FINAL

RATTLESNAKE CREEK FINAL STATUS SURVEY PLAN

TONAWANDA, NEW YORK

February 2004 (Rev 01 September 2005)

U.S. Army Corps of Engineers
Buffalo District Office
Formerly Utilized Sites Remedial Action Program

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prepared by
U.S. Army Corps of Engineers, Buffalo District Office, Formerly Utilized Sites Remedial Action Program

with technical assistance from
Environmental Assessment Division, Argonne National Laboratory

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ACRONYMS, ABBREVIATIONS, AND SYMBOLS

ac	acre(s)
ARAR	applicable or relevant and appropriate requirement
CCQC	contractor chemical/radiological quality control
COC	contaminant of concern
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CQC	contractor chemical/radiological quality control
CSM	conceptual site model
cm	centimeter(s)
CFR	*Code of Federal Regulations*
DCGL	derived concentration guideline limit
DOE	U.S. Department of Energy
DoD	U.S. Department of Defense
DOT	U.S. Department of Transportation
DQA	data quality assessment
DQCR	daily quality control reports
DQO	data quality objectives
EPA	U.S. Environmental Protection Agency
FUSRAP	Formerly Utilized Sites Remedial Action Program
ESD	explanation of significant differences
FSP	field sampling plan
FSS	final status survey
ft	foot (feet)
g	gram(s)
GPS	global positioning system
GWS	gamma walkover survey
H_0	null hypothesis
ha	hectare
IDW	investigation-derived waste
in.	inch(es)
IT	IT Corporation
Kg	kilogram
LBGR	lower bound of gray region
m	meter(s)
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
mrem	millirem(s)
MS/MSD	matrix spike/matrix spike duplicate
NaI	sodium iodide
NCR	nonconformance report
NRC	Nuclear Regulatory Commission
NYSDEC	New York State Department of Environmental Conservation
PARC	precision, accuracy, representativeness, completeness
pCi	picoCurie(s)
pvc	polyvinylchloride
PPE	personal protective equipment

ACRONYMS, ABBREVIATIONS AND SYMBOLS (CONT'D)

QA	quality assurance
QC	quality control
QAPP	quality assurance project plan
Ra	radium
RESRAD	RESidual RADioactivity
Rn	radon
ROD	record of decision
S	second
SAP	sampling and analysis plan
SS&HP	site safety and health plan
SOP	standard operating procedure
SOR	sum of ratios
Th	thorium
TPP	technical project planning
U	uranium
USACE	U.S. Army Corps of Engineers
XRF	x-ray fluorescence
yr	year

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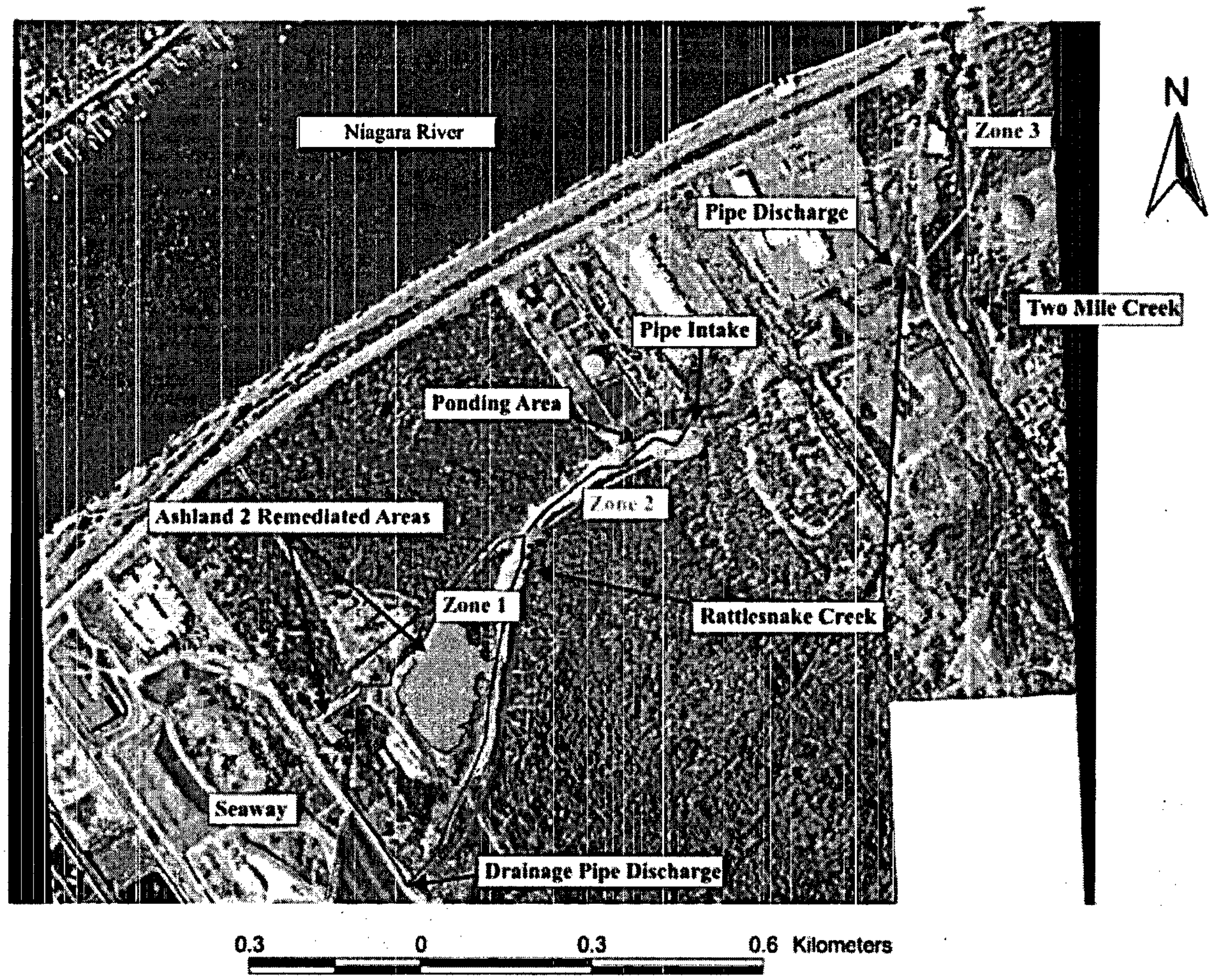
1 INTRODUCTION

This plan provides a framework for conducting a final status survey of Rattlesnake Creek sediment and floodplain soils located adjacent to the Ashland 2 site in Tonawanda, New York. The study area is illustrated in Figure 1-1. The survey will identify radioisotopes that are present and determine the levels and extent of residual radiological material, if any, in creek bed and floodplain sediments/soils. The results of the survey will be compared to cleanup goals established in the *Record of Decision for the Ashland 1 (including Seaway Area D) and Ashland 2 Sites, Tonawanda, New York* (ROD) (U.S. Army Corps of Engineers [USACE] 1998a). The guidance found in the *Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM)* (U.S. Environmental Protection Agency [EPA] 2000b), USACE's technical project planning (TPP) process (EM 200-1-2), and the data quality objective (DQO) process (EPA 1994 and 2000a) will be used to demonstrate compliance with the ROD. This plan includes a means to statistically evaluate sediment/soil contamination levels for residual radiological contaminants of concern (COCs) by using the MARSSIM process and outlines the contents of the final status survey report for each survey unit within the study area. This document is organized into the following sections:

1. Introduction – briefly describes this document's content and purpose
2. Site Description – contains a physical description of the site and site contaminants
3. Organization and Responsibilities – lists the parties involved in final status survey activities and the general responsibilities of each party
4. Data Quality Objectives – outlines a systematic procedure for defining the site criteria by which the data collection design is satisfied
5. Testing for Compliance with Cleanup Goals – calculates the number of samples required to satisfy data quality objectives and field procedures
6. Field Activities – specifies the methods used to conduct field activities
7. Laboratory Analysis – specifies the methods for analyzing soil/sediment samples collected during the final status sampling survey
8. Report of Survey Findings – provides an overview of the basic information to be provided in the final status sampling survey report
9. References – lists citations

This plan is based on information available at the time of its preparation. Radiological data from the *Rattlesnake Creek Investigation Report - Uranium Sediment Concentrations and Dose Impact Analysis* (USACE 1999) indicated the need for surveys along Rattlesnake Creek. Rattlesnake Creek was also part of the *Feasibility Study for the Tonawanda Site* originally conducted by the U.S. Department of Energy (DOE 1993b). Other sources of information used in the plan include the *Remedial Investigation for the Tonawanda Site* (DOE 1993a); the *Uranium-238 Investigation, Rattlesnake Creek — Phase I, Tonawanda, N.Y.* (USACE 1998b); *Rattlesnake Creek Investigation Summary Report* (IT 2001); *Rattlesnake Creek Follow-Up Investigation Report* (IT 2002); *Data Report for the Ashland-Rattlesnake Creek Site Sampling Tonawanda, New York* (Cabrera Services 2004); and *Data Report-Addendum 1 for the Ashland-Rattlesnake Creek Site Sampling Tonawanda, New York* (Cabrera Services 2005). Additional historic information on site operations, conditions encountered at the time of the survey implementation, and findings as the survey progresses may trigger modifications to this plan. If modifications are deemed necessary, they will be justified and documented, including appropriate project approvals.

Figure 1-1 Rattlesnake Creek Study Area



2 DESCRIPTION

Rattlesnake Creek originates on the Ashland Oil Refinery and Seaway properties in the Town of Tonawanda. It is a natural channel about 2,320 meters (m) (7,600 feet [ft]) long that drains a total area of 138 hectares (ha) (340 acres [ac]) before joining Two Mile Creek. About 305 m (1,000 ft) downstream of its confluence with Rattlesnake Creek, Two Mile Creek joins the Niagara River (DOE 1993a). The upper reaches of Rattlesnake Creek comprise drainage ditches on the Seaway and Ashland 1 site. The flow from these ditches is collected by a 335 m (1,100 ft) long, 1 m (3 ft) diameter reinforced concrete pipe running under Seaway, which discharges at the Niagara Mohawk property line (DOE 1993a).

Rattlesnake Creek crosses the Niagara Mohawk property and then Ashland 2. On the Ashland 2 property, the channel is approximately 3 m (10 ft) wide and about 1 m (3 ft) deep at bank-full capacity. Its slope across Ashland 2 is approximately 1.1%. Thick vegetation in the channel hinders flow. Through most of its length, the Rattlesnake Creek floodplain is approximately 30 m (100 ft) wide with a thick growth of cattails and bulrushes. The creek disappears in the lower reach after the confluence of the north and south branches. The elevation of the surrounding land increases and forms a cove like area where the creek appears to pond before entering an underground pipe. The creek reappears via the underground metal pipe approximately 30 m (100 ft) before the creek passes under Two Mile Creek Road. The floodplain is considerably less than 30 m (100 ft) wide from the underground pipe to the Niagara River (DOE 1993a).

The bulk of the Rattlesnake Creek floodplain and streambed is dry during the summer. Consequently, for the purposes of this plan the terms "soils" and "sediments" are used interchangeably when referring to soils/sediments within the Rattlesnake Creek area of concern.

A number of data collection programs have been conducted in the Rattlesnake Creek vicinity, primarily focusing on the streambed and adjacent floodplain. Between 1998 and prior to the start of remediation, more than 1,300 surface and subsurface soil samples were collected and analyzed for thorium-230 (Th-230), radium-226 (Ra-226), and uranium-238 (U-238). In addition, gamma walkover surveys using a 3×3 sodium iodide (NaI) detector were completed for a significant portion of the Rattlesnake Creek streambed and floodplain. Finally, more than 2,800 individual soil samples (surface and subsurface) were screened for total uranium content using x-ray fluorescence (XRF). For more detailed descriptions of the previous investigations and samples results, please see *Uranium-238 Investigation, Rattlesnake Creek — Phase I, Tonawanda, N Y,* (USACE 1998b); *Rattlesnake Creek Investigation Summary Report* (IT 2001); *Rattlesnake Creek Follow-Up Investigation Report* (IT 2002); *Data Report for the Ashland-Rattlesnake Creek Site Sampling Tonawanda, New York* (Cabrera Services 2004); and *Data Report-Addendum 1 for the Ashland-Rattlesnake Creek Site Sampling Tonawanda, New York* (Cabrera Services 2005). To summarize the findings to date, the Rattlesnake Creek area can be divided into three zones (Figure 1-1). Zone 1 encompasses the upper reaches of the creek and includes the two branches of Rattlesnake Creek that bracket the Ashland 2 remediated areas. Zone 2 is the reach of the creek from the confluence of the two branches to the location where the creek disappears in the pond area. Zone 3 is from the discharge of the underground pipe to where Two Mile Creek joins the Niagara River.

Zone 1 includes the north and south branches of Rattlesnake Creek. In the south branch, contamination above ROD requirements was observed almost continuously from the outfall of the Seaway pipe to the confluence of the north and south branches. Contamination appears to be confined to a depositional layer approximately 0.3 to 0.6 m (1 to 2 ft) thick that is buried at a depth of approximately 1 m (3 ft) at the Seaway outfall pipe. Moving downstream from the Seaway outfall towards the confluence, the data results indicate that the contaminated layer is closer to the surface and in some localized downstream areas contamination is detected at the surface. The width of the contamination in the south branch varies moving downstream, but in general it is confined to the streambed and the associated floodplain. The exception to this are contaminated spoils piles parallel to a portion of the east bank of the south branch that may have been the result of trenching activities performed within the drainage area of the creek. Contamination in the south branch is characterized by the presence of elevated Th-230, Ra-226, and U-238 activity concentrations. The ROD Sum of Ratio (SOR) exceedances are driven primarily by Th-230. Maximum activity concentrations observed in pre-remediation discrete (discrete samples are defined as samples representative of a 15 centimeters (cm) [6 in] interval of soil) sample results for Zone 1 were 91 picoCuries per gram (pCi/g), 11 pCi/g, and 166 pCi/g for Th-230, Ra-226, and U-238, respectively. Maximum activity concentrations observed in pre-remediation subsurface composite sample results for Zone 1 were 20 pCi/g, 2.7 pCi/g, and 90 pCi/g, for Th-230, Ra-226, and U-238, respectively.

The observed nature of contamination in the north branch is significantly different from that in the south. In the north branch contamination above ROD requirements appears to be much more localized and confined to surface/near surface soils. Contamination in the north branch is characterized by the presence of elevated Th-230 and Ra-226 activity concentrations, at times in the absence of U-238 above background levels. The bulk of contamination was again confined to the streambed and associated floodplain; however, in the case of the north branch, the flood plain is significantly narrower compared to the south branch. There was isolated evidence of very localized contamination along the west bank of the north branch, again possibly resulting from historical streambed trenching activities. Ashland 2 excavation activities extended into portions of both the north and south branches. Consequently some portions of Zone 1 had already been remediated.

In Zone 2, continuous contamination above ROD requirements was identified from the confluence of the north and south branches to the push-out pile area, located west of the ponding area. The push-out pile is comprised of debris/fill material that at some point after 1960 was pushed into the Rattlesnake Creek floodplain from the northwest, diverting the stream around its toe. An isolated area of contamination above ROD requirements was also identified between the push-out pile and the intake pipe marking the northern end of Zone 2. All of the contamination was confined to the streambed and associated floodplain and to surface/near surface soils. Contamination in Zone 2 is characterized by the presence of elevated Th-230, Ra-226, and U-238 activity concentrations. Maximum activity concentrations detected in pre-remediation discrete sample results for Zone 2 were 54 pCi/g, 7.5 pCi/g, and 100 pCi/g for Th-230, Ra-226, and U-238, respectively. Maximum activity concentrations observed in pre-remediation subsurface composite sample results for Zone 2 were 12 pCi/g, 3 pCi/g, and 27 pCi/g, for Th-230, Ra-226, and U-238, respectively.

In Zone 3, maximum activity concentrations detected in pre-remediation discrete sample results were 3.0 pCi/g, 1.8 pCi/g, and 27 pCi/g for Th-230, Ra-226, and U-238, respectively. Maximum activity concentrations observed in pre-remediation subsurface composite sample results for Zone 3 were 10 pCi/g, 1.2 pCi/g, and 36 pCi/g, for Th-230, Ra-226, and U-238, respectively. In 2004, additional soil coring and sample analyses were conducted immediately adjacent to the one anomalous (10 pCi/g) Th-230 composite sample result. These analyses did not identify any contamination above ROD requirements.

In all zones, contamination, when it occurs, appears to be contained in a 0.15 to 0.6 m (0.5 to 2 ft) thick layer that may be found anywhere from the surface to a depth of 1 m (3 ft). The maximum level of observed contamination, the fraction of samples that exceed derived concentration guideline limit (DCGL) requirements, and the average levels of contamination fall significantly as one moves from Zone 1, to Zone 2, and finally, to Zone 3.

The conceptual site model (CSM) for Rattlesnake Creek is as follows. Contamination found within the creek bed and floodplain originated from ore residuals placed on the Seaway and Ashland properties. COCs identified in the ROD include Ra-226, Th-230, and U-238. Radionuclide-contaminated material migrated via erosional processes into Rattlesnake Creek, which is the drainage feature for the area. Erosional episodes were likely associated with large rainfall and/or snowmelt events and probably occurred most heavily in the initial time period after residual ore placement on the Seaway and Ashland properties, before natural stabilization of that material took place through revegetation. Radionuclide-contaminated material was deposited in the creek stream bed and adjacent floodplain. Depositional processes would have been determined by the physical characteristics of the creek at the time. In general, one would expect deposition to be at its maximum immediately downstream from the Seaway and Ashland properties, with decreasing depositional zones farther downstream. One would expect to see decreasing deposition moving from the centerline of the creek bed orthogonally to the edge of the floodplain. There likely is a maximum depth differential between the ground surface for the creek bed and bank surface above which one would not find contaminated deposits. Given the time span since original ore placement, one would expect to see instances where contaminated sediments have been covered by more recent sedimentation from "clean" material. For all three COCs, Ra-226, Th-230, and U-238, the assumed initial transport mechanism was erosion and associated soil particle mobilization, transport, and deposition. However, given the greater solubility of uranium relative to thorium and radium, one would expect to see a more dispersed footprint laterally and vertically for uranium than for the other two radionuclides. The historical data show a deeper vertical footprint for uranium impacts than thorium or radium in the Rattlesnake Creek soils and sediments, indicative of vertical transport after deposition in a manner that was different from radium and thorium.

3 ORGANIZATION AND RESPONSIBILITIES

Argonne National Laboratory developed this final status survey plan for Rattlesnake Creek. The USACE or designee is responsible for the implementation of the final status survey as detailed in this plan and will maintain independence in the final status survey process consistent with USACE Headquarters policy.

. 4 DATA QUALITY OBJECTIVES

The DQOs for the Rattlesnake Creek final status sampling survey are provided below to establish a systematic procedure for defining the criteria that must be met for the data collection design to be satisfied. The DQO process includes a description of when to collect samples, where to collect samples, the tolerable level of decision errors for the study, and how many samples to collect. The DQO process has the following seven steps listed below (EPA 1994 and 2000a).

1. State the problem.
2. Identify the decision.
3. Identify inputs to the decision.
4. Define the study boundaries.
5. Develop the decision rule.
6. Specify tolerable limits on decision errors.
7. Optimize the design.

The DQO process is described in the following sections as it applies to the Rattlesnake Creek final status survey.

