APPENDIX 6

DEVELOPMENT OF DERIVED CLEANUP GUIDELINES FOR THE PELHAM RANGE 'BURIAL MOUND' FORT McCLELLAN

Development of Derived Cleanup Guidelines for the Pelham Range Burial Mound, Fort McClellan, Revision 2

September 8, 1999

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1.0 Introduction

1.1 Background

Fort McClellan is an army base sited on 45,679 acres adjacent to Anniston, AL. A part of the base, known as Rideout Field, served as a radiological training area from the mid 1950's through May of 1972. The radiological training area was decommissioned and some contaminated soil was excavated and moved to a burial mound located in the northwest corner of the Pelham Range. This mound, called the Pelham Burial Mound in this report, contains elevated concentrations of Co-60 and Cs-137.

1.2 Objective

The Army Base Closure and Realignment Committee has identified Fort McCellan as an installation for closure. Fort McCellan will therefore be closed, and the Pelham Range will be licensed to the Alabama Army National Guard (USACE, 1998). As part of this closure, the Fort's NRC radioactive materials licenses 01-02861-05 will be terminated. Termination of these licenses requires submission of a formal decontamination and decommissioning (D&D) plan. Cleanup levels form an integral part of this D&D plan. This report is intended to present the site-specific derived cleanup guidelines proposed for the Pelham Range Burial Mound and to document the method used to derive them and to assess the health protectiveness of the resulting residual soil concentrations on the site.

1.3 Organization of the Report

The remainder of this report is organized into four sections. Section 2, contains a description of the approach used to derive the cleanup goals. Section 3 contains the results of the exposure assessment performed on selected receptors. Section 4 presents the DCGL's and summarizes the report's recommendations. Appendix A contains the modeling parameters and results that form the basis for the DCGL's developed in this report.

2.0 Description of Approach

In order to terminate a NRC radioactive materials license and release a site, a licensee must demonstrate that the site is suitable for release in accordance with the criteria for decommissioning in Subpart E, "Radiological Criteria for License Termination," of 10 CFR 20, "Standards of Protection Against Radiation." This report uses site-specific information to derive the release criteria that must be met before the license can be terminated and the site licensed to the Alabama Army National Guard. These criteria are based on an annual dose limit of 25 mrem/y to a hypothetical residential family with a back-yard cow.

Information on the site was assembled and analyzed to develop a conceptual model of the site. This model provided a basis to identify the important sources of contamination, their principle means of radionuclide release, mechanisms of environmental transport from the release point, and hypothetical receptors.

Once these were identified, site-specific derived cleanup guidelines (DCGLs) were calculated using RESRAD version 5.82 (ANL, 1995). RESRAD was developed partially under contract with the NRC and is widely used in the decommissioning industry for calculating doses, risks, and soil cleanup criteria.

Because of the bimodal distribution of the radionuclide concentrations in the pile, it is expected that the average concentration of residual contamination in the pile will be much lower than the cleanup criteria. Using measured data, the expected residual concentrations that should result from the application of these cleanup criteria were determined. The residual concentrations were then compared to the concentrations predicted to produce 25 mrem/y to the critical member of a resident family, assuming immediate occupancy of the site[1]. The risks to the hypothetical farm family were also calculated using EPA guidance (EPA, 1989, EPA 1997, and EPA 1999) and presented and compared to the acceptable range of 10^{-6} to 10^{-4} excess cancer risks used by EPA at CERCLA sites (EPA 1990).

[1] This exposure scenario was selected to determine compliance with unconditional release of the property.

3.0 Exposure Assessment

The purpose of this exposure assessment is to estimate the nature and magnitude of potential exposures from the site under future conditions. This is accomplished by following a phased approach that involves the following tasks:

- Characterizing the exposure setting on and around the site,
- Identifying potentially complete human exposure pathways, and
- Quantifying the magnitude of contaminant intakes by hypothetical receptors.

This section presents a description of the methods used to evaluate exposures from Pelham Mound, and the results of that assessment. The setting and physical characteristics of the Site are summarized below in Section 3.1. Section 3.2 presents the conceptual model describing the sources, contaminant migration, receptors, and exposure routes evaluated for the Mound. Section 3.3 describes how RESRAD was applied to quantify potential exposures by the featured receptors. A summary of modeling results is presented in Section 3.4.

3.1 Characterization of the Site

The following sections summarize information on the physical setting of the site, its history, and its current and projected uses. For more detailed information on these and related subjects, see the Industrial Radiation Study No. 27-MH-0987-R2-97 (USCHPPM, Jan 1996).

