CFR 20.1402 and applicable State criteria. This evaluation will include a review of any facilities previously released for unrestricted use and any facilities or areas currently undergoing cleanup. Historical survey records will be reviewed from previously released areas to evaluate whether they meet current release standards, while other ongoing radiological cleanups will be coordinated with license termination activities.

This LTP describes the process to be used in meeting the requirements for terminating, gaining release from, or amending the affected NRC licenses. Section 2 reviews the building histories and the results of past characterization activities. On the basis of this review it is expected that no decontamination would be required. If, during the final status survey, it were found that some areas are above the release criteria, those areas would be remediated to acceptable levels (Sections 3 and 4). Section 5 describes the Final Status Survey Plan, which is consistent with the guidelines of the Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM, NRC 1997). Section 6 together with Section 5, describes the process for demonstrating compliance with the radiological criteria of Title 10, *Code of Federal Regulations,* Part 20.1402 (10 CFR 20.1402) for unrestricted future use for the affected buildings and structures.

2 HISTORY AND CHARACTERIZATION

Activities at the SEDA included storage and maintenance of radioactive commodities. The Army radioactive commodities at the site were mainly depleted uranium (DU) munitions. These commodities were used, stored, and maintained under the various licenses issued to the Army by NRC as listed in Section 1. Army radioactive commodities are ruggedly designed and contain a limited amount of radioactivity, which is typically in a nondispersible form. Commodities are not expected to have released contamination in areas where they were stored or handled.

2.1 Historical Site Assessment

A complete review of available records and files for the buildings included under the various license termination and release activities was conducted in 1999 and 2000. None of the inspection reports, survey data, or employee discussions indicated any accidents or incidents involving the commodities, either licensed or unlicensed. The periodic radiological surveys conducted by the Army in accordance with the licenses did not show any areas of concern. This review revealed the following facts:

- The SEDA was established in 1941 as an ammunition and general supply depot.

- During the 1940s, the SEDA stored barrels of pitchblende ore in 11 ammunition storage bunkers (E0801-E0811). In the 1980s, those bunkers were surveyed and remediated to allow unrestricted use (NRC 1988). Survey results showed no elevated readings for E0801 and E0802, the two bunkers included in this LTP (U.S. Army 1986).

- In the early 1950s, the Atomic Energy Commission (AEC) built and operated a special-weapons storage and maintenance facility on the north end of the Depot. In 1956, those facilities were taken over by the U.S. Army and were fully functional until 1993. The 64 special-weapons storage bunkers (A0101, A0102, A0201-A0218, A0301-A0317, A0401-A0409, A0501-A0508, and A0601-A0610) were surveyed in 1992 and 1993 and were released for unrestricted use. The remaining special weapons facilities are currently being surveyed for possible contamination as the part of the Army's environmental remediation program.

- Under license BML 12-00722-07, storage bunker A0701 was used to store light anti-tank rockets, with rocket sights containing promethium-147. The promethium-147 is contained in ceramic microspheres, mixed with self-luminous paint, and laminated between plastic sheets to provide illumination of the 100- and 150-yard markings in the front aiming sight according to the license application (U.S. Army 1997), the promethium-147 cannot escape unless the sight is subject to crushing, melting, or breaking across either the 100- or 150-yard markings. That scenario was considered unlikely.

- Warehouse 356 was used to store Columbite and tantalum ore containing thorium. NRC released the building for unrestricted use under Amendment 16 to STC-133 on December 22, 1994. Results of a June 10, 1993, New York State Department of Environmental Conservation (NYSDEC) survey of Warehouse 356 showed no significant deviations from background (Baker 1993). The interoffice memo in which the results are reported also noted that the Columbite ore (5,284 drums) had been transferred to a facility in Binghamton, New York, approximately 2 weeks prior to the survey date. It further noted that the Army had plans to clean the building with a HEPA filtered vacuum system and that all areas where the ore had been stored were surveyed, and wipes were taken for analysis.

- License SUC-1275 involved the use of five buildings (612, 5, 306, S-2084, and 2073) and 120 ammunition bunkers:

  - *Building 612* was used primarily as a point to unpackage, inspect, and repackage DU ammunition. License SUC-1275 also permitted demilitarization of munitions in Building 612, although this activity was never initiated. That activity would have involved mechanical separation of munitions. The license expressly directs that no cutting, grinding, or metallurgical processes were to be performed on DU. Building 612 underwent an extensive survey for release in 1999. Survey readings were very low. None approached the dose-based release limits used at the time of the survey. However, release limits have since been revised downward using revised inputs to the dose-model used (RESRAD-BUILD). Building 612 survey data will be reevaluated against the revised limits. Building 612 is proceeding directly to a Final Status Survey Report for release.

  - *Buildings 5, 306, S-2084, and 2073* were used as staging points to prepare the DU ammunition for shipment.

  - *120 ammunition bunkers* were only used to store packaged DU ammunition. Periodic surveys of these structures were conducted when DU ammunition operations were being conducted. No elevated levels of radioactivity were ever detected. The last of the depleted ammunition was shipped off the Depot by September 1999. Table 2-1 lists the affected bunkers.

Table 2-1
List of 121 Storage Bunkers under NRC Licenses[a]

A0201	B0109	C0203	D0104	E0103
A0316	B0411	C0303	D0105	E0105
A0317	B0501	C0307	D0107	E0112
A0508	B0602	C0308	D0108	E0211
A0701[b]	B0603	C0401	D0110	E0301
A0706	B0609	C0403	D0113	E0302
A0707	B0610	C0405	D0206	E0303
A0710	B0701	C0406	D0207	E0312
A0711	B0705	C0407	D0305	E0402
A0901	B0707	C0408	D0306	E0410
A0905	B0708	C0501	D0312	E0411
A1108	B0709	C0503	D0401	E0413
A1109	B0711	C0504	D0406	E0504
	B0801	C0505	D0407	E0506
	B0802	C0508	D0413	E0508
	B0804	C0510	D0601	E0510
	B0809	C0511	D0604	E0512
	B0810	C0513	D0607	E0602
	B0811	C0603	D0704	E0604
	B0909	C0604	D0705	E0609
		C0605	D0711	E0610
		C0606	D0712	E0702
		C0608	D0801	E0706
		C0701	D0805	E0711
		C0706		E0801
		C0707		E0802
		C0708		
		C0801		
		C0803		
		C0807		
		C0809		
		C0901		
		C0902		
		C0906		
		C0907		
		C0908		
		C0909		
		C0912[c]		

See footnotes on next page.

Table 2-1 (Con't)

[a]Except as otherwise indicated, bunkers were used for storage of packaged DU ammunition under SUC-1275.

[b]A0701 was used for storage of light anti-tank rockets containing promethium-147 under BML 12-00722-07.

[c]Bunker C0912 is a control bunker to establish radiological background levels.

2.2 Initial Area Classification

Historical site assessments were conducted to identify buildings and other structures, as well as land areas affected by the licensed activities, where radioactive commodities were stored or repaired. A review of the type of operation, as well as any accident/incident/leak test reports, was considered in the classification of areas. On the basis of the available historical information, areas under the license were divided into impacted and nonimpacted areas according to the criteria identified in MARSSIM (NRC 1997). Nonimpacted areas have no reasonable potential for residual contamination and therefore would not be included in the survey effort except to establish background levels. Impacted areas have some potential for containing residual radioactivity and are further divided into the MARSSIM–defined classes of 1, 2, or 3 on the basis of the potential for residual contamination and the BRAC radiological survey policy (U.S. Army 1998). Table 2-2 summarizes information about the areas affected by various NRC licenses.

2.2.1 Class 1 and Class 2 Areas

Areas were classified as Class 1 or 2 if historical information indicated that the commodity repair or maintenance activities conducted there compromised the nondispersible design of the commodities in accordance with the BRAC policy. Areas where tritium repair/maintenance occurred or where a past accidental release has not been remediated to present standards would also classified as Class 1 or Class 2 Areas. The previously surveyed and released 64 special weapons bunkers are the only known facilities where commodities containing tritium were stored and maintained. However, none of these is expected to contain residual tritium contamination.

In accordance with MARSSIM, areas were classified as Class 1 if potential radiological contamination (on the basis of site operating history) or known contamination (on the basis of previous radiological surveys) exists in excess of dose-based action levels. Building 612 is the only building or area classified as Class 1. The basis of this classification, however, relied on activities such as demilitarization of DU munitions that were permitted under SUC 1275, rather than activities that actually took place. As mentioned above, Building 612 has already undergone a survey for release. Survey data are currently being evaluated.

Areas were classified as Class 2 if the residual contamination was expected to be present, but not to exceed action levels at any location. The historical assessment resulted in classifying all of Buildings 5, 306, 2073, and S-2084 as Class 2 areas. This classification, however, is based solely on potential contamination for licensed activities. No confirmed contamination has been identified.

2.2.2 Class 3 Areas

Other indoor and outdoor areas where commodities were repaired, maintained, or stored were classified as Class 3 areas. Any areas where historical information indicated an accidental release had occurred but has already been remediated to present-day standards for unrestricted release were also classified as Class 3 areas. All of the storage bunkers initially have been classified as Class 3 areas. Storage bunkers were used only for storage of containerized DU ammunition, except for five bunkers, four of which were also used for previous special weapons storage, and one which was used for storage of rocket sights containing promethium-147. In addition to DU, the former bunkers will be surveyed for tritium and plutonium, and the latter for promethium-147, all as Class 3 areas. Warehouse 356 has also been classified as a Class 3 area, in this case for thorium associated with storage of Columbite and tantalum ore.

Table 2-2
Information Summary for Buildings under License SUC-1275 and Other NRC Licenses

Buildings/Structures	Radiological Status	Radionuclides of Concern	Area Classification for Final Status Survey	Type and Extent of Contamination	Other Licenses Affected	Operations Performed
Building 612	Building was surveyed in 1999. Walls, ceilings and floors were surveyed.	U-234, U-235, and U-238 (depleted uranium)	Class 1	Contamination, if present, is expected only on floor surfaces.	SUC-1380	Unpackage, inspect, and repackage DU ammunition
Building 5 Building 306 Building S-2084 Building 2073	During operations, periodic surveys were conducted and no elevated levels of radioactivity were ever detected. The last of the depleted ammunition was shipped off in September 1999.	U-234, U-235, and U-238 (depleted uranium)	Class 2	Contamination, if present, is expected only on floor surfaces	SUC-1380	Staging point to prepare DU ammunition for shipment
Storage Bunker A0701		Pm-147	Class 3	Contamination, if present, is expected only on floor surfaces	BML 12-00722-07 license managed by TACOM Rock Island	The license was for the possession of Pm-147 in the light anti-tank rocket system

Table 2-2 (Con't)

Buildings/Structures	Radiological Status	Radionuclides of Concern	Area Classification for Final Status Survey	Type and Extent of Contamination	Other Licenses Affected	Operations Performed
Of 11 pitchblende storage bunkers, E0801 and E-802 were under NRC license for subsequent DU storage	Were decontaminated and released for unrestricted use in 1985	Ra-226 (pitchblende ore) U-234, U-235, U-238	Class 3	Contamination, if present, is expected only on floor surfaces	SUC-1380	During the 1940s, the Depot stored barrels of pitchblende ore
Of 64 special weapons storage bunkers, A0201, A0316, A0317, and A0508 were under NRC license for later DU storage	Were surveyed in 1992 and 1993 and released for unrestricted use	Pu-239, U-234, U-235, U-238, and H-3	Class 3	Contamination, if present, is expected only on floor surfaces	SUC-1380	For special weapons storage
Ammunition Bunkers (see Table 2-1)	During operations, periodic surveys were conducted and elevated levels of radioactivity were never detected. The last of the depleted ammunition was shipped off in September 1999.	U-234, U-235, and U-238 (depleted uranium)	Class 3	Contamination, if present, is expected only on floor surfaces	SUC-1380	Storage of the packaged DU ammunition

Table 2-2 (Con't)

Buildings/Structures	Radiological Status	Radionuclides of Concern	Area Classification for Final Status Survey	Type and Extent of Contamination	Other Licenses Affected	Operations Performed
Warehouse 356	NRC released building for unrestricted use Amendment 16 to STC-133 on 12/22/94	Natural thorium	Class 3	Contamination, if present, is expected only on floor surfaces	STC-133 managed by Defense Logistic Agency	Warehouse was used to store Columbite and tantalum ore

3 IDENTIFICATION OF REMAINING DECONTAMINATION AND DECOMMISSIONING ACTIVITIES

On the basis of the historical site assessment and initial characterization information available, it is expected that no decontamination and decommissioning (D&D) would be required for the Seneca Army Depot Activity license termination. NRC concurred with the conclusion that a Decommissioning Plan is not required for this site in a July 26, 2000, letter to LTC Frank, Commanding Officer of the Depot (NRC 2000). If, during the final status survey, it is found that some areas are above the release criteria, a remediation plan would be developed, and those areas would be remediated.

4 REMEDIATION PLANS

At present, no D&D is thought to be required to meet NRC license termination criteria in Subpart E of 10 CFR 20 or unrestricted release criteria for any of the shared licenses listed in Section 1. Therefore, no remediation plan has been developed.

5 FINAL STATUS SURVEY PLAN

5.1 Introduction

The purpose of the Final Status Survey Plan is to describe the methods to be used in planning, designing, conducting, and evaluating final status surveys at SEDA. These surveys would serve to demonstrate that the dose from residual radioactivity is less than the maximum annual dose criterion for license termination for unrestricted use as specified in 10 CFR 20.1402. The Final Status Survey plan approach was developed following the Army radiological survey policy for BRAC sites (U.S. Army 1988) and MARSSIM (NRC 1997).

The Department of the Army radiological survey policy issued for BRAC sites where Army radioactive commodities have been present would be followed in the design and performance of surveys (U.S. Army 1998). According to that policy, commodity sites would typically proceed directly to closeout surveys (final status surveys under MARSSIM), consistent with a low likelihood of contamination. The overall process encompasses the following steps: (1) historical site assessment, (2) scoping surveys (if advantageous), (3) classification of areas, (4) formulation of survey plans with the host state and the U.S. Environmental Protection Agency (EPA), and (5) performance of closeout survey.

While several buildings remaining to be surveyed have been initially designated as Class 2 survey areas, meaning contamination is potentially present, the proposed surveys will be designed as final status surveys. Also, survey designs will incorporate some additional characterization sampling in selected locations to further confirm the absence of contamination. Sampling could include scans of air ducts and drains and the collection of material samples as deemed appropriate.

5.2 Scope

The Final Status Survey Plan would include the radiological assessment of all impacted structures and buildings and surrounding areas included under the NRC license. The purpose of the plan is to quantify the concentration of any residual radioactivity that may exist. Residual levels will be compared to dose-based concentration limits for all radionuclides of concern identified in the historical site assessment (Table 2-2) for soil and building surfaces. The unity rule will be followed in areas with more than one radionuclide of concern. These limits correspond to the maximum annual dose rate criterion for unrestricted release of licensed facilities as specified in 10 CFR 20.1402. The dose-based concentration limits are developed in Section 6 of this plan.

5.3 Summary of the Final Status Survey Process

The final status survey would provide data to demonstrate that all radiological parameters satisfy the established dose limits and conditions. The primary objectives of the final status survey are to (1) select or verify survey unit classification; (2) demonstrate that the potential dose from residual radioactivity is below the release criterion for each survey unit, and (3) demonstrate that the potential dose from small areas of elevated activity is below the release criterion for each survey unit. The final status survey process consists of four principal elements: (1) planning, (2) design, (3) implementation, and (4) assessment.

5.4 Survey Planning

Survey planning is performed to ensure that radiological surveys produce the data necessary to support release decisions. It involves historical site assessment and review of other pertinent characterization information to establish survey area classification and radionuclides of concern for each study area under the license. Concentration levels that correspond to the maximum annual dose criterion of 10 CFR 20.1402 are established by dose modeling for the type of contamination (surface or volume) found in the contaminated media (soil, building, or structures). The concentration criteria, referred as derived concentration guideline levels (DCGLs), allow for the practical implementation of the health-based dose limits.

For the purpose of performing radiological surveys, survey areas are divided into survey units, which are physical areas for which individual release decisions are made on the basis of survey measurements. A reference system is set up to document the location of survey measurements, whether taken in a biased manner, randomly, or over a grid. Reference areas are identified that are known to be free of contamination and that contain the types of materials existing in the survey units. Before surveying, radionuclide-specific DCGLs determined from dose modeling are converted to operational DCGLs, which are needed to interpret actual survey measurements. The survey measurements are conventionally made with survey instruments that measure gross radioactivity. The availability of the appropriate type and number of survey instruments with sufficient sensitivity to detect the operational DCGLs is then verified.

5.4.1 Classification of Survey Areas

Table 2-2 assigned initial classifications to all buildings and structures and surrounding areas on the basis of potential for residual contamination. These classifications represent the highest level of contamination known or expected to exist in the buildings based on historical information and surveys. The basis for the building classifications is given in Section 2.2. Table 5-1, below, presents the results of the latest round of surveys for the buildings of interest. The survey program has been an integral part of radiation safety portion of the NRC license. Regular surveys have been performed over the life of the license, giving further assurance of the uncontaminated condition of the facilities.

Table 5-1
Summary of Recent Building Surveys

Building No.	Date of Survey	Radio-nuclides of interest	Types of surveys performed	Instruments used	MDA (dpm/100 cm2)	Results
5		U-234, U-235, and U-238 (DU)	Dry swipe samples collected and analyzed at Redstone Arsenal, AL; walk-thru gamma survey	laboratory counters for swipes, Ludlum Model 3 pancake G-M for gamma rates	Alpha: 2 Beta: 6 Gamma: 109 Backgrd: 0.02 mR/hr	No results above background
306		U-234, U-235, and U-238 (DU)	As for Bld 5	As for Bld 5	As for Bld 5	No results above background
356		Th-232	As for Bld 5	As for Bld 5	As for Bld 5	No results above background
612	3/99 to 5/99	U-234, U-235, and U-238 (DU)	Over 2-m grid: Direct and swipes: alpha/beta/gamma Surface Scans alpha/beta/gamma 100 % scans	Hand-held and floor monitor gas-proportional counters, FIDLER low-energy gamma detector, laboratory counters for swipes	Swipes and gamma rate: as for Bld 5 Static direct: Alpha: 20/40 Beta: 1000/2000 Gamma: 16,000	No detects above action levels. (Data to be reviewed against revised action levels.)
2073		U-234, U-235, and U-238 (DU)	As for Bld 5	As for Bld 5	As for Bld 5	No results above background
S-2084		U-234, U-235, and U-238 (DU)	As for Bld 5	As for Bld 5	As for Bld 5	No results above background
Storage Bunkers		DU (all), Ra-226 (2 bunkers), H-3 and Pu-239 (4 bunkers)	As for Bld 5	As for Bld 5	As for Bld 5	No results above background

Within a survey area, one or more survey units may be defined that carry the same, or lower (numerically higher), contamination classification as the survey area. A survey unit is a physical area that has been subjected to a consistent set of contamination processes. It is the smallest area to which a release decision would apply. Survey units of the same classification within a survey area may vary substantially in size, but may be sampled with a similar number of measurements if they have similar contamination levels and variability and are subject to the same DCGL.

5.4.2 Survey Units

As described above, a survey unit is a physical area within a building or structure or land area of specified size and shape that would be considered as a unit during the final status survey process. Compliance criteria would be demonstrated for each survey unit. While individual rooms are considered in dose modeling to calculate DCGL values for buildings, survey units used to establish compliance with DCGLs may encompass more than a single room, as long as the total area of the survey unit does not exceed the following guidelines suggested in MARSSIM:

Class 1 Structures:	up to 100 m^2	Class 1 Land Areas:	up to 2,000 m^2
Class 2 Structures:	100 to 1,000 m^2	Class 2 Land Areas:	2,000 to 10,000 m^2
Class 3 Structures:	no limit	Class 3 Land Areas:	no limit

Floor plans showing survey area classifications within the buildings are given in figures 5-1 through 5-7. Table 5-2 presents the number and sizes of survey units proposed within the survey areas. For Class 2 areas within buildings, each room or distinct area within the Class 2 area is designated a separate survey unit. Class 3 areas may comprise a single or several survey units. A total of 21 Class 2 survey units are proposed for the four buildings that have Class 2 areas, and a total of 7 Class 3 survey units are proposed for the three main buildings that have Class 3 areas. The 121 storage bunkers will each be surveyed as a single Class 3 survey unit. The proposed survey unit sizes fall well within the guidelines. Note that Building 612 surveys have already been performed (walls, ceilings, and floors) with some survey units exceeding Class 1 size guidelines. If, upon review, residual contamination levels are found to be well below action levels, the few such survey units may be found to be of acceptable size to support release decisions. As noted in Table 2-2, contamination in all buildings, if present, is expected to exist only on floor surfaces. Walls and ceilings will not be sampled with direct measurements at specific locations, but will be scanned and sampled as determined by judgement.