4.1 STATE THE PROBLEM

This final status survey plan will be used to determine whether residual radionuclide concentrations in Rattlesnake Creek soils/sediments comply with cleanup criteria as defined in the ROD (USACE 1998a) and associated *Explanation of Significant Differences for the Rattlesnake Creek Portion of the Ashland Sites, Tonawanda, New York (*ESD) (USACE 2004). Descriptions of the key elements for showing compliance with the ROD are provided in Section 4.2. Compliance with the ROD will be demonstrated by using guidance found in MARSSIM (EPA 2000b). Specifically, compliance will be demonstrated by performing gamma surface scans, where possible, and collecting systematic (i.e., samples associated with a grid) and biased (i.e., samples targeting specific locations or intervals of concern) sediment/soil samples consistent with MARSSIM guidance. When the Rattlesnake Creek study area demonstrates compliance with the criteria specified in the ROD, it may be released for unrestricted use.

4.2 IDENTIFY THE DECISION

This plan assumes that the Rattlesnake Creek sediments/soils have been contaminated with radioactive materials migrating from the Seaway and Ashland properties. The intent of this plan is, therefore, to use final status survey data to determine whether site contaminants are present at levels above or below cleanup levels in the ROD. The ROD requirements are the following:

1. Soils exceeding the derived guideline of 40 pCi/g Th-230 will be excavated and shipped off site for disposal (ROD-specific derivation based on Title 40, Part 192, of the *Code of Federal Regulations* [40 CFR Part 192]).

2. Ra-226 concentrations shall not exceed background levels by more than 5 pCi/g in the top 15 cm (6 in.) or by more than 15 pCi/g in any subsequent 15 cm (6 in.) layer, averaged over 100 m^2 (Subpart B of 40 CFR 192).
3. The release of radon-222 (Rn-222) and radon-220 (Rn-220) into the atmosphere resulting from the management of uranium and thorium by-product materials shall not exceed an average release rate of 20 pCi/m^2-s (Subpart D of 40 CFR 192).
4. The radiological dose to a potential residential receptor must be equal to or less than 25 mrem/yr (Subpart E of 10 CFR 20).

These requirements determine compliance with site cleanup goals. If any one of these conditions is not met for any survey unit, the survey unit cannot be released. RESRAD modeling has established that ROD requirement 3 will be satisfied if requirements 1 and 2 are met, and so consideration of ROD requirement 3 will be dropped for the purposes of this final status survey plan. Appendix B contains the details of that modeling.

This final status survey plan will be consistent with MARSSIM. MARSSIM uses two activity concentration cleanup requirements known as derived concentration guideline levels (DCGLs). They are derived from dose or risk goals. The first, the $DCGL_w$, refers to a wide area average that must hold over areas the size of a survey unit. The second, the $DCGL_{emc}$, refers to an elevated measurement comparison that addresses more localized elevated areas that may significantly exceed the $DCGL_w$ at specific locations but not when averaged over a survey unit. DCGLs are developed so that post-remediation residual activity concentrations are consistent with the dose or risk goals set for the site.

The fourth ROD requirement states that the radiological dose to a potential residential receptor must be equal to or less than 25 millirems/year (mrem/yr) (Subpart E of 10 CFR 20). DCGLs for Rattlesnake Creek were developed to be consistent with this requirement for the three principal radionuclides of concern (Ra-226, Th-230, and U-238). Initial DCGLs were developed by using RESRAD 6.10 and site-specific parameters and scenarios detailed in the *Radionuclide Cleanup Guideline Derivation for Ashland 1, Ashland 2, and Seaway* (DOE 1997) and the *Rattlesnake Creek Investigation Summary Report* (IT 2001). DCGLs were developed for surficial soils (top 15 cm [6 in.] of soil presumed contaminated, all soils beneath at background levels) and subsurface soils (soils at depths greater than 15 cm [6 in.]). Three DCGLs were derived for both surface and subsurface soils. These included a $DCGL_w$ and two $DCGL_{emc}$ requirements. In the case of the $DCGL_w$ for subsurface soils, contamination was assumed to be vertically averaged over a depth of 15 cm (6 in.) to 1 m (3 ft). The first $DCGL_{emc}$ addressed 100-m^2 areas and vertical intervals equal to 15 cm (6 in.). The second $DCGL_{emc}$ addressed 1-m^2 areas and vertical intervals equal to 15 cm (6 in.). All DCGLs were derived by assuming no cover for the site to be consistent with the scenario described in the *Radionuclide Cleanup Guideline Derivation for Ashland 1, Ashland 2, and Seaway* (DOE 1997). Details on the DCGL development can be found in Appendix A.

There were three reasons for selecting a 0.15 to 1 m (0.5 to 3 ft) averaging depth for evaluation of $DCGL_w$ requirements in the subsurface. First, while it is true that subsurface contamination is typically confined to a relatively thin layer within the Rattlesnake Creek channel, the depth of that layer can vary from near surface to a depth of 1 m (3 ft), based on historical data. This makes assigning a $DCGL_w$ requirement to a particular depth interval problematic. Historical data suggests that if contamination exists at a particular location, it will be identified within a 1 m (3 ft) depth. Second, MARSSIM does not provide guidance on how to demonstrate that subsurface soils comply with the cleanup criteria. This plan attempts to address the subsurface soils in a manner consistent with MARSSIM concepts. For surface soils, the $DCGL_w$ is a wide area average value. A natural extension to the subsurface would be to interpret the $DCGL_w$ as a volumetric average. The averaging volume should correspond to those soils that are likely to contribute to a potential receptor's dose. Again, consistent with historical information, a 0.15 to 1 m (0.5 to 3 ft) depth was selected to represent the subsurface volume. The RESRAD-derived DCGL values for the subsurface honor this dose scenario (with no assumption of cover). Finally, on the basis of the historical data, the USACE recognized that there is a potential for thin layers of subsurface soils within a 1 m (3 ft) depth to contain concentrations of elevated radionuclides. For that reason, the USACE also derived 15 cm (6 in.) interval specific $DCGL_{emc}$ requirements that must be met at each sampling location.

Table 4-1 contains the DCGL values for Rattlesnake Creek. The values in Table 4-1 represent the lowest values resulting from either the DCGL values for surface or subsurface soils derived from the fourth ROD requirement, or specified activity concentrations contained in the first and second ROD requirements. For example, the $DCGL_{emc}$ for Ra-226 in 100-m^2 area surface soils based on the 25 mrem/yr requirement was higher than the ROD requirement that specifies a Ra-226 activity concentration of 5 pCi/g over 100-m^2 areas. In this case, the 5 pCi/g requirement was retained. The $DCGL_{emc}$ for Th-230 in subsurface soil over 100-m^2 areas derived from the 25 mrem/yr requirement was lower than the first ROD requirement of 40 pCi/g. In this case, the 14 pCi/g $DCGL_{emc}$ was adopted for Th-230. These proposed DCGLs result in a dose for residential use that is less than 25 mrem/yr. The proposed DCGLs are incremental to background. Because the 25 mrem/yr is a measure of total dose, the implementation of DCGLs will be handled through the use of sum of ratios. The $DCGL_w$ will be applied to areas the size of survey units. It was derived so that the 25 mrem/yr dose requirement would be met if the $DCGL_w$ was achieved regardless of survey unit size.

Table 4-1. Derived Concentration Guideline Levels for Rattlesnake Creek

Radionuclide	$DCGL_w$ (pCi/g)	$DCGL_{emc}$ (pCi/g)	
	Survey Unit	100 m^2	1 m^2
Ra-226	4.3	5	16
Th-230	12	14	46
U-238	350	450	2000

For the purposes of the final status survey work, the ROD requirements can be distilled into the following MARSSIM-consistent requirements:

1. SOR values will be used to evaluate the $DCGL_w$. SOR values averaged over each final status survey unit must be less than or equal to 1. SOR values will be calculated by using the relevant activity concentration guidelines for Th-230, Ra-226, and U-238 (12, 4.3, and 350 pCi/g, respectively).

SOR values will be calculated for surface soils (as represented by samples from the top 15 cm [6 in.] of soil) and for subsurface soils (as represented by samples obtained from homogenized, 0.15 to 1 m [0.5 to 3 ft] deep soil cores). Both surface and subsurface soil samples will be required to comply with the same $DCGL_w$ requirement.

2. SOR values will also be used to evaluate $DCGL_{emc}$ standards:

   a. SOR values derived from the 100-m^2 $DCGL_{emc}$ requirements and averaged over 100-m^2 areas must be less than or equal to 1. In this case, SOR values pertinent to 100-m^2 areas will be calculated by using the relevant activity concentration guidelines for Th-230, Ra-226, and U-238 (14, 5, and 450 pCi/g, respectively), after adjusting for background.

      SOR values will be calculated for surface soils (as represented from the top 15 cm [6 in.] of soil) and for subsurface soils. Subsurface soils will be represented by samples obtained from 0.15 to 1 m (0.5 to 3 ft) deep homogenized soil cores and by biased samples from those cores, if it is determined by scans that individual intervals potentially exceed $DCGL_{emc}$ standards. Surface and subsurface samples will be required to comply with the 100-m^2 $DCGL_{emc}$ standard.

   b. For all sampled locations, the SOR value derived from the 1-m^2 $DCGL_{emc}$ requirements must be less than or equal to 1. SOR values for individual locations will be calculated by using the relevant activity concentration guidelines for Th-230, Ra-226, and U-238 (46, 16, and 2,000 pCi/g, respectively), after adjusting for background.

      SOR values will be calculated for surface soils (as represented from the top 15 cm [6 in.] of soil) and for subsurface soils. Subsurface soils will be represented by samples obtained from 0.15 to 1 m (0.5 to 3 ft) deep homogenized soil cores and by biased samples from those cores, if it is determined by scans that individual intervals potentially exceed $DCGL_{emc}$ standards. Surface and subsurface samples will be required to comply with the 1-m^2 $DCGL_{emc}$ standard.

The background values to be used for Ra-226 and Th-230 are 1.1 pCi/g and 1.4 pCi/g, respectively as reported in the *Remedial Investigation Report for the Tonawanda Site* (DOE 1993a). The background value to be used for U-238 is 1.2 pCi/g as reported by the New York State Department of Conservation (NYSDEC) (NYSDEC 2003).

An analysis of data obtained to date from the Rattlesnake Creek area indicates that Th-230 will be the primary COC from a final status survey perspective. There is no evidence that U-238 exceeds DCGLs defined for the site, and only very limited evidence that Ra-226 exceeds DCGLs in isolated locations. The majority of DCGL exceedances observed to date involve Th-230.

4.3 IDENTIFY INPUTS TO THE DECISION

Guidance provided in MARSSIM (EPA 2000b) is the basis for this final status sampling survey. The MARSSIM guidance was developed collaboratively by the Nuclear Regulatory Commission (NRC), EPA, DOE, and U.S. Department of Defense (DoD), for use in designing, implementing, and evaluating final status radiological surveys. This guidance emphasizes the use of DQO and data quality assessment (DQA) processes, along with a sound program of quality assurance/quality control. The "graded approach" concept is also used to assure that survey efforts are maximized in those areas with the highest probability for residual contamination or greatest potential for adverse impacts of residual contamination. The use of a graded approach is primarily reflected by the categorization of a site into survey unit classes, with the level of data collection dependent on survey unit classification.

Information on radiological COCs must be collected from two key components in the field for the final status survey sampling: (1) surface soil and sediments within the Rattlesnake Creek floodplain and (2) subsurface soils. A more detailed discussion of specific field activities is included in Section 6.1. Three techniques will be used in the field to generate information pertinent to the final status survey requirements. These include surface gamma scans, scans of subsurface soil cores, and surface/subsurface soil sampling combined with an appropriate laboratory analytical technique (e.g., gamma and alpha spectrometry).

4.3.1 Surface Gamma Scans

Surficial scans, where possible, are particularly effective at identifying spatial trends in surficial contamination and potential $DCGL_{emc}$ concerns. Surficial gamma scans will be collected through systematic walkovers and/or through stationary readings at selected locations using a 3 × 3-in NaI detector. Locations for both mobile and stationary scans will be logged using a global positioning system (GPS) unit or some equivalent technique. Gamma walkover surveys may not be feasible for some areas of the Rattlesnake Creek study area. The primary problem is that some of the area is seasonally covered with a thin layer of water. The water is not of uniform depth; therefore, gamma readings would be affected inconsistently. In addition, the sampling area is densely vegetated with both herbaceous and woody plants, and there are steep banks that are sometimes overlain with thick foliage. Mechanized land clearing, resulting in considerable ground disturbance, would be required in order to accomplish a 100% walkover survey. This would not address the primary problem of thin water cover over much of the area.

Table 4-2 lists radiological field survey instruments that are commonly used. (Functional and performance equivalents may be used, as determined by a certified health physicist.) Site-specific detection sensitivities for the Tonawanda Formerly Utilized Sites Remedial Action Program (FUSRAP) site have been calculated by following the approach detailed in NUREG-1507 (NRC 1998). While Th-230 alone is not readily identifiable at DCGL levels using a 3 × 3-in. NaI detector, the presence of collocated Ra-226 and/or U-238 enhances the ability of scans to identify Th-230 problems. An analysis of the pre-excavation data sets found that Th-230 contamination that ranged between 14 and 83 pCi/g had, on average, 2 pCi/g of Ra-226 associated with it, indicating that it should be marginally detectable. If possible, an investigation level for surficial soils will be developed by determining background count rates for a set of locations across the Rattlesnake Creek area of concern, determining an average background response and its variability, developing a detection limit estimate based on MARSSIM's recommended process, and using this gross activity detection limit as the investigation level for further investigation/biased sampling.

Table 4-2. Typical Gamma Scan Instruments

Description	Application	Approximate Detection Sensitivity (pCi/g) [a]
Ludlum Model 44-10;. 3 × 3-in. NaI gamma scintillation detector	Gamma scans of all surfaces	Th-230 (2,120); Ra-226 (2.8); total uranium (80)
Ludlum Model 2221; Rate meter/scaler (with earphones)	Readout instrument for gamma scintillation detector	Not applicable

[a] Isotopic detection sensitivity is based on radiological characteristics of that isotope when a 1-second (s) acquisition time is assumed. The presence of other commingled radionuclides may significantly increase the sensitivity to some radionuclides as a result of the detection of surrogates. In addition, longer acquisition times will also lower detection limits.

4.3.2 Subsurface Soil Core Scans

At the Ashland sites, enough Ra-226 was commingled with Th-230 to allow reliable identification of Th-230 above the ROD cleanup level via gamma walkover surveys using a 2 × 2-in. NaI sensor to guide the excavation. This is not the case at Rattlesnake Creek. Also, at Rattlesnake Creek, there is the possibility of contaminated layers buried beneath clean surficial sediments, thus, identification of Th-230 DCGL exceedances in subsurface soils with gross gamma techniques is probably not likely. However, a review of pre-excavation subsurface data from Rattlesnake Creek indicates that total uranium activity concentrations are generally higher than the activity concentrations of Th-230. This suggests that total uranium measured using XRF could be used to screen for elevated thorium intervals. Subsurface soil core scans are particularly effective in determining vertical contamination trends in subsurface soils for specific locations and in identifying potential $DCGL_{emc}$ exceedances. Subsurface soil core intervals will be scanned for the presence of total uranium by using XRF.

Field applicability of XRF was evaluated during pre-remediation characterization work to determine the most appropriate screening/scanning technology for subsurface soil cores and to develop the necessary investigation levels/implementation protocols. Field applicability studies of XRF found excellent agreement between XRF results and laboratory analyses for total uranium. Detection limits for XRF as deployed were in the range of 16 ppm, well below levels of concern. Based on analyses of a subset of historical data, an initial investigation level of 90 ppm was determined that appeared to separate soil samples with DCGL exceedances from those with results below DCGL standards. Subsequent data sets generated by the deployment of XRF as part of pre-excavation data collection activities determined that uranium was not reliably collocated with Th-230 in the north branch of the creek, and that in the south branch 40 ppm total uranium provided better performance for identifying potential Th-230 exceedances than did 90 ppm.

Subsurface soil cores may be retrieved through either traditional soil augering techniques or direct push technologies.

4.3.3 Soil and Sediment Samples

Physical samples will be collected from surface and subsurface soils to support the MARSSIM final status survey process. The primary data collection activities for Rattlesnake Creek involve soil/sediment samples. It is important to note, however, that the vast majority of these sediments will not be covered by water at the time of field work and so the approach to characterizing "sediment" contamination potential is the same as would be applied to soils.

Physical samples from surface soils/sediments will be representative of the top 15 cm (6 in.) of soil. Physical samples from subsurface soils/sediments will be of two types: samples from 0.15 to 1 m (0.5 to 3 ft) deep homogenized soil cores that will be used to determine average residual concentration levels for comparison against a $DCGL_w$ value, and samples representative of 15 cm (6 in.) intervals when scanning techniques or visual evidence identify subsurface intervals that may pose $DCGL_{emc}$ concerns. Physical soil samples will be submitted for gamma or alpha spectrometry analysis of Ra-226 and for alpha spectrometry analysis of Th-230 and U-238.

4.4 DEFINE THE STUDY BOUNDARY

The Rattlesnake Creek area is composed of three components: the actual stream channel or creek bed itself which is relatively narrow (approximately 3 m (10 ft) wide or less), the adjacent flood plain which can range from 10 to 60 m (33 to 197 ft) in width and is characterized by cattails (and is also dry most of the season), and uplands, characterized by the emergence of woody plants (DOE 1993a). The distinction between uplands/woody plants and the floodplain is distinct and well-defined for most of the stream length.

The study boundary encompasses the area of concern associated with Rattlesnake Creek, which includes the creek bed itself and adjacent floodplains where they exist. Field work at the site indicates that the creek bed is approximately 3 m (10 ft) wide and about 1 m (3 ft) deep at the bank-full capacity. Through most its length the Rattlesnake Creek floodplain is approximately 30 m (100 ft) wide; however, the actual flood plain width for any particular portion of the reach can vary significantly (DOE 1993a). The creek disappears in the lower reach after the confluence of the east and west branches. The elevation of the surrounding land increases and forms a cove-like area where the creek appears to pond before entering an underground pipe. The creek reappears via an underground metal pipe approximately 30 m (100 ft) before the creek passes under Two Mile Creek Road. The floodplain is considerably less than 30 m (100 ft) wide from the underground pipe to the Niagara River. Almost all contaminated samples from past characterization work were confined to either the stream channel or adjacent floodplain; consequently, that is the focus of the final status survey work. The estimated study area is around 41,000 m^2 (10 ac). The size of the estimated study area is subject to change on the basis of the pre-excavation data collection activities. These activities include more detailed civil surveys to be conducted prior to initiation of the final status survey work to better define floodplain boundaries and map areas where deposition could have taken place.

The study area will be divided into Class 1, Class 2, and Class 3 units. Class 1 units will be areas where remediation has taken place or where data indicate the presence of contamination above DCGL requirements. For Rattlesnake Creek, excavation is expected for portions of the study area, particularly in Zone 1, and in the reaches directly below the Ashland 2 area. These locations correspond to the areas where the highest and most consistently elevated concentrations of radionuclides have been encountered. In general, Class 1 units will conform to the streambed and associated floodplain, if present. The exact lateral boundaries and shape of Class 1 final status survey units may be modified based on additional characterization data and excavation footprints. Class 1 final status survey units are expected to be 2,000 m^2 in size. The excavation work in the creek bed may be spotty and discontinuous, reflecting the nature of the deposited contamination. Consequently, individual Class 1 units may include both excavated and unexcavated portions of the creek bed and/or flood plain.

Class 2 units will be areas where there is evidence of elevated levels of residual radionuclides but no evidence that the levels exceed DCGL requirements. Class 2 units will capture the balance of the area not covered by Class 1 units in Zones 1 and 2. Class 2 areas may be as large as 10,000 m^2. Class 2 units will extend from the centerline of the creek bed to the physical limits of the floodplain, as defined by civil surveys. Class 2 units will be located in Rattlesnake Creek reaches below Class 1 units to the end of Zone 2.

Zone 3 will be considered a single Class 3 unit since there is little evidence that the soils/sediments have been impacted on the basis of the historical samples, and no evidence of contamination above DCGL levels.

