Kaiser Aluminum
Corporate Environmental Affairs

October 6, 2003
Project No. 5427L-01

ATTN: Document Control Clerk
U.S. Nuclear Regulatory Commission
Washington, DC 20555

40-2377

Revision to Kaiser Phase II Decommissioning Plan (May 2003)
Tulsa, Oklahoma Facility
Kaiser Aluminum & Chemical Corporation

Dear Mr. Buckley:

Enclosed please find two copies of the revised Chapter 14.0, "Facility Radiation Surveys" of the Phase II Decommissioning Plan (DP) for the Kaiser Aluminum & Chemical Corporation (Kaiser) Tulsa, Oklahoma facility. During the development of the final status survey plan it was discovered that a Chapter 14.0 parameter, Average Derived Concentration Level ($ADCL_W$), was incorrectly identified as the acceptance criteria for the 14-acre pond parcel area of the site.

Initially in the Remediation Feasibility Study and subsequently in the DP the concept of segregation of the pond parcel material was developed as follows: **Material with Th-232 activity concentrations greater than 31.1 pCi/g will be segregated and disposed of at a permitted facility. Material with activity concentrations less than 31.1 pCi/g will be placed in the pond parcel excavation as backfill. The average Th-232 content of the below-criteria material is estimated to be 7 pCi/g.** Implementation of the plan results in off-site disposal of material with Th-232 concentrations greater than 31.1 pCi/g as exempt material. This cutoff concentration was selected because (1) dose evaluations using the resident farmer as the critical group have demonstrated that the remaining average concentrations result in a dose significantly less than the 25 mrem/yr dose criteria established by NRC, and (2) the average concentration of material to be disposed off site will meet the definition of exempt material (less than 0.05 wt% thorium), thereby greatly reducing disposal costs.

To support the implementation of the final status survey, Derived Concentration Guideline Values (DCGL) were developed. The concentration of residual radioactivity (per radionuclide) distinguishable from background that, if distributed uniformly throughout a survey unit, results in a TEDE of 25 mrem in 1 year to an average member of the critical group is the single-radionuclide $DCGL_W$. However, two parameters were developed to describe the segregation concept: 1) the Derived Cutoff Concentration Level (DCCL) of 31.1 pCi/g Th-232, the dividing line concentration between material which must be exported to an off-site disposal facility and material which can remain on site under an unrestricted release scenario, and 2) the average concentration of below-criteria material remaining on site, the Average Derived Concentration Level ($ADCL_W$). Based upon dose evaluations, the $ADCL_W$, rounded to 7 pCi/g Th-232, results in a postremediation TEDE well below 1 mrem/yr. The actual TEDE resulting from 7 pCi/g of Th-232 is 0.286 mrem while the TEDE resulting from 31.1 pCi.g Th-232 is 1.2 mrem.

9141 Interline Avenue, Suite 1A Baton Rouge, LA 70809-1957

NMSS01

Both the ADCL and the DCCL are both well below the definition of DCGL value (equal to 25 mrem TEDE) and compliance with either will result in unrestricted release that is ALARA. The current version of Chapter 14.0 identifies the ADCL (i.e. the DCGL) as the release criterion for material returned to the excavation after separation of above-DCCL material. However, the ADCL represents the projected average concentration of material returned to the excavation. Material as high as 31.1 pCi/g will be returned to the excavation. Final surveys compared to the projected average value of 7 pCi/g will result in failing survey units that are significantly below acceptance criteria. The intended acceptance criteria for material returned to the excavation is the DCCL value of 31.1 pCi.g of Th-232. The implementation of the remedial action (segregation of material at 31.1 pCi/g Th-232) will still result in an average concentration of approximately 7 pCi/g, well below 31.1 pCi/g.

Revisions to Chapter 14.0 are minimal with the substitution of "DCCL" for "$ADCL_w$" accounting for the majority. No other revisions to the DP are necessary. The revisions to Chapter 14 will not change the scope of work in the approved DP or the protectiveness of the cleanup. Please review and approve the enclosed revised Chapter 14 at your earliest convenience. If you should have any questions concerning the two enclosures, please do not hesitate to call me at (225) 231-5116.