3.1.1 Physical Setting

Fort McClellan is an army based sited on 45,679 acres adjacent to Anniston, AL. It is divided into three areas: the Main Post, the Choccolocco Corridor, and the Pelham Range. The Pelham Range Burial Mound is located at UMT coordinates 593300 E, 3732500 N, which is near the northwest corner of Pelham Range, on the northern end of the Battle Drill Area of Range 24C. The mound is oblong in shape and is approximately 25 meters long by 15 meters wide. It extends to three to four meters below grade, and is piled up to approximately two meters above grade in places.

3.1.2 Site History

Part of the area known as Rideout Field served as a radiological training area from the mid 1950's through May of 1972. The area was also used as an active radiological material burial

site as late as 1959. Best information indicates radioactive low-level laboratory waste and contaminated dirt were collected and placed in one burial mound located in the northwest corner of the Pelham Range.

3.1.3 Current Land Use

The area surrounding the burial mound has historically been used as a maneuver training area for students at the U.S. Army Chemical and Military Police Schools, and by Active Duty, Reserve, and Alabama National Guard units. The area will continue to be used as a maneuver training area for the foreseeable future. The potential for unexploded munitions also exists in some areas of the Pelham Range[2].

Because of its current use and the potential danger to the public from unexploded munitions, access is generally restricted to authorized personnel only. This restriction is enforced by limited access along controlled roads, and physical barriers like fences and gates.

3.2 Conceptual Model of the Site

The conceptual model for the Pelham Range Burial Mound has been developed to provide the basis for identifying and evaluating the potential risks to human health from radioactive materials at this site. This model presents the relationships between the following elements necessary to construct a complete exposure pathway:

- Sources and contaminants
- Release mechanisms
- Transport pathways
- Exposure routes
- Receptors

Figure 3-1 presents the conceptual model for potential human exposure to the contaminants detected in the Burial Mound soil. The objective of this conceptual model development and the concurrent analysis of potential exposure routes and receptors is to focus subsequent efforts on those pathways and sources that drive the potential impacts on human health risk.

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[2] The Decommissioning Plan includes an OE Avoidance Plan to eliminate an unexpected encounter (with ordnance and explosives).

The conceptual model illustrated in Figure 3-1 of this appendix traces the exposure pathways and receptors for the Mound from the source through likely release mechanisms and exposure routes to selected receptors. The conceptual model also indicates which exposure routes are carried through the quantitative dose assessment for each receptor.

3.2.1 Sources and Release Mechanisms

The radionuclides of concern at this site are Co-60 and Cs-137. This material is mixed with soil and the soil has been collected into a discrete pile that extends both above and below grade level. This burial mound is the principle source of radioactive material at this site, and it is a relatively small, discrete area. A previous investigation (USCHPPM, 1996) collected data that indicate the majority of the pile does not contain measurable amounts of Co-60 or Cs-137 (Figures 3-2 and 3-3 of this appendix.)

The exposed surface of the pile is subject to limited water and wind erosion. In addition, rainwater percolating through the pile may mobilize one or both of the contaminants. The impact of these releases is expected to be minimal during the study duration, but they are included in the conceptual model for completeness.

3.2.2 Potential Transport Pathways

If released, these contaminants could be transported by wind, or groundwater to the vicinity of the receptor. In addition, plants may absorb some contaminants via root uptake. Each of these pathways has been included in the exposure assessment calculations made in this report.

3.2.3 Potential Exposure Routes

A receptor can come into contact with the Co-60 and Cs-137 in the Mound in a variety of ways, generally as the result of a receptor's behavior or lifestyle that brings him/her into contact with a contaminated exposure medium. This assessment defines a route mechanism as a stylized description of the behavior that brings a receptor into contact with a contaminated medium.

An exposure route describes how a radionuclide may enter or affect humans. Exposures are divided into two types: internal exposures and external exposures. Internal exposures occur when contaminants enter the human body through inhalation and ingestion. External exposures do not require physical contact and occur when a receptor is close to a source of radiation. Proximity to such a source can result in the irradiation of an individual by penetrating radiation.