These definitions are for planning purposes only. The actual layout of units and individual unit boundaries may be redefined at the discretion of the field team leader with the approval of USACE, as dictated by field conditions and sample data. The discovery of unexpected contamination during final status survey work in Class 2 areas may require remediation and reclassification of areas as Class 1 units. Likewise, contamination above DCGL levels that may be unexpectedly encountered in the Class 3 unit will require remediation and reclassification of affected areas as Class 1 units.

4.5 DEVELOP THE DECISION RULE

Figure 4-1 is a flow diagram that illustrates the sequence of events in each Class 1 survey unit. The flow of events is consistent with MARSSIM guidance and is intended to determine whether a survey unit is ready for release or if other action is required. If contamination above DCGL requirements is encountered in a survey unit (including small areas of elevated activity), the USACE will evaluate options, including the collection of additional data. This determination may be made by performing surface scans with NaI detectors or comparable radiation detectors, collecting soil and sediment samples, and testing sample results against statistical criteria (as described in Appendix I, Section 11 of MARSSIM). For Rattlesnake Creek, the Sign test will be used for $DCGL_w$ statistical evaluations. The primary point of comparison is the SOR value derived for the radionuclides of concern. To be consistent with past final status survey activities at Ashland 1 and Ashland 2, background values will not be subtracted from sample results when calculating $DCGL_w$ SOR values. When comparing sample results to the $DCGL_{emc}$, the SOR calculation will include removing background activity concentrations from the radionuclide results. The background values to be used for Ra-226 and Th-230 are 1.1 pCi/g and 1.4 pCi/g, respectively (DOE 1993a), and the background value to be used for U-238 is 1.2 pCi/g (NYSDEC 2003).

Figure 4-2 is a flow diagram that illustrates the sequence of events in each Class 2 survey area. A detailed discussion of the steps presented in Figures 4-1 and 4-2 is contained in Section 5 of this plan.

4.6 SPECIFY TOLERABLE LIMITS ON DECISION ERROR

As part of the DQO process, the null hypothesis for demonstrating compliance of data with cleanup goals must be stated. The null hypothesis (H_0) tested is that residual contamination exceeds the acceptance criterion (cleanup goal). If the null hypothesis is rejected, the alternative hypothesis must be accepted, and the finding of the evaluation is that the site satisfies the guideline. The Sign test will be used, as described in MARSSIM, to test the null hypothesis for $DCGL_w$ compliance. For the $DCGL_{emc}$ requirements, scan results will be compared against scanning/screening investigations derived for that purpose, and sample results will be compared directly to $DCGL_{emc}$ requirements.

To enable testing of data relative to the cleanup criteria, the USACE has established acceptable decision errors. There are two types of fundamental decision errors. The Type I (alpha) decision error to be used in data testing is 0.025 or 2.5%. The Type II (beta) decision error to be used is 0.25 or 25%. The probability of a Type II error is used to determine sample quantity per survey unit for demonstrating compliance with the $DCGL_w$. Type II errors do not adversely impact public safety and health. The USACE may decide to revise acceptable Type II error rates based on experience gained during remediation.

Data quality indicators for precision, accuracy, representativeness, completeness (PARC), and comparability have been established.

- Precision will be determined by comparison of replicate values from field measurements and sample analysis; the objective will be a relative percent difference of 30% or less at 50% of the criterion value.
- Accuracy is the degree of agreement with the true or known; the objective for this parameter will be ± 30% at 50% of the criterion value.
- Representativeness and comparability are assured through the selection and proper implementation of systematic sampling and measurement techniques.
- Completeness refers to the portion of the data that meets acceptance criteria and is therefore usable for statistical testing. The objective is 90% for this project.

The generic PARC criteria that focus on activity concentrations results and analytical performance around the DCGL requirements may not be meaningful if no contamination is encountered, which will likely be the case during final status survey work, and so other factors should be taken into account when evaluating quality and usability of the produced data sets.

Figure 4-1 Decision Flow Diagram for Class 1 Units

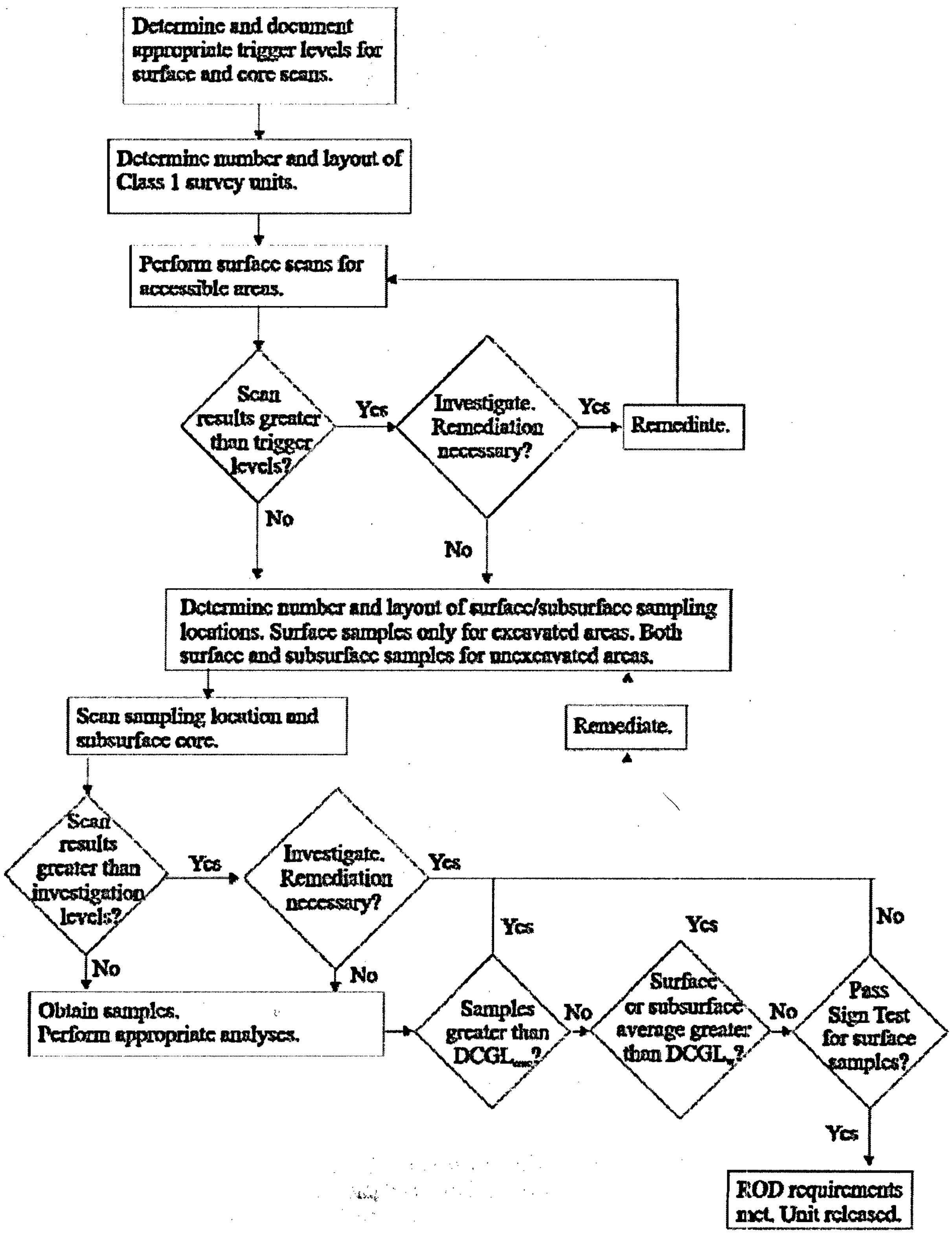
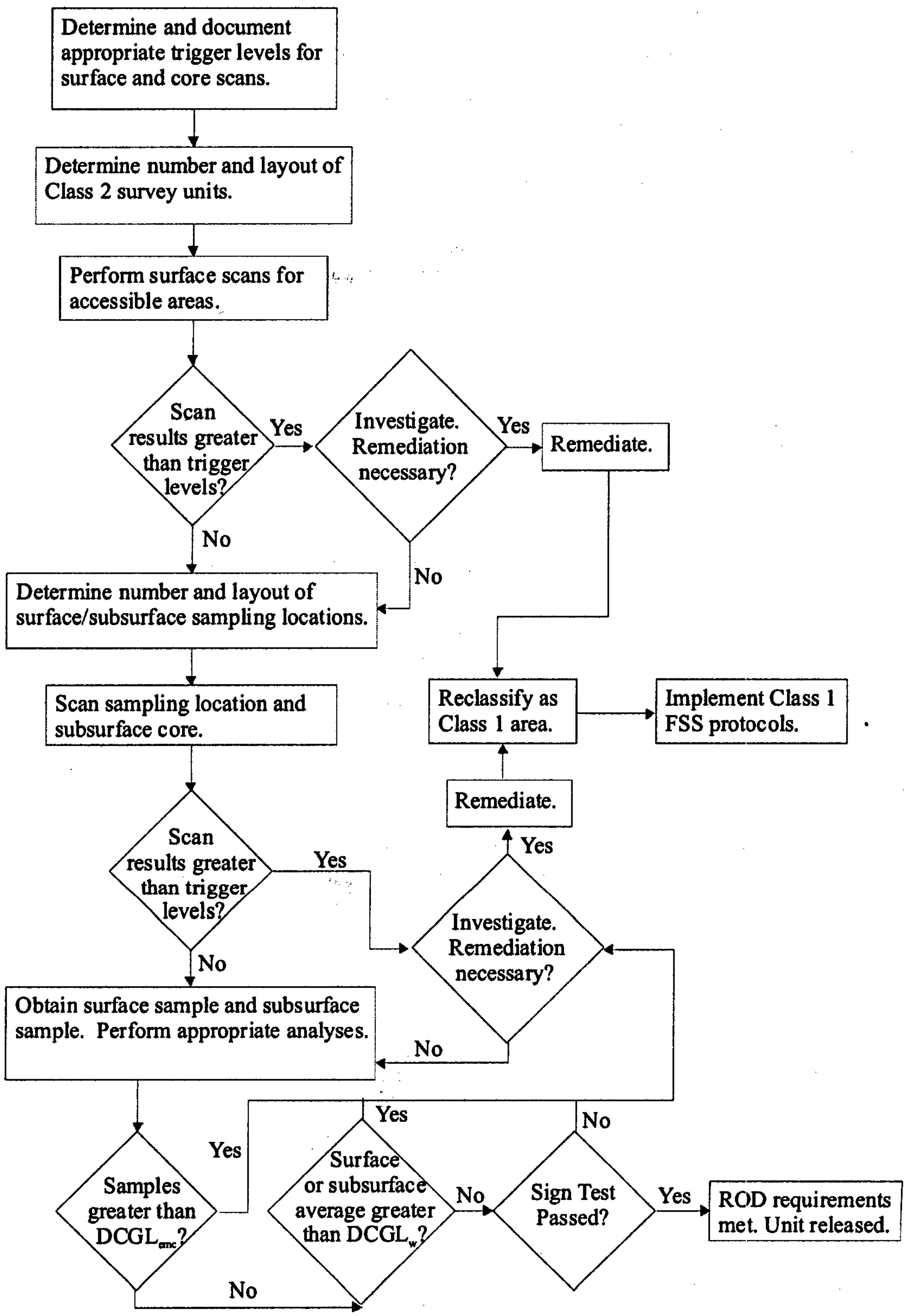


Figure 4-2 Decision Flow Diagram for Class 2 Units



4.7 OPTIMIZE THE DESIGN

Field screening techniques, soil sampling, soil sample analysis, gamma measurements, and the DQA process will be used, as appropriate, throughout the final status sampling survey to focus efforts and minimize cost. As data are collected and analyzed, the assumptions in this plan should be reviewed for accuracy. Therefore, because the number of samples calculated in the next section is based on biased data and conservative assumptions, if data from early survey units indicate that conditions are significantly different than the initial assumptions, the sample density and survey unit class may be adjusted for subsequent units.

5 TESTING FOR COMPLIANCE WITH CLEANUP GOALS

The number of samples necessary to statistically demonstrate compliance with $DCGL_W$ requirements can be calculated by using MARSSIM guidance. The data used for the preliminary calculations are based on pre-remedial characterization data from the Rattlesnake Creek area. Section 5.1 lists and describes all equations used. The number of samples per survey unit is calculated in Section 5.1.5 by using the characterization data sets.

5.1 CALCULATION METHOD FOR SAMPLE NUMBERS

This section presents the equations and methods used to estimate the number of samples required for each survey unit to determine whether the unit may be released without radiological restrictions in accordance with MARSSIM guidance for radionuclides. Sample numbers provided here may be modified on the basis of additional information. There are eight basic steps for calculating the number of samples. Each of the steps that follow is described in detail in the following sections.

1. Classify survey units.
2. Specify decision error.
3. Determine $DCGL_W$.
4. Determine relative shift.
5. Obtain the number of samples per survey unit.
6. Estimate the sample grid spacing.
7. Address small areas with elevated radioactivity.
8. Determine if the number of samples is reasonable.

5.1.1 Classification of Survey Units

MARSSIM defines impacted areas as areas that have some potential for contamination. Impacted areas are subdivided into three classes:

- Class 1 areas have, or had prior to remediation, radionuclide contamination that exceeded the $DCGL_W$.
- Class 2 areas have a potential for radioactive contamination or known contamination, but levels are not expected to exceed the $DCGL_W$.

- Class 3 areas are expected to contain no residual radioactivity or levels of residual activity at only a small fraction of the $DCGL_W$.

By definition, any area requiring remediation will be encompassed by Class 1 units. For soils, MARSSIM suggests that a Class 1 unit be limited to a maximum area of 2,000 m^2 and a Class 2 unit be limited to a maximum area of 10,000 m^2. There is no limitation to the size of Class 3 units. Section 4.4 discusses the definition and layout of final status survey units for the Rattlesnake Creek area in more detail. Figure 5-1 shows the proposed layout. This layout should be expected to change in response to information generated during the pre-remediation characterization, remediation, and final status survey process. In general, for Class 1 units, where practicable, survey units will conform to excavation boundaries. However, because of the shape of the area of concern and the likely highly irregular shapes of excavation, some Class 1 units may include both excavated and unexcavated areas.

5.1.2 Decision Error

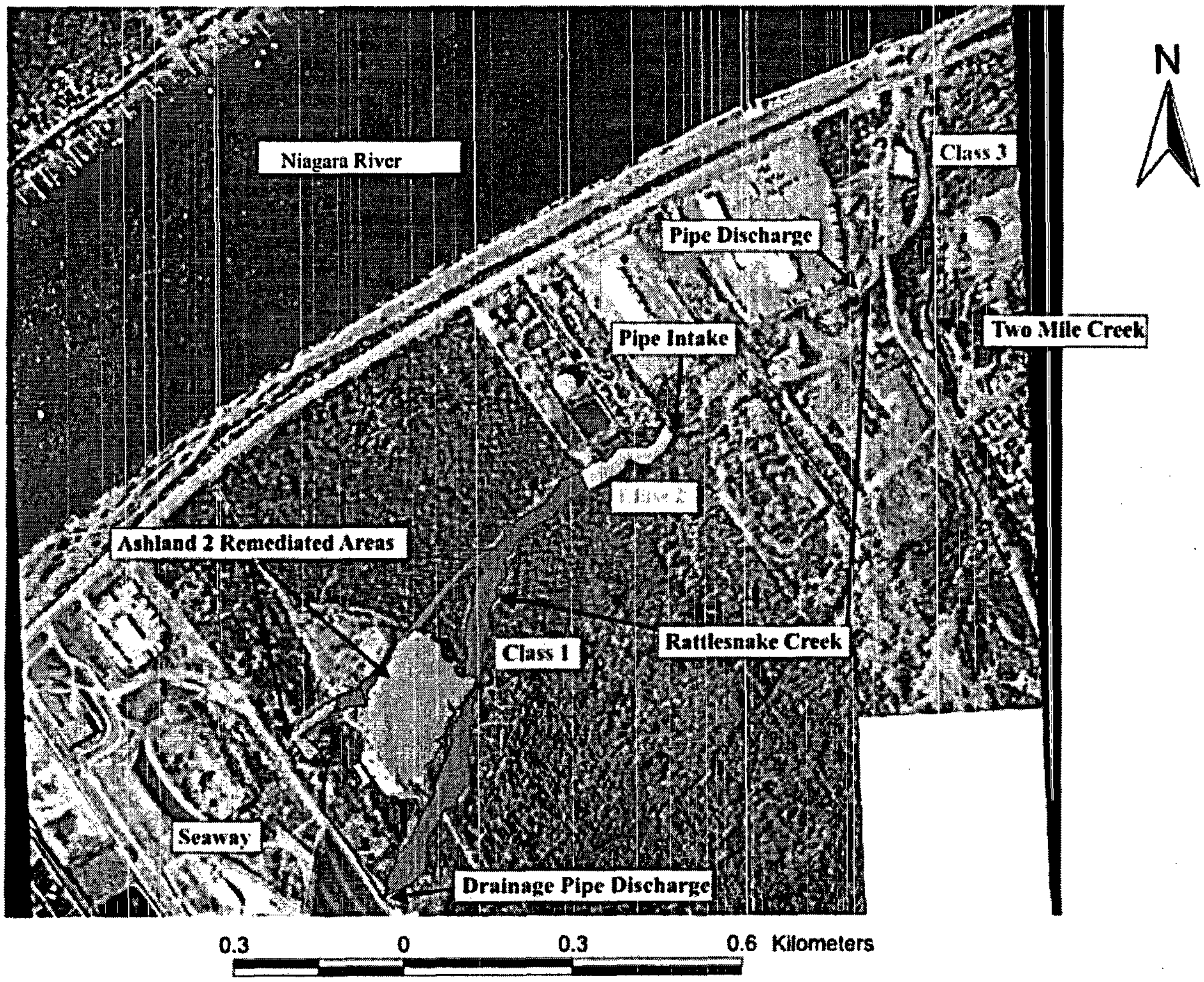
The probability of making decision errors can be controlled by adopting an approach called hypothesis testing. The null hypothesis (H_0) is treated like a baseline condition and is defined as follows:

H_0 = residual radioactivity in the survey unit exceeds the release criteria.

This means that survey units are assumed to be contaminated above criteria until proven otherwise. A Type I error occurs when an area is determined to be below the criteria when it is really above the criteria (survey unit is incorrectly released). A Type II error occurs when an area is determined to be above the criteria when it is really below the criteria (survey unit is incorrectly not released).

For a given test that will statistically evaluate whether the null hypothesis is true or false, Type I and Type II error rates may be specified. Sample numbers can then be calculated so that the desired Type I and Type II error rates are achieved. For a fixed Type II error rate, lowering Type I error rates increases the number of samples required. Likewise, for a fixed Type I error rate, lowering the acceptable Type II error rate also increases the number of samples required. Type I error rates are important from the perspective of limiting residual risk. Type II error rates are important from the perspective of remediation costs. The Type I error rate for Rattlesnake Creek is set at 0.025 or 2.5%. The Type II error rate is set at 0.25 or 25%, but may be adjusted up or down depending on the requirements of the USACE.

Figure 5-1 Layout of Final Status Survey Unit Classes



5.1.3 Derived Concentration Guideline Limit

The DCGL is defined in MARSSIM as the radionuclide-specific activity concentration within a survey unit corresponding to the release criterion. DCGLs are of two types, $DCGL_w$ (wide area average criteria, applied to areas the size of survey units) and $DCGL_{emc}$ (elevated area criteria, applied to areas much smaller than a survey unit). Site compliance with the $DCGL_w$ is demonstrated by using samples (e.g., samples from a 15 cm [6 in.] soil interval) and a nonparametric statistical test. By using appropriate equations, one can determine the sample numbers required per survey unit to achieve desired Type I and Type II error rates for a particular statistical test.