Respectfully submitted,

Bill Vinzant

J. W. (Bill) Vinzant
Manager, Corporate Environmental Affairs

JWV:tls

Enclosures

cc: Mr. John Buckley – U.S. Nuclear Regulatory Commission
Mr. Dwight Chamberland – U.S. Nuclear Regulatory Commission, Region IV
Ms. Pamela Bishop – Oklahoma Department of Environmental Quality
Ms. Kelly Hunter Burch – State of Oklahoma
Dr. Max Scott – ADA Consultants
Mr. Tre Fischer – Houston
Mr. M. David Tourdot – Earth Sciences
Al Gutterman – Morgan, Lewis & Bockius LLP
Mr. Paul Handa – Tulsa
Ms. Roberta Fowlkes – Ann Green Communications
Mr. Scott Van Loo – City of Tulsa

W:\54271\corr\nrc.doc

Table of Contents

14.0 Facility Radiation Surveys

This chapter presents the general framework for facility radiation surveys relative to the decommissioning of the Tulsa facility. The chapter focuses on the 14-acre Pond Parcel area. Supplemental information relative to facility radiation surveys for the "former operational area" of the facility is provided in Chapter 14.0 of the May 2002 DPA (Revised May 2003).

14.1 Release Criteria

The site will be remediated in accordance with decommissioning criteria of Subpart E, Radiological Criteria for License Termination of 10 CFR Part 20, Standards of Protection Against Radiation. Specifically, Subpart E, 10 CFR 20.1402, Radiological Criteria for Unrestricted Use, allows release of a site for unrestricted use if the residual radioactivity distinguishable from background results in a TEDE to an average member of the critical group that does not exceed 25 mrem/yr and the residual radioactivity has been reduced to levels that are ALARA.

Dose modeling is used to estimate the TEDE to the average member of the critical group (that group reasonably expected to receive the greatest exposure to residual radioactivity for any applicable circumstances). The concentration of residual radioactivity (per radionuclide) distinguishable from background that, if distributed uniformly throughout a survey unit, results in a TEDE of 25 mrem in 1 year to an average member of the critical group is the single-radionuclide $DCGL_W$. Preliminary $DCGL_W$ values for the radionuclides of concern at the Kaiser site have been calculated using the guidance provided in NUREG-1549, Decision Methods for Dose Assessment to Comply With Radiological Criteria for License Termination. In order to account for the presence of multiple radionuclides, the Unity Rule was applied, and $DCGL_W$ values adjusted as shown in Table 14-1.

Table 14-1
$DCGL_W$ Values

Radionuclide	Single Radionuclide $DCGL_W$ (pCi/g)	Ratio to Th-232 Assuming Equilibration	Average Concentration with Th-232 at Single Rad $DCGL_W$ (pCi/g)	Adjusted $DCGL_W$ to Meet Unity Rule (pCi/g)
Pb-210	1.751	0.043	0.15	0.12
Ra-226	5.9	0.082	0.28	0.24
Ra-228	4.3	1	3.4	3
Th-228	3.4	1	3.4	3
Th-230	102	3.5	12	10
Th-232	3.4	1	3.4	3

In developing the remedial action plan, a derived cutoff concentration level (DCCL) of 31.1 pCi/g Th-232 has been determined. This value represents the dividing line concentration between material which must be exported to an off-site disposal facility and material which can remain on site under an unrestricted release scenario. Based upon kriging analyses (Appendix A), on average, material above the DCCL is exempt. Moreover, the kriging volume estimates together with the dose assessment presented in Chapter 5.0 demonstrate that unrestricted release dose levels can be achieved when material below the DCCL is returned to the excavation as described in Chapter 8.0. The average concentration of below-criteria material remaining on site is termed herein as the Average Derived Concentration Level (ADCL). Based upon dose evaluations, the ADCL, rounded to 7 pCi/g Th-232, results in a postremediation TEDE well below 1 mrem/yr.

The three important threshold concentration criteria and their significance are summarized below in Table 14-2.