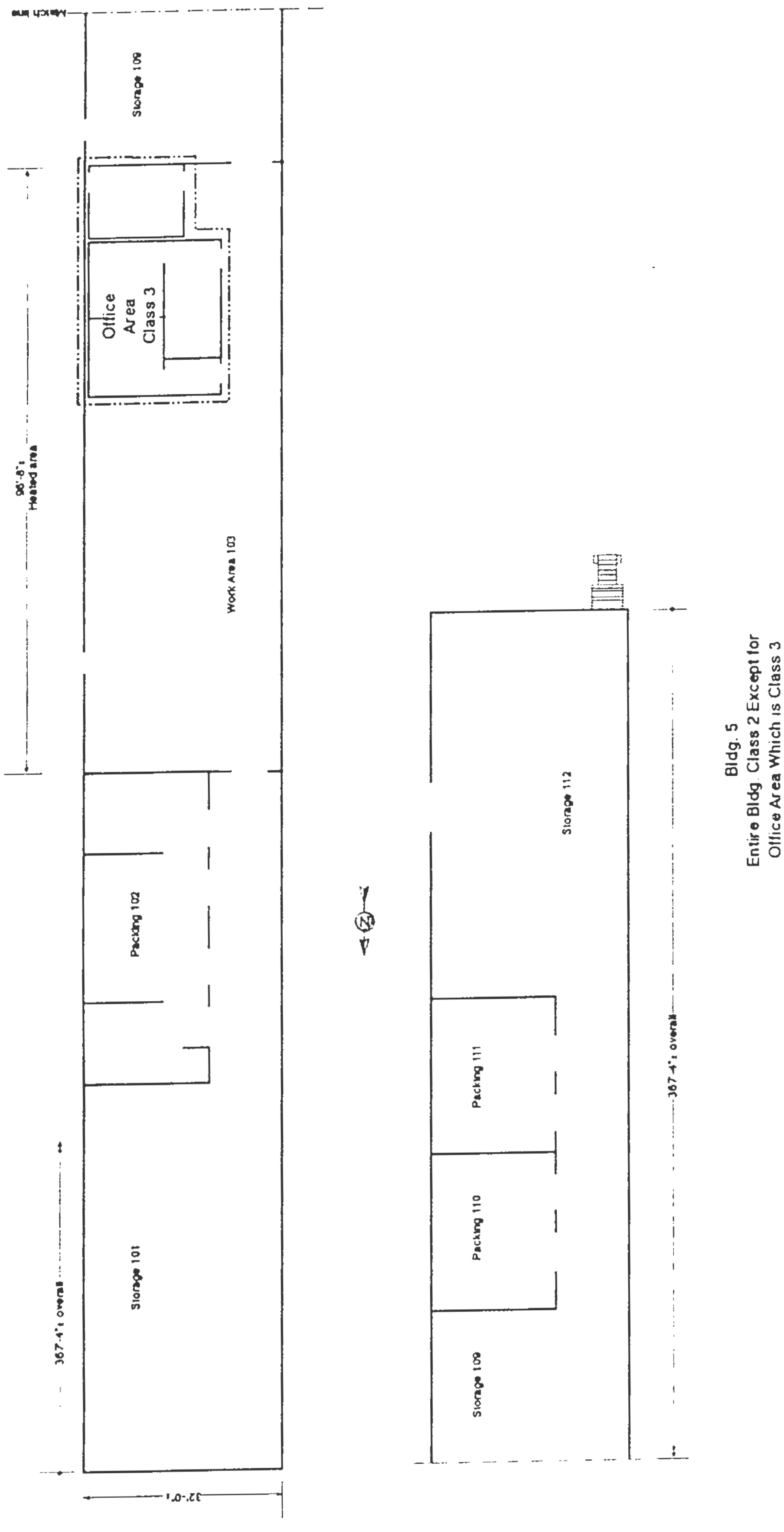


FIGURE 5-1 Building 5 Survey Areas

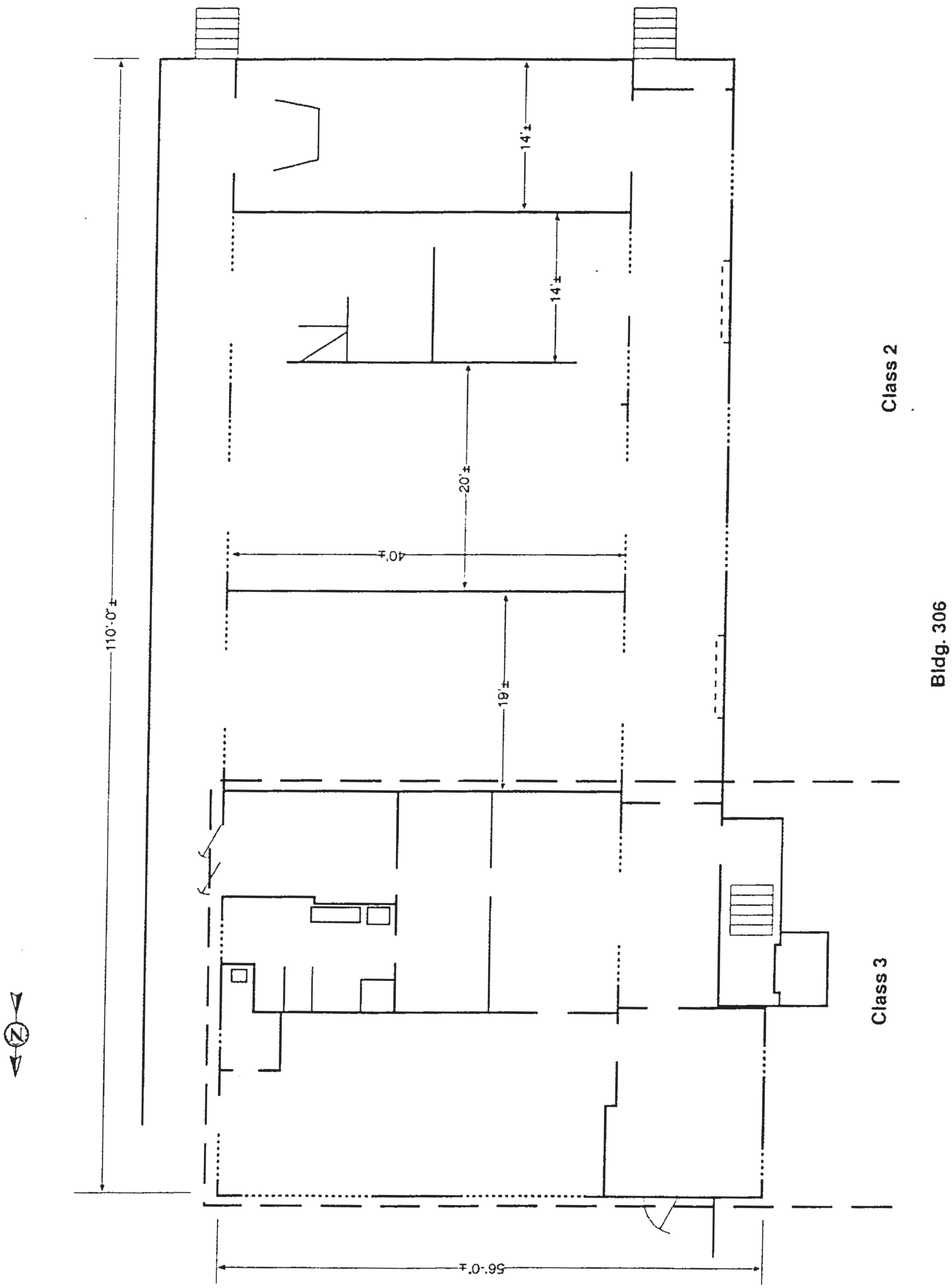


FIGURE 5-2 Building 306 Survey Areas

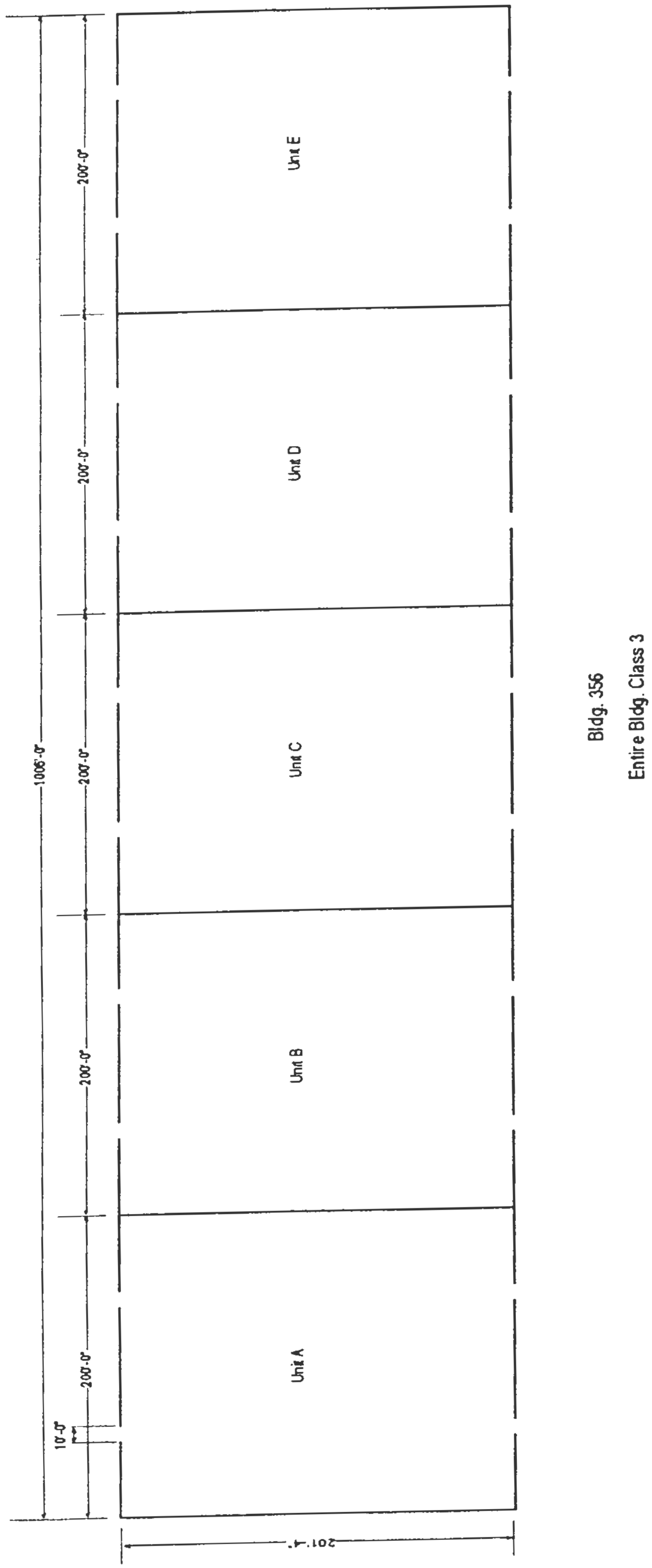
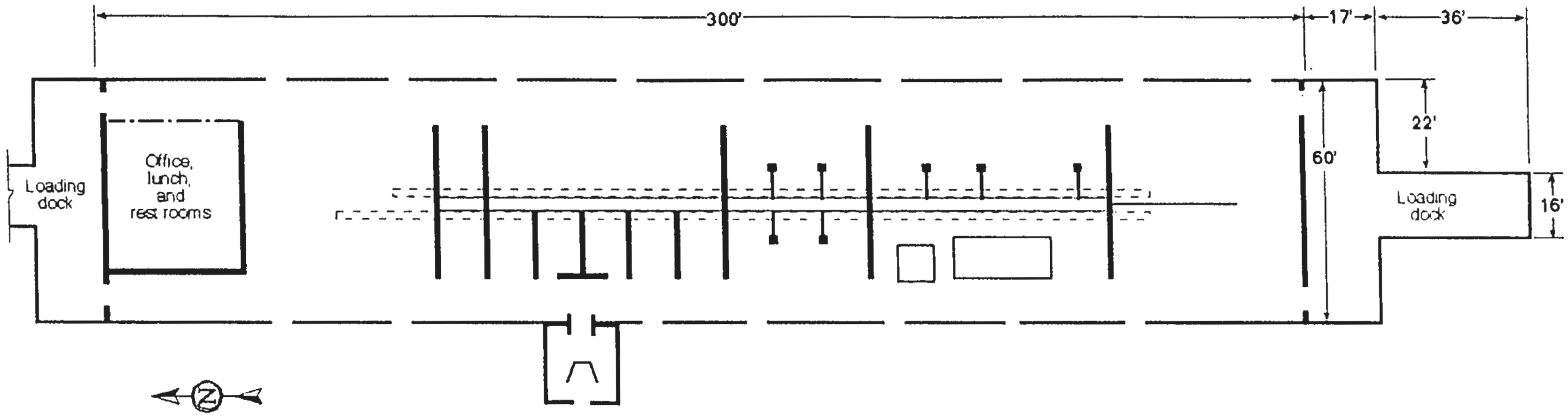


FIGURE 5-3 Building 356 Survey Areas



Bldg. 612

Class 1
(Surveys done)

FIGURE 5-4 Floor Plan of Building 612 (surveys previously performed in 28 Class 1 survey units)

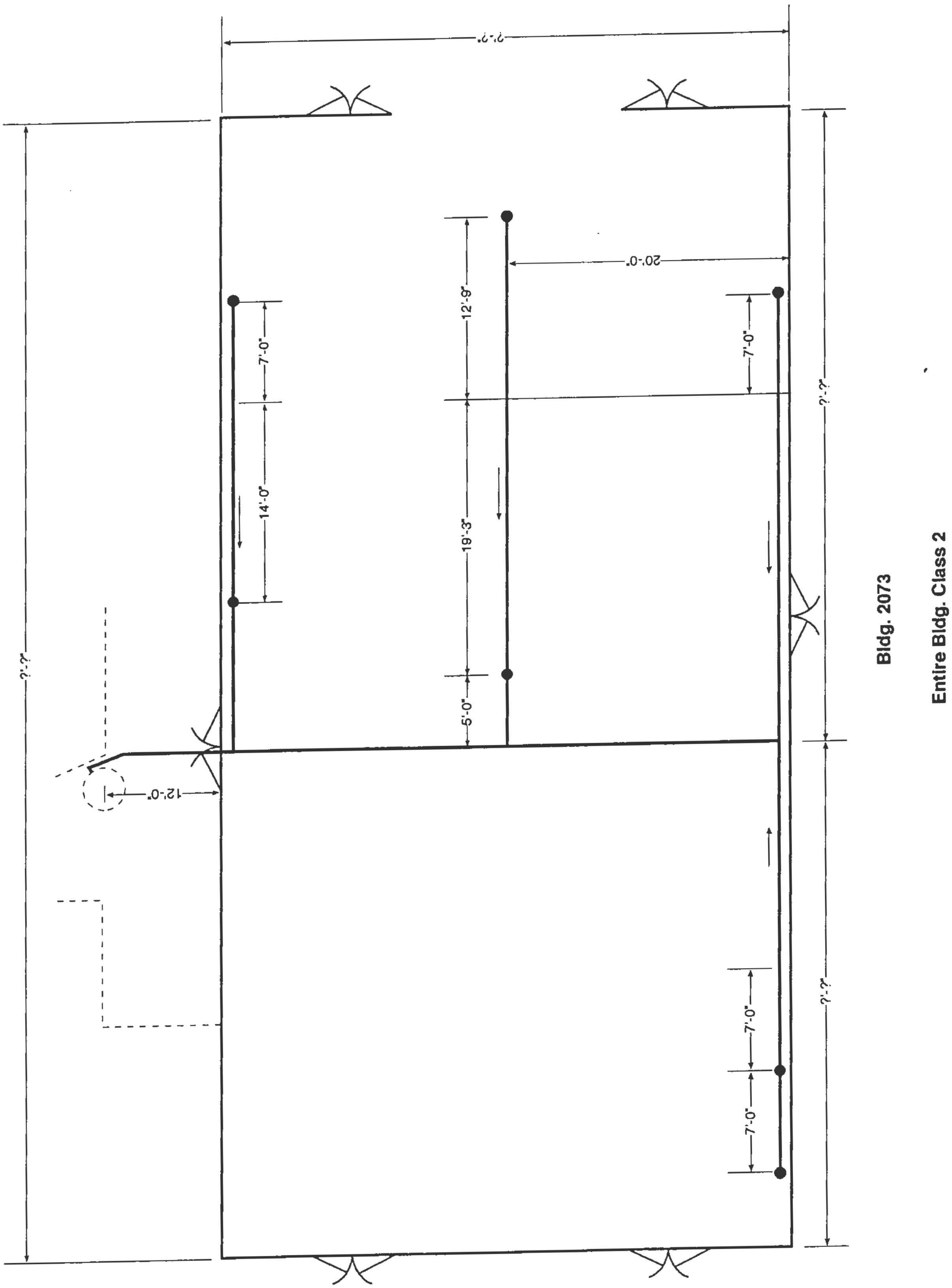


FIGURE 5-5 Survey Areas for Building 2073

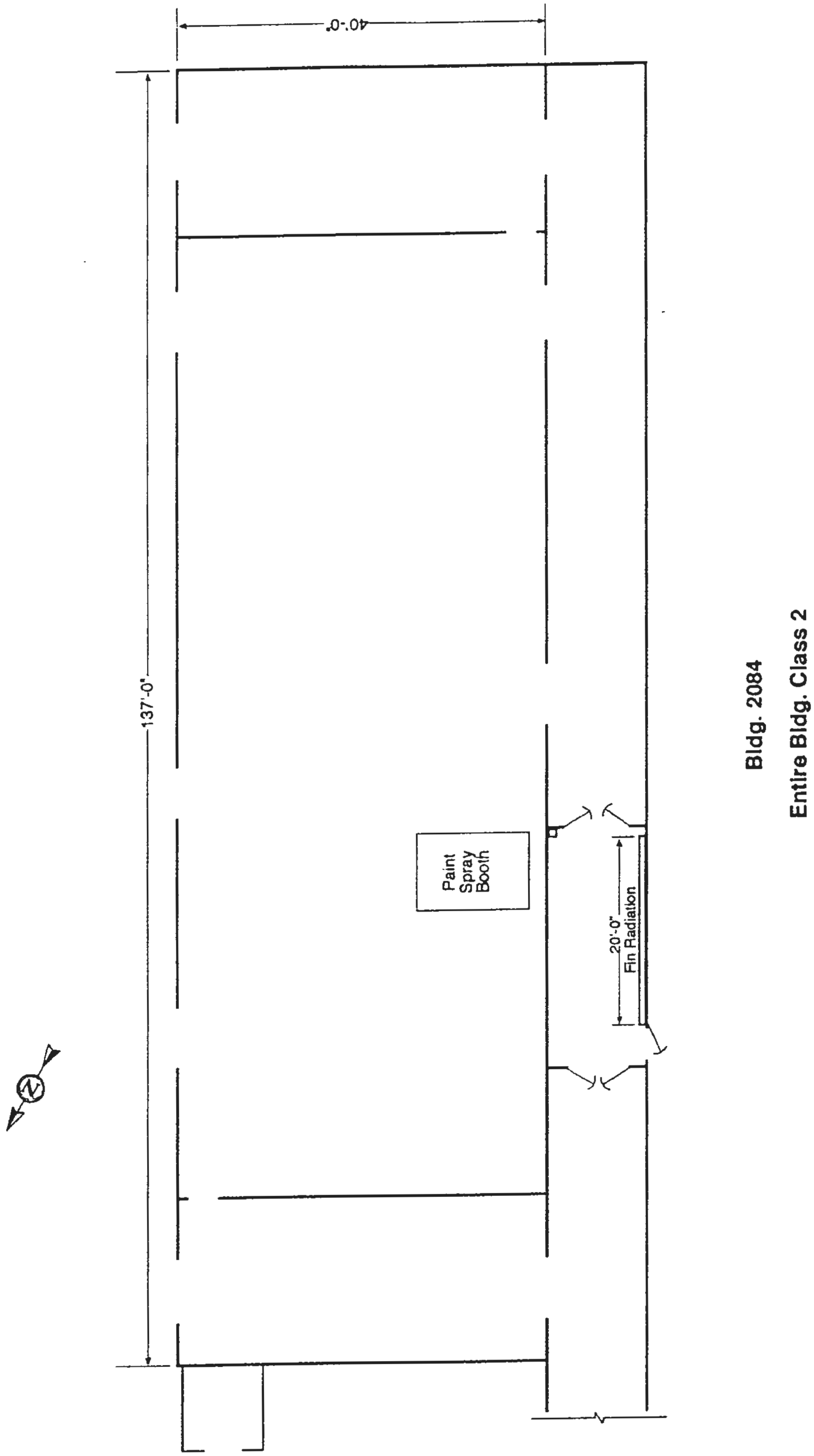
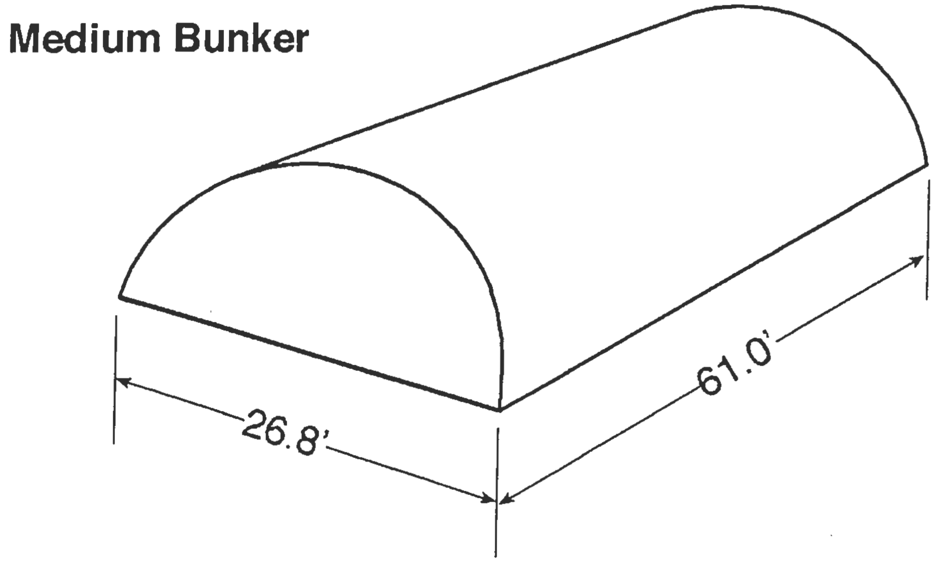
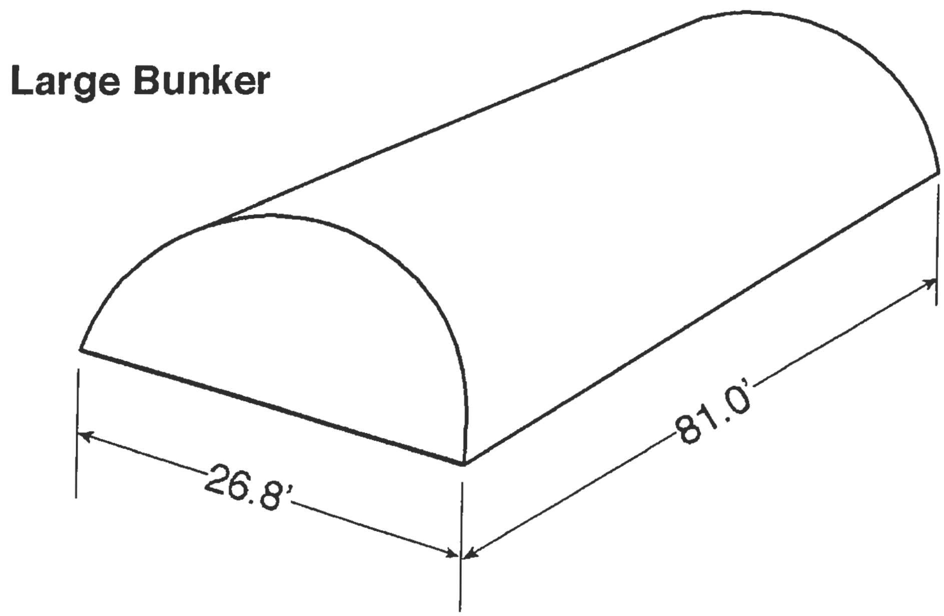


FIGURE 5-6 Survey Areas for Building S-2084





Class 3

FIGURE 5-7 Survey Areas for Storage Bunkers

Table 5-2
Summary of Building Survey Units

Building No.	Total floor area (m^2)	No. Survey Units/Size (m^2)		
		Class 1	Class 2	Class 3
5	1092	0	7 (1000 total)	1 (92)
306	536	0	7 (312 total)	1 (224)
356	18,600	0	0	5 (3720 ea.)
612	1,730	28 (3-250, completed)	0	0
2073	280	0	3 (280 total)	0
S-2084	510	0	4 (510 total)	0
Storage Bunkers (121 total)	150 (20-m length) 200 (25-m length)	0	0	93 (150 ea.) 28 (200 ea.)