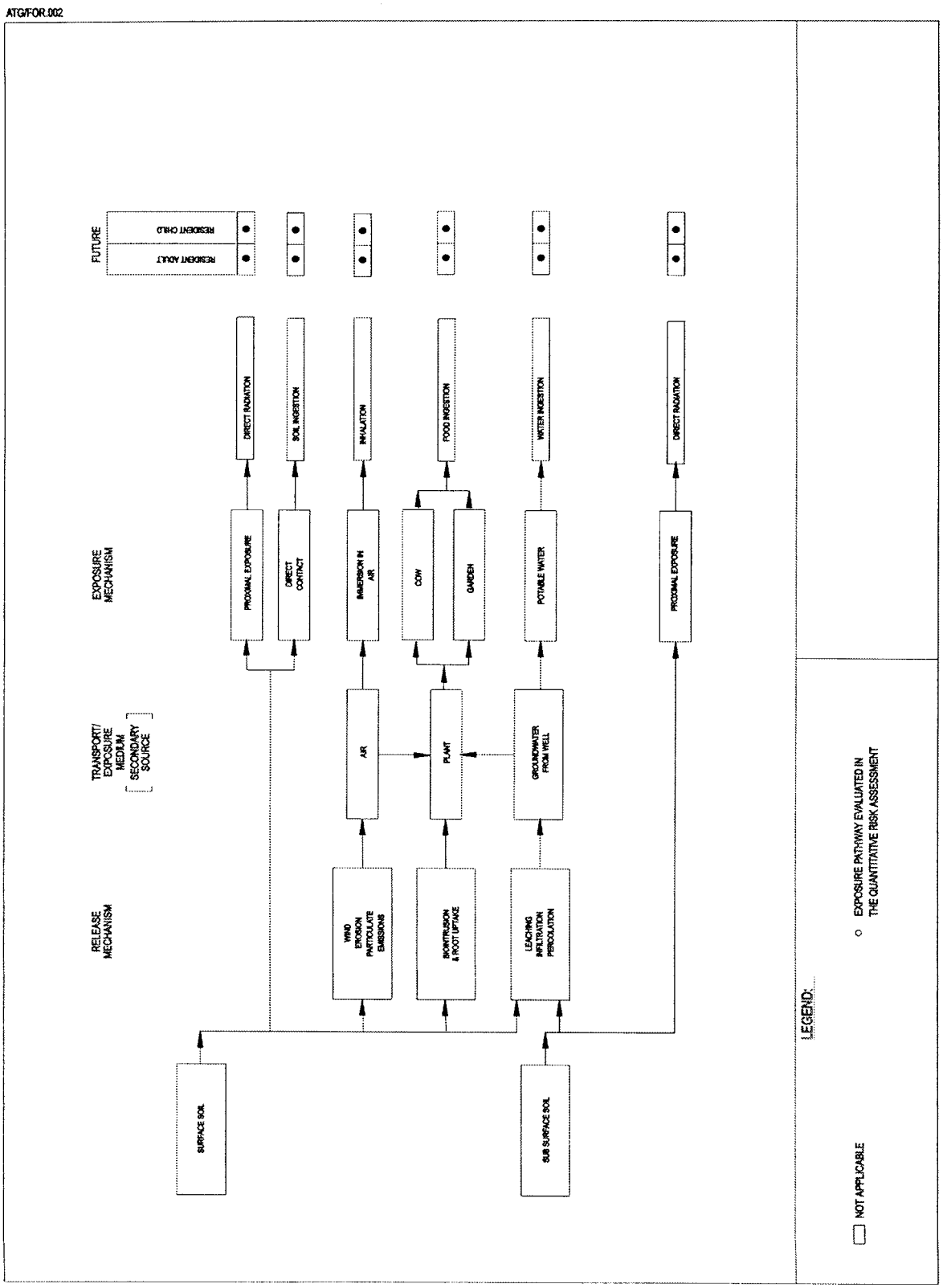
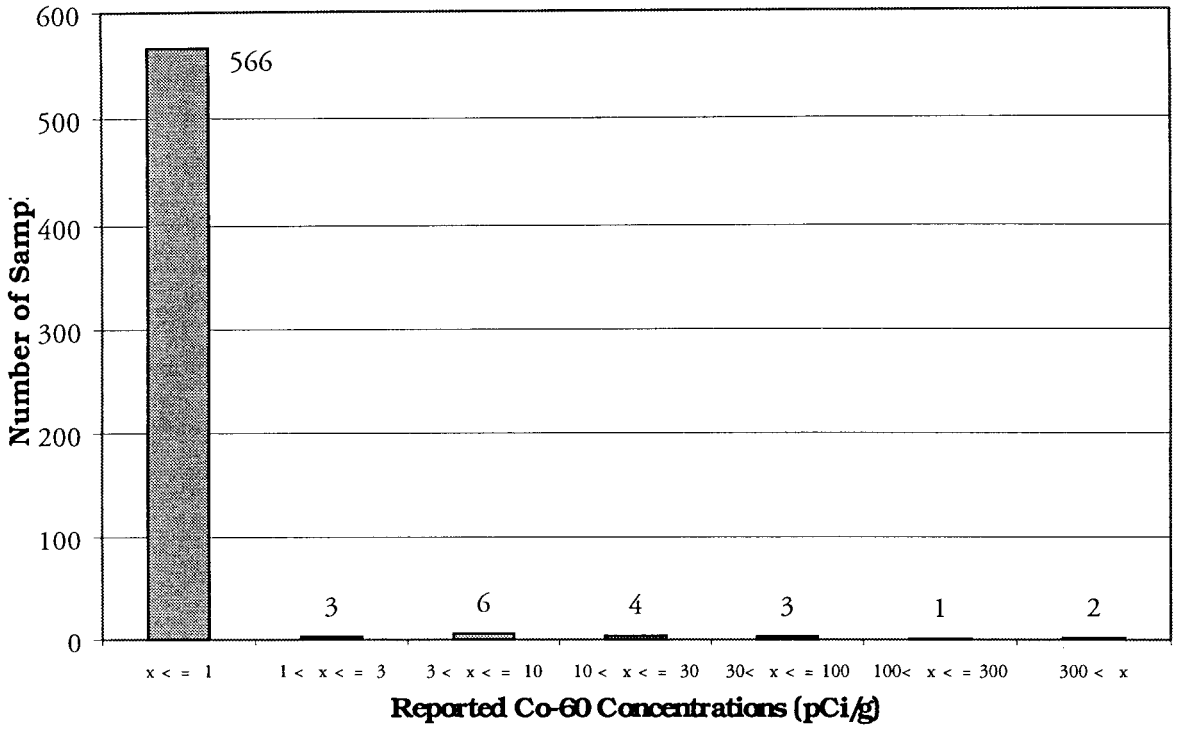