Site compliance with the $DCGL_{emc}$ is demonstrated through a combination of scanning and sampling. When a suitable scanning technology sensitive enough to detect $DCGL_{emc}$ exceedances exists and this scanning technology can be implemented for 100% of a survey unit's surface, $DCGL_{emc}$ compliance may be demonstrated with scans alone. For situations where either a suitable scanning technology does not exist, or where it is not practicable to obtain complete coverage with a scanning technique, $DCGL_{emc}$ compliance demonstration may also require discrete sampling. In the course of $DCGL_w$ compliance sampling, sufficient systematic samples may be collected to demonstrate $DCGL_{emc}$ compliance as well (or vice versa).

Section 4.2 describes the derivation of DCGL values for Rattlesnake Creek in detail. DCGL values are listed in Table 4-1.

5.1.4 Relative Shift

The relative shift is defined in MARSSIM as the Δ/σ, where Δ is the DCGL minus the LBGR (lower bound of the gray region) and σ is the standard deviation of the contaminant distribution in the survey unit. The LBGR is the average level of residual contamination that one would expect to find in a survey unit once remediation in an area is complete. For areas where remediation is not implemented, the LBGR is the residual contamination level that currently exists. The relative shift is actually a measure of the probability that one would encounter an individual sample below the $DCGL_w$ if one were to sample a survey unit. The larger the relative shift, the easier it is to demonstrate compliance with a $DCGL_w$. Relative shift values that are below 1 result in relatively large sampling requirements to show $DCGL_w$ compliance. Relative shifts that range above 3 generally no longer have an impact on the number of samples required to show $DCGL_w$ compliance.

Within Rattlesnake Creek, Zone 1 is expected to require remediation, and so the existing data from that zone are not representative of the final residual concentrations that will exist during the final status survey process. Zone 2 is likely to require selective remediation to address elevated area concerns. Given this fact, the existing data for this zone are more representative of the levels of residual contamination one is likely to encounter during the final status survey process. Of the six surface samples collected and analyzed from Zone 2, one exceeded the $DCGL_w$. This corresponds to a 1-Sign p value of 0.16, representing a relative shift of approximately 1.0 for surface soils. In contrast, none of the 17 subsurface samples homogenized over a 1 m (3 ft) depth and scattered across Zone 2 yielded results greater than the $DCGL_W$, indicating a very low 1-Sign p value and consequently, a large relative shift for the subsurface.

5.1.5 Number of Samples per Survey Unit for $DCGL_W$

The relative shift can be used to obtain the minimum number of samples necessary to satisfy Sign test requirements by using the MARSSIM equation presented below:

$$N = \frac{(Z_{1-\alpha} + Z_{1-\beta})^2}{4(Sign\,p - 0.5)^2} \quad \text{Eq. 1}$$

N in Equation 1 is the number of samples required to be collected from a survey unit. $Z_{1-\alpha}$ and $Z_{1-\beta}$ are critical values that can be found in MARSSIM Table 5.2 or statistics textbooks and handbooks, and *Sign p* is a measure of probability available from MARSSIM Table 5.4. A 20% increase in *N* is recommended to allow for lost or unusable samples. Equation 1 is provided for illustration purposes. Sample numbers were not calculated using equation 1, but rather obtained from MARSSIM Table 5.5 as discussed below.

Using a relative shift of 1.0, a Type I error rate of 0.025, and a Type II error rate of 0.25, Table 5.5 from MARSSIM indicates up to 18 samples per survey unit would be appropriate (this already includes a 20% increase in *N* to account for lost or unusable samples). If Type II error rates are not a concern, to obtain the prescribed Type 1 error rate of 0.025, only six samples are needed from each survey unit to demonstrate compliance with the $DCGL_W$.

5.1.6 Sample Grid Spacing

The grid spacing is estimated in one of two ways depending on the shape of the grid. If a triangular grid is used (preferred), the grid spacing is estimated as follows:

$$L = \sqrt{\frac{A}{0.866 \times n}} \quad \text{Eq. 2}$$

where A = the surface area in the survey unit and n = the number of samples required.

If a square grid is used, the spacing is estimated as follows:

$$L = \sqrt{\frac{A}{n}} \quad \text{Eq. 3}$$

If the study area is long and narrow, the sample grid will extend linearly and not in a square or triangular grid. For small portions of the study area, the width of the study area is less than the distance between grid nodes. Under this condition, the spacing between samples is calculated as follows:

$$\frac{A}{width} = total\ length \qquad \text{Eq. 4}$$

$$\frac{total\ length}{\#samples + 1} = L\,(length\ between\ samples) \qquad \text{Eq. 5}$$

The "+ 1" term in Equation 5 is added to the denominator so that sample locations do not overlap when long and narrow units lie end to end. Systematic grids will always make use of a randomly selected initial starting point.

5.1.7 Small Areas of Elevated Activity

Small, isolated elevated areas may be encountered either in surface soils, or in subsurface soils. MARSSIM (and this final status survey plan) addresses these areas through the definition of $DCGL_{emc}$ requirements. These types of areas would be identified by one or two surficial samples or subsurface 15 cm (6 in.) soil core intervals that exceed the $DCGL_{emc}$ requirements for Rattlesnake Creek.

The DCGL derivation for Rattlesnake Creek included two $DCGL_{emc}$ requirements, one that applies to areas equal to 100 m^2, and a second that functions as a never-to-exceed value. Never-to-exceed $DCGL_{emc}$ requirements are typically handled as "respond-to" requirements during final status surveys. In other words, if any contamination is encountered that exceeds this type of standard, remediation will be required.

5.1.7.1 Elevated Areas with Lateral Footprints

Given the difficulty of providing 100% coverage of the Rattlesnake Creek area by means of surficial walkover surveys, the 1-m^2 $DCGL_{emc}$ requirement will be addressed when encountered during final status survey work. If any contamination is encountered (either by scanning techniques or through discrete sampling) that identifies residual radionuclide concentrations above the 1-m^2 $DCLG_{emc}$ requirement, additional remediation will be required in that area. Pre-remedial characterization data results from the Rattlesnake Creek area suggest that it is highly unlikely that either Ra-226 or U-238 concentrations exist that would pose a concern from the perspective of this $DCGL_{emc}$ requirement. While some areas have been identified that pose Th-230 concerns in the context of this $DCGL_{emc}$ requirement, these are expected to be remediated before final status survey work begins.

In the case of the 100-m^2 $DCGL_{emc}$ requirement, one can develop a sampling program that can determine, with a fixed level of confidence, the sampling density required to identify an elevated area of known shape and size. In this case, the maximum sample density would be one sample per 100-m^2. When discrete samples are required to establish compliance with a $DCGL_{emc}$ requirement, MARSSIM recommends using the more conservative of the two sampling number requirements determined through a $DCGL_w$ and $DCGL_{emc}$ analysis.

For Rattlesnake Creek, Final Status Survey sample numbers will range between 6 to 20 per Class 1 survey unit, depending on the survey unit size. Survey units of less than 600 m^2

would be assigned a minimum of 6 sample locations. A minimum of 6 locations is required to guarantee a Type I error rate of 0.025 for the Sign test. Survey units that ranged between 600 and 2,000 m^2 would be assigned one sample location per 100 m^2 area. No more than 20 locations will be required per survey unit. The expectation is that the majority, if not all, of Class 1 final status survey units will be between 1,500 and 2,000 m^2 in size.

Within MARSSIM, elevated area concerns are assumed to be primarily associated with Class 1 survey units. However, the data collection that has taken place to date indicates that isolated elevated areas may exist across the Rattlesnake Creek floodplain at the surface or at depth. Consequently, an elevated area evaluation should also be a component of the final status survey process for Class 2 units as well. Twenty samples per Class 2 survey unit would provide sufficient information for a $DCGL_w$ evaluation and result in one sample per 500 m^2. This would be equivalent to surveying approximately 20% of each Class 2 unit for 100-m^2 $DCGL_{emc}$ concerns, a coverage rate consistent with MARSSIM guidance for scanning in Class 2 units.

In Class 1 and Class 2 areas, sufficient surficial soil sampling is planned to address $DCGL_{emc}$ concerns. However, in addition, surficial scans will be used to complement discrete soil sampling. In the case of both Ra-226 and U-238, the presence of residual concentrations above the 100-m^2 $DCGL_{emc}$ requirement should be readily identifiable by using a 3 × 3-in. NaI detector. An analysis of existing data for the Rattlesnake Creek area indicates that even for Th-230 at 14 pCi/g, sufficient incremental Ra-226 activity concentrations should be present to allow the area to be differentiated from background. The 3 × 3-in. NaI investigation level for $DCGL_{emc}$ compliance determination will be derived if possible. This derivation will be based on the minimum elevated activity detectable by the instrument. The primary purpose of investigation level definition is to identify appropriate investigation levels for the instrument in the context of Rattlesnake Creek that do not yield unacceptable false positive rates. Locations identified for surface sampling will have a stationary 3 × 3-in. NaI measurement before sampling.

5.1.7.2 Isolated Vertical Intervals with Elevated Activity Concentrations

MARSSIM does not explicitly address subsurface contamination concerns. Consequently, MARSSIM does not provide guidance on how to address closure for subsurface soils, such as those found in Rattlesnake Creek. Section 4.2 and 4.3 of MARISSM discusses the development of DCGLs appropriate for Rattlesnake Creek in detail.

The proposed approach for Rattlesnake Creek would apply the 100-m^2 $DCGL_{emc}$ requirements to each 15 cm (6 in.) vertical interval. Because establishing compliance through sampling each 15 cm (6 in.) interval is not practicable, scans of vertical cores will be used to identify elevated intervals that might pose $DCGL_{emc}$ concerns. Each 15 cm (6 in.) layer of the core will be scanned for elevated activity by using XRF analysis. Investigation levels appropriate for screening for $DCGL_{emc}$ concerns were developed and documented for XRF technology as described in Section 4.3.2. If an interval exhibits mass concentrations above the investigation levels, a biased sample will be collected from that core interval. Soils will also be visually screened to identify possible sample intervals that appear different from native soils. Biased soil samples may be selected for analysis on the basis of visual inspection.

It is important to note that a sample from a 0.15 to 1 m (0.5 to 3 ft) homogenized vertical core is really composed of soils from approximately five 15-cm (6 in.) intervals. Consequently, as long as the SOR value (based on $DCGL_{emc}$ requirements) is less than 0.2 after accounting for background, one can conclude on the basis of the 0.15 to 1 m (0.5 to 3 ft) homogenized soil sample result alone that no $DCGL_{emc}$ concerns exist for that core. For example, if four of the intervals were at background conditions and the remaining interval was exactly at the $DCGL_{emc}$ requirement, the SOR value for the homogenized core would be 0.2. If any individual 15 cm (6 in.) interval contained contamination with an SOR value greater than 1, then the homogenized sample SOR value would have to be greater than 0.2.

5.1.8 Reasonable Number of Samples

Assuming that the number of samples per unit has been calculated, it should then be determined if that number is reasonable. The calculated number of samples may be unreasonably high as a result of the analysis for small areas of elevated activity (e.g., 400 samples in a 2,000-m^2 area may *seem* excessive), or in cases where final status survey unit sizes are small, as might be the case for Class 1 units that conform to excavation footprints. It is the responsibility of the site managers and health physicists to evaluate whether the number of samples is reasonable. If it is determined that the number of samples is inadequate or excessive, the DQOs should be reevaluated.

5.2 PLANNING AND SCHEDULING

A potential layout for the Class 1 and Class 2 areas is shown in Figure 5-1. The number and layout of the actual final status survey units will likely deviate from Figure 5-1, depending on the final footprint of remediation.

The use of direct scanning technologies for screening potential surface contamination above $DCGL_{emc}$ requirements is most likely to be successful and implementable when both surface moisture and surface vegetation are at a minimum. This fact should be taken into consideration when final status survey data collection activities are being scheduled.

5.3 DECISION RULES FOR CLASS 1 UNITS

Figure 4-1 provides a flow diagram of the decision logic for final status survey data collection and decision making applied to Class 1 units. The following text describes the decision logic in Figure 4-1.

1. A technically defensible gross activity investigation level will be developed for surface scans using a 3 × 3-in. NaI detector, if possible. This investigation level will be set to either the minimum detectable incremental gross activity, or the gross activity that reliably identifies $DCGL_{emc}$ concerns, whichever is greater.

2. Technically defensible gross activity or concentration-based investigation levels will be developed for scanning the subsurface cores with XRF. These investigation levels will

be set to either the minimum detectable reading, or the reading that reliably identifies $DCGL_{emc}$ concerns, whichever is greater.

3. Post-remediation, Class 1 final status survey unit numbers and layout will be determined on the basis of sampling results to date and excavation footprints. Class 1 units should encompass all remediated areas and/or any areas where existing sample results are greater than $DCGL_W$ requirements.

4. Surface scans will be performed for accessible areas. If locations are identified with scan results greater than the investigation level and review of the data indicates an anomaly was discovered, either biased samples will be collected at these locations to confirm $DCGL_{emc}$ compliance, and/or additional remediation will take place.

5. The number of systematic surface/subsurface sample locations will be determined for each unit. There will be at least one sample location per 100-m^2 area. The minimum number of locations will be driven by $DCGL_W$ (Sign test) requirements but will not be less than six. Sampling locations will be laid out on triangular grids, where possible. For areas that have been remediated by excavation, subsurface samples will not be required.

6. When subsurface cores are collected (unexcavated areas of Class 1 units) subsurface cores will be generated for each location down to a minimum depth of 1 m (3 ft). Each 15 cm (6 in.) interval from this core will be scanned, with scan results recorded and compared to the investigation levels. If one or more intervals exhibit a reading greater than the investigation levels, a biased sample will be collected and analyzed from the interval with the highest reading. The SOR results from this analysis will be compared to the $DCGL_{emc}$ requirements. If the result is greater than the $DCGL_{emc}$, then either additional data will be collected to determine if 100-m^2 averages exceed the appropriate $DCGL_{emc}$, or remediation will take place. If the final interval indicates contamination levels of concern, the core will be extended to greater depth until contamination has been vertically bounded.

7. For the unexcavated areas of the Class 1 units, one surface sample representative of the top 15 cm (6 in.) of soil and one sample from the 0.15 to 1 m (0.5 to 3 ft) deep homogenized soil core will be collected. For excavated areas, only surface samples will be required. These samples will be analyzed by gamma or alpha spectrometry for Ra-226 and by alpha spectrometry for Th-230 and U-238. The resulting SOR scores will be compared to $DCGL_{emc}$ requirements. If a result is greater than a $DCGL_{emc}$, then either additional data will be collected to determine if 100-m^2 averages exceed the appropriate $DCGL_{emc}$, or additional remediation will take place. Average SOR scores for survey units will be computed on the basis of results from surface samples and subsurface samples from 0.15 to 1 m (0.5 to 3 ft) deep homogenized soil cores. If a surface or subsurface average exceeds the $DCGL_W$ requirement, additional remediation will be required for that survey unit. The Sign test will be applied to surface sample results. If the unit fails the Sign test, additional investigation may be undertaken to determine the cause, and additional remediation may be required.

8. If a survey unit satisfies all DCGL requirements, the unit will be considered to be in compliance with ROD requirements and ready for release. If a survey unit fails one or more of the DCGL requirements and requires additional remediation, the affected areas of the final status survey unit will be subjected to additional final status survey data collection to verify compliance with DCGL requirements.

5.4 DECISION RULES FOR CLASS 2 UNITS

Figure 4-2 provides a flow diagram of the decision logic for final status survey data collection and decision making applied to Class 2 units. The following text describes the decision logic in Figure 4-2.

1. A technically defensible gross activity investigation level will be developed for surface scans using a 3 × 3-in. NaI detector, if possible. This investigation level will be set to either the minimum detectable incremental gross activity, or the gross activity that reliably identifies $DCGL_{emc}$ concerns, whichever is greater.

2. A technically defensible gross activity or concentration-based investigation levels will be developed for the scanning subsurface cores with XRF. These investigation levels will be set to either the minimum detectable reading, or the reading that reliably identifies $DCGL_{emc}$ concerns, whichever is greater.

3. Post-remediation, Class 2 final status survey unit numbers and layout will be determined on the basis of sampling results to date, excavation footprints, and civil surveys. Class 2 units should encompass all areas in the study area not included in Class 1 or 3 units.

4. Surface scans will be performed for accessible areas. If locations are identified with results greater than the investigation level and the data indicate an anomaly was discovered, either biased sampling will take place at these locations to confirm $DCGL_{emc}$ compliance, or remediation will take place.

5. The number of systematic surface/subsurface sampling locations will be determined for each unit. There will be at least one sample location per 500-m^2 area. The minimum number of locations will be driven by $DCGL_W$ (Sign test) requirements but will not be less than six. Sampling locations will be laid out on triangular grids, where possible.

6. Subsurface cores will be generated for each location down to a minimum depth of 1 m (3 ft). Each 15 cm (6 in.) interval from this core will be scanned, with scan results recorded and compared to investigation levels. If one or more intervals exhibit a reading greater than the investigation levels, a biased sample will be collected and analyzed from the interval with the highest reading. The SOR results from this analysis will be compared to the $DCGL_{emc}$ requirements. If the result is greater than the $DCGL_{emc}$, then either additional data will be collected to determine if 100-m^2 averages exceed the appropriate $DCGL_{emc}$, or remediation will take place.

7. One surface sample representative of the top 15 cm (6 in.) of soil and one sample from the 0.15 to 1 m (0.5 to 3 ft) deep homogenized soil core will be collected. These samples will be analyzed by gamma or alpha spectrometry for Ra-226 and by alpha spectrometry for U-238 and Th-230. The resulting SOR scores will be compared to $DCGL_{emc}$ requirements. If a result is greater than a $DCGL_{emc}$, then either additional data will be collected to determine if 100-m^2 averages exceed the appropriate $DCGL_{emc}$, or additional remediation will take place. Average SOR scores for the surface and subsurface will be computed on the basis of results from surface samples and 0.15 to 1 m (0.5 to 3 ft) deep homogenized subsurface samples. If an average exceeds the $DCGL_w$ requirement, additional remediation will be required for that survey unit. The Sign test will be applied to surface and subsurface sample results. If the unit fails the Sign test, additional investigation may be undertaken to determine the cause, and additional remediation may be required.

8. If a survey unit satisfies all DCGL requirements, the unit will be considered to be in compliance with ROD requirements and ready for release. If a survey unit fails one or more of the DCGL requirements and requires additional remediation, the affected areas of the final status survey unit will be reclassified as a Class 1 unit and subjected to additional final status survey data collection with Class 1 closure protocols to verify compliance with DCGL requirements.

5.5 DECISION RULES FOR CLASS 3 UNITS

Historical data sets already exist for the proposed Class 3 area of Rattlesnake Creek. Based on an initial review of existing data sets, the USACE believes the Class 3 area satisfies DCGL requirements for the site. As part of the closure process, the results contained in historical data sets (along with associated quality assurance/quality control [QA/QC] information) from the Class 3 area will be reviewed against the criteria listed below. If one or more sampling locations fail to meet either DCGL requirements or appropriate final status survey quality assurance goals, appropriate follow-on actions will be taken. Follow-on actions potentially include remediation and reclassification of the problem area as a Class 1 unit or additional data collection in a specific area to meet final status survey data gaps.

1. A technically defensible gross activity or concentration-based investigation levels will be developed for any additional core scans that will be done. These investigation levels will be set to either the minimum detectable reading, or the reading that reliably identifies $DCGL_{emc}$ concerns, whichever is greater.

2. Post-remediation, the Class 3 final status survey unit numbers and layout will be determined on the basis of sampling results to date, excavation footprints, and civil surveys. The Class 3 area will encompass all areas in the study area not included in Class 1 or 2 units.

3. The number of systematic surface/subsurface sampling locations will be determined for the Class 3 area. The minimum number of locations will be driven by $DCGL_w$ (Sign test) requirements but will not be less than six.