Table 14-2
Threshold Concentration Criteria

Parameter	Value (pCi/g Th-232)	Application
$DCGL_W$	3.0	Release criterion for soil stockpile/processing area
DCCL	31.1	Dividing line for off-site disposal of material
ADCL	7	Estimated average concentration of material left on site as backfill

Table 14-3 presents area factors (based upon MARSSIM guidance) to be used for elevated measurement comparisons (EMC) and to determine sampling requirements in situations where the scan instrument's minimum detectable concentration is greater than the $DCGL_W$ orDCCL depending on the survey area. The $DCLG_{EMC}$ values applicable to the stockpile/processing area are calculated by multiplying the $DCGL_W$ by the area factors presented in Table 14-3. $DCGL_{EMC}$ values are presented in Table 14-4.

$$DCGL_{EMC} = \text{Area Factor} * DCGL_W$$

For the segregated material below 31.1 pCi/g of Th-232 left onsite as backfill, the ADCL value was multiplied by the area factors presented in Table 14-3 and the results are presented in Table 14-5.

$$ADCL_{EMC} = \text{Area Factor} * ADCL$$

However, since the material used as backfill is material below 31.1 pCi/g of Th-232, the elevated measurement comparison is only applicable to concentrations exceeding 31.1 pCi/g of Th-232. The ADCL value of 7 pCi/g of Th-232 was conservatively used to establish elevated measurement criteria for the backfill material greater than 31.1 pCi/g of Th-232, to maintain the average concentration of the backfill material ALARA.

Table 14-3
Area Factors

	Area Factors								
Radio-nuclide	1 m^2 ($11 ft^2$)	3 m^2 ($32 ft^2$)	10 m^2 ($108 ft^2$)	30 m^2 ($323 ft^2$)	100 m^2 ($1,076 ft^2$)	300 m^2 ($3,229 ft^2$)	1,000 m^2 ($10,764 ft^2$)	3,000 m^2 ($32,292 ft^2$)	10,000 m^2 ($107,639 ft^2$)
Th-232	12.5	6.2	3.2	2.3	1.8	1.5	1.1	1.0	1.0

Table 14-4
$DCGL_{EMC}$ Values for Processing Area

	$DCGL_{EMC}$ (pCi/g)								
Radio-nuclide	1 m^2 ($11 ft^2$)	3 m^2 ($32 ft^2$)	10 m^2 ($108 ft^2$)	30 m^2 ($323 ft^2$)	100 m^2 ($1,076 ft^2$)	300 m^2 ($3,229 ft^2$)	1,000 m^2 ($10,764 ft^2$)	3,000 m^2 ($32,292 ft^2$)	10,000 m^2 ($107,639 ft^2$)
Th-232	37.5	18.6	9.6	6.9	5.4	4.5	3.3	3.0	3.0

Table 14-5
$ADCL_{EMC}$ Values for Excavation Areas

	$ADCL_{EMC}$ (pCi/g)								
Radio-nuclide	1 m^2 ($11 ft^2$)	3 m^2 ($32 ft^2$)	10 m^2 ($108 ft^2$)	30 m^2 ($323 ft^2$)	100 m^2 ($1,076 ft^2$)	300 m^2 ($3,229 ft^2$)	1,000 m^2 ($10,764 ft^2$)	3,000 m^2 ($32,292 ft^2$)	10,000 m^2 ($107,639 ft^2$)
Th-232	87.5	43.4	22.4	16.1	12.6	10.5	7.7	7.0	7.0

14.2 Characterization Surveys

A series of radiological characterization surveys of the site have been performed from 1994 to 2001. A summary of each survey is provided.