Figure 3-1 Conceptual Model of Exposures for Pelham Range Burial Ground



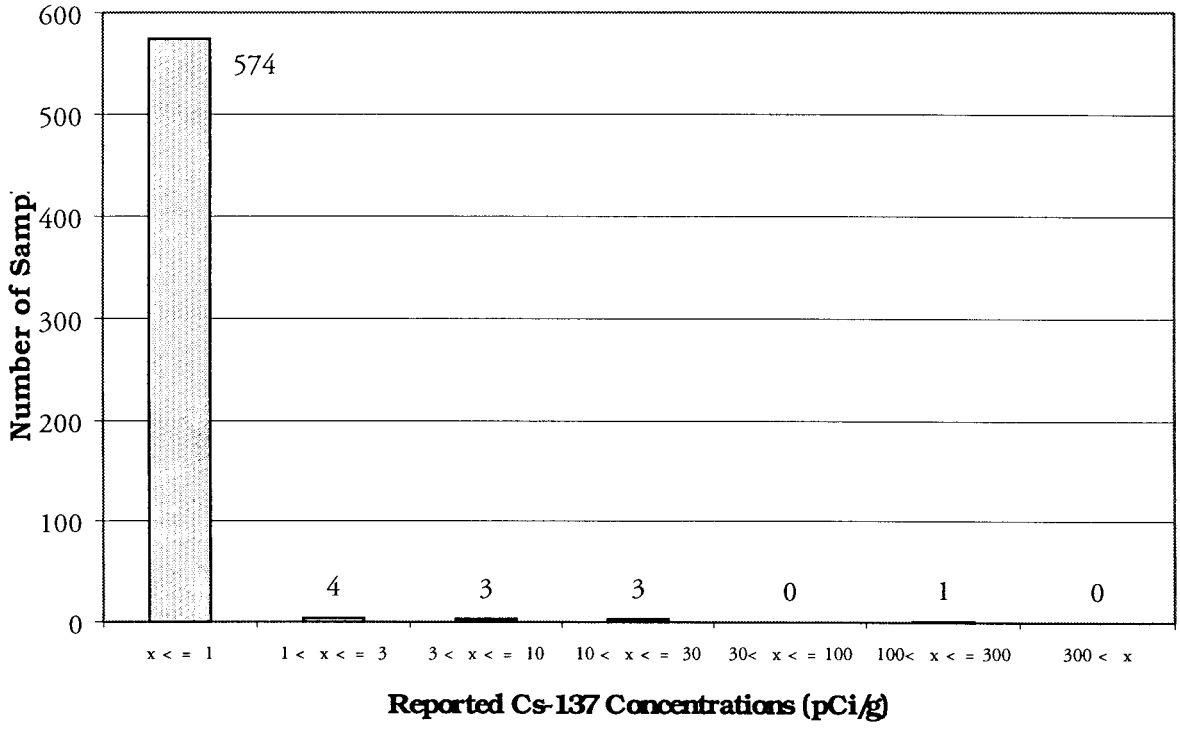


Figure 3.2 Frequency Distributions of Co-60 and Cs-137 Concentrations in Burial Mound Soil (Data from USCHPPM, 1996)