4. Historical results available from the Class 3 area (surface samples and subsurface samples homogenized over a 1 m [3 ft] depth) will be compared to the appropriate DCGL standards. If sample results indicate that all DCGL requirements have been met (i.e., the average activity concentrations for surface and subsurface samples are less than the $DCGL_w$ requirement, the Sign test passes for surface and subsurface samples, surface samples results are less than the $DCGL_{emc}$ requirements, and each subsurface homogenized sample is less than 20% of the $DCGL_{emc}$ requirement after accounting for background), the survey unit will have passed.

6. If any individual sample yields a result above DCGL requirements, remediation and reclassification of that area as a Class 1 unit will likely be necessary. If any subsurface homogenized sample yields a result greater than 20% of the $DCGL_{emc}$, but less than the $DCGL_{emc}$ (after accounting for background), a new core will be generated at that location down to a depth of 1 m (3 ft). Each 15-cm (6-in.) interval from this core will be scanned, with scanning results recorded and compared to investigation levels. If one or more intervals exhibit a reading greater than the investigation levels, a biased sample will be collected and analyzed from the interval with the highest reading. The SOR results from this analysis will be compared to the $DCGL_{emc}$ requirements. If the result is greater than the $DCGL_{emc}$, then either additional data will be collected to determine if 100-m^2 averages exceed the appropriate $DCGL_{emc}$, or additional remediation will take place and the area will be reclassified as a Class 1 unit.

7. For each additional core location, one surface sample representative of the top 15 cm (6 in.) of soil and one sample from the 0.15 to 1 m (0.5 to 3 ft) deep homogenized soil core will be collected. These samples will be analyzed by gamma or alpha spectrometry for Ra-226 and by alpha spectrometry for U-238 and Th-230. The resulting SOR scores will be compared to $DCGL_{emc}$ requirements. If a result is greater than a $DCGL_{emc}$, then either additional data will be collected to determine if 100-m^2 averages exceed the appropriate $DCGL_{emc}$, or remediation will take place. The results from these analyses will be pooled with the existing Class 3 data set. Average SOR scores for the surface and subsurface will be computed on the basis of results from surface samples and 0.15 to 1 m (0.5 to 3 ft) deep homogenized subsurface samples. If an average exceeds the $DCGL_w$ requirement, additional remediation will be required for that survey unit. The Sign test will be applied to surface and subsurface sample results. If the unit fails the Sign test, additional investigation may be undertaken to determine the cause, and additional remediation may be required, and the area affected may be reclassified as a Class 1 area.

8. If the Class 3 survey unit satisfies all DCGL requirements, the unit will be considered to be in compliance with ROD requirements and ready for release. If the survey unit fails one or more of the DCGL requirements and requires additional remediation, the affected areas of the final status survey unit will be reclassified as a Class 1 unit and subjected to additional final status survey data collection with Class 1 closure protocols to verify compliance with DCGL requirements.

6 FIELD ACTIVITIES

6.1 SOIL/SEDIMENT SAMPLING AND MEASUREMENTS

6.1.1 Soil and Sediment Sampling in Unexcavated Class 1 Areas and Class 2 Units

In unexcavated areas of Class 1 units and in Class 2 areas, soil samples will be collected from three intervals during the pre-excavation final status survey process: surface (0 to 0.15 m [0 to 6 in.]), homogenized subsurface (0.15 to 1.0 m [0.5 to 3 ft]), and subsurface 15 cm (6 in.) intervals. Surface soil samples will be collected by using a stainless steel scoop or spoon and will be homogenized in a stainless steel bowl or container prior to containerization. In general, samples will be analyzed using gamma spectrometry for Ra-226; however alpha spectrometry may be used if expedited analyses are required. Samples will be analyzed via alpha spectrometry for Th-230 and U-238. Table 6-1 summarizes sampling and analytical requirements. Table 6-1 includes a larger set of radionuclides than included in the ROD because these are automatically identified and quantified by the respective alpha and gamma spectrometry analyses. Matrix spike/matrix spike duplicate (MS/MSD), field duplicate, and USACE-Buffalo District QA split samples will be collected from the same locations to enhance comparability of results. Surface scans will be conducted as described in Section 4.3.1.

Subsurface soil samples will be collected by using a stainless steel hand auger or by direct push methods using a Geoprobe (where access permits). On the basis of historical investigation experience in the Rattlesnake Creek flood plain, it is not expected that refusal will be a problem for Geoprobe soil core activities. The Geoprobe will be used to collect soil samples by advancing a stainless steel core barrel (4 ft in length, approximately 2 in. in diameter) to the appropriate depth or to refusal. The undisturbed soil sample will be contained inside a clear acetate liner inserted into the core barrel prior to sampling. When the acetate liner containing the soil core is removed, it will be opened by cutting the liner lengthwise. After the sample is examined and logged, the soil will be removed, homogenized, and containerized as required. If soils contain excessive moisture, they may be open-air dried before scanning/screening. If the visual inspection or soil scanning identifies a lens of potentially contaminated material, a sample may be collected from the 15 cm (6 in.) interval in question (as opposed to collecting a sample from the entire homogenized core). The field team leader will decide if a specific interval should be collected and will provide justification.

In areas where standing water is present (such as deeper channels or ponded areas) subsurface soil samples can be collected by inserting a hand auger through a polyvinyl chloride (PVC) pipe or Shelby tube to prevent the borehole from filling with water. The use of this method will allow a subsurface soil sample to be collected with little or no contact from standing water. All soil samples will be collected and homogenized according to procedures contained in the project Quality Assurance Project Plan (QAPP).

Because the Rattlesnake Creek study area is irregularly shaped, use of the preferred triangular grid may not be feasible in all locations, particularly when the width of the area of concern is greater than grid node spacing. For areas of the stream where this is the case, locations may be systematically distributed linearly down the creek. In either case, the start point for the systematic grid will be randomly selected. At each systematic location, a 0 to 5 cm (0 to 6 in.) surface sample will be collected. At each systematic sampling location in unexcavated Class 1 areas, and Class 2 and Class 3 units, a 0.15 to 1 m (0.5 to 3 ft) (or to refusal) subsurface sample will be also be collected. Each subsurface sample (core) will be scanned with XRF to inspect for anomalies prior to compositing. If a lens of potentially contaminated material is identified within a core, that lens will be sampled and submitted for analysis. The field team leader may also collect biased samples, with the approval of USACE, of sedimentation areas or of surfaces with elevated gamma activity if they are identified.

Class 2 survey unit samples will be collected in the same manner as Class 1.

6.1.2 Soil and Sediment Sampling in Class 1 Excavated Areas

When excavation is complete, a gamma walkover survey (GWS), using a 3×3-in. NaI detector combined with a GPS and data logging capabilities, will be deployed as surface conditions allow. The GWS data sets will be evaluated for anomalies and spatial patterns or trends in gross activity that might be indicative of residual contamination of concern. If suspicious anomalies or patterns are identified that are not consistent with background, biased surface samples may be collected, and/or the concerns addressed via additional excavation.

For biased and gridded systematic sampling, a three-increment sample will be formed and sent for analysis from surface soils. No subsurface soil sampling is required for areas that have been excavated. The three increment sample will be centered on the systematic grid node or biased location, and will consist of soils representative of the 100-m^2 area, with one sample on the grid node/biased location, and the other two located on a line that passes through the node/biased location, one on either side 4.4 m from the node/biased location. This spacing was selected so that each of the samples represented an equivalent area. The orientation of the line will be based on randomly selecting a degree value between 0° and 180°, as measured from magnetic north. If the increment locations based on this method fail to fall within the excavation footprint being sampled, the line may be manually oriented to ensure both sampling locations fall within the excavated area.

The sampling tool selected will have a diameter such that the volume produced is at least one third of that required for laboratory analysis. One sample will be formed from these three equal-volume increments and submitted for analysis. The purpose of the three-increment sample is to obtain as representative a result of 100-m^2 as cost-effectively possible, minimizing the possibility of either missing contamination that should be removed, or excavating soil that in fact meets the DCGL requirements. The sum-of ratios (SOR) score for laboratory results will be computed based on the $DCGL_{emc}$ for 100-m^2 areas. If the SOR score exceeds a value of one, excavation of that 100-m^2 will be required.

An analytical result from a three increment sample is equivalent to finding the average of analytical results from the three increments contributing to the sample. For this reason, if the laboratory result meets the 100-m^2 $DCGL_{emc}$ requirement, then none of the three contributing increments could have exceeded the 1-m^2 $DCGL_{emc}$ requirement. This is because the 1-m^2

$DCGL_{emc}$ requirement is three times greater than the 100-m^2 $DCGL_{emc}$ requirement. For example, if two of the contributing increments are at background levels, but one is above the 1-m^2 $DCGL_{emc}$ requirement, both the average of the results from each of the three increments (if these had been analyzed) and the laboratory result from the three-increment sample would be a 100-m^2 $DCGL_{emc}$ SOR score greater than one.

6.1.3 Field Measurements

Field measurements to be conducted as part of the Rattlesnake Creek investigation will include organic vapor monitoring and field radiological screening. These measurements will be performed as specified in the health and safety and emergency response plan.

Radiological screening will be conducted to meet several requirements during this investigation. Field scans will be conducted by using radiological field screening instruments (e.g., Geiger-Mueller detectors and swipe counters) for the release of equipment and materials during and after the investigation and including samples and sample coolers. In addition, scans will be conducted to satisfy the requirements of the site safety and health plan (SS&HP) for radiological monitoring of personnel involved in on-site activities. Stationary scans using a 3 × 3-in. NaI detector will also be used to identify potentially elevated radionuclide levels in surface soils at sampling locations before samples are collected. These data will be logged and used to determine if the potential for contamination above $DCGL_{emc}$ requirements exists at individual locations. Investigation levels for $DCGL_{emc}$ compliance determination will be derived, if possible, and documented before final status survey activities begin.

Soil sample cores retrieved during surface and subsurface sampling work also will be screened for radioactivity and visually inspected. Each 15 cm (6 in.) layer of the core will be scanned for elevated activity that would be indicative of $DCGL_{emc}$ concerns. Investigation levels appropriate for screening for $DCGL_{emc}$ concerns will be developed and documented for the instruments before the initiation of final status survey work. If an interval exhibits radiation levels above the investigation levels, a biased sample will be collected from that core interval. Disturbed soil generated during hand augering or surface soil sampling will be screened prior to compositing or homogenization. For undisturbed soil samples collected with the Geoprobe, the sample core will be scanned prior to compositing. Soils will also be visually screened to identify possible sample intervals that appear different from native soils. Biased soil samples may also be selected for analysis on the basis of visual inspection. The screening results and corresponding depths of all scans will be recorded on the field boring log.

All radiological screening will be conducted in accordance with the contractor's radiological protection plan or applicable procedures.

Table 6-1. Sampling and Analytical Requirements for Surface and Subsurface Soil Samples for the Rattlesnake Creek Final Status Sampling Survey

Surface and Subsurface Soil Samples	Analytical Parameter	Test Method	Field Samples[a]	Field Duplicate Samples	MS/MSD Samples	Trip Blanks	Total Samples[b]	USACE QA Split Samples
All Samples	Ra-226	Gamma spectrometry[c]	1000	20	20	—	1040	20
All Samples	Isotopic thorium (Th-228, Th-230, and Th-232)	Alpha spectrometry	1000	20	20	—	1040	20
All Samples	Isotopic uranium (U-234, U-235, and U-238)	Alpha spectrometry	1000	20	20	—	1040	20

a - Sample numbers are approximate. Actual numbers will reflect soil interval screening results and biased sampling needs.
b - Estimates may be adjusted as additional data become available.
c - Sufficient in growth time will be required to provide accurate Ra-226 activity concentration estimates. Alpha spectrometry may also be used.

6.2 QUALITY ASSURANCE PROCEDURES

6.2.1 Contractor Quality Assurance Program

The contractor chemical/radiological quality control (CCQC) program to be utilized during this investigation consists of three primary phases: preparatory, initial, and follow-up. All CCQC functions and reviews will be directed by the chemical/radiological quality control (CQC) representative. Detailed procedures relating to the CCQC will be provided in the project QAPP developed to support the field sampling.

- *Preparatory Phase:* The preparatory phase of the CCQC program is documented by the CQC representative and includes meetings to be held with contractor and subcontractor personnel to address issues, including the review of procedures, field decontamination, investigation-derived waste (IDW) management, and sample management.

- *Initial Phase:* The initial phase of the CCQC program is conducted by the CQC representative and includes monitoring and audits associated with the initial work performed as part of each definable feature of work. Initial phase topics include field sampling oversight, sample management documentation, and inspection of field logbooks and other field records.

- *Follow-up Phase:* The follow-up phase of the CCQC program is conducted by the CQC representative and includes the daily performance of the activities noted in the initial phase until completion of the specific definable feature of work.

6.2.2 Daily Quality Control Reports

The contractor will prepare daily quality control reports (DQCRs) that will be signed and dated by the CQC representative. Daily reports then will be submitted to the USACE Project Manager and USACE Contracting Representative on a weekly basis. Each DQCR will address topics including a summary of work performed, weather conditions, and departures from the approved sampling and analysis plan (SAP). Any deviation that may affect the project DQOs will be immediately forwarded to the USACE Project Manager and USACE Contracting Representative.

6.2.3 Corrective Actions

Corrective actions will be initiated if problems relating to analytical/equipment errors or noncompliance with approved criteria are identified. Corrective actions will be documented through a formal corrective action program at the time the problem is identified.

Any nonconformance with the established procedures presented in the plan or in the project QAPP will be identified and corrected in accordance with the QAPP. The contractor Project Manager will issue a nonconformance report (NCR) for each nonconforming condition. In addition, corrective actions will be implemented and documented in the appropriate field logbook.

Detailed procedures for corrective actions relating to sample collection/field measurements and laboratory analyses will be explained in the QAPP developed to support the field sampling.

6.3 SAMPLE CHAIN-OF-CUSTODY/DOCUMENTATION

6.3.1 Field Logbooks

All information pertinent to field activities, including field instrument calibration data will be recorded in field logbooks. The logbooks will be bound and the pages will be consecutively numbered. Entries in the logbooks will be made in black waterproof ink and will include, at a minimum, a description of all activities, individuals involved in field activities, dates and times of drilling and sampling, weather conditions, any problems encountered, and all field measurements. Lot numbers, manufacturer names, and expiration dates of standards used for field instrument calibration will be recorded in the field logbooks. A summary of each day's activities also will be recorded in the logbooks.

Sufficient information will be recorded in the logbooks to permit reconstruction of all site characterization activities conducted. Information recorded on other project documents will not be repeated in the logbooks except in summary form where determined necessary. When not being utilized during field work, all field logbooks will be kept in the possession of the appropriate field personnel, or in a secure place. Upon completion of the field activities, all logbooks will become part of the final project evidence file.

Entries recorded in logbooks will include, but not be limited to, the following information:

- Author, date, and times of arrival at and departure from the work site;
- Purpose of the field activity and summary of daily tasks;
- Names and responsibilities of field crew members;
- Sample collection method;
- Number and volume of samples collected;
- Information regarding sampling changes, scheduling modifications, and change orders;
- Details of the sampling location, including a sketch map illustrating the sampling location;
- Field observations;
- Types of field instruments used and purpose of use, including calibration methods and results;
- Any field measurements made (e.g., radiological activity and landfill gas);
- Sample identification number(s); and
- Sample documentation information.

6.3.2 Photographs

Photographs taken during the project will be noted in the field logbook in accordance with the requirements of the field procedure. If photographs are taken to document sampling points, to facilitate relocating the point at a later date, two or more permanent reference points should be included within the photograph. In addition to the information recorded in the field logbook, one or more site photograph reference maps will be prepared as required.

6.3.3 Sample Numbering System

A unique sample numbering scheme will be used to identify each sample designated for laboratory analysis. The purpose of this numbering scheme is to provide a tracking system for the retrieval of analytical and field data on each sample. Sample identification numbers will be used on all sample labels or tags, field data sheets and/or logbooks, chain-of-custody records, and all other applicable documentation used during the project.

The sample numbering scheme used for field samples will also be used for duplicate samples so that these types of samples will not be discernible by the laboratory. Other field QC samples, however, will be numbered so that they can be readily identified. A summary of the sample numbering scheme to be used for the project is presented in Table 6-2.

6.4 SAMPLE DOCUMENTATION

The activities and procedures described in this section will be performed in accordance with the requirements of the project QAPP and field procedures presented in the QAPP.

Table 6-2. Sample ID Numbering Scheme

Site/Sample Type	USACE Sample ID[a]
Rattlesnake Creek	
Surface sample	RCWW-SSXXX-MM/DD/YY-Z.Z-Z.Z
Subsurface sample	RCWW-SBXXX-MM/DD/YY-Z.Z-Z.Z
Quality Control	
Trip blank sample	RCWW-TBXXX-MM/DD/YY
Duplicate sample	
Surface sample	RCWW-SS9XX-MM/DD/YY-Z.Z-Z.Z
Subsurface sample	RCWW-SB9XX-MM/DD/YY-Z.Z-Z.Z
Rinsate blank sample	RCWW-RBXXX-MM/DD/YY
Quality Assurance	
Split sample	
Surface sample	RCWW-SS8XX-MM/DD/YY-Z.Z-Z.Z
Subsurface Sample	RCWW-SB8XX-MM/DD/YY-Z.Z-Z.Z

[a]MM/DD/YY – Date of sample collection (e.g., 04/22/94).
RCWW – Rattlesnake Creek identifier where "WW" represents the Class number and Unit number, respectively.
XXX – Represents unique sample ID numbering, starting sequentially with 001 for each area.
8XX – Represents unique sample ID numbering, starting sequentially with 801 for the project for QA samples.
9XX – Represents unique sample ID numbering, starting sequentially with 901 for the project for QC samples.
Z.Z-Z.Z – Depth of sample collection in feet (e.g., 0.0-0.5).
Note: If a biased surface sample or a lens sample is collected as a surface or subsurface sample, the unique sample ID will use 030 as a starting value and then increase incrementally for each survey unit.

6.4.1 Sample Labels

Labels will be affixed to all sample containers during sampling activities. Information will be recorded on each sample container label at the time of sample collection. The information to be recorded on the labels will be as follows:

- Sample identification number,
- Sample type,
- Sampled interval (e.g., 0 - 6 in.),
- Site name and sampling station number,
- Analysis to be performed,
- Type of chemical preservative present in container,
- Date and time of sample collection, and
- Sampler's name and initials.

6.4.2 Cooler Receipt Checklist

The condition of shipping coolers and enclosed sample containers will be documented upon receipt at the analytical laboratory. This documentation will be accomplished by using the cooler receipt checklist as described in the project QAPP. A copy of the checklist will either be placed into each shipping cooler along with the completed chain-of-custody form or provided to the laboratory at the start of the project. Another copy of the checklist will be faxed to the contractor's field manager immediately after it has been completed at the laboratory. The original completed checklist will be transmitted with the final analytical results from the laboratory.

6.4.3 Chain-of-Custody Records

Chain-of-custody procedures implemented for the project will provide documentation of the handling of each sample from the time of collection until completion of laboratory analysis. The chain-of-custody form serves as a legal record of possession of the sample. A sample is considered to be under custody if one or more of the following criteria are met:

- The sample is in the sampler's possession,
- The sample is in the sampler's view after being in possession,
- The sample was in the sampler's possession and then was placed into a locked area to prevent tampering, and
- The sample is in a designated secure area.

Custody will be documented throughout the project field sampling activities by a chain-of-custody form initiated on each day that samples are collected. The chain-of-custody will accompany the samples from the site to the laboratory and will be returned to the laboratory coordinator with the final analytical report. All personnel with sample custody responsibilities will be required to sign, date, and note the time on a chain-of-custody form when relinquishing samples from their immediate custody (except in the case where samples are placed into designated secure areas for temporary storage prior to shipment). Bills of lading or airbills will be used as custody documentation during times when the samples are being shipped from the site to the laboratory, and they will be retained as part of the permanent sample custody documentation.