5.4.3 Reference Coordinate Systems

Each survey unit would have a benchmark defined that would serve as an origin for documenting survey results. For buildings, a grid numbering system will be used for buildings that starts, for example, in the northeast corner and is numbered consecutively beginning with an "F" for floors, "W" for walls, "C" for ceilings, and "H" for other horizontal surfaces. The location of judgment samples in buildings will be documented in terms of linear horizontal and vertical distances from a designated corner and will be recorded on a drawing of the area. Samples taken from the grounds outside of buildings will be recorded with a standard geographic reference system with respect to a local geographical marker.

5.4.4 Reference Areas

To represent background radiological conditions at the site (structures and buildings, land areas) and to provide reference areas for conducting statistical comparisons of study areas, measurements will be made in one or more reference areas that have not been affected by site operations. Measurements have previously been made to establish background levels for gross activity in various materials in two different buildings, C0912 and 722. Table 5-3 provides the results of measurements for different survey instruments in C0912, a storage bunker that was not used for any radiological storage (U.S. Army 2001). Bunker C0912 will continue to serve as a control for future surveys of storage bunkers. It will be surveyed again as part of the current license termination effort.

Table 5-3
Survey Results for Different Survey Instruments Used in Building CO912

Instrument	Floor or Wall (Bunker C0912)	Background Range (counts per minute, cpm)
Gas Proportional – Floor Monitor (probe area = 425 cm^2)	Floor- Alpha	3-8
	Floor –Beta	650-757
	Floor – Alpha + Beta (scanning)	400-800
Gas Proportional – Hand-Held (probe area = 100 cm^2)	Wall – Alpha	0-5 (0 for smears)
	Wall- Beta	121-166 (0 for smears)
	Wall – Alpha + Beta (scanning)	60-200
	Floor – Alpha + Beta (scanning)	60-200
Phoswich (plastic scintillator, probe area = 86 cm^2)	Floor – Alpha	0-3
	Floor – Beta	270-326
	Wall – Alpha	0-6
	Wall – Beta	216-411
	Floor – Alpha + Beta (scanning)	200-400
	Wall - Alpha + Beta (scanning)	200-460
FIDLER (sodium iodide crystal, probe area = 126 cm^2)	Floor – Gamma (direct)	7,849-8,219
	Wall – Gamma (direct)	7,583-8,136
	Floor – Gamma (scanning)	6,000-12,000
	Wall – Gamma (scanning)	5,800-10,500

Building 722 surveys were performed with the same or similar devices on a variety of surfaces, materials, and equipment items. Gross activity levels covered a range similar to that in C0912. Building 722 is no longer available as a reference area for buildings other than storage bunkers. Building 118 is a suitable reference building and is proposed to serve that purpose for buildings other than storage bunkers. In addition, an area of soil that has not been impacted will be surveyed to establish background levels for field sodium iodide (NaI) detectors.

5.4.5 Selection of DCGLs

Two types of DCGLs are used for comparison of survey data. When computed for the average residual radioactivity in a survey unit, the derived guideline level is called a $DCGL_W$. A second guideline is derived for application to smaller areas, typically within a Class 1 survey unit. It is called the $DCGL_{EMC}$, where EMC stands for elevated measurement comparison. Both guidelines derive from the same dose, with the $DCGL_{EMC}$ corresponding to somewhat higher concentration levels in small areas that are computed using area factors. Used together for comparison to survey measurements, the two DCGL values ensure that an individual would not receive a dose in excess of the established criterion for unrestricted use.

Section 6 describes the modeling performed to develop the radionuclide-specific DCGLs for soil and building surfaces. These values will be used to establish operational DCGLs for survey units where measurements will be made that are not radionuclide-specific. They would also be used in the case when surrogate radionuclides were used. The operational DCGLs will be established for each survey unit on the basis of a representative radionuclide mix. For alpha or beta surface activity measurements, field measurements will consist of gross activity assessment. In these cases, gross activity DCGLs would be established on the basis of a representative radionuclide mix. The surrogate DCGLs, if needed, would be computed from the activity ratio between a difficult-to-detect radionuclide and the easy-to-detect radionuclide. The activity ratio would be established from characterization data. To establish $DCGL_{EMCs}$, area factors would be calculated.

In areas where there is more than one radionuclide of concern, the unity rule would be followed. That is, the sum of the ratios of the residual concentration of each radionuclide to its respective DCGL would not exceed unity. For the current plan, DU is the only contaminant of concern for the vast majority of areas. DU consists of U-238, U-235, and U-234, and their associated progeny. To simplify the release criteria, the isotopic composition of DU will be factored into a single operational DCGL value that can be implemented in a single gross alpha activity measurement. The combined DCGL will account for all the radioactive isotopes in the standard composition of DU stored at the Depot.

5.5 Final Status Survey Design Elements

After the $DCGL_w$ is established, a survey design will be developed that will select the appropriate survey instruments and techniques to provide adequate coverage of survey units though a combination of scans, fixed measurements, smears, and material sampling. This survey design process will ensure that data of sufficient quantity and quality are obtained to make decisions as to whether survey units meet the release criterion. Components of this process are as follows:

- Scanning measurements will be used to locate areas of elevated radioactivity, which may be evaluated in terms of the $DCGL_{EMC}$. Scanning measurements are made by moving a detector over an area at a uniform rate and distance from the surface. Measurements of gross alpha, beta and/or gamma activity will be made as determined by the nature of the radioactivity of the radionuclides of concern in a survey unit.

- Direct measurements of gross radioactivity will be taken at the centers of a systematic grid laid over survey units. A direct measurement is made by holding a detector at a fixed location over a surface for a specific counting duration. These measurements will be averaged over a survey unit for statistical comparison to the $DCGL_W$ using the Wilcoxon Rank Sum test. Grids will be laid out with a randomly determined starting point so measurements at the grid centers can be considered unbiased for statistical comparisons.

- Smear samples will be taken in survey units at the same locations as direct measurements. Where tritium is a contaminant of concern, wet smears will be taken. Results will be used for diagnostic purposes.

- Air duct and drain surveys may be performed in Class 2 buildings. Survey instruments, such as a "peanut" NaI detector, may be inserted into ducts or drains by using a rod or similar device to reach the accessible reaches of these conduits for characterization purposes. Smears or material samples may also be taken at the entry points of air ducts and drains.

- In situ measurements of gross gamma activity in soil will be taken at selected locations to detect the presence of any activity that may have been carried outside (e.g., by foot traffic or floor sweeping). Soil samples may be taken at locations of elevated activity. Measurements will be compared to soil DCGLs (Section 6.3).

5.5.1 Selecting the Number of Fixed Measurements and Locations

Fixed measurement surveys will be designed to meet the data quality objectives (DQOs) of the survey program. DQOs define the types, number, and locations of measurements needed to support a decision within prescribed limits of error, in this case, decisions regarding meeting release criteria. DQOs further indicate which survey instruments are appropriate for performing the surveys. Procedures for designing fixed and scanning measurement surveys and selecting instruments to meet program DQOs are given in MARSSIM. The BRAC radiological survey policy applies the principles in MARSSIM to BRAC commodity storage and repair sites in the specification of semi-standard survey designs.

5.5.1.1 Class 1 and 2 Survey Units

In accordance with MARSSIM and the BRAC radiological survey policy, Class 1 and 2 survey units will be surveyed with a combination of scanning measurements, direct measurements, and smear samples of removable activity. Material samples may also be taken from drains and air vents.

Scans will be performed over all or portions of Class 1 and Class 2 survey units:

- Class 1 surface areas receive a 100% scan of all surfaces

- Class 2 survey units receive scans of between 10 and 100% of floor and lower wall sections and between 10 and 50% of upper walls and ceilings. The specific areas to be scanned in Class 2 survey units will be determined by judgment on the basis of process knowledge and the potential for radiological contamination. Scans may also be performed inside drains and air ducts. Also, any fixtures or furniture that will be transferred along with the building will be scanned before release.

Direct measurements of radioactivity will be made on a systematic grid laid over a survey unit:

- For Class 2 areas, the number of direct measurements to be taken within a survey unit have been determined according to the methods and equations given in MARSSIM (Section 5.5.2). For contaminants present in background, such as uranium isotopes, or when gross activity measurements are made, as in the current case, data from direct measurements are evaluated in terms of the $DCGL_W$ by using the Wilcoxon Rank Sum test. The number of samples required to perform this statistical test depends on several factors, including predetermined acceptable rates of decision errors, the width of the "gray region" on a decision plot (MARSSIM, Section 5.5.2.2), and the variability of residual contaminant levels. Specific values of acceptable decision error rates, estimates of the standard deviation, and the resultant number of samples for the currently proposed surveys are provided in Table 5-4. While only 6 or 7 samples are required in survey units because of generally large relative shifts, a standard number of **10 samples per survey unit** is proposed for all Class 2 survey units to ensure a sufficient number of samples.

- Class 1 areas would be subject to an additional effort to detect areas of elevated contamination in excess of the $DCGL_{EMC}$. Because the $DCGL_{EMC}$ corresponds to the same dose as the widearea $DCGL_W$, but for a small area, it has a corresponding higher value. The actual value of the $DCGL_{EMC}$ is a function of the potential size of such elevated areas. The maximum size of an elevated area that would not be detected by direct grid measurements is roughly of the size of a grid cell. Therefore, grid size may have to be reduced and direct measurement numbers increased, to limit the size of elevated areas using Area Factors as described in MARSSIM (Section 5.5.2.4).

The currently proposed surveys include only areas initially classified as Class 2 or Class 3 areas. If any contamination exceeding $DCGL_w$'s were to be found in the scanning measurements of the Class 2 areas, these areas would be reclassified as Class 1 (see Section 5.5.3). As this possibility is considered remote, grid sizes and sample numbers will be determined without regard to the need to meet criteria for elevated areas. Should an area be reclassified as Class 1, however, grid sizes for direct measurements will be recalculated, taking into account the need to implement the $DCGL_{EMC}$ for elevated areas. As indicated above, all non-bunker buildings, except Warehouse 356 and Building 612, and grounds will initially contain at least one Class 2 area. Warehouse 356 is designated a Class 3 area, while Building 612 has already been surveyed in its entirety as Class 1.

Table 5-4
Minimum Number of Direct Measurements to be taken in Class 2 Survey Units

Bldg. No.	Limiting[1] radio-nuclide	Operational[2] $DCGL_w$ (dpm/100 cm^2)	LBGR[3] (dpm/100 cm^2)	CV[4]	Relative[5] Shift	α[6]	β[7]	N/2 for[8] WRS test
5 306 612 2073 S-2084 Storage Bunkers	U-235	5690	500 (alpha)	0.3	35	0.05	0.10	6
356	Th232+ Ra-228+ Th-228	340	200 (alpha)	0.3	2.3	0.05	0.10	7
A0201 A0316 A0317 A0508	Pu-239 H-3	2020 3.58E+09	200 (alpha) 3xE+05 (beta)	0.3 0.3	30 3.9E+4	0.05 0.05	0.10 0.10	6 6
A0701	Pm-147	3.47E+07	3E+04 (beta)	0.3	3850	0.05	0.10	6

[1]The limiting radionuclide of potential concern in a given building has the lowest DCGLw as given in Table 6-8 for any radionuclide for any room size.

[2]The operational DCGLw is associated with the limiting nuclide. It is the lowest value for any room size and allows conservative implementation of dose limits using gross activity field measurements.

[3]The lower bound of the gray region (LBGR) is the highest residual contamination level for which specified decision error rates are applicable. That is, it is the highest residual level that can be shown to be below action levels based on sample data, given expected sampling and analysis error. The selected LBGR affects the number of samples, N, needed to perform the WRS test. The value of 500 dpm/100 cm^2 for U-235 (DU) is an order of magnitude below the DCGL yet far above expected residual levels. The value of 200 dpm/100 cm2 selected for other alpha emitters, including DU, Pu-239, and natural thorium, is an order of magnitude above the MDA of the floor monitor, about 20 dpm/100cm2, yet well below DCGLs. Actual residuals are expected to be close to background (1-2 cpm/100 cm2). The value of 3E+05 dpm/100 cm2 for H-3 is one-half of ANSI N13.12 (1999), the surface standard for clearance. The value 3E+04 dpm/100 cm2 for Pm-147 is an order of magnitude above the MDA for beta for the floor monitor, roughly 3000 dpm/100 cm2, and far below the DCGL.

[4]The coefficient of variation, CV, is the estimated relative standard deviation of measurements of residuals. It is set at 0.3 per MARSSIM, Section 5.5.2.1, in the absence of preliminary data.

[5]The relative shift is defined as (DCGLw – LBGR)/σ, where σ is the estimated standard deviation of the survey unit, in this case, CV x LBGR.

[6]α is the specified acceptable level of Type I (false positive) decision errors, when the null hypothesis is that the survey unit exceeds the cleanup standard.

[7]β is the specified acceptable level of Type II (false negative) decision errors.

[8]N/2 is the number of samples required in survey units and background units to perform the WRS test given the specified relative shift and decision error limits. N is calculated as follows:

$$N = (Z_{1-\alpha}+Z_{1-\beta})^2 \; / \; 3(P_r-0.5)^2$$

Where:

$Z_{1-\alpha}$ and $Z_{1-\beta}$ are values from the standard normal distribution, and

P_r is the probability that a random measurement from the survey unit exceeds a random measurement from the background reference area by less than the $DCGL_w$ when the survey unit median is equal to the LBGR above background.

5.5.1.2 Class 3 Survey Units

By definition, MARSSIM Class 3 survey units are not expected to contain any areas of contamination. They will not, therefore, be subjected to wide-area scanning. Rather, a judgment approach will be used to select areas that would most likely be contaminated if any contamination were present. Areas will be selected on the basis of process knowledge and pathway analysis to select locations that, if free of contamination, would indicate that the survey unit as a whole was also clean.

In accordance with the BRAC radiological survey policy, Class 3 areas will undergo random sampling to verify that release criteria are met. Random sample locations are determined from a random number table or generator; they are not laid out over a grid. Following the BRAC policy, and consistent with MARSSIM, 30 random samples will be collected over an indoor area of up to 1,500 m^2. All of the approximately 120 storage bunkers and surrounding grounds under the license will be surveyed as Class 3 areas.

5.5.2 Judgmental Assessment

As discussed above, radiological surveys will be conducted in a judgmental manner to various extents in Class 2 and Class 3 areas as process knowledge and history would indicate. The purpose of such surveys is to confirm the absence of contamination in locations where it most likely would exist. Locations would be selected from a conceptual model of what processes took place within the facilities and how and where contamination might have migrated or collected. Surveys will typically be performed with scanning measurements. However, if areas of interest are small, such as at a drain opening, direct measurements may also be taken to improve detection limits.

5.5.3 Data Investigations

A review of survey data will be performed as they are collected to support two main objectives — to ensure that measurement devices are working within their expected normal ranges, and to support accurate classification of survey areas, which supports the design of final status surveys. Such data reviews would help assure the effectiveness of the final surveys. Accurate initial classification of areas would prevent under or over surveying of those areas.

The criteria selected for use in data investigations will depend on survey unit classification. In the current program, all survey units will be initially classified as either Class 2 or Class 3. In Class 2 survey units, no measurements are expected to exceed $DCGL_W$'s. Therefore, any direct or scan measurement approaching or exceeding $DCGL_W$'s will be investigated. In Class 3 areas, any direct measurement or scan above background would be investigated, as these areas are assumed to be uncontaminated.

Data investigations would address concerns of the existence of isolated areas of elevated radioactivity that are not addressed in the design of Class 2 or Class 3 surveys. They will involve first confirming the elevated measurement with a second measurement. If the elevated reading is confirmed, the area around the measurement point would be investigated to define the extent of contamination. Possible sources of the contamination would be postulated, and the conceptual model would be modified to suggest other locations of similar concern. Pending the results of these efforts, an area may be reclassified to a more restrictive classification. Such reclassification may require resurvey of the study areas under an appropriate survey design. This procedure may be conducted without NRC approval. Conversely, any reclassifications to less restrictive classifications would require preapproval by NRC.

5.6 Survey Implementation and Data Collection

Survey implementation is the process of carrying out the survey plan for a given survey unit. This consists of making scan measurements and fixed measurements, and collecting and analyzing samples. Scan measurements will always be made, while fixed measurements and sampling may not be necessary.

5.6.1 Survey Methods

Surveys will employ a combination of judgmental and statistical measurements, using scanning, direct, and material sampling, to implement dose-based release criteria. The degree and proportion that each of these types of measurements will be used will depend on area classifications. Measurement devices will be employed that are appropriate in terms of the types of radiation expected and sensitivity required for the various types of measurements being made. The devices will be calibrated to NIST-traceable standards in accordance with the NRC licenses.

5.6.2 Survey Instrumentation

5.6.2.1 Scanning Surveys

Instruments selected for scanning surveys will be of a type that responds to the principal types of radiation, alpha, beta, or gamma that are emitted from radionuclides of concern. As DU is the contaminant of concern in the vast majority of areas covered by this plan and because the primary emissions of its constituents are alpha particles, gross alpha detectors will be the primary instruments used in these surveys. In a few locations, where tritium or promethium-147, which are beta emitters, will be of interest, instruments that detect gross beta will be used. Tritium and other low-energy emitters will be analyzed primarily on smear samples using laboratory liquid scintillation counting (LSC). Gamma detection instruments, such as NaI devices, will be used to a limited extent in buildings, primarily for characterization of uranium isotopes or decay products in selected locations or in locations that are difficult to access with alpha probes. Gamma detectors, however, would play a primary role in any outdoor scanning surveys.

The devices listed in Table 5-5 have been used effectively in the past at the Depot for both scanning and direct measurements (U.S. Army 2000, 2001). The same or similar instruments will be used in the current surveys. The minimum detectable activities (MDAs) listed in Table 5-5 were determined (U.S. Army 2000) using MARSSIM equations 6-8, 6-9, and 6-10 combined as follows:

$$MDA_{scan} = \frac{\frac{60}{i} * 1.38\sqrt{B_R * t}}{\sqrt{p}E_d E_s \frac{A}{100cm^2}}$$

MDA_{scan}	=	Minimum detectable scanning activity in dpm per 100 cm^2
B_R	=	Background rate in cpm
P	=	Surveyor efficiency (0.5, MARSSIM)
i	=	Observation time interval in seconds
t	=	Scan observation interval in minutes (0.03 mins, MARSSIM)
E_s	=	Surface efficiency in counts per disintegration (0.5, MARSSIM)
E_d	=	Detector efficiency in counts per disintegration
A	=	Active probe area in cm^2

The value for the observational time interval (i), the time a given point is under the probe during scanning is assumed to be 2 seconds (0.03 minutes) per MARSSIM guidance. The factor 1.38 in the numerator of the above equation is taken from MARSSIM table 6.5 and corresponds to a 95% rate of true detects and a 60% rate of false positives. Such error rates are compatible with the objective of first-time screening of areas where one wants to err on the side of detection.

5.6.2.2 Direct Measurements

Direct radioactivity measurements will primarily be made with the same devices used for scanning (Table 5-5). When the same device is used for both scanning and direct measurements, such measurements may be carried out concurrently in an area to optimize field efforts. A standard counting time of, for example, 1-minute will be used for direct measurements. MDAs should be no higher than 10-50% of DCGLs to assure detection of concentrations of interest. MDAs listed in Table 5-5 were calculated from MARSSIM equation 6-7 as follows:

$$MDA = \frac{3 + 4.65\sqrt{B}}{E * \frac{A}{100}}$$

where

MDA = Minimum detectable concentration

B = Background counts in cpm

E = Detector efficiency in counts per disintegration

A = Active probe area in cm^2

From the discussion in Section 6.7.1 of MARSSIM, the constants in the numerator of the above equation, 3 and 4.65, correspond to false positive and false negative rates for detection of 5%.

Smear samples will be screened in the field for gross alpha and gross beta activity with a hand-held gas proportional detector. Smears and/or material samples may also be sent for laboratory analysis of specific radionuclides. The analyses would be performed to confirm the radiological composition of the contamination underlying elevated gross activity measurements. Laboratory methods would employ conventional spectrometric and counting methods that meet the survey program measurement objectives.

For the interpretation of gross activity readings in the field, flag values will be computed in terms of the instrument count rate (cpm) that is equivalent to the operational DCGL for a given radionuclide mix in dpm/100 cm^2 plus background (Bkg) count rate (cpm) as follows:

$$\text{Flag cpm} = \text{Bkg cpm} + A \times E \times \text{DCGL}/100\ cm^2$$

where

A = detector probe size (cm^2),

E = detector efficiency (unitless), and

DCGL = the operational DCGL (pCi/g or dpm/100 cm^2).

Table 5-5
Instruments Used in Previous Seneca Depot Activity Surveys[a]

Instrument[b]	Model	Serial No.	Probe Area (cm^2)	Rad Type	Source	Eff	Bkg (cpm)	Scan MDA dpm/100 cm^2)	Static MDA (dpm/100 cm^2)
Floor monitor	Ludlum 2360	138256	425	Alpha	Th-230	0.12	2	60	20
Floor monitor	Ludlum 2360	138256	425	Beta	Tc-99	0.22	800	610	140
Floor monitor	Ludlum 2360	138262	425	Alpha	Th-230	0.09	1	50	20
Floor monitor	Ludlum 2360	138262	425	Beta	Tc-99	0.20	440	500	120
Hand-held	Ludlum 2360	138238	100	Alpha	Th-230	0.18	1	110	40
Hand-held	Ludlum 2360	138238	100	Beta	Tc-99	0.20	73	870	280
Hand-held	Ludlum 2360	138254	100	Alpha	Th-230	0.20	1	100	40
Hand-held	Ludlum 2360	138254	100	Beta	Tc-99	0.21	81	870	210
FIDLER[c]	Bicron Analyst	A959P	126	Gamma	Am-241	0.02	6500	65,000	15,000

[a] Notation:
cm^2 = square centimeters
Eff = detector efficiency (ratio of detector counts per minute to source disintegrations per minute at a fixed geometry)
Bkg = background
cpm = counts per minute
MDA = minimum detectable activity (dpm/100cm^2 of area scanned)
dpm = disintegration per minute

[b] Floor monitor and hand-held devices are gas proportional counters; the FIDLER is a sodium iodide (NaI) detector. Laboratory LSC will be used to analyze low-energy beta emitters, including H-3 on smears.

[c] The apparent low efficiency of the FIDLER will be checked for future surveys.