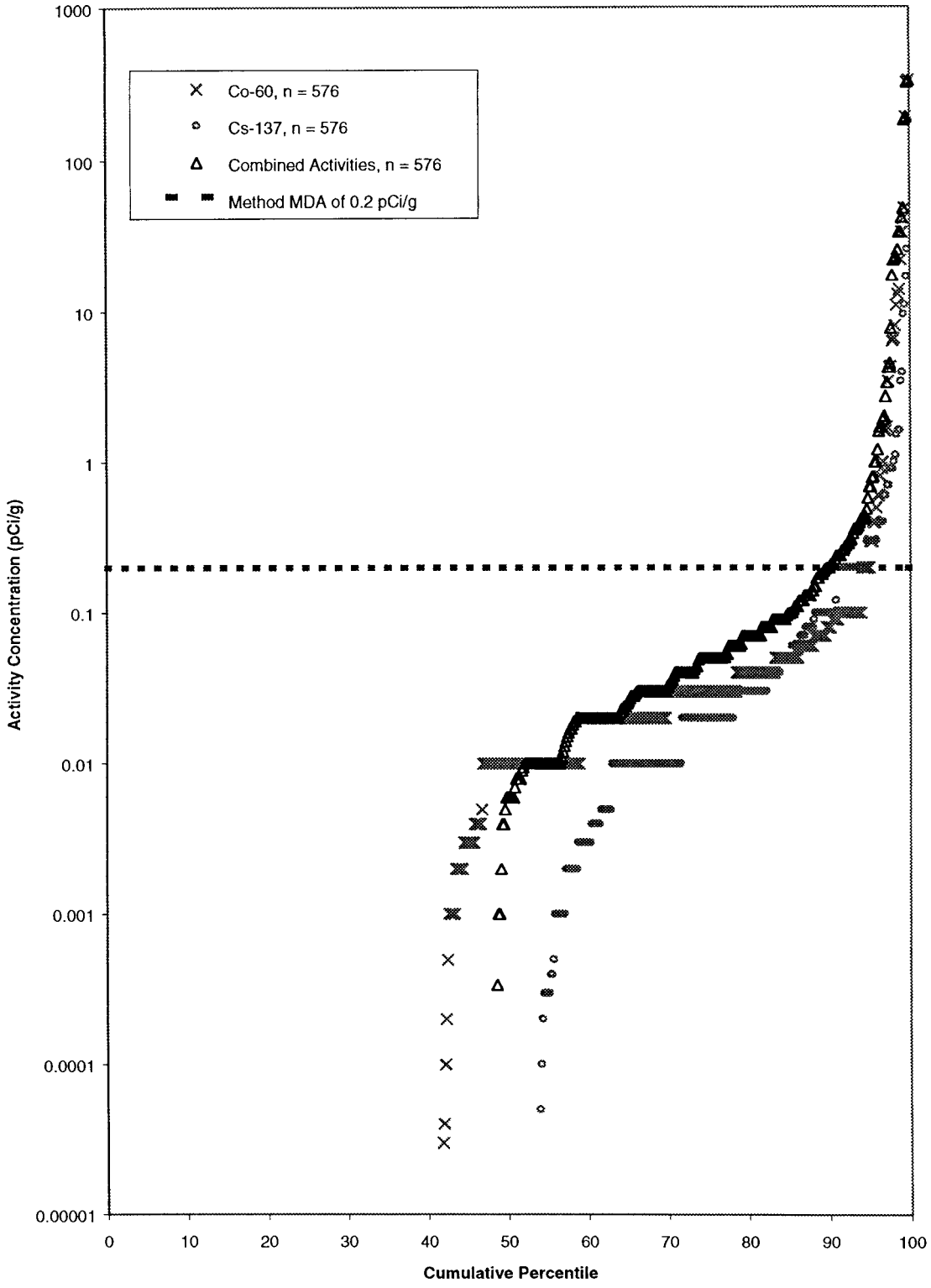


Figure 3-3 Cumulative Probability Plot of Co-60 and Cs-137 Concentrations in Soil

The remainder of this section describes the exposure routes evaluated in this assessment. The receptors evaluated for these exposure routes are described in Sections 3.2.4 and Section 3.2.5.