Chain-of-custody forms will be used to document the integrity of all samples collected. To maintain a record of sample collection, transfer between personnel, shipment, and receipt by the laboratory, chain-of-custody forms will be filled out for sample sets as deemed appropriate during the course of fieldwork. An example of the chain-of-custody form to be used for the project will be provided in the project QAPP.

The individual responsible for shipping the samples from the field to the laboratory will be responsible for completing the chain-of-custody form and noting the date and time of shipment. This individual will also inspect the form for completeness and accuracy. After the form has been inspected and determined to be satisfactorily completed, the responsible individual will sign, date, and note the time of transfer on the form. The chain-of-custody form will be put in a sealable plastic bag and placed inside the cooler used for sample transport after the field copy of the form has been detached. The field copy of the form will be appropriately filed and kept at the site for the duration of the site activities.

In addition to the chain-of-custody form, chain-of-custody seals will also be placed on each cooler used for sample transport. These seals will consist of a tamper-proof adhesive material placed across the lid and body of the coolers. The chain-of-custody seals will be used to ensure that no sample tampering occurs between the time the samples are placed into the coolers and the time the coolers are opened for analysis at the laboratory. Cooler custody seals will be signed and dated by the individual responsible for completing the chain-of-custody form contained within the cooler.

6.4.4 Receipt of Sample Forms

The contracted laboratory will document the receipt of environmental samples by accepting custody of the samples from the approved shipping company. In addition, the contracted laboratory will document the condition of the environmental samples upon receipt.

6.5 DOCUMENTATION PROCEDURES

The tracking procedure to be utilized for documentation of all samples collected during the project will involve the following series of steps.

- Collect and place samples into laboratory sample containers.
- Complete sample container label information, as defined in Section 6.4.
- Complete sample documentation information in the field logbook, as defined in Section 6.3.
- Complete project and sampling information sections of the chain-of-custody form(s) as defined in Section 6.4.
- Complete the airbill for the cooler to be shipped.
- Perform a completeness and accuracy check of the chain-of-custody form(s).

- Complete the sample relinquishment section of the chain-of-custody form(s) as defined in Section 6.4 and place the form(s) into cooler.
- Place chain-of-custody seals on the exterior of the cooler as defined in Section 6.4.3.
- Package and ship the cooler to the laboratory as defined in Section 6.7.
- Receive cooler at the laboratory, inspect contents, and fax contained chain-of-custody form(s) and cooler receipt form(s), as defined in the project QAPP.
- Transmit original chain-of-custody form(s) with final analytical results from laboratory.

6.6 CORRECTIONS TO DOCUMENTATION

All original information and data in field logbooks, on sample labels, on chain-of-custody forms, and on any other project-related documentation will be recorded in black waterproof ink and in a completely legible manner. Errors made on any accountable document will be corrected by crossing out the error and entering the correct information or data. Any error discovered on a document will be corrected by the individual responsible for the entry. Erroneous information or data will be corrected in a manner that will not obliterate the original entry, and all corrections will be initialed and dated by the individual responsible for the entry.

6.7 SAMPLE PACKAGING AND SHIPPING

6.7.1 Sample Packaging

Sample containers will be packaged in thermally insulated rigid-body coolers. Sample packaging and shipping will be conducted in accordance with procedures that will be described in the project QAPP and applicable U.S. Department of Transportation (DOT) specifications.

A checklist to be provided in the project QAPP will be used by the individual responsible for packaging environmental samples to verify completeness of sample shipment preparations. In addition, the laboratory will document the condition of the environmental samples upon receipt. This documentation will be accomplished by using the cooler receipt checklist to be provided in the project QAPP.

6.7.2 Additional Requirements for Samples Classified as Radioactive Materials

Transportation of radioactive materials is regulated by the DOT under 49 CFR 173.401. Samples generated during project activities will be transported in accordance with procedures that ensure compliance with regulatory requirements. In addition to the packaging and shipping requirements cited in Section 6.7, the following will be performed for radioactive materials:

- The cooler must have the shipper and receiver addresses affixed to it in case the Federal Express airbill is lost during shipping.
- Samples will be screened prior to packing to determine if they meet the definition of a DOT class 7 (radioactive) material.
- For samples that meet DOT requirements for radioactive materials:
    - The cooler will be surveyed for radiation and to ensure the package meets the requirements for limited quantity as found in 49 CFR.

- A notice must be enclosed on the inside of the cooler that includes the name of the consignor and the statement "This package conforms to the conditions and limitations specified in 49 CFR 173.421 for radioactive material, excepted package-limited quantity of material, UN2910." The outside of the inner packaging or, if there is no inner packaging, the outside of the package itself must be labeled "Radioactive."
- The following labels will be placed on the cooler:
  - Appropriate hazard class label and
  - "Cargo Aircraft Only," if applicable.
- The airbill for the shipment will be completed and attached to the top of the shipping box/cooler, which will then be transferred to the courier for delivery to the laboratory.

6.7.3 Sample Shipping

All environmental samples collected during the project will be shipped no later than 48 to 72 hours after the time of collection. The latter time of 72 hours may be necessary if the samples are collected on a Friday and have to be shipped on a Monday via commercial courier. During the time period between collection and shipment, all samples will be stored in a secure area. All coolers containing environmental samples will be shipped overnight to the laboratory by Federal Express, similar courier, or laboratory courier.

6.8 INVESTIGATION-DERIVED WASTE

USACE-Buffalo District is conducting field activities that generate environmental media in support of FUSRAP under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). The media generally consist of soil, sludge, water, and spent personal protective equipment (PPE) resulting from drilling operations, sampling activities, remedial actions, and associated site activities. When accumulated, the media must be managed appropriately to minimize the exposure and risks to human health and the environment while adhering to applicable regulatory requirements. The objective of this section is to establish specific management practices for the handling and subsequent disposition of these media.

The IDW includes all materials generated during project performance that cannot be effectively reused, recycled, or decontaminated in the field. It consists of both materials that could potentially pose a risk to human health and the environment (e.g., sampling and decontamination wastes) and materials that have little potential to pose risk to human health and the environment (e.g., sanitary solid wastes). Two types of IDW will be generated during the implementation of field activities: indigenous and nonindigenous. Indigenous IDW expected to be generated during site characterization activities at the Rattlesnake Creek site includes subsurface and surface soils. Nonindigenous IDW expected to be generated includes decontamination fluid/water and miscellaneous trash, including PPE. When accumulated, the media must be managed appropriately to minimize exposure and risks to human health and the environment while adhering to applicable regulatory requirements.

Soil cuttings generated during hand auger and Geoprobe sampling will be returned to the area from which they were collected. Decontamination fluids will be collected and contained.

6.9 FIELD DECONTAMINATION

Field sampling equipment used during surface and subsurface soil sampling will be decontaminated according to the standard operating procedure (SOP) of the field sampling plan (FSP). Equipment to be decontaminated includes stainless steel scoops, bowls, spoons, core barrels, and hand auger barrels. Other equipment used during sampling activities that does not directly contact sample materials (down-hole rods, shovels, etc.) will be cleaned by a pressurized steam cleaner to remove visible soil contamination.

Field decontamination will be conducted in an area near the field equipment staging area or in an area approved by the USACE-Buffalo District. Decontamination activities will be conducted so that all solid and liquid wastes generated can be containerized and disposed of as described in Section 6.8.

7 LABORATORY ANALYSIS

Samples will be transferred to a USACE-certified radio-analytical laboratory for analyses in accordance with documented laboratory-specific standard methods and the sampling and analysis program plan for the Ashland sites. Specific analyses for each sample will generally include alpha and gamma spectrometry. In accordance with MARSSIM, analytical techniques will provide a minimum detection level of 25% of the individual radionuclide cleanup goals for all primary contaminants, with a preferred target minimum detection level of 10% of these individual radionuclide cleanup goals.

Soil samples of approximately 1 kilogram (kg) will be obtained, Samples will be packaged and uniquely identified in accordance with chain-of-custody and site-specific procedures. High-resolution gamma spectrometry will be used for quantification of Ra-226. In the case of gamma spectrometry, samples will be held for a sufficient time to allow in-growth of Ra-226 progeny. If turn around times are a concern, alpha spectrometry may be used instead of gamma spectrometry. Wet chemistry separation and alpha spectrometry will be used to measure concentrations of Th-230 and U-238. Activity concentrations in soil will be reported in units of pCi/g. Other quality control activities are incorporated into specific field survey procedures.

8 REPORT OF SURVEY FINDINGS

Survey procedures and results will be documented in a final status sampling survey report, following the general guidance for Final Status Survey Reports in draft NUREG/CR-5849 (NRC 1992) and in MARSSIM. This final status sampling survey report will become an integral part of the site radiological assessment report. This final status sampling survey report will, at a minimum, contain the following information:

- A facility map that shows scan data, locations of elevated direct radiation levels, and sampling locations from each survey unit;
- Tables of radionuclide concentrations in each sample from each survey unit, including, but not limited to, the result in pCi/g, measurement errors, detection limits, and sample depths;
- Summary statistics for analytical data, surface scan data, and gamma logging data from each survey unit;
- A graphical display of individual sample concentrations in the form of posting plots and/or histograms for each survey unit and visual identification of trends; and
- Results of the Sign test.

Interpretation of survey results will follow the DQA process as outlined in both Chapter 8 and Section 2.3 of Appendix E of MARSSIM. There are five steps in the DQA process.

1. Review the DQOs and survey design.
2. Conduct a preliminary data review.
3. Select a statistical test.
4. Verify the assumptions of the statistical test.
5. Draw conclusions about the data.

The primary purpose of the DQO and survey design review is to ascertain post-data collection that the original assumptions built into the DQO process that generated the data collection strategy are still valid. Examples where deviations might have taken place include the spatial scope of the data collection (i.e., field work indicates contamination extending beyond spatial boundaries originally defined by the DQO process), or the unexpected presence of other contaminants of concern. These types of deviations would require revisiting the DQO process, adjusting for realities uncovered by field work, and determining whether the data collected still meet the original objectives of the data collection, and if not, what corrective steps are required.

The preliminary data review should include reviewing quality assurance reports to ensure that the data produced are of the quality assumed by the DQO process, and reviewing data sets themselves to identify trends and properties that may be pertinent to the decisions that must be made based on the data. This would include basic data analysis such as creating posting maps, histograms, determining means and standard deviations, etc.

For the purposes of this final status survey, the statistical test has already been chosen. The principal requirement of the DQA process is to check, based on the data review, that the statistical test selected is still a valid choice. As a non-parametric test, the Sign test imposes very few assumptions on the character of the data set for use, other than that non-detect results do not form a significant fraction of the overall results, and that detection limits are below the DCGL requirements.

The last step of the DQA process involves performing the statistical tests and data analyses specified by the final status survey, drawing conclusions, and documenting results.

9 REFERENCES

Cabrera Services 2004, *Data Report for the Ashland-Rattlesnake Creek Site Sampling Tonawanda, New York*, Final, October 15.

Cabrera Services 2005, *Data Report - Addendum 1 for the Rattlesnake Creek Site Sampling Tonawanda, New York*, Draft, July 15.

DOE 1993a, *Remedial Investigation for the Tonawanda Site*, DOE/OR/21949-300.

DOE 1993b, *Feasibility Study for the Tonawanda Site, DOE/OR/21950-234, Oak Ridge, TN,* November.

DOE 1997, *Radionuclide Cleanup Guideline Derivation for Ashland 1, Ashland 2, and Seaway,* DOE/OR/21950-1023.

EPA 1994, *Guidance for the Data Quality Objectives Process*, EPA QA/G-4, EPA/600/R-96/055, Quality Assurance Management Staff, Washington, D.C., September.

EPA 2000a, *Data Quality Objectives Process for Hazardous Waste Site Investigations*, EPA QA/G-4HW Final, EPA/600/R-00/007, January.

EPA 2000b, *Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM)*, EPA 402-R-97-016, Rev. 1, August.

IT Corporation 2001, *Rattlesnake Creek Investigation Summary Report*, Final, March.

IT Corporation 2002, *Rattlesnake Creek Follow-Up Investigation Report*, Draft, January.

New York State Department of Environmental Conservation (NYSDEC) 2003, *Review of Background Concentrations of Uranium, Thorium and Radium at the Praxair site*, January.

NRC 1992, *Manual for Conducting Radiological Surveys in Support of License Termination*, NUREG/CR-5849 (draft), June.

NRC 1998, *Minimum Detectable Concentrations with Typical Radiation Survey Instruments for Various Contaminants and Field Conditions*, NUREG-1507, June.

USACE 1998a, *Record of Decision for the Ashland 1 (including Seaway Area D) and Ashland 2 Sites, Tonawanda, New York*, Final, April.

USACE 1998b, *Uranium-238 Investigation, Rattlesnake Creek - Phase I, Tonawanda, NY*, December.

USACE 1999, *Rattlesnake Creek Investigation Report - Uranium Sediment Concentrations and Dose Impact Analysis*, Tonawanda NY, June.

USACE 2004, *Explanation of Significant Differences for the Rattlesnake Creek Portion of the Ashland Sites, Tonawanda, NY*, February.

APPENDIX A

DCGL DEVELOPMENT

B.1 DEVELOPMENT OF RESIDUAL RADIOACTIVE SOIL GUIDELINES

Residual radioactive soil guidelines (i.e., DCGLs) were developed for the Rattlesnake Creek with the RESRAD computer code (version 6.101). The radionuclides of concern included U-234, U-235, U-238 and U-total (assuming natural uranium activity ratios), Ra-226 and Th-230; however, residual radioactive soil guidelines were developed for all radionuclides.

A resident gardening scenario was chosen for the analysis. The scenario assumed a resident grew 5% of their plant foods on-site. Other pathways considered incidental soil ingestion, external gamma radiation, and inhalation. The exposure pathways considered in the analysis are summarized in Table A-1. Since Rattlesnake Creek and groundwater below the site are not viable sources of potable or irrigation water, the groundwater and surface water pathways were not used in the guideline calculation (DOE 1993, 1997). It is assumed that the municipal water supply source, currently Lake Erie/Niagara River, is used for these purposes. DCGL values were based on a 25 mrem/yr dose limit (Subpart E of 10 CFR 20), one of the applicable or relevant and appropriate requirements (ARARs) cited in the ROD for the Ashland 1 and 2 sites (USACE 1998). Note that this dose assessment is also consistent with the other ARARs stated in the *Record of Decision for the Ashland 1 (including Seaway Area D) and Ashland 2 Sites, Tonawanda, New York* (ROD) (USACE 1998), i.e., 40 CFR 192, which limits the concentration of Ra-226 to 5 pCi/g within a 100 m^2 area. The parameter values (including the site-specific and default values) for the resident gardening scenario were obtained from the following documents: *Radionuclide Cleanup Guideline Derivation for Ashland 1, Ashland 2 and Seaway Tonawanda New York* (DOE 1997), and the *Rattlesnake Creek Investigation Summary Report, Volume 2 of 2* (IT 2001). The guideline derivation document was the basis for the cleanup criterion published in the Ashland 1 and 2 ROD. Since Rattlesnake Creek is being remediated under the same ROD, the same RESRAD parameters were used to develop the DCGLs for consistency.

A comprehensive listing of parameter values used in the RESRAD code is provided at the end of this appendix.

Soil guideline values were developed for four specific areas: 1 m^2, 100 m^2, 2000 m^2, and 10,000 m^2. The $DCGL_W$ values for Rattlesnake Creek are based on an area of 10,000 m^2, the expected size of a Class 2 survey unit. The resulting residual radioactive soil guidelines are listed in Tables A-2 and A-3. Figures A-1 through A-6 charts the residual radioactive soil guidelines for areas ranging from 1 m^2 to 10,000 m^2 for the radionuclides of concern (i.e., U-234, U-235, U-238, U-total, Ra-226, and Th-230).

Table A-1. RESRAD exposure pathways based on the residential gardening scenario.

RESRAD Exposure Pathway	Active/Suppressed
External Gamma Radiation	Active
Inhalation of Particulates	Active
Ingestion of Plant Foods	Active
Incidental Ingestion of Soil	Active
Ingestion of Meat Products	Suppressed
Ingestion of Milk	Suppressed
Ingestion of Fish/Crustacea	Suppressed
Ingestion of Water	Suppressed
Radon	Suppressed[1]

The Radon pathways were considered independently and the results are provided in Appendix B.

Table A-2. Uranium DCGLs for areas of 1 to 10,000 m^2 based on the residential gardening scenario (external gamma, inhalation, plant ingestion, soil ingestion), no use of groundwater for irrigation or other purposes, 5% contaminated plant fraction (25 mrem/yr dose limit).

Radionuclide	Approximate Area (m^2)	Guideline (pCi/g)
U-234	1	3,800
U-235	1	560
U-238	1	2,000
U-Total	1	2400
U-234	100	3,200
U-235	100	87
U-238	100	450
U-Total	100	660
U-234	2,000	1,800
U-235	2,000	76
U-238	2,000	360
U-Total	2,000	520
U-234	10,000	1,800
U-235	10,000	74
U-238	10,000	350
U-Total	10,000	510

Table A-3. Th-230 and Ra-2226 DCGLs for areas of 1 to 10,000 m² based on the residential gardening scenario (external gamma, inhalation, plant ingestion, soil ingestion), no use of groundwater for irrigation or other purposes, 5% contaminated plant fraction (25 mrem/yr dose limit).

Radionuclide	Approximate Area (m^2)	Guideline (pCi/g)
Th-230	1	46
Ra-226	1	16
Th-230	100	14
Ra-226	100	5
Th-230	2,000	12
Ra-226	2,000	4.4
Th-230	10,000	12
Ra-226	10,000	4.3

Figure A-1. U-234 DCGLs for areas of 1 to 10,000 m^2 based on the residential scenario (external gamma, inhalation, plant ingestion, soil ingestion), no use of groundwater for irrigation or other purposes, 5% contaminated plant fraction (25 mrem/yr dose limit).

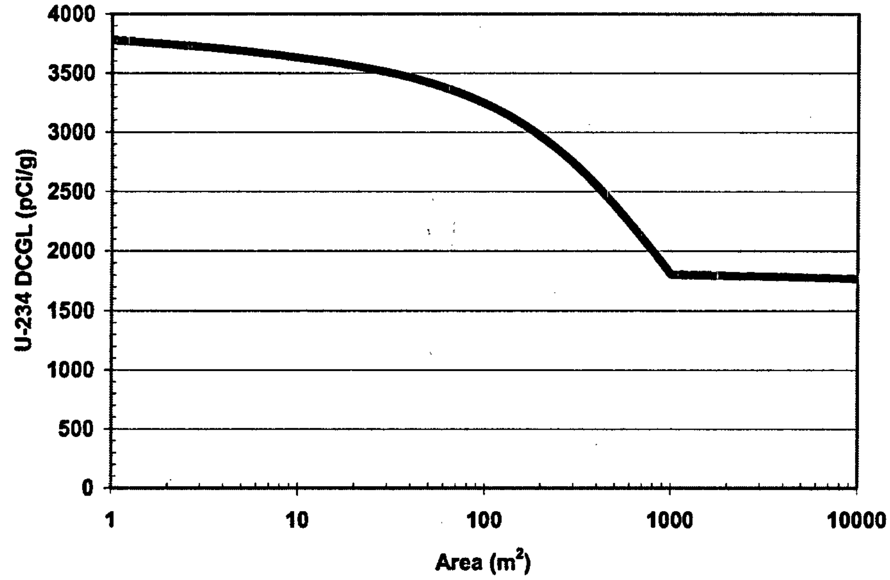


Figure A-2. U-235 DCGLs for areas of 1 to 10,000 m^2 based on the residential scenario (external gamma, inhalation, plant ingestion, soil ingestion), no use of groundwater for irrigation or other purposes, 5% contaminated plant fraction (25 mrem/yr dose limit).