5.6.3 Survey Considerations

5.6.3.1 Scanning Thresholds and Locations and ALARA

Some guidelines are necessary for the conduct and interpretation of scanning measurements in Class 2 and Class 3 areas. The MDAs of the scanning instruments used may be above the $DCGL_W$ release criteria, particularly in outdoor areas. Also, in Class 2 and Class 3 areas, $DCGL_{EMC}$ criteria for elevated areas are not employed, because the probability of the presence of such areas is considered remote. In such cases, the principle of "best reasonable effort" will be used to achieve practical scanning detection thresholds used in systematic or judgmental scanning surveys.

Detecting DU on building surfaces at $DCGL_W$ release criteria (Section 6) with conventional gas proportional counters does not appear to be a problem, considering established MDAs. Detection limits may be more of an issue for scanning measurements made in land areas with NaI detectors, such as the FIDLER. However, it is expected that direct readings with such devices should be able to detect, for example, uranium-238 at the soil DCGL of 103 pCi/g (MARSSIM, Appendix H, and Section 6.3 of this report). In judgmental surveys using NaI detectors, in order to improve detection limits, scanning speed may be reduced or direct measurements made in locations deemed most likely, on the basis of conceptual models, to be contaminated. This approach would be considered as achieving the goal of detecting contamination "as low as reasonably achievable" or ALARA.

Along these lines, the strategy for selecting locations for 10 to 100% scanning in Class 2 areas will be based on a conceptual model of contaminant distribution, focusing on areas most likely to be contaminated. If no other basis for determining scanning locations exists, at least 10% of areas would be scanned along systematic transects of survey units, or with randomly selected grid cells. In either Class 2 or Class 3 areas, any survey reading above background levels will be investigated further by appropriate means.

5.6.3.2 Surveying Land Areas

The grounds around the major buildings and areas outside the entranceways to the storage bunkers will be included in investigations. Land areas will initially be investigated by taking in situ gamma measurements in selected locations. If any indication of contamination is found, survey units will be defined. Such soil survey units might encompass two or more adjacent buildings. Radionuclides of concern for land areas would be the same as for the associated building or buildings. Survey instruments for land areas, however, will differ from those used inside buildings. Outdoor surveys will rely primarily on gamma detection of radionuclides of concern or associated decay products. Both scanning and direct measurements may be made with a FIDLER or other gamma detector, such as a 2X2 NaI crystal.

5.7 Survey Data Assessment

The survey data assessment process includes data verification and validation, review of survey design basis, and data analysis. For a given survey unit, the survey data are evaluated to determine if the residual radioactivity in the survey unit meets the applicable release criterion and if any areas of elevated activity exist. MARSSIM specifies two non-parametric statistical tests (Sign test and Wilcoxon Rank Sum test) to be applied to final status survey data to evaluate whether a set of measurement results demonstrates compliance with the release criterion for a given survey unit. The Sign test is applied if data are radionuclide specific and the radionuclide of interest is not present in the background. The Wilcoxon Rank Sum test is applied if the radionuclide does appear in the background or if gross activity measurements are considered.

5.8 Final Status Survey Reports

The documentation describing the final status survey for a given survey unit would be prepared and made available to NRC. The survey report would be a stand-alone report and would include the following:

- A physical description of the survey area that encompasses the survey units (the survey areas and survey units may be same);
- The characterization data associated with the survey area;
- The classification history of the survey unit;
- The remediation activities (if any) performed in the survey unit;
- A discussion of the survey design;
- Tabular and graphical depiction of survey results;
- Discussion of data assessment, including graphical depictions; and
- Conclusions that survey units meet all applicable criteria.

5.9 Quality Assurance and Quality Control Measures

Quality assurance and control measures (QA/QC) are employed throughout the final status survey process to ensure that all decisions are made on the basis of data of acceptable quality. As described above, the DQO process would be followed in the design of surveys and in the specification of measurement types and instrumentation. A Quality Assurance Project Plan (QAPP) will be prepared that will cover all project QA/QC requirements and activities, as well as project DQOs.

Data quality indicators (DQIs) are quantitative and qualitative measures of the reliability of the selected measurement methods. Such indicators include the inherent accuracy, precision, representativeness, completeness, and comparability of the data. Measurement instruments and methods will be evaluated in terms of these indicators when they are selected for surveys. DQIs will be included in the QAPP.

A quality assurance program will be carried out during surveys that, in accordance with the QAPP, will specify and measure the performance of measurement methods through the collection of an appropriate number or frequency of QC samples. Such samples could include blanks, replicates, and spiked samples, as well as measurements in reference areas. Field instruments will be calibrated on NIST-traceable standards at a frequency prescribed in the QAPP. Twice-daily response checks will be performed for all field instruments before use. Corrective actions will be carried out if performance falls outside expected ranges.

In addition, QA/QC measures will ensure that trained personnel carry out surveys with approved QAPP procedures and properly calibrated instruments. Procedures would cover sample documentation, chain of custody, field and laboratory QC measurements, and data management.

6 COMPLIANCE WITH THE RADIOLOGICAL CRITERIA FOR LICENSE TERMINATION OR RELEASE

The licensee needs to clearly present in the LTP the radiological criteria proposed for license termination or release. The licensee should describe the methods used to demonstrate compliance.

6.1 Site Release Criteria

The release criteria for the SEDA site will correspond to the dose criterion of 10 mrem/yr (New York State TAGM 4003, 1993). According to this dose criterion, 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 10 mrem/yr.

Levels of residual radioactivity that correspond to the allowable radiation dose are calculated by analysis of various scenarios and pathways through which exposures could be reasonably expected to occur. These derived levels, or derived concentration guideline levels (DCGLs), are the concentration of residual radioactivity distinguishable from background that, if uniformly distributed throughout a survey unit, would result in a TEDE to an average member of a critical group equivalent to the allowable dose. The NRC applies a TEDE standard of 25 mrem/yr; for this site, a TEDE of 10 mrem/yr (a more restrictive criterion) based on the TAGM 4003 guide was selected.

License termination will require evaluation of residual radiological contamination from two sources, building surfaces and soil outside buildings. DCGLs for both sources are calculated below, each based on a dose of 10 mrem/yr to the critical receptor. That receptor, therefore, could not receive a total dose in excess of 20 mrem/yr. Further, such dose would be reduced by at least the amount attributed to soil external gamma to the receptor while indoors, since soil beneath the buildings is not contaminated as assumed in the soil DCGL computations.

6.2 Dose Modeling Approach

6.2.1 Overview

The basic components in a dose modeling assessment include: source term assumptions; exposure scenarios; mathematical dose models; and the parameter values used in the dose models.

Considering the activities that occurred on the SEDA site, it is expected that any residual radioactivity would be confined to the surface soil layer or on the building surfaces. On the basis of the historical site assessment, the radionuclides associated with licensed operations are listed in Table 6-1, along with their half-lives and associated radiations. The radionuclides included are H-3, Pm-147, Pu-239, Ra-226, Ra-228, Th-228, Th-232, U-234, U-235, and U-238. DCGLs were developed for these radionuclides and their progeny in the decay chain (Sm-147, Pa-231, Ac-227, Th-230, and Pb-210).

To calculate DCGLs, dose models which translate levels of residual radioactivity in environmental media or on interior building surfaces into potential radiation doses to members of the public were developed based on the guidance found in several NRC documents (DG-4006, NUREG-1727, NUREG/CR-5521, Volume 1, and NUREG-1549). The approach taken for dose modeling for the SEDA site is consistent with the information provided in Section 5 and Appendix C of NUREG-1727.

Two scenarios were considered — resident farmer and building occupancy — similar to the scenarios described in NUREG/CR-5512, Volume 1. The resident farmer scenario was chosen to develop soil DCGLs, and the building occupancy scenario was used to develop building DCGLs. The RESRAD (Version 6.21) computer code was used to model the resident farmer scenario and RESRAD-BUILD (Version 3.21) was used to model the building occupancy scenario. The DCGLs were derived from the deterministic and the probabilistic modules of RESRAD and RESRAD-BUILD codes. The probabilistic analysis was performed to identify sensitive parameters for individual radionuclides. The conservative parameter values were selected in accordance with the guidance presented in NUREG/CR-6755, -6676, -6692, and -6697. Conservative values for the key (sensitive) parameters were used in the deterministic analysis to ensure conservative results. DCGLs were derived for all radionuclides listed in Table 6-1.

6.2.2 Resident Farmer Scenario

A resident farmer scenario similar to the residential scenario described in NUREG/CR-5512, Volume 1, was selected to estimate the dose resulting from the residual radioactivity in soil. Under this scenario, a hypothetical farmer who resides on the site was identified as the average member of the critical group, the subject of the dose modeling. The resident farmer lives on the site after the site is released for unrestricted use, drinks water obtained from a well located at the downgradient edge of the study area, ingests plant foods grown in a garden in the study area, ingests fish taken from a pond that is assumed to be constructed adjacent to and downgradient of the study area, and ingests meat and milk from livestock raised in the study area. All water used for drinking, household purposes, irrigation, and livestock watering is assumed to be drawn from the on-site well. It is implausible that any other set of human activities would occur on site that would result in a dose exceeding that for a resident farmer. It is more likely that the behavior of the future resident would result in a lower dose. For example, the hypothetical dose in an industrial setting from residual radioactivity in the soil would be much less than for a resident farmer, because the industrial worker would not ingest the food derived from on-site.

Table 6-1

List of Radionuclides, Their Half-Lives, and Associated Radiations (gammas with collapsed energies and yields)

Principal Radionuclides	Half-Life (yr)	Associated Decay Chain	Product Radionuclide	Half-Life (yr)	Associated Radiations
H-3	12.35	-	He-3	-	Beta
Pm-147	2.6234	-	Sm-147	1.06E11	Beta, and gamma (86.4 keV, 5E-5)
Sm-147	1.06E11	-	Nd-143	-	Alpha
Ra-226+D[a]	1600	Rn-222, Po-218, Pb-214, At-218, Bi-214, Po-214, Tl-210	Pb-210	22.3	Alpha, beta, and gammas (26.7 keV, 0.138; 93.0 keV, 0.246; 481 keV, 1.27; 1530 keV, 0.679)
Pb-210	22.3	Bi-210, Po-210	Pb-206	-	Alpha, beta, and gamma (12.4 keV, 0.237; 46.5 keV, 0.0405)
Ra-228+D	5.75	Ac-228	Th-228	1.9131	Beta, and gamma (14.9 keV, 0.358; 301 keV, 0.492; 1010 keV, 0.766)
Th-228+D	1.9131	Ra-224, Rn-220, Po-216, Pb-212, Bi-212, Po-212, Tl-208	Pb-208	-	Alpha, beta, and gamma (13.6 keV, 0.314; 177 keV, 0.947; 654 keV, 0.603; 2550 keV, 0.387)
Th-232[b]	1.41E10	-	Ra-228	5.75	Alpha, few low-energy gamma (14.5 keV, 0.08; 72.1 keV, 0.0025)
U-234	2.45E5	-	Th-230	7.7E4	Alpha, few low-energy gamma (15.3 keV, 0.105; 71.3 keV, 0.00166)
Th-230	7.7E4	-	Ra-226	1600	Alpha and gammas (14.5 keV, 0.081; 82.7 keV, 0.0045)
U-235+D	7.038E8	Th-231	Pa-231	3.28E4	Alpha and gamma (16.8 keV, 1.14; 159 keV, 1.01)
Pa-231	3.28E4	-	Ac-227	21.6	Alpha and gamma (16.2 keV, 0.787; 90.9 keV, 0.00695; 283 keV, 0.13)
Ac-227	21.6	Th-227, Fr-223, Ra-223, Rn-219, Po-215, Pb-211, Bi-211, Tl-207, Po-211	Pb-207	-	Alpha, beta, and gammas (14 keV, 0.641; 94.2 keV, 0.906; 330 keV, 0.86)
U-238+D	4.468E9	Th-234	U-234	2.45E5	Alpha and gamma (15.5 keV, 0.191; 82.7 keV, 0.102; 915 keV, 0.0146)
Pu-239	2.41E4	-	U-235	7.038E8	Alpha and low-energy gamma (16.1 keV, 0.0417; 48.8 keV, 0.00027; 187 keV, 0.00021)

[a]+D indicates that the associated radionuclides with half-lives less than 6 months are assumed to be in equilibrium with principal radionuclide.

[b]Th-232 may actually be in equilibrium with its progeny Ra-228 and Th-228, which means it can be detected from detecting either Ra-228 or Th-228.

6.2.3 Building Occupancy Scenario

A building occupancy scenario similar to the building occupancy scenario described in NUREG/CR-5512, Volume 1, was selected to estimate the dose resulting from residual radioactivity on concrete surfaces in buildings. The scenario identifies a hypothetical person who uses the building as a residence (spends about 16.3 hours per day inside the building) as the average member of the critical group, the subject of the dose modeling. The person occupies the building in a normal manner without deliberately disturbing sources of residual radioactivity. The person is exposed to external radiation directly from the source, radioactive material deposited on the floor; external radiation from submersion in airborne dust; internal dose from inhalation of airborne radionuclides; internal dose from inadvertent ingestion of radionuclides directly from the source; and the internal dose from inadvertent ingestion of radionuclides from the source. It is implausible that any other set of activities would occur in the standing building that would result in a dose exceeding that for a building resident. If a building were used for commercial activities, the building occupant would occupy the building for much less time than a resident, resulting in a lower dose.

6.3 RESRAD and RESRAD-BUILD Codes

RESRAD (Yu et al., 2001) and RESRAD-BUILD (Yu et al., 1994) are two multimedia computer codes developed by Argonne National Laboratory under sponsorship of the U.S. Department of Energy (DOE) for use in evaluating radioactively contaminated sites and buildings, respectively. RESRAD and RESRAD-BUILD are pathway analysis models designed to evaluate the TEDE incurred by an individual who lives at a site with radioactively contaminated soil or who resides/works in a building containing residual radioactive material.

The RESRAD code addresses radioactive contaminants in soil and their transport in air, water, and biological media to a hypothetical receptor. Nine exposure pathways are considered in RESRAD: direct exposure; inhalation of particulates and radon; and ingestion of plant foods, meat, milk, aquatic foods, water, and soil. Figure 6.1 illustrates conceptually the exposure pathways considered in RESRAD. RESRAD calculates the time-integrated annual dose, soil cleanup guidelines, radionuclide concentration, and lifetime cancer risk as a function of time. The code also estimates at which time within the 1,000 year modeling period the peak dose occurs for each radionuclide.

The RESRAD-BUILD code computes dose to a receptor from residual contamination on interior building surfaces. Contamination may be released into the indoor air by diffusion, mechanical removal, or erosion. Seven exposure pathways are considered in RESRAD-BUILD: external exposure directly from the source; external exposure to materials deposited on the floor; external exposure due to air submersion; inhalation of airborne radioactive particulates; inhalation of aerosol indoor radon progeny; inadvertent ingestion of radioactive material directly from the sources; and inadvertent ingestion of materials deposited on the surfaces of the building's rooms

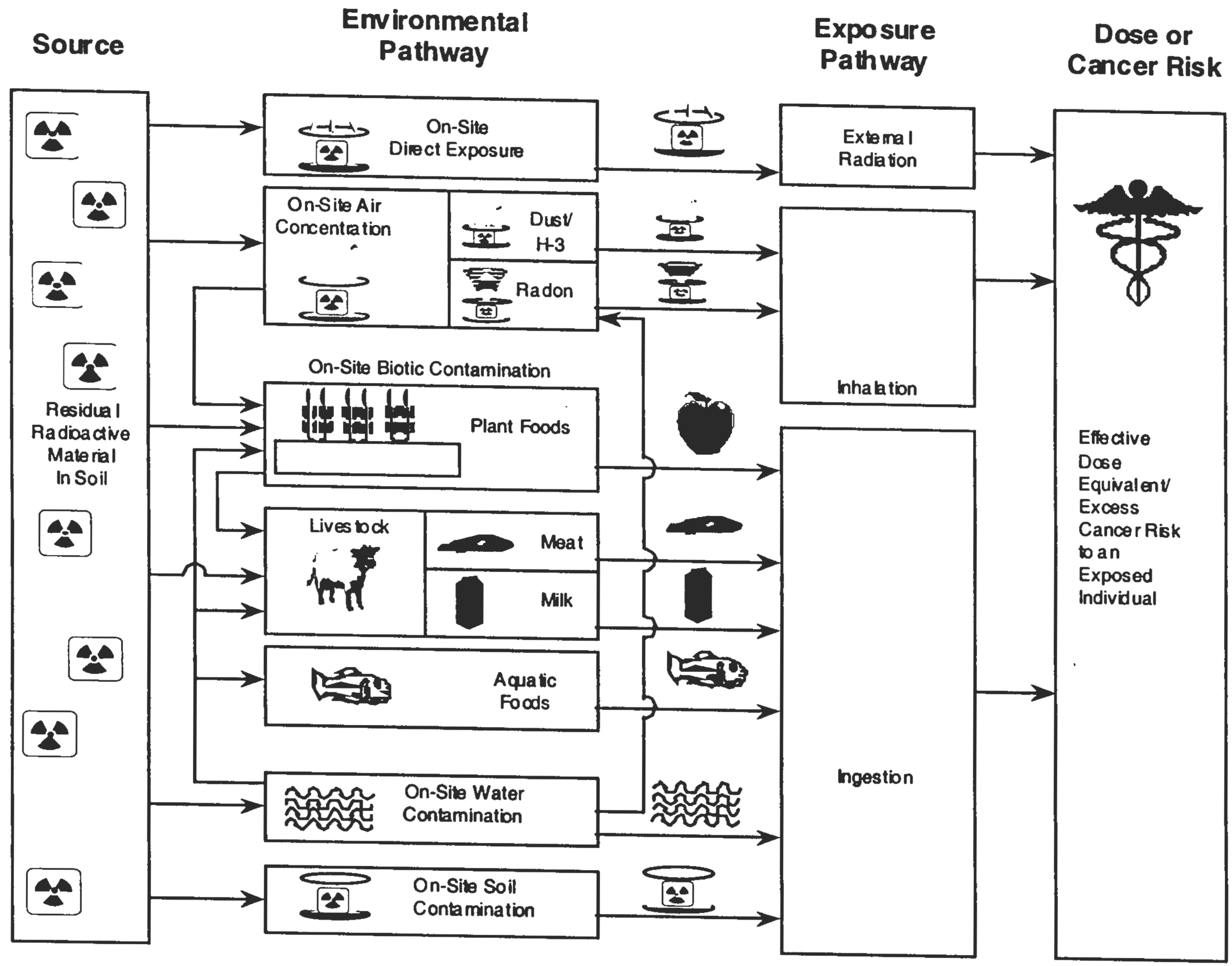


Figure 6.1 Exposure Pathways Considered in the RESRAD Code

or furniture. Figure 6.2 shows the release mechanisms and the pathways considered in RESRAD-BUILD code.

RESRAD and RESRAD-BUILD codes have been used for many years to make deterministic, or single value, estimates of dose. Deterministic analysis uses a single value for each input parameter, resulting in a single-dose output value. The recently developed probabilistic approach, on the other hand, uses a probability distribution for each model input parameter of uncertain value. The model is run repeatedly (for a specified number of iterations), using randomly selected values from the defined distributions of each of the uncertain input parameter for each run. Instead of yielding a single model output as in a deterministic run, probabilistic analysis produces a set (distribution) of output values that quantify the uncertainty in dose estimates resulting from uncertainty in the input parameters.

The two primary reasons for performing probabilistic analysis were (1) to characterize uncertainty in model output (dose) and (2) to identify input parameters that were sources of uncertainty in model output (dose). Most of the variations in the output dose distribution could be attributed to uncertainty in a small set of input parameters that could be considered as sensitive parameter distributions (key parameters). A correlation/regression analysis can be used to identify these key parameters. The probabilistic modules of the RESRAD and RESRAD-BUILD codes facilitate the analysis of effects of uncertainty in input parameters in the model.

The codes output cumulative probability distributions of dose and correlation coefficients that identify the relationship of the resultant doses with the input parameters. The correlation results include a table of partial correlation coefficients (PCC), standardized regression coefficients (SRC), partial rank correlation coefficients (PRCC), and the standardized rank regression coefficient (SRRC) as well as their associated correlation ranks. The correlation ranking of the parameters is based on the absolute value of the correlation coefficients; rank 1 is assigned to the parameter with the highest value. Thus, a parameter with a correlation rank of 1 has the strongest relationship with the dose. Information obtained from this analysis is used to select appropriately conservative values for the sensitive input parameters for the deterministic runs as discussed in the next section.

6.4 Parameter Value Selection Process

The RESRAD/RESRAD-BUILD dose modeling described above requires the selection of values for a large number of input parameters used by the models. The parameter value selection process was developed in accordance with the guidance presented in NUREG/CR-6755, -6676, -6692, and -6697. The process ensures that conservative values are selected in the dose modeling. Figure 6.3 outlines the selection process.