3.2.3.1 Exposures from Inhalation

This route assumes a receptor is immersed in air containing suspended particulates from the Mound. Subsequent exposures occur via inhalation.

3.2.3.2 Exposures from Ingestion

This route assumes a receptor eats or drinks contaminated soil, food, or water.

3.2.3.3 Direct Exposure to Radiation

Direct exposures to radiation from radioactive material can occur when a receptor is near a radioactive source. Physical contact with a contaminated exposure medium is not necessary for exposure to external radiation to occur. The magnitude of exposure is directly related to the distance of the receptor from the source, the activity of the radionuclides present, and the amount of shielding between the source and the postulated receptor.

3.2.4 Receptor Scenarios Considered

This site is currently part of a military base. At decommissioning, it will be licensed to the Alabama Army National Guard for use as a battle drill training area. This land use is expected to continue for the foreseeable future in order to comply with the recommendations of the 1995 Defense Base Closure and Realignment Committee. Therefore public access to the site will be restricted by administrative controls and base security.

At some point in the future, the Pelham Range may be released to the general public for unrestricted use. It is not anticipated that this will occur in the near future, but to assess the potential doses from this possibility, hypothetical exposures are assessed from materials in the Pelham Mound to a family living on the site immediately after remediation. This scenario assumes governmental control of the site ceases immediately after decommissioning. If administrative controls cease, many types of land use become possible. In this case, it was judged that residential types of land use would produce the greatest exposure potential. Therefore, a residential scenario with back yard garden and cow has been used to evaluate the exposures from unrestricted release of the site.

3.2.4.1.1 Resident Adult Scenario

A residential adult was selected to evaluate exposures immediately after decommissioning. This hypothetical resident is assumed to grow his own vegetables, meat, and milk while residing at the site for 30 years. Table 3-1 presents the parameters used to quantify this receptor's behavior.

3.2.4.1.2 Resident Child Scenario

A typical residential family consists of both adults and children. A hypothetical child, aged 1 to 6 years old, was selected for evaluation because children are a critical subpopulation that may have higher exposures than an adult. The child's behavior pattern is similar to the adult , and Table 3-1 presents the parameters used to quantify this receptor's behavior.

3.3 Application of RESRAD

The resident scenarios involve activities performed while on top of the burial mound soil. The computer code RESRAD 5.82 (ANL,1993) was used to assess the potential doses and long-term risks from these activities. Default input parameters were used, except where otherwise noted in Table 3-1. Summary input files presented in Appendix A contain a detailed list of parameter values used in the RESRAD calculations for each receptor assessed.

Doses and risks to a resident living on a uniform layer of the mound material after decommissioning were calculated for the following pathways using the parameter values listed in Table 3.1:

- Drinking water,
- Food ingestion (home-grown vegetables, meat, and milk),
- Soil ingestion,
- Inhalation of resuspended soil, and
- Direct exposure to external radiation.

Table 3-1 Parameters Used to Estimate Potential Exposures for the Fort McCellan Pelham Burial Mound

Pathway / Parameter (units)	Future Hypothetical Receptors: Resident Adult Age 19+		Resident Child Age 1-6	
Time and duration of exposure				
ET indoors (hr/d)	16.4	a	20.2	b
ET outdoors (hr/d)	2	a	3.3	b
EF (d/yr)	350	c	350	d
ED (yr)	30	c	6	d
Inhalation of dust				
IR (m3/hr)	0.83	e	0.31	f
Incidental ingestion of soil				
IR (kg/d)	0.00005	g	0.00020	h
Ingestion of Food and Water				
IR_{lveg} (kg/d)	0.100	i	0.042	j
IR_{oveg} (kg/d)	0.208	i	0.087	j
IR_{fruit} (kg/d)	0.244	i	0.102	j
IR_{water} (L/d)	2.4	k	1.4	l
IR_{meat} (kg/d)	0.100	m	0.175	n
IR_{milk} (L/d)	0.400	m	1.287	n

a - Recommended values for residential and outdoor exposures from Table 5-176 in Exposure Factors Handbook, EPA 1997.

b - Time weighted average of mean values for residential and outdoor exposures for 1-4 year old from Table 15-131 and Table 15-132 in Exposure Factors Handbook, EPA 1997. (Indoor = 1211 min/d, and Outdoor = 196 min/d).