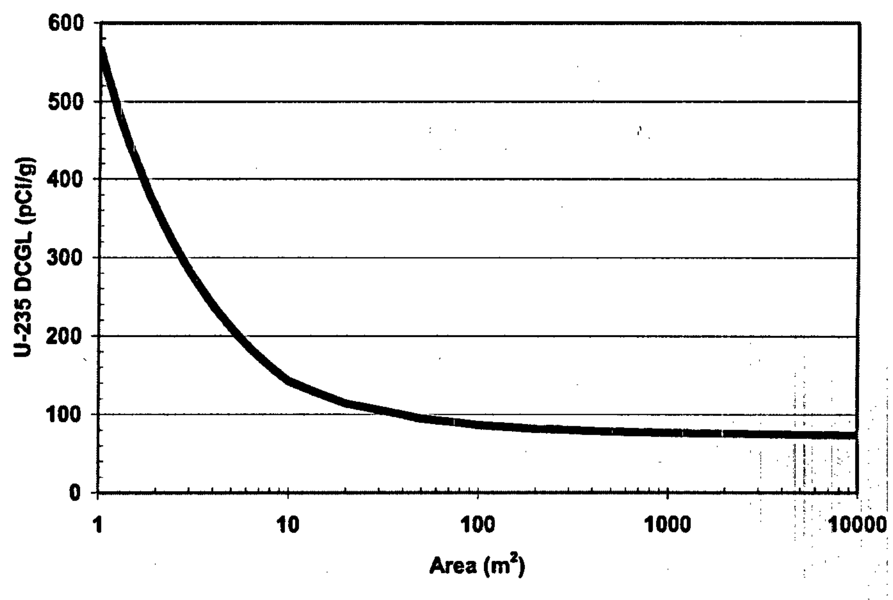


Figure A-3. U-238 DCGLs for areas of 1 to 10,000 m^2 based on the residential scenario (external gamma, inhalation, plant ingestion, soil ingestion), no use of groundwater for irrigation or other purposes, 5% contaminated plant fraction (25 mrem/yr dose limit).

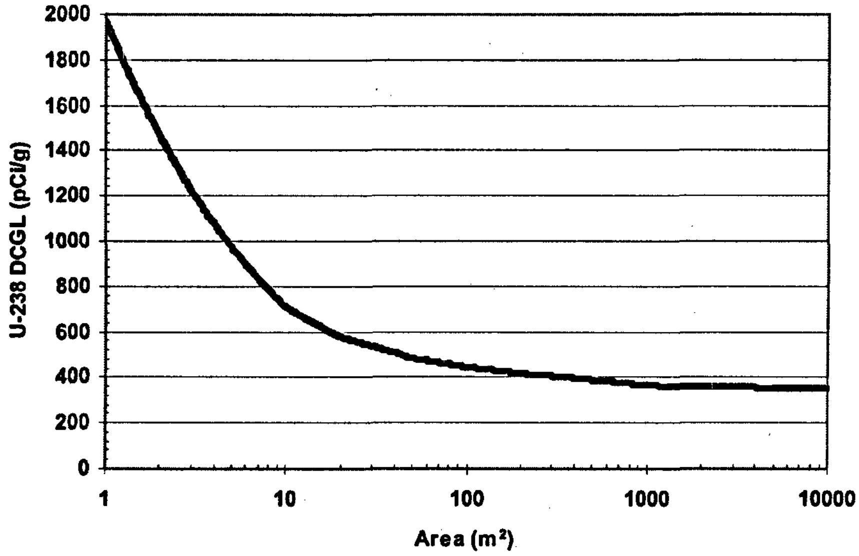


Figure A-4. Total uranium DCGLs for areas of 1 to 10,000 m^2 based on the residential scenario (external gamma, inhalation, plant ingestion, soil ingestion), no use of groundwater for irrigation or other purposes, 5% contaminated plant fraction (25 mrem/yr dose limit).

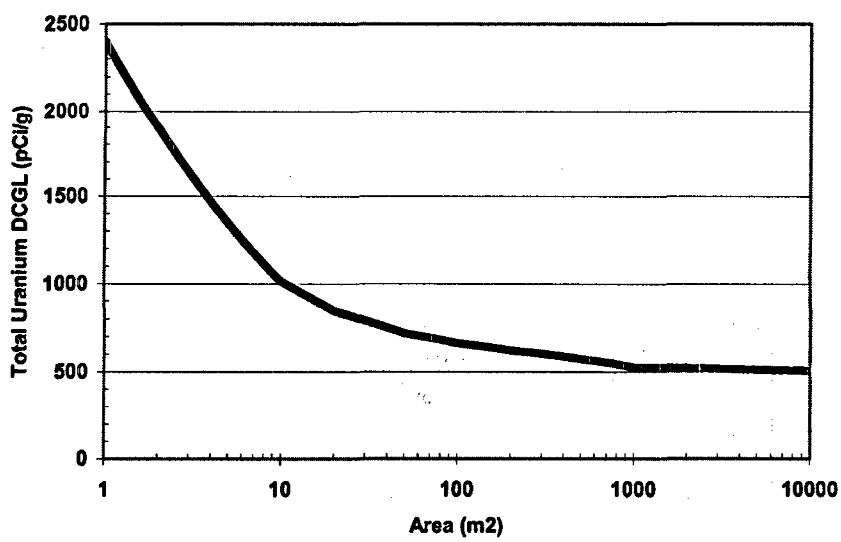


Figure A-5. Ra-226 DCGLs for areas of 1 to 10,000 m^2 based on the residential scenario (external gamma, inhalation, plant ingestion, soil ingestion), no use of groundwater for irrigation or other purposes, 5% contaminated plant fraction (25 mrem/yr dose limit).

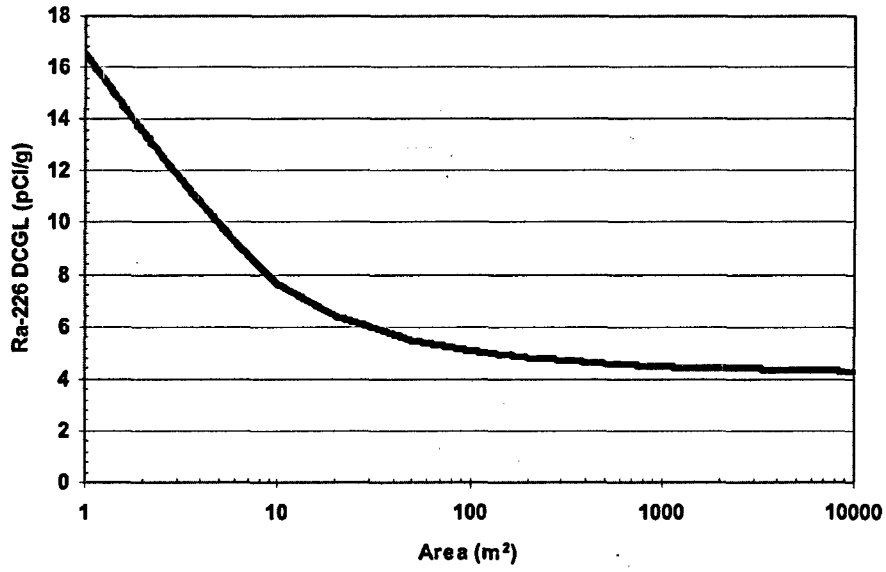
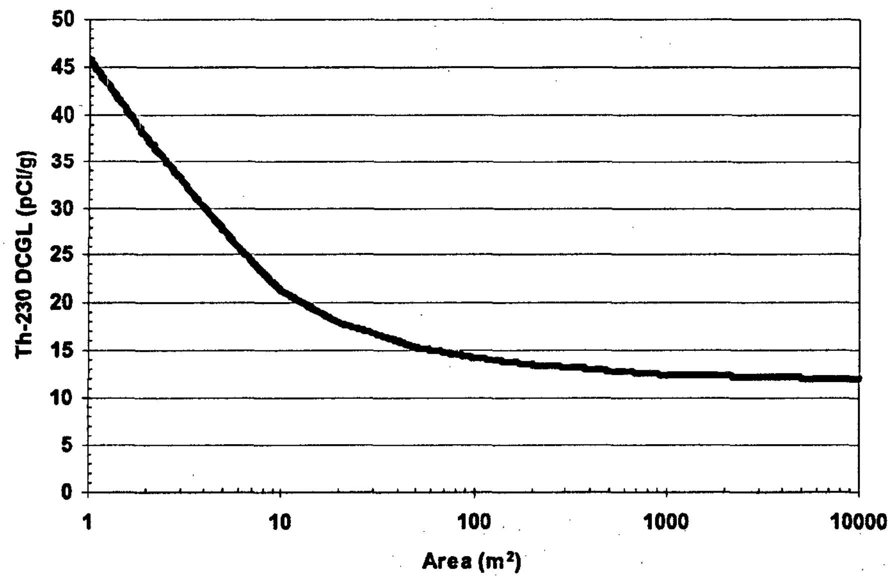


Figure A-6. Th-230 DCGLs for areas of 1 to 10,000m2 based on the residential scenario (external gamma, inhalation, plant ingestion, soil ingestion), no use of groundwater for irrigation or other purposes, 5% contaminated plant fraction (25 mrem/yr dose limit).



A.2 REFERENCES

DOE 1993, *Remedial Investigation for the Tonawanda Site,* DOE/OR/21949-300.

DOE 1997, *Radionuclide Cleanup Guideline Derivation for Ashland 1, Ashland 2 and Seaway Tonawanda New York,* DOE/OR/21950-1023.

IT Corporation 2001, *Rattlesnake Creek Investigation Summary Report, Volume 2 of 2,* March.

USACE 1998, *Record of Decision for the Ashland 1 (including Seaway Area D) and Ashland 2 Sites,* Tonawanda, New York, April.

Dose Conversion Factor (and Related) Parameter Summary
File: FGR 13 Morbidity

0 Menu	Parameter	Current Value	Default	Parameter Name
B-1	Dose conversion factors for inhalation, mrem/pCi:			
B-1	Ac-227+D	6.720E+00	6.720E+00	DCF2(1)
B-1	Pa-231	1.280E+00	1.280E+00	DCF2(2)
B-1	Pb-210+D	2.320E-02	2.320E-02	DCF2(3)
B-1	Ra-226+D	8.600E-03	8.600E-03	DCF2(4)
B-1	Th-230	3.260E-01	3.260E-01	DCF2(5)
B-1	U-234	1.320E-01	1.320E-01	DCF2(6)
B-1	U-235+D	1.230E-01	1.230E-01	DCF2(7)
B-1	U-238+D	1.180E-01	1.180E-01	DCF2(8)
D-1	Dose conversion factors for ingestion, mrem/pCi:			
D-1	Ac-227+D	1.480E-02	1.480E-02	DCF3(1)
D-1	Pa-231	1.060E-02	1.060E-02	DCF3(2)
D-1	Pb-210+D	7.270E-03	7.270E-03	DCF3(3)
D-1	Ra-226+D	1.330E-03	1.330E-03	DCF3(4)
D-1	Th-230	5.480E-04	5.480E-04	DCF3(5)
D-1	U-234	2.830E-04	2.830E-04	DCF3(6)
D-1	U-235+D	2.670E-04	2.670E-04	DCF3(7)
D-1	U-238+D	2.690E-04	2.690E-04	DCF3(8)
D-34	Food transfer factors:			
D-34	Ac-227+D , plant/soil concentration ratio, dimensionless	2.500E-03	2.500E-03	RTF(1,1)
D-34	Ac-227+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	2.000E-05	2.000E-05	RTF(1,2)
D-34	Ac-227+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	2.000E-05	2.000E-05	RTF(1,3)
D-34				
D-34	Pa-231 , plant/soil concentration ratio, dimensionless	1.000E-02	1.000E-02	RTF(2,1)
D-34	Pa-231 , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	5.000E-03	5.000E-03	RTF(2,2)
D-34	Pa-231 , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	5.000E-06	5.000E-06	RTF(2,3)
D-34				
D-34	Pb-210+D , plant/soil concentration ratio, dimensionless	1.000E-02	1.000E-02	RTF(3,1)
D-34	Pb-210+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	8.000E-04	8.000E-04	RTF(3,2)
D-34	Pb-210+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	3.000E-04	3.000E-04	RTF(3,3)
D-34				
D-34	Ra-226+D , plant/soil concentration ratio, dimensionless	4.000E-02	4.000E-02	RTF(4,1)
D-34	Ra-226+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	1.000E-03	1.000E-03	RTF(4,2)
D-34	Ra-226+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	1.000E-03	1.000E-03	RTF(4,3)
D-34				
D-34	Th-230 , plant/soil concentration ratio, dimensionless	1.000E-03	1.000E-03	RTF(5,1)
D-34	Th-230 , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	1.000E-04	1.000E-04	RTF(5,2)

0 Menu	Parameter	Current Value	Default	Parameter Name
0		Current		Parameter
D-34	Th-230 , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	5.000E-06	5.000E-06	RTF(5,3)
D-34				
D-34	U-234 , plant/soil concentration ratio, dimensionless	2.500E-03	2.500E-03	RTF(6,1)
D-34	U-234 , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	3.400E-04	3.400E-04	RTF(6,2)
D-34	U-234 , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	6.000E-04	6.000E-04	RTF(6,3)
D-34				
D-34	U-235+D , plant/soil concentration ratio, dimensionless	2.500E-03	2.500E-03	RTF(7,1)
D-34	U-235+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	3.400E-04	3.400E-04	RTF(7,2)
D-34	U-235+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	6.000E-04	6.000E-04	RTF(7,3)
D-34				

Menu	Parameter	Value	Default	Name
D-34	U-238+D , plant/soil concentration ratio, dimensionless	2.500E-03	2.500E-03	RTF(8,1)
D-34	U-238+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	3.400E-04	3.400E-04	RTF(8,2)
D-34	U-238+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	6.000E-04	6.000E-04	RTF(8,3)
D-5	Bioaccumulation factors, fresh water, L/kg:			
D-5	Ac-227+D , fish	1.500E+01	1.500E+01	BIOFAC(1,1)
D-5	Ac-227+D , crustacea and mollusks	1.000E+03	1.000E+03	BIOFAC(1,2)
D-5				
D-5	Pa-231 , fish	1.000E+01	1.000E+01	BIOFAC(2,1)
D-5	Pa-231 , crustacea and mollusks	1.100E+02	1.100E+02	BIOFAC(2,2)
D-5				
D-5	Pb-210+D , fish	3.000E+02	3.000E+02	BIOFAC(3,1)
D-5	Pb-210+D , crustacea and mollusks	1.000E+02	1.000E+02	BIOFAC(3,2)
D-5				
D-5	Ra-226+D , fish	5.000E+01	5.000E+01	BIOFAC(4,1)
D-5	Ra-226+D , crustacea and mollusks	2.500E+02	2.500E+02	BIOFAC(4,2)
D-5				
D-5	Th-230 , fish	1.000E+02	1.000E+02	BIOFAC(5,1)
D-5	Th-230 , crustacea and mollusks	5.000E+02	5.000E+02	BIOFAC(5,2)
D-5				
D-5	U-234 , fish	1.000E+01	1.000E+01	BIOFAC(6,1)
D-5	U-234 , crustacea and mollusks	6.000E+01	6.000E+01	BIOFAC(6,2)
D-5				
D-5	U-235+D , fish	1.000E+01	1.000E+01	BIOFAC(7,1)
D-5	U-235+D , crustacea and mollusks	6.000E+01	6.000E+01	BIOFAC(7,2)
D-5				
D-5	U-238+D , fish	1.000E+01	1.000E+01	BIOFAC(8,1)
D-5	U-238+D , crustacea and mollusks	6.000E+01	6.000E+01	BIOFAC(8,2)

0 Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R011	Area of contaminated zone (m**2)	1-10,000	1.000E+04	---	AREA
R011	Thickness of contaminated zone (m)	2.000E+00	2.000E+00	---	THICK0
R011	Length parallel to aquifer flow (m)	1.000E+02	1.000E+02	---	LCZPAQ
R011	Basic radiation dose limit (mrem/yr)	2.500E+01	2.500E+01	---	BRDL
R011	Time since placement of material (yr)	0.000E+00	0.000E+00	---	TI
R011	Times for calculations (yr)	1.000E+00	1.000E+00	---	T(2)
R011	Times for calculations (yr)	3.000E+00	3.000E+00	---	T(3)
R011	Times for calculations (yr)	1.000E+01	1.000E+01	---	T(4)
R011	Times for calculations (yr)	3.000E+01	3.000E+01	---	T(5)
R011	Times for calculations (yr)	1.000E+02	1.000E+02	---	T(6)
R011	Times for calculations (yr)	3.000E+02	3.000E+02	---	T(7)
R011	Times for calculations (yr)	1.000E+03	1.000E+03	---	T(8)
R011	Times for calculations (yr)	not used	0.000E+00	---	T(9)
R011	Times for calculations (yr)	not used	0.000E+00	---	T(10)
R012	Initial principal radionuclide (pCi/g): Ra-226	1.000E+00	0.000E+00	---	S1(4)
R012	Initial principal radionuclide (pCi/g): Th-230	1.000E+00	0.000E+00	---	S1(5)
R012	Initial principal radionuclide (pCi/g): U-234	4.890E-01	0.000E+00	---	S1(6)
R012	Initial principal radionuclide (pCi/g): U-235	2.250E-02	0.000E+00	---	S1(7)
R012	Initial principal radionuclide (pCi/g): U-238	4.890E-01	0.000E+00	---	S1(8)
R012	Concentration in groundwater (pCi/L): Ra-226	not used	0.000E+00	---	W1(4)
R012	Concentration in groundwater (pCi/L): Th-230	not used	0.000E+00	---	W1(5)
R012	Concentration in groundwater (pCi/L): U-234	not used	0.000E+00	---	W1(6)
R012	Concentration in groundwater (pCi/L): U-235	not used	0.000E+00	---	W1(7)
R012	Concentration in groundwater (pCi/L): U-238	not used	0.000E+00	---	W1(8)
R013	Cover depth (m)	0.000E+00	0.000E+00	---	COVER0
R013	Density of cover material (g/cm**3)	not used	1.500E+00	---	DENSCV
R013	Cover depth erosion rate (m/yr)	not used	1.000E-03	---	VCV
R013	Density of contaminated zone (g/cm**3)	1.500E+00	1.500E+00	---	DENSCZ
R013	Contaminated zone erosion rate (m/yr)	6.000E-05	1.000E-03	---	VCZ
R013	Contaminated zone total porosity	4.500E-01	4.000E-01	---	TPCZ
R013	Contaminated zone field capacity	2.000E-01	2.000E-01	---	FCCZ
R013	Contaminated zone hydraulic conductivity (m/yr)	1.230E+02	1.000E+01	---	HCCZ
R013	Contaminated zone b parameter	5.300E+00	5.300E+00	---	BCZ
R013	Average annual wind speed (m/sec)	2.000E+00	2.000E+00	---	WIND
R013	Humidity in air (g/m**3)	not used	8.000E+00	---	HUMID
R013	Evapotranspiration coefficient	4.600E-01	5.000E-01	---	EVAPTR
R013	Precipitation (m/yr)	1.230E+00	1.000E+00	---	PRECIP
R013	Irrigation (m/yr)	2.000E-01	2.000E-01	---	RI
R013	Irrigation mode	overhead	overhead	---	IDITCH
R013	Runoff coefficient	2.500E-01	2.000E-01	---	RUNOFF
R013	Watershed area for nearby stream or pond (m**2)	1.000E+06	1.000E+06	---	WAREA
R013	Accuracy for water/soil computations	1.000E-03	1.000E-03	---	EPS
R014	Density of saturated zone (g/cm**3)	1.500E+00	1.500E+00	---	DENSAQ
R014	Saturated zone total porosity	4.000E-01	4.000E-01	---	TPSZ