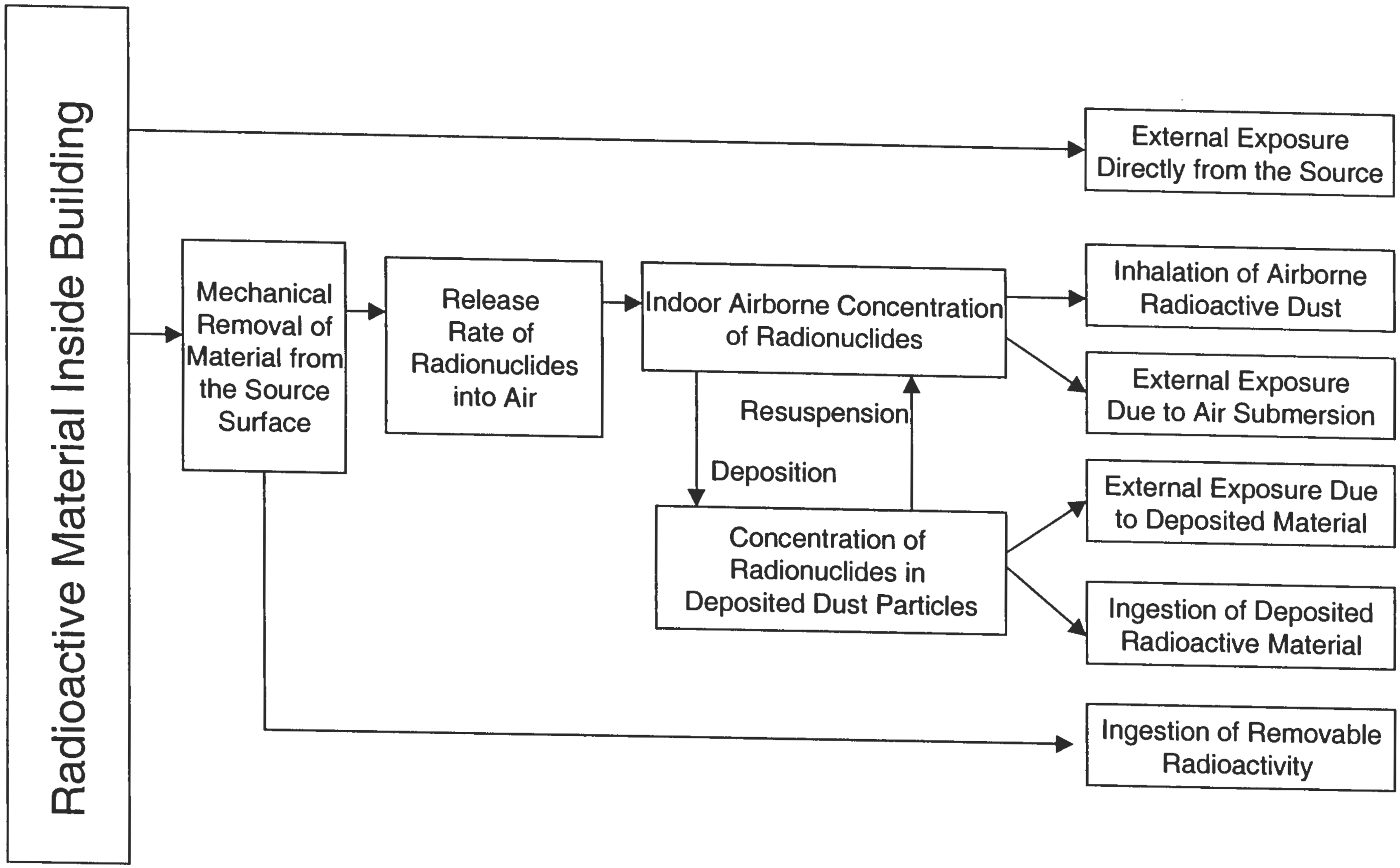


Figure 6.2 Exposure Pathways and Release Mechanisms Considered in the RESRAD-BUILD Code

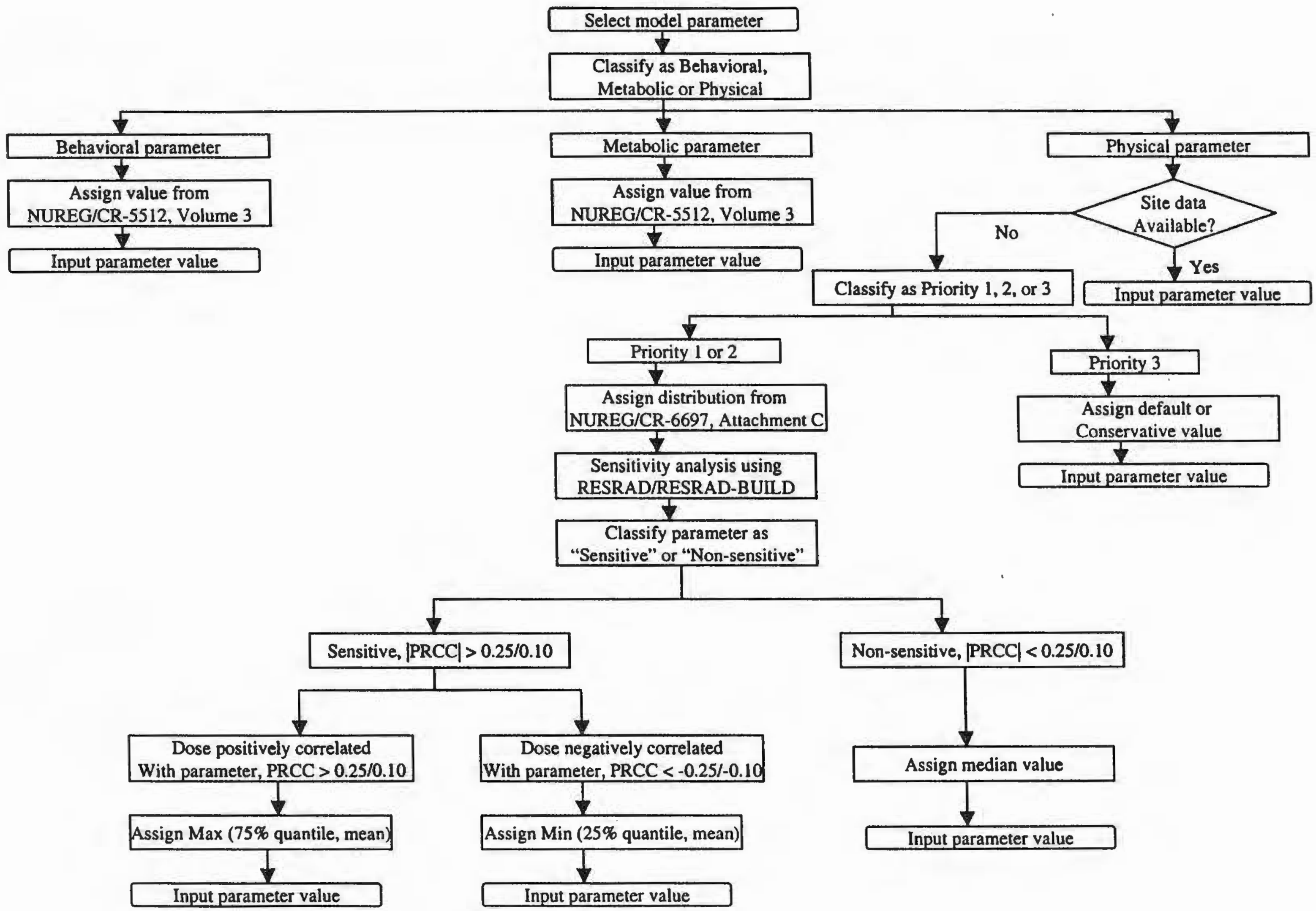


Figure 6.3 Parameter Selection Process

6.4.1 Parameter Classification

The RESRAD code requires about 150 input parameters and RESRAD-BUILD requires about 50 input parameters, which are presented in more detail in the next section. To begin the process of assigning proper input parameter values, parameters were classified into three types - physical, behavioral, and metabolic. The physical parameters are source- and site-specific and would not change if a different group of receptors were considered. Behavioral parameter values depend on the receptor's behavior and the scenario definition. For the same group of receptors, behavior parameter values could change if the scenario changed (e.g., parameters for other use of the site could be different from those for residential use). A metabolic parameter represents a metabolic characteristic of the potential receptor and is independent of the scenario.

6.4.2 Parameter Prioritization

The NUREG/CR-6697 ranked parameters into three priority levels: high priority, medium priority, and low priority. The assignment of priority was based on four attributes: (1) relevance of parameters in dose calculations, (2) variability of radiation dose as a result of changes in the parameter value, (3) parameter type, and (4) data availability. The numeric scores of the four attributes were summed for each parameter, and an overall rank of 1-to-3 was assigned on the basis of the sum of the scores. Thus, the current parameters were ranked and placed in one of three priority categories (priority 1 through 3). Priority 1 was assigned to the most relevant (high priority) parameters and priority 3 to the least (low priority) parameters. Priority 3 parameters were excluded from probabilistic analysis because parameters in this category had already been determined to be of insignificant impact on the overall results of dose estimation (in NUREG/CR-6697 analysis). Therefore, distributions were assigned to most priority 1 and 2 parameters in RESRAD and RESRAD-BUILD.

6.4.3 Parameter Treatment

Deterministic runs were conducted using a single value for all inputs. In the probabilistic runs, the parameters were treated as deterministic or probabilistic depending on parameter type, priority, availability of site-specific data and the relevance of the parameter in dose calculations. As shown in Figure 6.3, the behavioral and metabolic parameters were treated as deterministic. The physical parameters for which site-specific values were available were also treated as deterministic. The remaining physical parameters for which no site specific values were available were classified as priority 1, 2, or 3. Priority 1 and 2 parameters were treated as probabilistic and the priority 3 parameters, which were determined to be of insignificant impact on the overall dose, were treated as deterministic inputs.

6.4.4 Sensitivity Analyses

The purpose of the sensitivity analysis was to determine which of the probabilistic parameters (parameters for which a distribution was developed in NUREG/CR-6697) have the greatest influence on the resultant dose and hence the DCGLs. Based on the sensitivity analysis the parameters found to be sensitive were assigned conservative values in the deterministic analysis. The analysis was performed using the probabilistic modules of the RESRAD, Version 6.21, and RESRAD-BUILD Version 3.21. The probabilistic parameters were assigned distributions from NUREG/CR-6697, Attachment C. The analyses were run using 1000 observations and 1 repetition. The Latin Hypercube Sampling (LHS) technique was used to generate the input parameter values from the assigned distribution. In cases for which a clear relationship exists between parameters (such as density and porosity, porosity and effective porosity), strong rank correlations were used as inputs to ensure proper pairing.

The sensitivity analysis was performed for each of the radionuclides listed in Table 6-1. The partial rank correlation coefficient (PRCC) for the peak dose, which estimates nonlinear monotonic relationship and quantifies the unique contribution of the input parameter to the resultant dose, was used as a measure of the sensitivity of the each parameter to the peak dose. For the resident farmer scenario, a parameter was identified as sensitive if the absolute value of PRCC was greater than or equal to 0.25 and not sensitive if the absolute value of PRCC was less than 0.25. For the building occupancy scenario, a parameter was identified as sensitive if the absolute value of PRCC was greater than or equal to 0.10 and not sensitive if the absolute value of PRCC was less than 0.10. The thresholds for PRCC are based on the guidance in NUREG/CR-6676.

6.4.5 Parameter Value Assignment

For the deterministic RESRAD/RESRAD-BUILD runs, parameter values were assigned based on considerations of the parameter type, site-specific data availability, priority, and the parameter sensitivity in dose calculations. For the probabilistic RESRAD/RESRAD-BUILD runs, if a parameter were treated as probabilistic, the parameter distribution was assigned from NUREG/CR-6697, and if the parameter was treated as deterministic, the same value as the deterministic run was assigned. Figure 6.3 shows how the values are assigned.

The behavioral and metabolic parameters were assigned values from NUREG/CR-5512, Volume 3; NUREG/CR-6697; or RESRAD/RESRAD-BUILD defaults (in order of priority).

The physical parameters were assigned values as follows:

- Physical parameters for which site-specific data were available were assigned site-specific values.

- Priority 1 and 2 physical parameters which were found to be sensitive (|PRCC| ≥ 0.25 in the case of RESRAD and |PRCC| ≥ 0.10 in the case of RESRAD-BUILD) were assigned conservative values. Depending on whether the parameter was positively or negatively correlated with dose, the 75% or 25% quantile value of the distribution for that parameter was used, respectively. The mean value of the distribution was also calculated for those parameters which were positively or negatively correlated with dose. For positively correlated parameters, if the mean of the distribution was greater than the 75% quantile value (skewed distribution), the parameter was assigned the mean value. For negatively correlated parameters, if the mean of the distribution was less than the 25% quantile value (skewed distribution), the parameter was assigned the mean value.

- Priority 1 and 2 physical parameters which were found to be sensitive (|PRCC| ≥ 0.25 in the case of RESRAD and |PRCC| ≥ 0.10 in the case of RESRAD-BUILD) and were also correlated with other physical parameters were assigned conservative values based on the sensitivity and dose correlation.

    - When both parameters were sensitive and the dose correlations were similar to the parameter correlation, values for both parameters were assigned as described above.

    - When both parameters were sensitive and dose correlations were not similar to the parameter correlation (i.e., for positively correlated parameters dose increases with an increase in one parameter and decreases with an increase in the other parameter), mean values were assigned to both parameters.

- Priority 1 and 2 physical parameters shown to be non-sensitive (|PRCC| < 0.25 in the case of RESRAD and |PRCC| < 0.10 in the case of RESRAD-BUILD) but correlated with a physical parameter shown to be sensitive were assigned values based on the conservative value assigned to the sensitive parameter.

- Priority 1 and 2 physical parameters shown to be non-sensitive (|PRCC| < 0.25 in the case of RESRAD and |PRCC| < 0.10 in the case of RESRAD-BUILD) were assigned median values from NUREG/CR-6697, Attachment C.

- Priority 3 physical parameters were assigned values from NUREG/CR-5512, Volume 3, or from the RESRAD/RESRAD-BUILD default library.

6.5 Computing DCGLs for Soil

According to NUREG-1727, Section 6.3.3 of Appendix C, either a probabilistic approach or a deterministic analysis approach can be used to demonstrate compliance with the dose criteria. For the SEDA site, soil DCGLs were derived from both probabilistic and deterministic RESRAD analyses. The deterministic values provide the basis for comparison of survey results.

For the probabilistic analysis, the peak of the mean dose, based on the guidance provided in Section 8.3.2.2 Appendix C of the NUREG/CR-6697, was used in calculating the derived concentration guideline levels. For the deterministic run, conservative values for the key parameters were used. Sensitivity analysis was done to identify the key parameters as discussed above. Figure 6.4 shows the DCGL derivation process for the probabilistic and the deterministic RESRAD runs.

The resident farmer scenario, in accordance with the guidance provided in NUREG/CR-5512, was chosen to derive the soil DCGLs. Considering the activities that occurred on the SEDA site, it is expected that any residual radioactivity would be confined to surface soil; the analysis assumed contamination to be in the top 15 cm of soil. The DCGLs were derived for a dose limit of 10 mrem/yr on the basis of the TAGM 4003 guide.

6.5.1 Dose Model

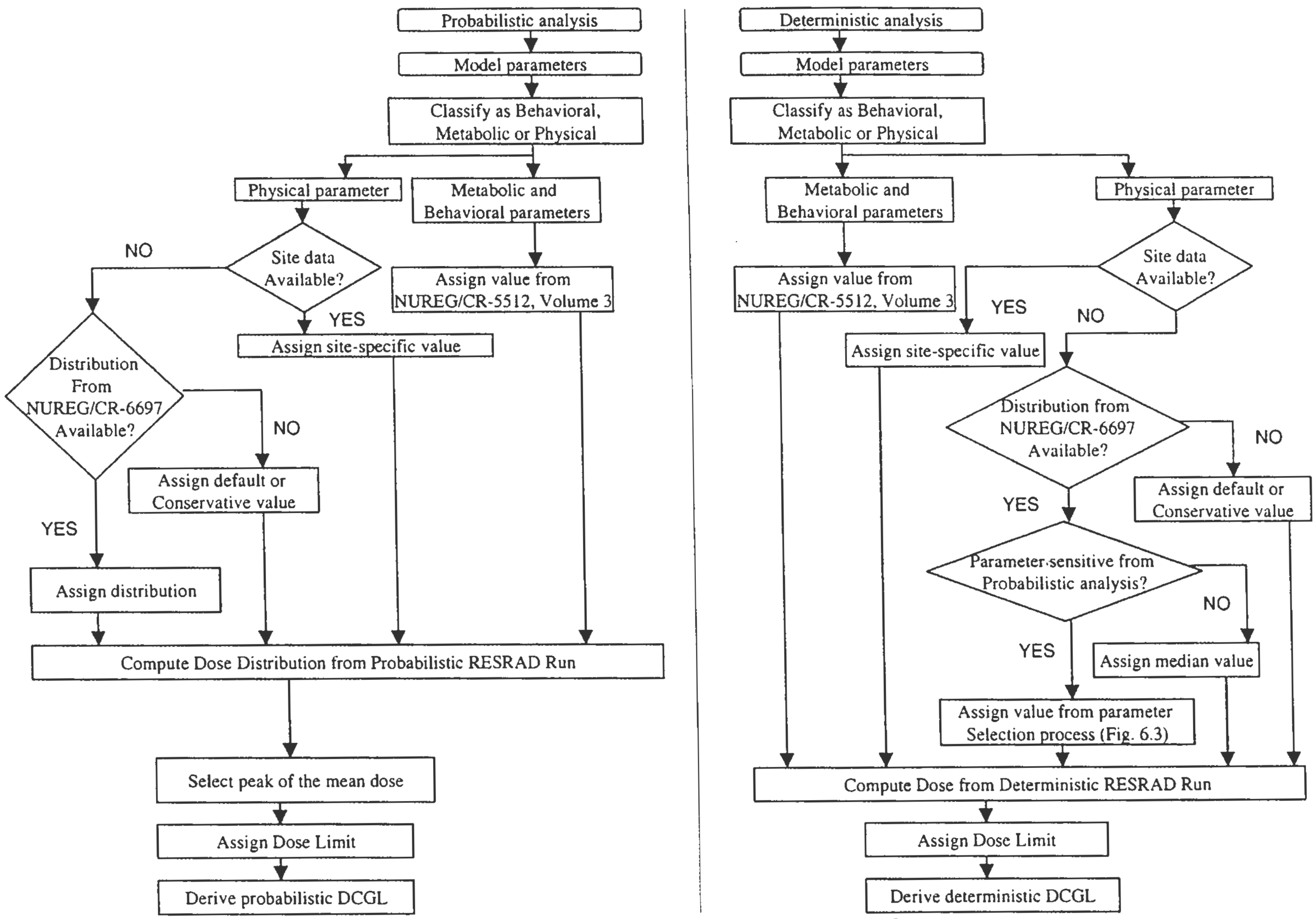
The DCGLs for soil were calculated using the resident farmer scenario. The residual radioactive material was assumed to be contained in a thin soil layer on the property that can be used for residential and farming activities. The average member of the critical group is the resident farmer, who lives on the contaminated area, ingests plant foods grown on-site, ingests meat and milk from livestock fed with forage grown on-site, and catches and consumes fish and other aquatic organisms from an on-site pond. The groundwater drawn from a well located on-site is the only water source for drinking, household purposes, livestock watering, and irrigation.

The potential pathways used to estimate human radiation exposure resulting from residual radioactivity in the soil include the following:

- Direct exposure to external radiation from the soil containing residual radioactivity,
- Internal dose from inhalation of contaminated dust,
- Internal dose from inhalation of emanating radon,
- Internal dose from ingestion of
  - contaminated soil
  - plant food grown in the soil containing residual radioactivity
  - meat and milk from livestock fed with fodder that is grown in soil containing residual radioactivity and water drawn from the on-site well
  - drinking water drawn from the on-site well
  - fish from a pond downgradient from the site

Doses were calculated over a 1,000-year time frame. The peak dose occurring at any time during this period was used in the calculation of DCGLs.

Figure 6.4 DCGL Derivation Process



6.5.2 Conceptual Model

The site conceptual model includes a contaminated zone, an unsaturated zone, and a saturated zone. It was assumed there is no cover on the top of the contaminated soil. The residual radioactivity was assumed to be in top 15 cm of the soil and covered an area of 10,000 m^2. Table 6-2 lists the median parameter values assigned for the deterministic RESRAD run as well as the parameter values/distributions assigned for the probabilistic RESRAD run and the basis for assigning them. For some radionuclides in a deterministic run the value for a priority 1 or priority 2 (see Fig. 6.3) parameter may have been changed from a median value to a more conservative value (see Section 6.4.5) on the basis of the sensitivity analysis. In such cases, the latter value is provided in Table 6-3 for a given radionuclide.

6.5.3 Sensitivity Analysis Results

A probabilistic RESRAD run was performed for an individual radionuclide to identify the sensitive parameters for that radionuclide. An initial radionuclide concentration of 1 pCi/g was assumed. As mentioned in Section 6.4.4, a parameter was identified as sensitive if the absolute value of PRCC was greater than or equal to 0.25 and not sensitive if absolute value of PRCC was less than 0.25 for the resident farmer scenario. Table 6-3 lists the probabilistic parameters identified as sensitive parameters for each radionuclide from peak of the mean dose and peak dose analysis. The sensitive parameters are listed in order of decreasing sensitivity along with their PRCC values and conservative values selected based on the parameter selection process shown in Figure 6.3.

6.5.4 DCGL Determination

The DCGLs are the concentration of residual radioactivity distinguishable from background that, if uniformly distributed throughout a survey unit, would result in a dose equal to the dose limit (10 mrem/yr) to an average member of a critical group. Given a dose limit, DL, the DCGL for an individual radionuclide can be calculated as:

$$DCGL = \frac{DL}{DSR},$$

where DSR is the dose/source concentration ratio.

The sum-of-fractions rule applies when DCGLs for multiple radionuclides are implemented. The summation of the residual radionuclide concentrations, S_i, divided by each respective $DCGL_i$ should not be greater than unity; that is,

TABLE 6-2

Input Parameters Used at Seneca Army Depot Site for Probabilistic and Deterministic RESRAD Analysis

Input Parameter	Units	Type[a]	Priority	Deterministic[b]	Probabilistic analysis					Basis/Reference
						Distribution's statistical parameters[c]				
					value/ distribution	1	2	3	4	
Initial Nuclide Concentration in Soil	pCi/g	P	2	1 for each radionuclide	1 for each radionuclide	NR[d]	NR	NR	NR	DCGLs independent of initial concentration
Distribution coefficients in contaminated, unsaturated, and saturated zones	cm^3/g	P	1		for all truncated lognormal-n					For deterministic analysis median values from distribution are used
Ac-227				825	-	6.72	3.22	.001	.999	NUREG/CR-6697
H-3				0.06	-	-2.81	0.5	.001	.999	NUREG/CR-6697
Pa-231				380	-	5.94	3.22	.001	.999	NUREG/CR-6697
Pb-210+D				2392	-	7.78	2.76	.001	.999	NUREG/CR-6697
Pm-147				825	-	6.72	3.22	.001	.999	NUREG/CR-6697
Pu-239				953	-	6.86	1.89	.001	.999	NUREG/CR-6697
Ra-226+D				3533	-	8.17	1.70	.001	.999	NUREG/CR-6697
Ra-228+D				3533	-	8.17	1.70	.001	.999	NUREG/CR-6697
Sm-147				825	-	6.72	3.22	.001	.999	NUREG/CR-6697
Th-228				5884	-	8.68	3.62	.001	.999	NUREG/CR-6697
Th-230				5884	-	8.68	3.62	.001	.999	NUREG/CR-6697
Th-232				5884	-	8.68	3.62	.001	.999	NUREG/CR-6697
U-234				126	-	4.84	3.13	.001	.999	NUREG/CR-6697
U-235				126	-	4.84	3.13	.001	.999	NUREG/CR-6697
U-238				126	-	4.84	3.13	.001	.999	NUREG/CR-6697
Plant transfer factors	pCi/g plant per pCi/g soil	P	1		for all truncated lognormal-n					For deterministic analysis median values from distribution are used
Ac-227				1E-3		-6.91	1.1	.001	.999	NUREG/CR-6697
H-3				4.8		1.57	1.1	.001	.999	NUREG/CR-6697
Pa-231				1E-2		-4.61	1.1	.001	.999	NUREG/CR-6697
Pb-210+D				4E-3		-5.52	0.9	.001	.999	NUREG/CR-6697
Pm-147				2E-3		-6.21	1.1	.001	.999	NUREG/CR-6697
Pu-239				1E-3		-6.91	0.9	.001	.999	NUREG/CR-6697
Ra-226+D				4E-2		-3.22	0.9	.001	.999	NUREG/CR-6697
Ra-228+D				4E-2		-3.22	0.9	.001	.999	NUREG/CR-6697
Sm-147				2E-3		-6.21	1.1	.001	.999	NUREG/CR-6697
Th-228				1E-3		-6.91	0.9	.001	.999	NUREG/CR-6697

TABLE 6-2 (Cont.)