c - The resident is assumed to spend 30 years living in a house build on the site, and take two weeks of vacation away from the home each year (EPA's 1991 OSWER Directive 9285.6-03.).

d - Reflects six years of life as a member of the resident farm family, between birth and age 6..

e - Inhalation rate of adult. From Table 5-23 of Exposure Factors Handbook, EPA 1997 (15.2 m^3/d x d/24 h).

f - Time weighted average of recommended values inhalation rate of children, ages 1-6. From Table 5-23 of Exposure Factors Handbook, EPA 1997. (1 y x 4.5 m^3/d + 2 y x 6.8 m^3/d + 2 y x 8.3 m^3/d + 1 y x 10 m^3/d) / 6 y x d/24 h).

g - Rate of incidental soil ingestion by adult (Exposure Factors Handbook, EPA 1997, Table 4-23).

h - Soil ingestion rate by child (Exposure Factors Handbook, EPA 1997, pg. 4-24).

i - Recommended home produced fruit and vegetable ingestion rates by a 71.8 kg adult (Exposure Factors Handbook, EPA 1997, pg. 9-44). Leafy vegetables assumed to compose 13.3% of dietary intake of all vegetables (Exposure Factors Handbook, EPA 1997, Table 9-25).

j - Recommended home produced fruit and vegetable ingestion rates by a 30.1 kg child (Exposure Factors Handbook, EPA 1997, pg. 9-44).

k - 90%tile tap water ingestion rate by a 71.8 kg adult (0.034 L/kg-d * 71.8 kg; Exposure Factors Handbook, EPA 1997, pg. 3-26).

l - Weighted average of the 90%tile tap water ingestion rates listed for children 0-6 years old ((1 y* 0.65 L/d +5 y *1.5 L/d) / 6y; Exposure Factors Handbook, EPA 1997, pg. 3-26).

m – Standard default ingestion rate for meat and dairy products (Meat = 0.1 kg/d; Milk = 0.4 L/d; OSWER Directive 9285.6-03, pg. 11).

n - 95% meat and dairy product ingestion rates (Exposure Factors Handbook, EPA 1997; Body weights for ages 0-6 from Tables 7-6 and 7-7; Meat ingestion rates for ages 0-6 from Table 11-1, and dairy ingestion rates for ages 0-6 from Table 11-2).

3.4 Summary of Receptor Exposures

The results of the RESRAD runs described in this section are summarized in Table 3-2. The residual soil concentrations for the resident adult with a backyard garden and cow yield a calculated dose of 25 mrem/y.

Table 3-2 Allowable Concentrations in Current Soil for Future Land Use

Scenario Radionuclide	RESRAD Soil Guideline (25 mrem/y Limit)	Resulting Risk (c/Life)
Resident Adult		
Co-60	2.9 pCi/g	9 E-5
Cs-137	12 pCi/g	3 E-4
Resident Child		
Co-60	2.3 pCi/g	6 E-5
Cs-137	9.2 pCi/g	9 E-5

3.4.1 Resident Adult with Backyard Garden and Cow

Exposures to the hypothetical adult evaluated in this study would be dominated by direct gamma radiation emitted directly by the soil (over 96% for Co-60 and aver 80% of the Cs-137). About 10% of the dose from Cs-137 is associated with consumption of homegrown fruit and vegetables, and another 8% from homegrown meat and dairy products.

3.4.2 Resident Child with Backyard Garden and Cow

Exposures to the hypothetical child evaluated in this study are very similar to those of the adult discussed earlier. They would be dominated by direct gamma radiation emitted directly by the soil (over 97% for Co-60 and almost 82% of the Cs-137) . About 10% of the dose from Cs-137 would be attributable to consumption of homegrown dairy products, and another 8% from eating homegrown meat and plants. The dose based soil guidelines for the child are lower than for the parent because the child is assumed to spend more time per year on site exposed to the underlying soil, and the time spent exposed to external radiation is the dominant factor in this assessment.

4.0 Derived Cleanup Guidelines

4.1 Role of Dose Based Criteria

Potential radiation exposures from the Pelham Mound and surrounding areas must be limited to safe levels before the NRC license can be terminated. The NRC has determined that a dose limit of 25 mrem/y is health protective at NRC licensed sites (10CFR20). The Derived Cleanup Guidelines (DCGLs) developed in this document are judged to be meet this requirement under the hypothetical future land use evaluated for the site.