0 Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R014	Saturated zone hydraulic gradient	2.000E-02	2.000E-02	---	HGWT
R014	Saturated zone b parameter	5.300E+00	5.300E+00	---	BSZ
R014	Water table drop rate (m/yr)	1.000E-03	1.000E-03	---	VWT
R014	Well pump intake depth (m below water table)	1.000E+01	1.000E+01	---	DWIBWT
R014	Model: Nondispersion (ND) or Mass-Balance (MB)	ND	ND	---	MODEL
R014	Well pumping rate (m**3/yr)	2.500E+02	2.500E+02	---	UW
R015	Number of unsaturated zone strata	1	1	---	NS
R015	Unsat. zone 1, thickness (m)	4.000E+00	4.000E+00	---	H(1)
R015	Unsat. zone 1, soil density (g/cm**3)	1.500E+00	1.500E+00	---	DENSUZ(1)
R015	Unsat. zone 1, total porosity	4.000E-01	4.000E-01	---	TPUZ(1)
R015	Unsat. zone 1, effective porosity	2.000E-01	2.000E-01	---	EPUZ(1)
R015	Unsat. zone 1, field capacity	2.000E-01	2.000E-01	---	FCUZ(1)
R015	Unsat. zone 1, soil-specific b parameter	5.300E+00	5.300E+00	---	BUZ(1)
R015	Unsat. zone 1, hydraulic conductivity (m/yr)	1.000E+01	1.000E+01	---	HCUZ(1)
R016	Distribution coefficients for Ra-226				
R016	Contaminated zone (cm**3/g)	9.100E+03	7.000E+01	---	DCNUCC(4)
R016	Unsaturated zone 1 (cm**3/g)	9.100E+03	7.000E+01	---	DCNUCU(4,1)
R016	Saturated zone (cm**3/g)	9.100E+03	7.000E+01	---	DCNUCS(4)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	2.220E-05	ALEACH(4)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(4)
R016	Distribution coefficients for Th-230				
R016	Contaminated zone (cm**3/g)	5.800E+03	6.000E+04	---	DCNUCC(5)
R016	Unsaturated zone 1 (cm**3/g)	5.800E+03	6.000E+04	---	DCNUCU(5,1)
R016	Saturated zone (cm**3/g)	5.800E+03	6.000E+04	---	DCNUCS(5)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	3.483E-05	ALEACH(5)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(5)
R016	Distribution coefficients for U-234				
R016	Contaminated zone (cm**3/g)	1.000E+01	5.000E+01	---	DCNUCC(6)
R016	Unsaturated zone 1 (cm**3/g)	1.000E+01	5.000E+01	---	DCNUCU(6,1)
R016	Saturated zone (cm**3/g)	1.000E+01	5.000E+01	---	DCNUCS(6)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	1.980E-02	ALEACH(6)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(6)
R016	Distribution coefficients for U-235				
R016	Contaminated zone (cm**3/g)	1.000E+01	5.000E+01	---	DCNUCC(7)
R016	Unsaturated zone 1 (cm**3/g)	1.000E+01	5.000E+01	---	DCNUCU(7,1)

0 Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R016	Saturated zone (cm**3/g)	1.000E+01	5.000E+01	---	DCNUCS(7)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	1.980E-02	ALEACH(7)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(7)
R016	Distribution coefficients for U-238				
R016	Contaminated zone (cm**3/g)	1.000E+01	5.000E+01	---	DCNUCC(8)
R016	Unsaturated zone 1 (cm**3/g)	1.000E+01	5.000E+01	---	DCNUCU(8,1)
R016	Saturated zone (cm**3/g)	1.000E+01	5.000E+01	---	DCNUCS(8)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	1.980E-02	ALEACH(8)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(8)
R016	Distribution coefficients for daughter Ac-227				
R016	Contaminated zone (cm**3/g)	2.400E+03	2.000E+01	---	DCNUCC(1)
R016	Unsaturated zone 1 (cm**3/g)	2.400E+03	2.000E+01	---	DCNUCU(1,1)
R016	Saturated zone (cm**3/g)	2.400E+03	2.000E+01	---	DCNUCS(1)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	1.000E-02	ALEACH(1)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(1)
R016	Distribution coefficients for daughter Pa-231				
R016	Contaminated zone (cm**3/g)	2.700E+03	5.000E+01	---	DCNUCC(2)
R016	Unsaturated zone 1 (cm**3/g)	2.700E+03	5.000E+01	---	DCNUCU(2,1)
R016	Saturated zone (cm**3/g)	2.700E+03	5.000E+01	---	DCNUCS(2)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	4.025E-03	ALEACH(2)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(2)
R016	Distribution coefficients for daughter Pb-210				
R016	Contaminated zone (cm**3/g)	5.500E+02	1.000E+02	---	DCNUCC(3)
R016	Unsaturated zone 1 (cm**3/g)	5.500E+02	1.000E+02	---	DCNUCU(3,1)
R016	Saturated zone (cm**3/g)	5.500E+02	1.000E+02	---	DCNUCS(3)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	3.672E-04	ALEACH(3)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(3)
R017	Inhalation rate (m**3/yr)	7.300E+03	8.400E+03	---	INHALR
R017	Mass loading for inhalation (g/m**3)	3.000E-05	1.000E-04	---	MLINH
R017	Exposure duration	3.000E+01	3.000E+01	---	ED
R017	Shielding factor, inhalation	4.000E-01	4.000E-01	---	SHF3
R017	Shielding factor, external gamma	7.000E-01	7.000E-01	---	SHF1
R017	Fraction of time spent indoors	6.200E-01	5.000E-01	---	FIND
R017	Fraction of time spent outdoors (on site)	2.000E-02	2.500E-01	---	FOTD
R017	Shape factor flag, external gamma	1.000E+00	1.000E+00	>0 shows circular AREA.	FS
R017	Radii of shape factor array (used if FS = -1):				
R017	Outer annular radius (m), ring 1:	not used	5.000E+01	---	RAD_SHAPE(1)
R017	Outer annular radius (m), ring 2:	not used	7.071E+01	---	RAD_SHAPE(2)
R017	Outer annular radius (m), ring 3:	not used	0.000E+00	---	RAD_SHAPE(3)
R017	Outer annular radius (m), ring 4:	not used	0.000E+00	---	RAD_SHAPE(4)

0 Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R017	Outer annular radius (m), ring 5:	not used	0.000E+00	---	RAD_SHAPE(5)
R017	Outer annular radius (m), ring 6:	not used	0.000E+00	---	RAD_SHAPE(6)
R017	Outer annular radius (m), ring 7:	not used	0.000E+00	---	RAD_SHAPE(7)
R017	Outer annular radius (m), ring 8:	not used	0.000E+00	---	RAD_SHAPE(8)
R017	Outer annular radius (m), ring 9:	not used	0.000E+00	---	RAD_SHAPE(9)
R017	Outer annular radius (m), ring 10:	not used	0.000E+00	---	RAD_SHAPE(10)
R017	Outer annular radius (m), ring 11:	not used	0.000E+00	---	RAD_SHAPE(11)
R017	Outer annular radius (m), ring 12:	not used	0.000E+00	---	RAD_SHAPE(12)
R017	Fractions of annular areas within AREA:				
R017	Ring 1	not used	1.000E+00	---	FRACA(1)
R017	Ring 2	not used	2.732E-01	---	FRACA(2)
R017	Ring 3	not used	0.000E+00	---	FRACA(3)
R017	Ring 4	not used	0.000E+00	---	FRACA(4)
R017	Ring 5	not used	0.000E+00	---	FRACA(5)
R017	Ring 6	not used	0.000E+00	---	FRACA(6)
R017	Ring 7	not used	0.000E+00	---	FRACA(7)
R017	Ring 8	not used	0.000E+00	---	FRACA(8)
R017	Ring 9	not used	0.000E+00	---	FRACA(9)
R017	Ring 10	not used	0.000E+00	---	FRACA(10)
R017	Ring 11	not used	0.000E+00	---	FRACA(11)
R017	Ring 12	not used	0.000E+00	---	FRACA(12)
R018	Fruits, vegetables and grain consumption (kg/yr)	1.600E+02	1.600E+02	---	DIET(1)
R018	Leafy vegetable consumption (kg/yr)	1.400E+01	1.400E+01	---	DIET(2)
R018	Milk consumption (L/yr)	not used	9.200E+01	---	DIET(3)
R018	Meat and poultry consumption (kg/yr)	not used	6.300E+01	---	DIET(4)
R018	Fish consumption (kg/yr)	not used	5.400E+00	---	DIET(5)
R018	Other seafood consumption (kg/yr)	not used	9.000E-01	---	DIET(6)
R018	Soil ingestion rate (g/yr)	3.650E+01	3.650E+01	---	SOIL
R018	Drinking water intake (L/yr)	not used	5.100E+02	---	DWI
R018	Contamination fraction of drinking water	not used	1.000E+00	---	FDW
R018	Contamination fraction of household water	not used	1.000E+00	---	FHHW
R018	Contamination fraction of livestock water	not used	1.000E+00	---	FLW
R018	Contamination fraction of irrigation water	0.000E+00	1.000E+00	---	FIRW
R018	Contamination fraction of aquatic food	not used	5.000E-01	---	FR9
R018	Contamination fraction of plant food	5.000E-02	-1	---	FPLANT
R018	Contamination fraction of meat	not used	-1	---	FMEAT
R018	Contamination fraction of milk	not used	-1	---	FMILK
R019	Livestock fodder intake for meat (kg/day)	not used	6.800E+01	---	LFI5
R019	Livestock fodder intake for milk (kg/day)	not used	5.500E+01	---	LFI6
R019	Livestock water intake for meat (L/day)	not used	5.000E+01	---	LWI5
R019	Livestock water intake for milk (L/day)	not used	1.600E+02	---	LWI6
R019	Livestock soil intake (kg/day)	not used	5.000E-01	---	LSI

Site-Specific Parameter Summary (continued)

0 Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R019	Mass loading for foliar deposition (g/m**3)	1.000E-04	1.000E-04	---	MLFD
R019	Depth of soil mixing layer (m)	5.000E-02	1.500E-01	---	DM
R019	Depth of roots (m)	9.000E-01	9.000E-01	---	DROOT
R019	Drinking water fraction from ground water	not used	1.000E+00	---	FGWDW
R019	Household water fraction from ground water	not used	1.000E+00	---	FGWHH
R019	Livestock water fraction from ground water	not used	1.000E+00	---	FGWLW
R019	Irrigation fraction from ground water	1.000E+00	1.000E+00	---	FGWIR
R19B	Wet weight crop yield for Non-Leafy (kg/m**2)	7.000E-01	7.000E-01	---	YV(1)
R19B	Wet weight crop yield for Leafy (kg/m**2)	1.500E+00	1.500E+00	---	YV(2)
R19B	Wet weight crop yield for Fodder (kg/m**2)	not used	1.100E+00	---	YV(3)
R19B	Growing Season for Non-Leafy (years)	1.700E-01	1.700E-01	---	TE(1)
R19B	Growing Season for Leafy (years)	2.500E-01	2.500E-01	---	TE(2)
R19B	Growing Season for Fodder (years)	not used	8.000E-02	---	TE(3)
R19B	Translocation Factor for Non-Leafy	1.000E-01	1.000E-01	---	TIV(1)
R19B	Translocation Factor for Leafy	1.000E+00	1.000E+00	---	TIV(2)
R19B	Translocation Factor for Fodder	not used	1.000E+00	---	TIV(3)
R19B	Dry Foliar Interception Fraction for Non-Leafy	2.500E-01	2.500E-01	---	RDRY(1)
R19B	Dry Foliar Interception Fraction for Leafy	2.500E-01	2.500E-01	---	RDRY(2)
R19B	Dry Foliar Interception Fraction for Fodder	not used	2.500E-01	---	RDRY(3)
R19B	Wet Foliar Interception Fraction for Non-Leafy	2.500E-01	2.500E-01	---	RWET(1)
R19B	Wet Foliar Interception Fraction for Leafy	2.500E-01	2.500E-01	---	RWET(2)
R19B	Wet Foliar Interception Fraction for Fodder	not used	2.500E-01	---	RWET(3)
R19B	Weathering Removal Constant for Vegetation	2.000E+01	2.000E+01	---	WLAM
C14	C-12 concentration in water (g/cm**3)	not used	2.000E-05	---	C12WTR
C14	C-12 concentration in contaminated soil (g/g)	not used	3.000E-02	---	C12CZ
C14	Fraction of vegetation carbon from soil	not used	2.000E-02	---	CSOIL
C14	Fraction of vegetation carbon from air	not used	9.800E-01	---	CAIR
C14	C-14 evasion layer thickness in soil (m)	not used	3.000E-01	---	DMC
C14	C-14 evasion flux rate from soil (1/sec)	not used	7.000E-07	---	EVSN
C14	C-12 evasion flux rate from soil (1/sec)	not used	1.000E-10	---	REVSN
C14	Fraction of grain in beef cattle feed	not used	8.000E-01	---	AVFG4
C14	Fraction of grain in milk cow feed	not used	2.000E-01	---	AVFG5
C14	DCF correction factor for gaseous forms of C14	not used	8.894E+01	---	CO2F
STOR	Storage times of contaminated foodstuffs (days):				
STOR	Fruits, non-leafy vegetables, and grain	1.400E+01	1.400E+01	---	STOR_T(1)
STOR	Leafy vegetables	1.000E+00	1.000E+00	---	STOR_T(2)
STOR	Milk	1.000E+00	1.000E+00	---	STOR_T(3)
STOR	Meat and poultry	2.000E+01	2.000E+01	---	STOR_T(4)
STOR	Fish	7.000E+00	7.000E+00	---	STOR_T(5)

0 Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
STOR	Crustacea and mollusks	7.000E+00	7.000E+00	---	STOR_T(6)
STOR	Well water	1.000E+00	1.000E+00	---	STOR_T(7)
STOR	Surface water	1.000E+00	1.000E+00	---	STOR_T(8)
STOR	Livestock fodder	4.500E+01	4.500E+01	---	STOR_T(9)
R021	Thickness of building foundation (m)	not used	1.500E-01	---	FLOOR1
R021	Bulk density of building foundation (g/cm**3)	not used	2.400E+00	---	DENSFL
R021	Total porosity of the cover material	not used	4.000E-01	---	TPCV
R021	Total porosity of the building foundation	not used	1.000E-01	---	TPFL
R021	Volumetric water content of the cover material	not used	5.000E-02	---	PH2OCV
R021	Volumetric water content of the foundation	not used	3.000E-02	---	PH2OFL
R021	Diffusion coefficient for radon gas (m/sec):				
R021	in cover material	not used	2.000E-06	---	DIFCV
R021	in foundation material	not used	3.000E-07	---	DIFFL
R021	in contaminated zone soil	not used	2.000E-06	---	DIFCZ
R021	Radon vertical dimension of mixing (m)	not used	2.000E+00	---	HMIX
R021	Average building air exchange rate (1/hr)	not used	5.000E-01	---	REXG
R021	Height of the building (room) (m)	not used	2.500E+00	---	HRM
R021	Building interior area factor	not used	0.000E+00	---	FAI
R021	Building depth below ground surface (m)	not used	-1.000E+00	---	DMFL
R021	Emanating power of Rn-222 gas	not used	2.500E-01	---	EMANA(1)
R021	Emanating power of Rn-220 gas	not used	1.500E-01	---	EMANA(2)
TITL	Number of graphical time points	32	---	---	NPTS
TITL	Maximum number of integration points for dose	17	---	---	LYMAX

APPENDIX B

RADON EMANATION ESTIMATES

One of the ROD requirements applicable to Rattlesnake Creek imposes a constraint on radon emanation. Specifically, the requirement states that the release of Rn-222 and Rn-220 into the atmosphere resulting from the management of uranium and thorium by-product materials shall not exceed an average release rate of 20 pCi/m^2-s (Subpart D of 40 CFR 192). In addition to this requirement, other ROD requirements restrict the average residual activity concentration for contaminants of concern, including those (Ra-226 and Th-230) that contribute to the formation of radon in contaminated soils.

RESRAD (version 6.101) was used to estimate the potential radon emanation rates that might be expected for the Rattlesnake Creek area if remediation attained the activity concentration requirements specified by the ROD. The radon calculations for Rattlesnake creek used the default radon parameters in RESRAD. The thickness of the contaminated zone (2 m) was the same as that used for previous Rattlesnake Creek dose assessments and is the default used in RESRAD.

With these parameter values, for total U, the maximum outdoor radon flux occurred at 1,000 years and was 4.3E-5 pCi/m^2/s per pCi/g of total U. For total U the maximum indoor radon flux occurred at 1,000 years and was 9.9E-6 pCi/m^2/s per pCi/g of total U.

With these parameter values, for Ra-226, the maximum outdoor radon flux occurred at 0 years and was 0.74 pCi/m^2/s per pCi/g Ra-226. For Ra-226 the maximum indoor radon flux occurred at 0 years and was 0.13 pCi/m^2/s per pCi/g Ra-226.

With these parameter values, for Th-230, the maximum outdoor radon flux occurred at 1000 years and was 0.2 pCi/m^2/s per pCi/g Th-230. For Th-230 the maximum indoor radon flux occurred at 1000 years and was 0.043 pCi/m^2/s per pCi/g Th-230.

Neglecting the difference in time of maximum radon emanation rates for these three radionuclides, and assuming that they all began at activity concentrations equal to their $DCGL_w$ requirements, the maximum radon emanation rate would be 5.6 pCi/m^2/s for outdoor conditions, and 1.1 pCi/m^2/s indoors. Both of these values are well below the radon flux requirements specified in the ROD.

FINAL
GAMMA WALKOVER SURVEY
SAMPLING AND ANALYSIS PLAN

PROJECT WORK PLANS, ACQUISITION OF FIELD DATA AND TECHNICAL SUPPORT FOR SHALLOW LAND DISPOSAL AREA (SLDA) PARKS TOWNSHIP ARMSTRONG COUNTY, PENNSYLVANIA

CONTRACT NO. DACW49-01-D-0001
DELIVERY ORDER 0010

APRIL 21, 2003

DEPARTMENT OF THE ARMY

Prepared by

URS Group, Inc.

G3624

URS Corporation
INDEPENDENT TECHNICAL REVIEW REPORT

Client: Unites States Army Corps. of Engineers   Project Number: 11172781.00000

Project Name: Shallow Land Disposal Area

I. Assigned Independent Reviewer: Duane Lenhardt
(To be completed by Project Manager)
Documents Reviewed: Field Sampling Plan, Site Safety and Health Plan, and Quality Assurance Project Plan
(Title/Revision Number) Shallow Land Disposal Area - Gamma Walkover Survey Work Plans
The scope of the review: Technical Content and Completeness
Submitted by: Tom Fralick 12/1/2002 Author: Kevin Shanahan 12/1/2002
Project Manager Date Date

II. Review Summary
(To be completed by the Independent Reviewer)
I have reviewed the above-referenced docuent in accordance with the appropriate checklist(s) and project scope.
My conclusions are as follows:

Reference comments on: [X] work product [ ] or attached, pages ____ through ____

III. Reviewer Report
(To be completed by the Independent Reviewer; Approved by PM or PIC)

A. [X] The Reviewer's comments have been provided. Reviewer's Initials: DRL Date: 12/17/02

B. [X] Verification of correct incorporation of resolved comments into final document is complete.

Submitted by: Duane S. Lenhardt Date: 2/12/03
Independent Reviewer

C. This review has been completed. Any significant issues not resolved between the Independent Reviewer and the Originator have been resolved by me.

Approved by: Thomas Fralick Date: 2/12/03
Project Manager, Principal-in-Charge or designee
(As applicable)

NOTE: If there is a dispute between the author and reviewer, the PM or PIC is consulted.

cc: Project QA File
Office QA Officer