Input Parameter	Units	Type[a]	Priority	Deterministic[b]	Probabilistic analysis					Basis/Reference
					value/ distribution	Distribution's statistical parameters[c]				
						1	2	3	4	
Th-230				1E-3		-6.91	0.9	.001	.999	NUREG/CR-6697
Th-232				1E-3		-6.91	0.9	.001	.999	NUREG/CR-6697
U-234				2E-2		-6.21	0.9	.001	.999	NUREG/CR-6697
U-235				2E-2		-6.21	0.9	.001	.999	NUREG/CR-6697
U-238				2E-2		-6.21	0.9	.001	.999	NUREG/CR-6697
Meat transfer factor	pCi/kg per pCi/d	P	2		for all truncated lognormal-n					For deterministic analysis median values from distribution are used
Ac-227				2E-5		-10.82	1.0	.001	.999	NUREG/CR-6697
H-3				1.2E-2		-4.42	1.0	.001	.999	NUREG/CR-6697
Pa-231				5E-6		-12.21	1.0	.001	.999	NUREG/CR-6697
Pb-210+D				8E-4		-7.13	0.7	.001	.999	NUREG/CR-6697
Pm-147				2E-3		-6.21	1.0	.001	.999	NUREG/CR-6697
Pu-239				1E-4		-9.21	0.2	.001	.999	NUREG/CR-6697
Ra-226+D				1E-3		-6.91	0.7	.001	.999	NUREG/CR-6697
Ra-228+D				1E-3		-6.91	0.7	.001	.999	NUREG/CR-6697
Sm-147				2E-3		-6.21	1.0	.001	.999	NUREG/CR-6697
Th-228				1E-4		-9.21	1.0	.001	.999	NUREG/CR-6697
Th-230				1E-4		-9.21	1.0	.001	.999	NUREG/CR-6697
Th-232				1E-4		-9.21	1.0	.001	.999	NUREG/CR-6697
U-234				8E-4		-7.13	0.7	.001	.999	NUREG/CR-6697
U-235				8E-4		-7.13	0.7	.001	.999	NUREG/CR-6697
U-238				8E-4		-7.13	0.7	.001	.999	NUREG/CR-6697
Milk transfer factor	pCi/L per pCi/d	P	2		for all truncated lognormal-n					For deterministic analysis median values from distribution are used
Ac-227				2E-6		-13.12	0.9	.001	.999	NUREG/CR-6697
H-3				1.2E-2		-4.61	0.9	.001	.999	NUREG/CR-6697
Pa-231				5E-6		-12.21	0.9	.001	.999	NUREG/CR-6697
Pb-210+D				3E-4		-8.11	0.9	.001	.999	NUREG/CR-6697
Pm-147				6E-5		-9.72	0.9	.001	.999	NUREG/CR-6697
Pu-239				1E-6		-13.82	0.5	.001	.999	NUREG/CR-6697
Ra-226+D				1E-3		-6.91	0.5	.001	.999	NUREG/CR-6697
Ra-228+D				1E-3		-6.91	0.5	.001	.999	NUREG/CR-6697
Sm-147				6E-5		-9.72	0.9	.001	.999	NUREG/CR-6697
Th-228				5E-6		-12.21	0.9	.001	.999	NUREG/CR-6697
Th-230				5E-6		-12.21	0.9	.001	.999	NUREG/CR-6697
Th-232				5E-6		-12.21	0.9	.001	.999	NUREG/CR-6697

TABLE 6-2 (Cont.)

Input Parameter	Units	Type[a]	Priority	Deterministic[b]	Probabilistic analysis: value/ distribution	Distribution's statistical parameters[c]: 1	2	3	4	Basis/Reference
U-234				4E-4		-7.82	0.6	.001	.999	NUREG/CR-6697
U-235				4E-4		-7.82	0.6	.001	.999	NUREG/CR-6697
U-238				4E-4		-7.82	0.6	.001	.999	NUREG/CR-6697
Fish bioaccumulation factor	pCi/kg per pCi/L	P	2		for all lognormal-n					For deterministic analysis median values from distribution are used
Ac-227				15		2.7	1.1			NUREG/CR-6697
H-3				1		0	0.1			NUREG/CR-6697
Pa-231				10		2.3	1.1			NUREG/CR-6697
Pb-210+D				300		5.7	1.1			NUREG/CR-6697
Pm-147				30		3.4	1.1			NUREG/CR-6697
Pu-239				30		3.4	1.1			NUREG/CR-6697
Ra-226+D				50		3.9	1.1			NUREG/CR-6697
Ra-228+D				50		3.9	1.1			NUREG/CR-6697
Sm-147				25		3.2	1.1			NUREG/CR-6697
Th-228				100		4.6	1.1			NUREG/CR-6697
Th-230				100		4.6	1.1			NUREG/CR-6697
Th-232				100		4.6	1.1			NUREG/CR-6697
U-234				10		2.3	1.1			NUREG/CR-6697
U-235				10		2.3	1.1			NUREG/CR-6697
U-238				10		2.3	1.1			NUREG/CR-6697
Crustacea bioaccumulation factor	pCi/kg per pCi/L	P	3							RESRAD default
Ac-227				1,000	1,000	NR	NR	NR	NR	RESRAD default
H-3				1	1	NR	NR	NR	NR	RESRAD default
Pa-231				110	110	NR	NR	NR	NR	RESRAD default
Pb-210+D				100	100	NR	NR	NR	NR	RESRAD default
Pm-147				1,000	1,000	NR	NR	NR	NR	RESRAD default
Pu-239				100	100	NR	NR	NR	NR	RESRAD default
Ra-226+D				250	250	NR	NR	NR	NR	RESRAD default
Ra-228+D				250	250	NR	NR	NR	NR	RESRAD default
Sm-147				1,000	1,000	NR	NR	NR	NR	RESRAD default
Th-228				500	500	NR	NR	NR	NR	RESRAD default
Th-230				500	500	NR	NR	NR	NR	RESRAD default
Th-232				500	500	NR	NR	NR	NR	RESRAD default
U-234				60	60	NR	NR	NR	NR	RESRAD default
U-235				60	60	NR	NR	NR	NR	RESRAD default
U-238				60	60	NR	NR	NR	NR	RESRAD default
Number of unsaturated zones	none	P	3	1	1	NR	NR	NR	NR	RESRAD default

TABLE 6-2 (Cont.)

Input Parameter	Units	Type[a]	Priority	Deterministic[b]	Probabilistic analysis: value/ distribution	Distribution's statistical parameters[c]: 1	2	3	4	Basis/Reference
Time since material placement	years	P	3	0	0	NR	NR	NR	NR	RESRAD default
Groundwater concentration	pCi/L	P	3	0	0	NR	NR	NR	NR	RESRAD default
Solubility limit	mol/L	P	3	0	0	NR	NR	NR	NR	RESRAD default
Leach rate	/year	P	3	0	0	NR	NR	NR	NR	RESRAD default
Use plant soil ratio	check box	NA	3	No	No	NR	NR	NR	NR	RESRAD default
Basic radiation dose limit	mrem/yr	NA	3	10	10	NR	NR	NR	NR	NYSDEC TAGM
Calculation times	years	P	3	1,3,10,30,100,300,1000	1,3,10,30,100,300,1000	NR	NR	NR	NR	RESRAD default
Thickness of contaminated zone	m	P	2	0.15	0.15	NR	NR	NR	NR	Activity is only on the surface, scenario assumption
Area of contaminated zone	m^2	P	2	10,000	10,000	NR	NR	NR	NR	Scenario assumption
Length parallel to aquifer flow	m	P	2	100	100	NR	NR	NR	NR	Scenario assumption
Cover depth	m	P	2	0	0	NR	NR	NR	NR	Contamination begins at the surface
Density of cover material	g/cm^3	P	1	Not used	Not used	NR	NR	NR	NR	NA
Cover erosion rate	m/yr	P, B	2	Not used	Not used	NR	NR	NR	NR	NA
Density of contaminated zone	g/cm^3	P	1	1.51	Truncated normal	1.5105	0.1855	.001	.999	Distribution from NUREG/CR-6697 for the site specific soil type[e]
Contaminated zone erosion rate	m/yr	P, B	2	1.48E-3	Continuous logarithmic					Distribution from NUREG/CR-6697
Contaminated zone total porosity	none	P	2	0.43	Truncated normal	0.43	0.0699	.001	.999	Distribution from NUREG/CR-6697 for the site specific soil type
Contaminated zone field capacity	none	P	3	0.2	0.2	NR	NR	NR	NR	RESRAD default
Contaminated zone hydraulic conductivity	m/yr	P	2	1.43	Truncated lognormal-n	0.362	1.59	.001	.999	Distribution from NUREG/CR-6697 for the site specific soil type
Contaminated zone b parameter	none	P	2	7.1	Truncated lognormal-n	1.96	0.265	.001	.999	Distribution from NUREG/CR-6697 for the site specific soil type
Humidity in air	g/m^3	P	2	7.24	Truncated lognormal-n	1.98	0.334	.001	.999	Distribution from NUREG/CR-6697
Evapotranspiration coefficient	none	P	2	0.625	Uniform	0.5	0.75			Distribution from NUREG/CR-6697
Wind speed	m/s	P	2	4.24	Bounded lognormal-n	1.445	0.2419	1.4	13	Distribution from NUREG/CR-6697
Precipitation rate	m/yr	P	2	0.87	0.87	NR	NR	NR	NR	Site specific value[f]
Irrigation rate	m/yr	B	3	0.1125	0.1125	NR	NR	NR	NR	Value from NUREG/CR-6697
Irrigation mode	none	B	3	Overhead	Overhead	NR	NR	NR	NR	RESRAD default
Runoff coefficient	none	P	2	0.45	Uniform	0.1	0.8			Distribution from NUREG/CR-6697
Watershed area for nearby stream or pond	m^2	P	3	1E6	13E6	NR	NR	NR	NR	RESRAD default

TABLE 6-2 (Cont.)

Input Parameter	Units	Type[a]	Priority	Deterministic[b]	Probabilistic analysis					Basis/Reference
					value/ distribution	Distribution's statistical parameters[c]				
						1	2	3	4	
Accuracy for water soil computation	none	NA	3	0.001	0.001	NR	NR	NR	NR	RESRAD default
Density of saturated zone	g/cm^3	P	1	1.51	Truncated normal	1.5105	0.1855	.001	.999	Distribution from NUREG/CR-6697 for the site specific soil type
Saturated zone total porosity	none	P	1	0.43	Truncated normal	0.43	0.0699	.001	.999	Distribution from NUREG/CR-6697 for the site specific soil type
Saturated zone effective porosity	none	P	1	0.342	Truncated normal	0.342	0.0705	.001	.999	Distribution from NUREG/CR-6697 for the site specific soil type
Saturated zone field capacity	none	P	3	0.2	0.2	NR	NR	NR	NR	RESRAD default
Saturated zone hydraulic conductivity	m/yr	P	1	1.43	Truncated lognormal-n	0.362	1.59	.001	.999	Distribution from NUREG/CR-6697 for the site specific soil type
Saturated zone hydraulic gradient	none	P	2	6.02E-3	Bounded lognormal-n	-5.11	1.77	7E-5	0.5	Distribution from NUREG/CR-6697
Saturated zone b parameter	none	P	2	7.1	Truncated lognormal-n	1.96	0.265	.001	.999	Distribution from NUREG/CR-6697 for the site specific soil type
Water table drop rate	m/yr	P	3	0.001	0.001	NR	NR	NR	NR	RESRAD default
Well pump intake depth (below water table)	m	P	2	14.5	Triangular	6	10	30		Distribution from NUREG/CR-6697
Model: nondispersion (ND) or mass balance (MB)	none	P	3	ND	ND	NR	NR	NR	NR	RESRAD default
Well pumping rate	m^3/yr	B, P	2	884	Uniform	250	1519			Minimum is RESRAD default and maximum from NUREG/CR-6697
Number of unsaturated zones	none	P	3	1	1	NR	NR	NR	NR	Default value used
Unsaturated zone thickness	m	P	1	1	1	NR	NR	NR	NR	Site specific value[g]
Unsaturated zone density	g/cm^3	P	2	1.51	Truncated normal	1.5105	0.1855	.001	.999	Distribution from NUREG/CR-6697 for the site specific soil type
Unsaturated zone total porosity	none	P	2	0.43	Truncated normal	0.43	0.0699	.001	.999	Distribution from NUREG/CR-6697 for the site specific soil type
Unsaturated zone effective porosity	none	P	2	0.342	Truncated normal	0.342	0.0705	.001	.999	Distribution from NUREG/CR-6697 for the site specific soil type
Unsaturated zone field capacity	none	P	3	0.2	0.2	NR	NR	NR	NR	RESRAD default
Unsaturated zone hydraulic conductivity	m/yr	P	2	1.43	Truncated lognormal-n	0.362	1.59	.001	.999	Distribution from NUREG/CR-6697 for the site specific soil type
Unsaturated zone b parameter	none	P	2	7.1	Truncated lognormal-n	1.96	0.265	.001	.999	Distribution from NUREG/CR-6697 for the site specific soil type
Inhalation rate	m^3/yr	M, B	3	8,578	8578	NR	NR	NR	NR	NUREG/CR-5512, Vol. 3
Mass loading for inhalation	g/m^3	P, B	2	2.35E-5	Continuous linear					Distribution from NUREG/CR-6697
Exposure duration	yr	B	3	30	30	NR	NR	NR	NR	RESRAD default

TABLE 6-2 (Cont.)

Input Parameter	Units	Type[a]	Priority	Deterministic[b]	Probabilistic analysis					Basis/Reference
					value/ distribution	Distribution's statistical parameters[c]				
						1	2	3	4	
Indoor dust filtration factor	none	P, B	2	0.55	Uniform	0.15	0.95			Distribution from NUREG/CR-6697
External gamma shielding factor	none	P	2	0.27	Bounded lognormal-n	-1.3	0.59	0.044	1	Distribution from NUREG/CR-6697
Indoor time fraction	none	B	3	0.6571	0.6571	NR	NR	NR	NR	NUREG/CR-5512, Vol. 3
Outdoor time fraction	none	B	3	0.1181	0.1181	NR	NR	NR	NR	NUREG/CR-5512, Vol. 3
Shape of the contaminated zone	none	P	3	circular	circular	NR	NR	NR	NR	RESRAD default
Fruit vegetable and grain consumption	kg/yr	M, B	2	112	112	NR	NR	NR	NR	NUREG/CR-5512, Vol. 3
Leafy vegetable consumption	kg/yr	M, B	3	21.4	21.4	NR	NR	NR	NR	NUREG/CR-5512, Vol. 3
Milk consumption	L/yr	M, B	2	233	233	NR	NR	NR	NR	NUREG/CR-5512, Vol. 3
Meat and poultry consumption	kg/yr	M, B	3	65.1	65.1	NR	NR	NR	NR	NUREG/CR-5512, Vol. 3
Fish consumption	kg/yr	M, B	3	20.6	20.6	NR	NR	NR	NR	NUREG/CR-5512, Vol. 3
Other seafood consumption	kg/yr	M, B	3	0.9	0.9	NR	NR	NR	NR	RESRAD default
Soil ingestion rate	g/yr	M, B	2	18.26	18.26	NR	NR	NR	NR	NUREG/CR-5512, Vol. 3
Drinking water intake	L/yr	M, B	2	478.8	478.8	NR	NR	NR	NR	NUREG/CR-5512, Vol. 3
Drinking water contaminated fraction	none	B, P	3	1	1	NR	NR	NR	NR	RESRAD default
Household water contaminated fraction	none	B, P	3	1	1	NR	NR	NR	NR	RESRAD default
Livestock water contaminated fraction	none	B, P	3	1	1	NR	NR	NR	NR	RESRAD default
Irrigation water contaminated fraction	none	B, P	3	1	1	NR	NR	NR	NR	RESRAD default
Aquatic food contaminated fraction	none	B, P	2	1	1	NR	NR	NR	NR	NUREG/CR-5512, Vol. 3
Plant food contaminated fraction	none	B, P	3	1	1	NR	NR	NR	NR	NUREG/CR-5512, Vol. 3
Meat contaminated fraction	none	B, P	3	1	1	NR	NR	NR	NR	NUREG/CR-5512, Vol. 3
Milk contaminated fraction	none	B, P	3	1	1	NR	NR	NR	NR	NUREG/CR-5512, Vol. 3
Livestock fodder intake for meat	kg/d	M	3	27.1	27.1	NR	NR	NR	NR	NUREG/CR-5512, Vol. 3
Livestock fodder intake for milk	kg/d	M	3	63.2	63.2	NR	NR	NR	NR	NUREG/CR-5512, Vol. 3
Livestock water intake for meat	L/d	M	3	50	50	NR	NR	NR	NR	NUREG/CR-5512, Vol. 3
Livestock water intake for milk	L/d	M	3	60	60	NR	NR	NR	NR	NUREG/CR-5512, Vol. 3
Livestock soil intake	kg/d	M	3	0.5	0.5	NR	NR	NR	NR	RESRAD default
Mass loading for foliar deposition	g/m^3	P	3	0.0004	0.0004	NR	NR	NR	NR	NUREG/CR-5512, gardening
Depth of soil mixing layer	m	P	2	0.233	Triangular	0	0.15	0.6		Distribution from NUREG/CR-6697
Depth of roots	m	P	1	2.15	Uniform	0.3	4			Distribution from NUREG/CR-6697
Groundwater fractional usage for drinking water	none	B, P	3	1	1	NR	NR	NR	NR	RESRAD default

TABLE 6-2 (Cont.)

Input Parameter	Units	Type[a]	Priority	Deterministic[b]	Probabilistic analysis: value/ distribution	Distribution's statistical parameters[c]: 1	2	3	4	Basis/Reference
Groundwater fractional usage for household water	none	B, P	3	1	1	NR	NR	NR	NR	RESRAD default
Groundwater fractional usage for livestock water	none	B, P	3	1	1	NR	NR	NR	NR	RESRAD default
Groundwater fractional usage for irrigation water	none	B, P	3	1	1	NR	NR	NR	NR	RESRAD default
Wet weight crop yield for non-leafy vegetables	kg/m^2	P	2	1.75	Truncated lognormal-n	0.56	0.48	.001	.999	Distribution from NUREG/CR-6697
Wet weight crop yield for leafy vegetables	kg/m^2	P	3	2.88921	2.88921	NR	NR	NR	NR	NUREG/CR-5512, Vol. 3
Wet weight crop yield for fodder	kg/m^2	P	3	18868	18868	NR	NR	NR	NR	NUREG/CR-5512, Vol. 3
Length of growing season for non-leafy vegetables	yr	P	3	0.246	0.246	NR	NR	NR	NR	NUREG/CR-5512, Vol. 3
Length of growing season for leafy vegetables	yr	P	3	0.123	0.123	NR	NR	NR	NR	NUREG/CR-5512, Vol. 3
Length of growing season for fodder	yr	P	3	0.082	0.082	NR	NR	NR	NR	NUREG/CR-5512, Vol. 3
Translocation factor for non-leafy	none	P	3	0.1	0.1	NR	NR	NR	NR	NUREG/CR-5512, Vol. 3
Translocation factor for leafy	none	P	3	1	1	NR	NR	NR	NR	NUREG/CR-5512, Vol. 3
Translocation factor for fodder	none	P	3	1	1	NR	NR	NR	NR	NUREG/CR-5512, Vol. 3
Weathering removal constant	1/yr	P	2	32.9	Triangular	5.1	18	84		Distribution from NUREG/CR-6697
Wet foliar interception fraction for non-leafy	none	P	3	0.35	0.35	NR	NR	NR	NR	NUREG/CR-5512, Vol. 3
Wet foliar interception fraction for leafy	none	P	2	0.581	Triangular	0.06	0.67	0.95		Distribution from NUREG/CR-6697
Wet foliar interception fraction for fodder	none	P	3	0.35	0.35	NR	NR	NR	NR	NUREG/CR-5512, Vol. 3
Dry-foliar interception fraction for non-leafy	none	P	3	0.35	0.35	NR	NR	NR	NR	NUREG/CR-5512, Vol. 3
Dry-foliar interception fraction for leafy	none	P	3	0.35	0.35	NR	NR	NR	NR	NUREG/CR-5512, Vol. 3
Dry-foliar interception fraction for fodder	none	P	3	0.35	0.35	NR	NR	NR	NR	NUREG/CR-5512, Vol. 3
Storage times of contaminated food stuff										Behavioral priority 3 parameters, default values used
Fruits, non leafy vegetables, and grain	days	B	3	14	14	NR	NR	NR	NR	RESRAD default
Leafy vegetables	days	B	3	1	1	NR	NR	NR	NR	RESRAD default
Milk	days	B	3	1	1	NR	NR	NR	NR	RESRAD default

TABLE 6-2 (Cont.)

Input Parameter	Units	Type[a]	Priority	Deterministic[b]	Probabilistic analysis					Basis/Reference
					value/ distribution	Distribution's statistical parameters[c]				
						1	2	3	4	
Meat	days	B	3	20	20	NR	NR	NR	NR	RESRAD default
Fish	days	B	3	7	7	NR	NR	NR	NR	RESRAD default
Crustacea and mollusk	days	B	3	7	7	NR	NR	NR	NR	RESRAD default
Well water	days	B	3	1	1	NR	NR	NR	NR	RESRAD default
Surface water	days	B	3	1	1	NR	NR	NR	NR	RESRAD default
Livestock fodder	days	B	3	45	45	NR	NR	NR	NR	RESRAD default

[a] P = physical, B = behavioral, and M = metabolic; when more than one parameter type is listed, the more conservative parameter type is used in the analysis.

[b] Parameter values (median value from the distribution for a probabilistic parameter) used in the deterministic run unless changed from a median value to a more conservative value because of sensitivity analysis. See Section 6.4.5 for parameter value assignment process.

[c] For truncated normal and lognormal distributions, distribution parameter 1 is the mean, 2 is the standard deviation, 3 is the lower quantile value, and 4 is the upper quantile. For bounded lognormal distribution, parameter 3 and 4 are the actual lower and upper bounds. Parameters for continuous linear and continuous logarithmic distributions are not provided in this table (values are from NUREG/CR-6697 Appendix C). For uniform distribution, parameter 1 is the minimum and parameter 2 is the maximum value. For triangular distribution, parameter 1 is the minimum value, parameter 2 is the most likely value, and parameter 3 is the maximum value of the distribution.