4.2 Dose Based Cleanup Guidelines

The dose based cleanup level for a nuclide is the smaller of the soil concentrations calculated for the two receptors (Table 3-2). The individual dose based Derived Cleanup Guidelines (DCGLs) are 2.3 pCi/g for Co-60 and 9.2 pCi/g Cs-137.

The risks to the selected receptors from these soil concentrations were calculated using EPA guidance (EPA 1997, EPA 1996, EPA 1995, EPA 1991,and EPA 1989). The risks associated with the DCGLs are within the acceptable risk range of 10^{-6} to 10^{-4} used by EPA at CERCLA sites (EPA, 1990).

4.3 Impact of DCGLs and Soil Sorting on Final Status of Burial Mound Soil

The previous section presents DCGL's for the Burial Mound soil. For the purpose of this project these become the residual soil concentrations allowed to remain, averaged over a survey unit.

The soil sorter is capable of discerning Co-60 and Cs-137 at 9 pCi/g and 16 pCi/g, respectively. These levels have been selected as the defacto delineation between aliquoits of soil that will remain on site and those that will be packaged and transported to an off-site disposal facility. Because only a small percentage of soil samples contained Co-60 or Cs-137 concentrations exceeding the guidelines, it is anticipated that the average concentrations of these two radionuclides in the soil remaining on site will be much less than those required for unconditional release of the site after the soil has been sorted by activity (Table 4-1).[3]

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[3] Analysis of the soil data, collected from various locations and depths of the pile, indicates the bulk of the material in the pile does not contain appreciable levels of either Co-60 or Cs-137. In fact, less than 10% of the samples contain these radionuclides in concentrations exceeding the contract MDA (Figures 3-2 and 3-3 in this appendix). This implies that the pile is essentially clean dirt, with some limited areas of elevated concentration.

Table 4-1 Impact of Sorter on Residual Soil Concentrations

	Cs-137		Co-60	
Statistic	No Action Conc. (pCi/g)	Conc. After Sorting (pCi/g)	No Action Conc. (pCi/g)	Conc. After Sorting (pCi/g)
n	585	581	585	575
mean	0.46	0.06	1.83	0.08
SD	7.53	0.48	20.72	0.60
$UCL_{95\%\ mean}$*	**0.97**	**0.09**	**3.24**	**0.13**
Max. value	179.0	9.5	330.0	8.0
95th Prcntl	0.30	0.20	0.20	0.10
iterated t	1.647508	1.647522	1.647508	1.647555
t calc	*0.05000*	*0.05000*	*0.05000*	*0.05000*

*The 95% UCL on the arithmetic mean (= ArithMean + (t_score * StDev / SQRT(n)))

The intent of the remedial action is to remove soil containing more than 9 pCi/g Co-60 or 16 pCi/g Cs-137 from the site. If this is done, current sampling results indicate the average concentrations of each isotope in the remaining soil will be at or near 0.1 pCi/g, which are well below the dose based criteria. (Table 4-2).

Table 4-2 Comparison of DCGL and Residual Soil Concentrations

Radionuclide	DCGL (pCi/g)	Final Projected Soil Concentration (pCi/g)
Co-60	2.3	0.13
Cs-137	9.2	0.09

4.4 Health Protectiveness of Expected Residual Soil Contamination Levels.

Once the average expected residual concentration was determined, RESRAD was used to confirm the health-protectiveness of the remedy. This was done by calculating the risks to the selected receptors from the expected residual soil concentrations (Table 4-3).

Table 4-3 Health Protectiveness of Selected Remedy

Radionuclide	Final Projected 95%UCL Soil Concentration (pCi/g)	Resulting Dose to Child (mrem/y)	Resulting Dose to Adult (mrem/y)	Resulting Risk to Child (c/Life)	Resulting Risk to Adult (c/Life)
Co-60	0.13	1.4	1.1	4 E-6	5 E-6
Cs-137	0.09	0.2	0.19	8 E-7	2 E-6
Total	na	1.6	1.3	4 E-6	7 E-6

4.5 Health Protectiveness of Final Configuration of Site

After remediation, the health protectiveness of the site will be verified. Dose rates (above background) from external exposures will be measured throughout the site. The contribution to dose from soil, water, and on-property food sources will be investigated using the measured values of Co-60 and Cs-137 in soil and the RESRAD scenario for immediate occupation by a hypothetical residential family. These results will be combined to demonstrate the annual dose (above background) to the hypothetical receptors from the remediated site meets the 25 mrem/y release limit to allow for unconditional release.

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