[d] NR = not required (RESRAD parameters for which distributions are not developed and for which statistical parameters are not required).

[e] SEDA is located within one distinct unit of glacial till that covers the entire area between the western shore of lake Cayuga and the eastern shore of Lake Seneca. The till is consistent across the entire depot. The glacial till in this area have a high percentage of silt and clay with trace amounts of fine gravel (Table E.1 of U.S. Army 2001). Based on these site characteristics the soil properties of silty clay loam are used in the analysis.

[f] The site-specific precipitation value used is from Table 1-1 of the U.S. Army (2001).

[g] The site-specific unsaturated zone thickness used is from Table E.1 of the U.S. Army (2001).

Table 6-3

Results of Probabilistic Analysis of Individual Radionuclide in Identifying Sensitive Parameters

Radionuclide	Sensitive parameters[a], Partial rank correlation coefficient (PRCC), and parameter values selected from parameter selection process for deterministic analysis							
Ac-227	Parameters	BRTF(1)	SHF1	DROOT	DM			
	PRCC	0.79	0.79	-0.61	-0.46			
	Value	2.1E-3	0.398	1.22	0.15			
H-3	Parameters	DROOT	RUNOFF	EVAPTR	DENSCZ			
	PRCC	-0.97	0.88	0.35	0.30			
	Value	1.22	0.625	0.687	1.63			
Pa-231	Parameters	BRTF(1)	DROOT	VCZ	Kd cont			
	PRCC	0.96	-0.89	-0.35	0.32			
	Value	2.1E-2	1.22	7.6E-4	3.3E3			
Pb-210	Parameters	BRTF(1)	DROOT	BRTF(3)	DM	BRTF(2)		
	PRCC	0.80	-0.71	0.66	-0.59	0.46		
	Value	7.3E-3	1.22	5.5E-4	0.15	1.3E-3		
Pm-147	Parameters	BRTF(2)	BRTF(1)	DM	DROOT			
	PRCC	0.81	0.72	-0.61	-0.53			
	Value	3.9E-3	4.2E-3	0.15	1.22			
Pu-239	Parameters	BRTF(1)	DROOT	DM				
	PRCC	0.89	-0.83	-0.75				
	Value	1.8E-3	1.22	0.15				
Ra-226	Parameters	SHF1	BRTF(1)	DROOT	VCZ	BRTF(1) For Pb		
	PRCC	0.87	0.76	-0.66	-0.30	0.25		
	Value	0.398	7.3E-2	1.22	7.6E-4	7.3E-3		
Ra-228	Parameters	SHF1	BRTF(1)	DROOT				
	PRCC	0.84	0.75	-0.63				
	Value	0.398	7.3E-2	1.22				
Sm-147	Parameters	BRTF(2)	BRTF(1)	DM	DROOT			
	PRCC	0.84	0.72	-0.69	-0.54			
	Value	3.9E-3	4.2E-3	0.15	1.22			

Table 6-3 (Cont.)

Radionuclide	Sensitive parameters[a], Partial rank correlation coefficient (PRCC), and parameter values selected from parameter selection process for deterministic analysis							
Th-228	Parameters	SHF1	Kd cont					
	PRCC	0.98	0.25					
	Value	0.398	1.3E6					
Th-230	Parameters	VCZ	Kd cont	DROOT	SHF1			
	PRCC	-0.65	0.48	-0.36	0.36			
	Value	7.6E-4	1.3E6	1.22	0.398			
Th-232	Parameters	SHF1	VCZ	BRTF(1) for Ra	Kd cont	DROOT		
	PRCC	0.68	-0.59	0.46	0.41	-0.40		
	Value	0.398	7.6E-4	7.3E-2	1.3E6	1.22		
U-234	Parameters	DM	BRTF(1)	BRTF(3)	DROOT	BRTF(2)	Kd cont	
	PRCC	-0.72	0.71	0.61	-0.60	0.46	0.31	
	Value	0.15	3.7E-3	6.0E-4	1.22	1.3E-3	8.5E3	
U-235	Parameters	SHF1	Kd cont	BRTF(1)				
	PRCC	0.92	0.53	0.28				
	Value	0.398	8.5E3	3.7E-3				
U-238	Parameters	SHF1	DM	BRTF(1)	BRTF(3)	DROOT	Kd cont	BRTF(2)
	PRCC	0.77	-0.54	0.53	0.48	-0.45	0.42	0.32
	Value	0.398	0.15	3.7E-3	6.0E-4	1.22	8.5E3	1.3E-3

[a] For sensitive parameters, only parameter abbreviations are listed. Parameter units are provided in Table 6.2. The abbreviation used are: plant transfer factor [BRTF (1)], external gamma shielding (SHF1), depth of soil mixing layer (DM), depth of roots (DROOT), density of contaminated zone (DENSCZ), evapotranspiration coefficient (EVAPTR), runoff coefficient (RUNOFF), contaminated zone erosion rate (VCZ), Kd of contaminated zone (Kd cont), meat transfer factor [BRTF(2)], and milk transfer factor [BRTF(3)].

$$\sum_i \frac{S_i}{DCGL_i} < 1.$$

6.5.4.1 Probabilistic DCGL Derivation

Parameter values/distributions assigned in the probabilistic run were taken from Table 6-2 for each individual radionuclide. RESRAD Version 6.21 was used in this analysis. Table 6-4 provides the probabilistic peak dose distribution. The peak dose distribution is provided at each 5 percentile increment along with the minimum, maximum, and the mean of the peak dose at an initial radionuclide concentration of 1 pCi/g. Table 6-4 also provides the peak of the mean dose. Since the mean of the peak dose is calculated from the peak dose distribution it is always greater than or equal to the peak of the mean dose. Therefore, the mean calculated from the peak dose distribution is used in calculating the soil DCGLs. The DCGLs as determined for the radiation dose limit of 10 mrem/yr are provided in Table 6-5.

6.5.4.2 Deterministic DCGL Derivation

Parameter values assigned in the deterministic run were from Table 6-3 (for parameters found to be sensitive) and from Table 6-2 (for parameters not found to be sensitive) for each individual radionuclide. RESRAD Version 6.21 was used in this analysis. The soil DCGLs determined for the radiation dose limit of 10 mrem/yr are provided in Table 6-5. Table 6-6 provides the maximum dose-to-source concentration ratios (DSR) and contribution of different pathways to the calculated maximum DSRs. The time when the maximum dose occurs is also provided. The deterministic wide area DCGLs in Table 6-5 are the values that should be used in the evaluation of survey data.

6.5.5 Area Factor Calculations for Soil Contamination

The above DCGLs assume exposure to a large homogeneously contaminated area and are termed wide-area-derived concentration levels ($DCGL_w$). For a small, isolated area of contamination (a hot spot), a soil concentration higher than the $DCGL_w$, would correspond to the same dose limit, depending on the size of the contaminated area. Values of the $DCGL_w$ may be scaled through the use of area factors to obtain a $DCGL_{EMC}$ that corresponds to the same dose over a smaller area, where EMC stands for elevated measurement comparison. The $DCGL_{EMC}$ is computed as the product of the applicable $DCGL_w$ and the area factor. The area factors for use with DCGL values were calculated for the residential farmer scenario. The deterministic RESRAD code was run repeatedly while changing the size of contaminated area and the corresponding fractions of plant

Table 6-4

Dose/Source Concentration Ratios (mrem/yr per pCi/g) at Different Dose Percentiles from Peak Dose Distribution for the Residential Farmer Scenario at the Seneca Army Depot Activity from the Probabilistic RESRAD Run

Percentile	Ac-227	H-3	Pa-231	Pb-210	Pm-147	Pu-239	Ra-226	Ra-228	Sm-147	Th-228	Th-230	Th-232	U-234	U-235	U-238
5%	5.64E-01	3.34E-04	4.19E-01	2.88E-01	4.14E-05	3.77E-02	2.40E+00	1.89E+00	6.19E-03	1.26E+00	1.67E-02	1.00E+00	1.07E-02	1.29E-01	3.74E-02
10%	6.24E-01	3.82E-04	5.76E-01	3.71E-01	4.83E-05	4.39E-02	2.66E+00	2.06E+00	7.62E-03	1.38E+00	2.17E-02	2.05E+00	1.28E-02	1.52E-01	4.23E-02
15%	6.75E-01	4.26E-04	6.57E-01	4.29E-01	5.42E-05	5.05E-02	2.87E+00	2.21E+00	8.55E-03	1.48E+00	2.78E-02	2.38E+00	1.46E-02	1.65E-01	4.61E-02
20%	7.22E-01	4.63E-04	7.86E-01	4.85E-01	5.98E-05	5.71E-02	3.05E+00	2.39E+00	9.80E-03	1.56E+00	3.25E-02	2.68E+00	1.64E-02	1.74E-01	4.88E-02
25%	7.56E-01	5.10E-04	8.83E-01	5.29E-01	6.81E-05	6.16E-02	3.26E+00	2.51E+00	1.09E-02	1.63E+00	3.69E-02	2.92E+00	1.76E-02	1.86E-01	5.16E-02
30%	7.97E-01	5.52E-04	9.98E-01	5.94E-01	7.43E-05	6.71E-02	3.38E+00	2.62E+00	1.22E-02	1.72E+00	4.22E-02	3.13E+00	1.93E-02	1.94E-01	5.41E-02
35%	8.33E-01	5.96E-04	1.09E+00	6.57E-01	7.96E-05	7.13E-02	3.53E+00	2.77E+00	1.36E-02	1.79E+00	4.63E-02	3.32E+00	2.09E-02	2.05E-01	5.65E-02
40%	8.71E-01	6.35E-04	1.21E+00	7.04E-01	8.51E-05	7.56E-02	3.69E+00	2.89E+00	1.49E-02	1.87E+00	5.15E-02	3.50E+00	2.23E-02	2.13E-01	5.91E-02
45%	9.04E-01	6.88E-04	1.39E+00	7.50E-01	9.30E-05	8.09E-02	3.84E+00	3.02E+00	1.67E-02	1.95E+00	5.77E-02	3.69E+00	2.44E-02	2.20E-01	6.16E-02
50%	9.38E-01	7.41E-04	1.55E+00	8.18E-01	1.02E-04	8.64E-02	4.08E+00	3.19E+00	1.80E-02	2.06E+00	6.75E-02	3.89E+00	2.64E-02	2.30E-01	6.41E-02
55%	9.84E-01	8.01E-04	1.73E+00	8.82E-01	1.12E-04	9.12E-02	4.30E+00	3.37E+00	1.98E-02	2.13E+00	7.87E-02	4.10E+00	2.88E-02	2.40E-01	6.79E-02
60%	1.03E+00	8.75E-04	1.93E+00	9.67E-01	1.23E-04	9.68E-02	4.45E+00	3.61E+00	2.24E-02	2.21E+00	8.85E-02	4.32E+00	3.12E-02	2.50E-01	7.09E-02
65%	1.08E+00	9.87E-04	2.16E+00	1.04E+00	1.35E-04	1.06E-01	4.63E+00	3.82E+00	2.45E-02	2.33E+00	1.02E-01	4.62E+00	3.38E-02	2.62E-01	7.46E-02
70%	1.15E+00	1.12E-03	2.50E+00	1.14E+00	1.50E-04	1.16E-01	4.96E+00	4.00E+00	2.76E-02	2.47E+00	1.19E-01	4.92E+00	3.66E-02	2.74E-01	7.82E-02
75%	1.22E+00	1.27E-03	2.93E+00	1.28E+00	1.66E-04	1.30E-01	5.28E+00	4.27E+00	3.08E-02	2.59E+00	1.41E-01	5.30E+00	3.99E-02	2.90E-01	8.27E-02
80%	1.33E+00	1.54E-03	3.63E+00	1.43E+00	1.88E-04	1.41E-01	5.82E+00	4.57E+00	3.51E-02	2.79E+00	1.90E-01	5.68E+00	4.45E-02	3.11E-01	8.89E-02
85%	1.44E+00	1.81E-03	4.59E+00	1.66E+00	2.16E-04	1.69E-01	6.35E+00	5.03E+00	4.05E-02	3.02E+00	3.58E-01	6.14E+00	4.98E-02	3.30E-01	9.37E-02
90%	1.63E+00	2.26E-03	6.15E+00	1.96E+00	2.64E-04	2.14E-01	7.04E+00	5.69E+00	5.09E-02	3.37E+00	8.55E-01	6.92E+00	5.79E-02	3.64E-01	1.04E-01
95%	2.19E+00	3.23E-03	8.82E+00	2.63E+00	3.58E-04	3.04E-01	8.34E+00	6.99E+00	6.95E-02	3.87E+00	1.39E+00	8.21E+00	7.77E-02	4.23E-01	1.20E-01
Mean	1.13E+00	1.10E-03	2.90E+00	1.09E+00	1.39E-04	1.17E-01	4.56E+00	3.69E+00	2.61E-02	2.22E+00	2.60E-01	4.27E+00	3.62E-02	2.47E-01	7.05E-02
Min	1.93E-01	1.95E-04	9.60E-02	1.00E-01	1.94E-05	2.17E-02	1.40E+00	1.32E+00	2.45E-03	9.47E-01	3.49E-03	5.99E-02	2.73E-03	4.82E-02	1.59E-02
Max	1.76E+01	7.84E-03	6.99E+01	1.77E+01	1.24E-03	1.54E+00	1.62E+01	1.73E+01	3.32E-01	5.35E+00	6.63E+00	1.98E+01	1.26E+00	9.53E-01	3.31E-01
Peak of the mean	1.13E+00	1.09E-03	2.62E+00	1.09E+00	1.39E-4	1.17E-01	4.37E+00	3.55E+00	2.59E-02	2.22E+00	1.91E-01	3.99E+00	3.08E-02	2.45E-01	6.96E-02

Table 6-5

Soil DCGLw's for the Residential Farmer Scenario from Deterministic and Probabilistic RESRAD Run at Seneca Army Depot Activity

Radionuclide	Wide Area DCGLs (pCi/g)	
	Deterministic[a]	Probabilistic
Ac-227	6.9	8.8
H-3	5800	9100
Pa-231	2.5	3.4
Pb-210	5.6	9.2
Pm-147	46000	72000
Pu-239	59	85
Ra-226	1.7	2.2
Ra-228	2.2	2.7
Sm-147	240	380
Th-228	3.8	4.5
Th-230	54	38
Th-232	1.5	2.3
U-234	180	280
U-235	33	40
U-238	98	140

[a] Deterministic value to be used for evaluating survey data.

Table 6-6

Maximum Dose/Source Concentration Ratios (mrem/yr per pCi/g) for the Resident Farmer Scenario at the Seneca Army Depot Activity from the Deterministic RESRAD Run

Radionuclide	Ac-227	H-3	Pa-231	Pb-210	Pm-147	Pu-239	Ra-226	Ra-228	Sm-147	Th-228	Th-230	Th-232	U-234	U-235	U-238
Peak Time	0	0	15.4	0	0	0	18.1	1.4	0	0	110.8	30.9	0	0	0
External exposure	6.84E-1	0	2.60E-1	1.72E-3	1.26E-5	8.21E-5	3.41	2.89	0	2.63	1.15E-1	4.63	1.14E-4	2.69E-1	5.02E-2
Inhalation of dust	5.20E-2	1.48E-5	1.83E-2	1.80E-4	2.71E-7	3.37E-3	8.55E-5	7.72E-4	5.87E-4	1.47E-3	7.25E-4	8.46E-3	1.04E-3	6.23E-4	9.28E-4
Ingestion of plant foods	4.99E-1	7.43E-4	3.53	8.54E-1	6.34E-5	1.05E-1	1.77	1.36	1.27E-2	1.14E-2	5.21E-2	1.51	1.71E-2	9.20E-3	1.63E-4
Ingestion of meat	9.57E-3	1.23E-4	3.53E-3	3.16E-1	1.20E-4	1.16E-2	1.28E-1	4.26E-2	2.40E-2	1.43E-3	4.61E-3	4.97E-2	1.22E-2	7.40E-3	1.16E-2
Ingestion of milk	3.49E-3	8.32E-4	6.33E-3	5.09E-1	6.84E-6	4.22E-4	3.87E-1	2.33E-1	2.51E-3	2.59E-4	1.08E-2	2.44E-1	2.08E-2	1.26E-2	1.98E-2
Ingestion of soil	2.05E-1	1.39E-7	1.37E-1	1.01E-1	1.30E-5	4.98E-2	3.69E-2	1.34E-2	2.60E-3	6.15E-3	3.38E-3	3.76E-2	3.99E-3	2.42E-3	3.79E-3
Ingestion of water	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ingestion of fish	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total of all pathways	1.45E+0	1.71E-3	3.96	1.78	2.16E-4	1.70E-1	5.74	4.55	4.24E-2	2.65	1.86E-1	6.47	5.53E-2	3.01E-1	1.03E-1

food, meat, and milk from the site, and keeping other parameters unchanged. The area factor was calculated by taking the ratio of the dose from large contaminated area (10,000 m^2) to the dose from smaller contaminated areas.

Table 6-7 provides the contaminated fractions of plant food, meat, and milk from the site used for different contaminated area sizes used in area factor calculations. Equation D.5 of the RESRAD manual is used in calculating the contaminated fractions. Since the wide area DCGLs are derived by using a conservative contaminated fraction (twice the value calculated from D.5), the contaminated fractions calculated for smaller areas are also multiplied by a factor of 2. Table 6-8 lists the calculated area factors for the residential farmer scenario for all radionuclides. Linear extrapolation would be used when necessary for in-between area sizes. In the current application, the $DCGL_{EMC}$ for a given radionuclide is determined by multiplying its $DCGL_w$ in Table 6-5 by the area factor for the elevated area size of concern. For multiple radionuclides, the area factor for the radionuclide that would give the most conservative dose, a lowest area factor, would be used in the determination of $DCGL_{EMC}$ for all radionuclides.

6.6 DCGLs for Buildings

The RESRAD-BUILD code was used to calculate dose to a receptor from residual contamination on interior building surfaces. Figure 6.2 shows the exposure pathways and release mechanisms considered in the RESRAD-BUILD code. As for soil DCGLs, building DCGLs were derived from both the probabilistic and the deterministic RESRAD-BUILD analyses for all radionuclides listed in Table 6-1. A deterministic analysis uses a single value for each input parameter, resulting in a single-dose output value. A probabilistic analysis uses a probability distribution for each model input parameter of uncertain value. The probabilistic analysis was performed to characterize uncertainty in dose and to identify sensitive parameters. Based on the probabilistic analysis, sensitive parameters identified were assigned conservative values in deterministic analysis.

For the probabilistic analysis, the peak of the mean dose, based on the guidance provided in Section 8.3.2.2 Appendix C of the NUREG/CR-6697, was used in calculating the derived concentration guideline levels. For the deterministic run, conservative values for the key parameters were used. Sensitivity analysis was done to identify the key parameters as shown in Figure 6.3 and discussed in Section 6.4.4. Figure 6.4 shows the DCGL derivation process for the probabilistic and the deterministic RESRAD-BUILD analyses. The process shown in Figure 6.4 is discussed in detail in Section 6.5.

The building occupancy scenario, in accordance with the guidance provided in NUREG/CR-5512, was chosen to derive the DCGLs for buildings. Considering the activities that occurred on the SEDA site, it is expected that any residual radioactivity would be confined to the floor surface. The DCGLs were derived for a dose limit of 10 mrem/yr on the basis of the TAGM 4003 guide.

Table 6-7

Contaminated Area, Length Parallel to Aquifer Flow, and the Corresponding Contaminated Fraction of Plant Food, Meat, and Milk Used in Area Factor Calculation

Contaminated area, m^2	Length parallel to aquifer flow, m	Contaminated fraction		
		Plant	Meat	Milk
10,000	100	1	1.0	1.0
3,000	54.8	1	0.3	0.3
1,000	31.6	1	0.1	0.1
300	17.3	0.3	0.03	0.03
100	10.0	0.1	0.01	0.01
30	5.48	0.03	0.003	0.003
10	3.16	0.01	0.001	0.001
3	1.73	0.003	0.0003	0.0003
1	1	0.001	0.0001	0.0001

Table 6-8

Area factors for Resident Farmer Scenario for Different Contaminants in Surface Soil at the Seneca Army Depot Activity

Area, m^2	Area factor for contaminant of concern[a]														
	Ac-227	H-3	Pa-231	Pb-210	Pm-147	Pu-239	Ra-226	Ra-228	Sm-147	Th-228	Th-230	Th-232	U-234	U-235	U-238
10,000	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
3,000	1.0	1.7	1.0	1.5	1.7	1.1	1.1	1.1	1.8	1.0	1.1	1.1	1.7	1.1	1.3
1,000	1.0	2.0	1.0	1.7	2.1	1.1	1.1	1.1	2.3	1.0	1.1	1.1	2.2	1.1	1.4
300	1.7	6.7	2.8	5.7	5.6	3.5	1.6	1.5	7.3	1.1	1.6	1.4	6.8	1.2	1.9
100	2.1	20.1	5.8	16.9	10.9	9.6	1.9	1.8	19.7	1.3	2.1	1.7	17.4	1.3	2.3
30	2.9	65.9	10.6	55.0	18.6	26.1	2.5	2.4	49.9	1.6	3.1	2.3	40.5	1.6	3.1
10	4.2	193	17.6	157	29.0	53.4	3.7	3.6	93.1	2.4	4.8	3.5	69.6	2.3	4.4
3	8.3	618	37.4	489	61.3	90.7	7.9	7.7	144	5.2	10.3	7.5	104	4.9	9.2
1	16.9	1740	80.6	1340	131	122	18.6	17.3	184	12.0	24.1	17.5	133	11.0	20.4

[a] The $DCGL_{EMC}$ for a given radionuclide is determined by multiplying the $DCGL_W$ in Table 6-5 by the area factor for the area size of concern.

6.6.1 Dose Model

The building DCGLs were calculated using the building occupancy scenario. The residual radioactive material was assumed to be uniformly distributed over the floor surface of the room. The average member of the critical group is the resident, who lives in the contaminated building without deliberately disturbing the source.

The potential pathways used to estimate human radiation exposure resulting from residual radioactivity on the building floor surfaces include the following:

- External exposure directly from the source,
- External exposure from the material deposited on the floor,
- External exposure due to air submersion,
- Inhalation of airborne radioactive particulates and tritium,
- Inadvertent ingestion of radioactive material directly from the source,
- Inadvertent ingestion of radioactive material deposited on the surfaces of the building.

The peak dose at time zero, the time the building would be released, was used in the calculation of DCGLs.

6.6.2 Conceptual Model

A site conceptual model of a contaminated building provides the basis for computing dose estimates using RESRAD-BUILD code. For the current effort, it was conservatively assumed that the building can be modeled as one room and that the source and receptor were in the same room. Therefore, many parameters related with inflow and outflow from one room to another were not required. It was assumed that there was no shielding between the source and the receptor, and that the receptor was at the center of the source at a height of 1 m. The whole floor of the room was assumed to be contaminated, and the contamination was confined to a surface layer. Table 6-9 lists the median parameter values assigned for the deterministic RESRAD-BUILD run as well as the parameter values/distributions assigned for the probabilistic RESRAD-BUILD run and the basis for assigning them. For some radionuclides in a deterministic run the value for a priority 1 or priority 2 (see Figure 6.3) parameter may have been changed from a median value to a more conservative value (see Section 6.4.5) on the basis of the sensitivity analysis. In such cases, the latter value is provided in Table 6-10 for a given radionuclide.

6.6.3 Sensitivity Analysis Results

A probabilistic RESRAD-BUILD run was performed for an individual radionuclide to identify the sensitive parameters for that radionuclide. An initial radionuclide concentration of

Table 6-9

Input Parameters Used at Seneca Army Depot Site for Probabilistic and Deterministic RESRAD-BUILD Analysis

Input Parameter	Units	Type[a]	Priority	Deterministic[b]	Probabilistic analysis				Remarks
					value/ distribution	Distributions statistical parameters[c]			
						1	2	3	
External dose conversion factor	(mrem/yr) per (pCi/g)	M	3	Nuclide specific	Nuclide specific	NR[d]	NR	NR	Values are from Federal Guidance Report No.12 (FGR-12).
Inhalation dose conversion factor	mrem/pCi	M	3	Nuclide specific	Nuclide specific	NR	NR	NR	Values are from Federal Guidance Report No.11 (FGR-11).
Ingestion dose conversion factor	mrem/pCi	M	3	Nuclide specific	Nuclide specific	NR	NR	NR	Values are from Federal Guidance Report No.11 (FGR-11).
Air submersion dose conversion factor	(mrem/yr) per (pCi/m^3)	M	3	Nuclide specific	Nuclide specific	NR	NR	NR	Values are from Federal Guidance Report No.12 (FGR-12).
Exposure duration	days	B	3	365.25	365.25	NR	NR	NR	To match the occupancy period of 365.25 days in NUREG/CR-5512 building occupancy scenario.
Indoor fraction	none	B	2	0.6792	0.6792	NR	NR	NR	Resident spends16.3 h/d inside the building. The value greater than the indoor fraction of 0.6571 used in NUREG/CR-5512 resident scenario.
Number of evaluation times	none	P	3	1	1	NR	NR	NR	Dose is calculated at the time when the building is released for all the radionuclides of concern including progeny.
Time	yr	P	3	0	0	NR	NR	NR	Dose is calculated for one year exposure at the time (t =0 yr) building is released
Number of rooms	none	P	3	1	1	NR	NR	NR	NUREG/CR-5512 building occupancy scenario assumes only one contaminated room.
Deposition velocity	m/s	P	2	8.52E-5	Loguniform	2.7E-6	2.7E-3		Distribution from NUREG/CR-6697. Based on the guidance provided in NUREG/CR-6676, deposition velocity and resuspension rate were positively correlated (correlation coefficient = 0.9).
Resuspension rate	1/s	P, B	1	6.22E-8	Loguniform	2.8E-10	1.4E-5		Distribution from NUREG/CR-6697. Based on the guidance provided in NUREG/CR-6676, deposition velocity and resuspension rate were positively correlated (correlation coefficient = 0.9).
Room height	m	P	2	3.25	Uniform	2.5	4.0		To capture variability in room heights in different survey units at Seneca Army Depot
Room area	m^2	P	2	141	Loguniform	10	2000		To capture variability in room sizes in different survey units at Seneca Army Depot. Correlated with the source area, correlation coefficient = 0.99
Air exchange rate for building and room	1/h	B	2	1.52	1.52	NR	NR	NR	Median of the distribution from NUREG/CR-6697
Net flow	m^3/h	B	3	NR	NR	NR	NR	NR	Not required since only one room model is used.

Table 6-9 (Cont.)

Input Parameter	Units	Type[a]	Priority	Deterministic[b]	Probabilistic analysis				Remarks
					value/ distribution	Distributions statistical parameters[c]			
						1	2	3	
Outdoor inflow	m^3/h	B, P	3	NR	NR	NR	NR	NR	Outdoor inflow is calculated from room volume and air exchange rate.
Number of receptors	none	B	3	1	1	NR	NR	NR	Dose is calculated for one receptor.
Receptor room	none	B	3	1	1	NR	NR	NR	Only one room model is used.
Receptor location	m	B	3	0,0,1	0,0,1	NR	NR	NR	At 1-m height from the center of the contaminated floor surface.
Receptor time fraction	none	B	3	1	1	NR	NR	NR	Most conservative value
Receptor inhalation rate	m^3/d	M, B	2	23.5	23.5	NR	NR	NR	For the building resident it matches the breathing rate of the resident in the resident farmer scenario of NUREG/CR-5512
Receptor indirect ingestion rate	m^2/h	B	2	9E-5	9E-5	NR	NR	NR	Median of the distribution from NUREG/CR-6697
Number of sources	none	P	3	1	1	NR	NR	NR	Floor of the room is contaminated.
Source type	none	P	3	Area	Area	NR	NR	NR	Only surface source is considered in building occupancy scenario.
Source room or primary room	none	P	3	1	1	NR	NR	NR	Only one room is considered.
Source direction	none	P	3	z	z	NR	NR	NR	The direction perpendicular to the exposed area.
Source location	m	P	3	0,0,0	0,0,0	NR	NR	NR	Source center location.
Source area	m^2	P	2	141	Loguniform	10	2000		Correlated with the room area (Floor is contaminated), correlation coefficient = 0.99
Air release fraction	none	B	2	0.07/1.0	0.07/1.0	NR	NR	NR	For all radionuclides except tritium value used (0.07) is equal to the upper bound value for noncombustible solids from NUREG/CR-6697 and the value used for tritium (1.0) is the recommended value for gaseous form of tritium.
Direct ingestion rate	1/h	B	2	5.5E-8	5.5E-8	NR	NR	NR	Calculated from the default ingestion rate of 1.1E-4 m^2/h in NUREG/CR-5512 building occupancy scenario and the maximum contaminated area of 2,000 m2.
Removable fraction	none	P, B	1	0.1	0.1	NR	NR	NR	10% of the contamination is removable (NUREG/CR-5512 building occupancy scenario default).
Time for source removal or source lifetime	days	P, B	2	33230	Triangular	1,000	10,000	100,000	Distribution from NUREG/CR-6697
Radon release fraction	none	P, B	3	0	0	NR	NR	NR	Radon inhalation pathway is suppressed.
Radionuclide concentration	dpm/m^2	P	3	100	100	NR	NR	NR	DCGLs are independent of initial radionuclide concentration
Shielding thickness	cm	P, B	2	0	0	NR	NR	NR	No shielding is assumed between the source and receptor.
Shielding density	g/cm^3	P	1	NR	NR	NR	NR	NR	No shielding is assumed between the source and receptor.

Table 6-9 (Cont.)

Input Parameter	Units	Type[a]	Priority	Deterministic[b]	Probabilistic analysis: value/ distribution	Distributions statistical parameters[c]: 1	2	3	Remarks
Shielding material	none	P	3	NR	NR	NR	NR	NR	No shielding is assumed between the source and receptor.

[a] P = physical, B = behavioral, and M = metabolic; when more than one parameter type is listed, the more conservative parameter type is used in the analysis.

[b] Parameter values (median value from the distribution for a probabilistic parameter) used in the deterministic run. Values for the deterministic analysis are subject to change from a median value to a more conservative value on the basis of sensitivity analysis. See Section 6.4.5 for parameter value assignment process.

[c] For uniform and loguniform distributions, parameter 1 is the minimum and parameter 2 is the maximum value. For triangular distribution, parameter 1 is the minimum value, parameter 2 is the most likely value, and parameter 3 is the maximum value of the distribution.

[d] NR = not required for the analysis (RESRAD-BUILD parameters for which distributions are not developed or for which statistical parameters are not required.

Table 6-10

Results of Probabilistic Analysis in Identifying Sensitive Parameters and Parameter Values for Use As Inputs in Deterministic Analysis Using RESRAD-BUILD

Radionuclide	Sensitive parameters, Partial rank correlation coefficient (PRCC), and parameter values selected from parameter selection process for deterministic analysis				
Ac-227[a]	Parameters	Source lifetime	Source area	Room area	Room height
	PRCC	-0.77	0.49	-0.23	-0.19
	Value	18240	376	376	2.87
H-3[b]	Parameters	Source area	Source lifetime		
	PRCC	0.99	-0.47		
	Value	530	18240		
Pa-231[a]	Parameters	Source lifetime	Source area	Room area	Room height
	PRCC	-0.67	0.55	-0.17	-0.13
	Value	18240	376	376	2.87
Pb-210[b]	Parameters	Source area	Source lifetime		
	PRCC	0.98	-0.49		
	Value	530	18240		
Pm-147[a]	Parameters	Source area	Source lifetime	Room area	Room height
	PRCC	0.74	-0.60	-0.13	-0.10
	Value	376	18240	376	2.87
Pu-239[a]	Parameters	Source lifetime	Source area	Room area	Room height
	PRCC	-0.67	0.55	-0.17	-0.13
	Value	18240	376	376	2.87
Ra-226[a]	Parameters	Source area	Source lifetime	Room area	
	PRCC	1.00	-0.54	-0.15	
	Value	376	18240	376	
Ra-228[a]	Parameters	Source area	Source lifetime	Room area	
	PRCC	1.00	-0.51	-0.14	
	Value	376	18240	376	
Sm-147[a]	Parameters	Source lifetime	Source area	Room area	Room height
	PRCC	-0.76	0.48	-0.23	-0.18
	Value	18240	376	376	2.87
Th-228[a]	Parameters	Source lifetime	Source area	Room area	Room height
	PRCC	-0.70	0.68	-0.21	-0.15
	Value	18240	376	376	2.87
Th-230[a]	Parameters	Source lifetime	Source area	Room area	Room height
	PRCC	-0.79	0.48	-0.25	-0.20
	Value	18240	376	376	2.87
Th-232[a]	Parameters	Source lifetime	Source area	Room area	Room height
	PRCC	-0.78	0.48	-0.25	-0.21
	Value	18240	376	376	2.87
U-234[a]	Parameters	Source lifetime	Source area	Room area	Room height
	PRCC	-0.77	0.48	-0.23	-0.19
	Value	18240	376	376	2.87
U-235[a]	Parameters	Source lifetime	Source area	Room area	Room height
	PRCC	-0.74	0.57	-0.22	-0.17
	Value	18240	376	376	2.87
U-238[a]	Parameters	Source lifetime	Source area	Room area	Room height
	PRCC	-0.76	0.50	-0.23	-0.18
	Value	18240	376	376	2.87

1 dpm/100 cm^2 was assumed. As mentioned in Section 6.4.4, a parameter was identified as sensitive if the absolute value of PRCC was greater than or equal to 0.10 and not sensitive if the absolute value of PRCC was less than 0.10 for the building occupancy scenario. Table 6-10 lists the probabilistic parameters identified as sensitive parameters for each radionuclide from the peak dose analysis. The sensitive parameters are listed along with their PRCC values and conservative values selected on the basis of the parameter selection process shown in Figure 6.3 and described in Section 6.4.5.

6.6.4 DCGL Determination

The building DCGLs were derived for a dose limit of 10 mrem/yr, in a similar way as the soil DCGLs were derived (Section 6.5.4).

6.6.4.1 Probabilistic DCGL Derivation

Parameter values/distributions assigned in the probabilistic run were taken from Table 6-9 for each individual radionuclide. RESRAD-BUILD Version 3.21 was used in this analysis. Table 6-11 provides the probabilistic peak dose distribution. The peak dose distribution is provided at each 5 percentile increment along with the minimum, maximum, and the mean peak dose at initial radionuclide concentration of 1 dpm/100 cm^2. The DCGLs were determined for the radiation dose limit of 10 mrem/yr. The calculated DCGLs are provided in Table 6-12.

6.6.4.2 Deterministic DCGL Derivation

Parameter values assigned in the deterministic run were from Table 6-10 (for parameters found to be sensitive) and from Table 6-9 (for parameters not found to be sensitive) for each individual radionuclide. RESRAD-BUILD Version 3.21 was used in this analysis. The calculated DCGL values are provided in Table 6-12 for the radiation dose limit of 10 mrem/yr. Table 6-13 provides the contributions of different pathways to the calculated maximum DSRs. The deterministic wide area DCGL ($DCGL_w$) values in Table 6-12 should be used in the evaluation of survey data.

6.6.5 Area Factor Calculations for Building Contamination

The area factors for use with $DCGL_w$ values were also calculated for the building occupancy scenario. The deterministic RESRAD-BUILD code was run repeatedly while changing the source area and keeping other parameters unchanged. The area factor was calculated by taking the ratio of the dose from large contaminated area to the dose from smaller contaminated areas. Table 6-14 lists the calculated area factors for the building occupancy scenario for all

Table 6-11

Dose/Source Concentration Ratios (mrem/yr per dpm/100 cm^2) at Different Dose Percentiles from Peak Dose Distribution for the Building Occupancy Scenario at the Seneca Army Depot Activity from the Probabilistic RESRAD-BUILD Run

Percentile	Ac-227	H-3	Pa-231	Pb-210	Pm-147	Pu-239	Ra-226	Ra-228	Sm-147	Th-228	Th-230	Th-232	U-234	U-235	U-238
5%	2.43E-3	1.31E-9	6.89E-4	1.59E-4	5.67E-8	2.20E-4	9.57E-4	5.55E-4	2.46E-5	9.47E-4	9.83E-5	4.90E-4	4.31E-5	1.53E-4	6.09E-5
10%	3.02E-3	1.66E-9	8.59E-4	2.02E-4	7.06E-8	2.76E-4	1.08E-3	6.29E-4	3.09E-5	1.09E-3	1.23E-4	6.15E-4	5.41E-5	1.78E-4	7.43E-5
15%	3.63E-3	2.21E-9	1.08E-3	2.64E-4	8.59E-8	3.49E-4	1.22E-3	7.15E-4	3.81E-5	1.23E-3	1.47E-4	7.32E-4	6.60E-5	2.04E-4	8.64E-5
20%	4.18E-3	2.79E-9	1.29E-3	3.35E-4	1.00E-7	4.19E-4	1.37E-3	8.02E-4	4.41E-5	1.35E-3	1.73E-4	8.63E-4	7.65E-5	2.25E-4	9.86E-5
25%	4.91E-3	3.61E-9	1.50E-3	4.24E-4	1.18E-7	4.89E-4	1.52E-3	8.96E-4	5.22E-5	1.48E-3	2.00E-4	9.92E-4	8.98E-5	2.48E-4	1.11E-4
30%	5.51E-3	4.76E-9	1.74E-3	5.52E-4	1.38E-7	5.71E-4	1.68E-3	1.00E-3	5.92E-5	1.60E-3	2.27E-4	1.14E-3	1.01E-4	2.66E-4	1.25E-4
35%	6.13E-3	6.08E-9	1.98E-3	7.09E-4	1.67E-7	6.48E-4	1.85E-3	1.11E-3	6.69E-5	1.74E-3	2.56E-4	1.28E-3	1.13E-4	2.89E-4	1.38E-4
40%	6.90E-3	7.96E-9	2.40E-3	9.21E-4	2.01E-7	7.84E-4	2.03E-3	1.23E-3	7.56E-5	1.91E-3	2.90E-4	1.45E-3	1.29E-4	3.17E-4	1.55E-4
45%	7.92E-3	1.03E-8	2.91E-3	1.19E-3	2.49E-7	9.56E-4	2.23E-3	1.37E-3	8.67E-5	2.07E-3	3.26E-4	1.63E-3	1.47E-4	3.45E-4	1.71E-4
50%	8.95E-3	1.34E-8	3.44E-3	1.55E-3	3.01E-7	1.13E-3	2.43E-3	1.52E-3	9.83E-5	2.22E-3	3.76E-4	1.88E-3	1.67E-4	3.80E-4	1.93E-4
55%	1.04E-2	1.74E-8	4.18E-3	2.00E-3	3.70E-7	1.38E-3	2.66E-3	1.69E-3	1.17E-4	2.42E-3	4.22E-4	2.11E-3	1.93E-4	4.17E-4	2.24E-4
60%	1.20E-2	2.28E-8	5.05E-3	2.60E-3	4.58E-7	1.67E-3	2.92E-3	1.89E-3	1.37E-4	2.60E-3	4.83E-4	2.41E-3	2.23E-4	4.58E-4	2.55E-4
65%	1.37E-2	2.96E-8	6.18E-3	3.37E-3	5.74E-7	2.04E-3	3.20E-3	2.13E-3	1.56E-4	2.80E-3	5.64E-4	2.81E-3	2.58E-4	5.03E-4	2.87E-4
70%	1.65E-2	3.86E-8	7.72E-3	4.40E-3	7.30E-7	2.56E-3	3.54E-3	2.41E-3	1.88E-4	3.05E-3	6.53E-4	3.27E-3	3.11E-4	5.61E-4	3.37E-4
75%	1.89E-2	5.05E-8	9.62E-3	5.75E-3	9.21E-7	3.19E-3	3.94E-3	2.77E-3	2.21E-4	3.36E-3	7.63E-4	3.81E-3	3.58E-4	6.30E-4	3.87E-4
80%	2.25E-2	6.56E-8	1.21E-2	7.49E-3	1.18E-6	4.01E-3	4.40E-3	3.19E-3	2.66E-4	3.63E-3	8.91E-4	4.44E-3	4.24E-4	7.05E-4	4.56E-4
85%	2.73E-2	8.53E-8	1.51E-2	9.71E-3	1.49E-6	5.02E-3	4.95E-3	3.71E-3	3.20E-4	3.99E-3	1.08E-3	5.36E-3	5.18E-4	7.98E-4	5.39E-4
90%	3.31E-2	1.11E-7	1.97E-2	1.26E-2	1.92E-6	6.54E-3	5.64E-3	4.38E-3	3.95E-4	4.46E-3	1.30E-3	6.49E-3	6.37E-4	9.34E-4	6.48E-4
95%	4.05E-2	1.45E-7	2.50E-2	1.65E-2	2.47E-6	8.31E-3	6.48E-3	5.22E-3	4.86E-4	5.01E-3	1.57E-3	7.81E-3	7.67E-4	1.08E-3	7.89E-4
Mean	1.38E-2	3.56E-8	6.91E-3	4.06E-3	6.60E-7	2.29E-3	2.91E-3	2.03E-3	1.59E-4	2.51E-3	5.52E-4	2.75E-3	2.59E-4	4.70E-4	2.82E-4
Min	1.38E-3	9.80E-10	4.07E-4	1.18E-4	4.08E-8	1.28E-4	8.30E-4	4.80E-4	1.34E-5	7.62E-4	5.44E-5	2.69E-4	2.41E-5	1.15E-4	3.99E-5
Max	8.73E-2	1.89E-7	3.27E-2	2.15E-2	3.22E-6	1.09E-2	7.54E-3	6.29E-3	9.69E-4	6.27E-3	4.18E-3	2.10E-2	1.71E-3	1.81E-3	1.57E-3

Table 6-12

Building DCGLw's for the Building Occupancy Scenario from Deterministic and Probabilistic RESRAD-BUILD Run at Seneca Army Depot Activity

Radionuclide	Wide Area DCGLs (dpm/100cm^2)	
	Deterministic[a]	Probabilistic
Ac-227	6.70E2	7.25E2
H-3	2.07E8	2.81E8
Pa-231	1.36E3	1.45E3
Pb-210	1.79E3	2.46E3
Pm-147	1.69E7	1.52E7
Pu-239	4.24E3	4.37E3
Ra-226	2.87E3	3.44E3
Ra-228	3.79E3	4.93E3
Sm-147	5.75E4	6.29E4
Th-228	3.95E3	3.98E3
Th-230	1.62E4	1.81E4
Th-232	3.09E3	3.64E3
U-234	3.51E4	3.86E4
U-235	1.82E4	2.13E4
U-238	3.16E4	3.55E4

[a] Deterministic value to be used for evaluating survey data.

Table 6-13

Percentage Contribution of Different Pathways[a] for the Building Occupancy Scenario at the Seneca Army Depot Activity from the Deterministic RESRAD-BUILD Run

Radionuclide	External	Deposition	Immersion	Inhalation	Ingestion
Ac-227	4.21	0.00	0.00	42.47	53.40
H-3	0.00	0.00	0.00	0.16	99.79
Pa-231	1.15	0.00	0.00	18.16	80.76
Pb-210+D	0.18	0.00	0.00	0.35	99.46
Pm-147	8.89	0.00	0.00	5.55	85.67
Pu-239	0.06	0.00	0.00	17.50	82.63
Ra-226+D	77.08	0.00	0.00	0.22	22.69
Ra-228+D	67.42	0.00	0.00	1.86	30.87
Sm-147	0.00	0.00	0.00	41.38	58.62
Th-228+D	74.31	0.00	0.00	10.91	14.74
Th-230	0.40	0.00	0.00	50.81	48.71
Th-232	3.21	0.00	0.00	48.77	47.84
U-234	0.85	0.00	0.00	44.56	54.74
U-235+D	51.64	0.00	0.00	21.72	26.82
U-238+D	17.22	0.00	0.00	36.08	46.84

[a] Because of round off error total pathway dose may be different than 100. Dose from deposition and immersion pathways is very small compared to other pathways.

Table 6-14

Area Factors for the Building Occupancy Scenario for Different Contaminants at the Seneca Army Depot Activity

Area, m^2	Area factor for contaminant of concern[a]														
	Ac-227	H-3	Pa-231	Pb-210	Pm-147	Pu-239	Ra-226	Ra-228	Sm-147	Th-228	Th-230	Th-232	U-234	U-235	U-238
530	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
376	1.0	1.4	1.0	1.4	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
300	1.2	1.8	1.3	1.8	1.2	1.3	1.1	1.1	1.3	1.1	1.3	1.2	1.3	1.1	1.2
100	3.5	5.3	3.7	5.3	3.3	3.8	1.6	1.7	3.8	1.6	3.7	3.6	3.7	2.0	2.9
30	10.3	17.7	11.8	17.4	8.8	12.5	2.5	2.8	12.5	2.6	12.2	10.8	11.8	3.4	6.6
10	26.3	53.0	33.4	51.7	20.3	37.1	4.2	4.7	37.7	4.4	35.7	28.2	33.3	5.9	13.4
3	74.3	177	104	169	52.9	122	9.1	10.3	125	9.4	115	81.6	103	12.9	32.0
1	202	530	299	498	139	365	22.2	25.1	377	23.0	338	225	295	31.7	80.8

[a] The $DCGL_{EMC}$ for a given radionuclide is determined by multiplying the $DCGL_w$ in Table 6-12 by the area factor for the area size of concern.

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