14.2.1 ADA 1994

In February of 1994, the site was divided into eight sections and a gamma walk-over survey was performed. Measurements were taken at 1 m above the ground every 15 feet. A Ludlum Model 3-97 Survey Meter (internal 1-inch-by-1-inch NaI [Tl] scintillator detector) calibrated to read micro-Roentgen per hour (μR/hr) was used. Background was established as 10 μR/hr, and readings of greater than twice background were observed in all eight sections of the site including a maximum of 400 μR/hr. Five 18-inch core boring samples, one background core boring, and four additional soil samples from test digs were taken. The samples were oven dried at approximately 50°C for 12 hours and then counted for a minimum of 100 minutes using an ORTEC Multichannel Analyzer connected to a Canberra High Purity Intrinsic Germanium Detector. Analytical results confirmed the presence of Th-228 in secular equilibrium with Th-232. Th-230 (from the natural uranium decay chain) also was identified. The Th-230 was 2.4 to 3.4 times the Th-232 activity.

14.2.2 ARS 1995

In October of 1994, a more extensive characterization of the site was performed. Two hundred and fifty samples were systematically collected from 90 borehole locations. Samples were collected in 500-ml Marinelli containers, weighed to the nearest 0.1 g, and counted for 10 minutes with a shielded 2-inch-by-2-inch NaI (Tl) scintillator detector. The instrument was a Bicron LabTech Dual Channel Analyzer.

Sixty 200-ml subsamples were taken from the 250 field samples. Subsamples were analyzed using a density compensating gamma spectroscopy system (Nuclear Fuel Systems, Inc.) for U-234, U-235, U-238, and Th-232. Referred to as the At Line Solution Assay System (ALSAS), it provided density corrected pCi/g values. A correlation coefficient (r) of 0.990 relating the total counts of the field 2-inch-by-2-inch NaI (Tl) detector field count to the analytical results (pCi/g) of the same sample was completed. Linear regression was used to determine an equation to calculate pCi/g values from counts. The results of the survey were total thorium (Th-232 + Th-228) pCi/g values ranging from below the MDA of 1 pCi/g to 425.6 pCi/g.

Alpha spectroscopy was performed on 11 of the samples and confirmed the previously established ratio of Th-232 to Th-230 in dross of between 1:2.4 and 1:3.4. The 11 samples were selected from 60 sample results that fell in the 1 to 50 pCi/g total thorium range. The 11 samples represented 3 of the 4 main areas surveyed including the Retention Pond, the Reserve Pond, and the land area between the railroad and the Retention Pond. The ratios calculated from these data ranged from 1:0.62 to 1:3.15. Data were consistent with previous characterization survey results and were used to estimate volumes of contaminated material and to map contamination at depth.

Surface water from the Retention Pond (two samples) and from Fulton Creek (one sample) were collected and analyzed by gamma spectroscopy. Results were below the MDA value of approximately 1.0 pCi/l Th-232.

14.2.3 Adjacent Land Remediation Plan Appendix A

In 1999, 24 samples were selected (on site) to confirm the Th-232 to Th-230 ratio in the dross. The samples were selected based on geographical distribution and included both the Retention and Reserve ponds and a range of depths. The data approximate the ratio to be 1:3.5. This ratio was used to calculate the Th-230 activity based on the measured Th-232 activity during Phase I remediation of adjacent (to Kaiser property) land.

14.2.4 Summary

NUREG-1575 (MARSSIM) defines areas that have no reasonable potential for residual contamination as "nonimpacted." These areas have no radiological impact from site operations. Areas with some potential for residual contamination are defined as "impacted." Impacted areas are further divided into Class 1, 2, or 3 areas based on the potential for contamination.

The former Freshwater Pond area is nonimpacted. Results of characterization surveys indicate that the remainder of the pond parcel east of the former Freshwater Pond area is impacted. The land areas have been classified in accordance with MARSSIM based on the existing characterization survey data. The classification is provided in the Final Status Survey Design section below. In addition, part of the adjacent land was impacted and was remediated in 2000-2001. The adjacent land area was surveyed under NUREG/CR-5849 and the unrestricted release approved by the NRC in 2002. Therefore, the entire area adjacent to the site as delineated by grids in Figure 2-4, is not addressed in this phase of decommissioning.

In addition to the characterization events detailed in Sections 14.2.1, 14.2.2, and 14.2.3, composite samples of characterization core samples and final status samples were taken during adjacent land remediation surveys. The composite samples were analyzed by alpha spectroscopy to further evaluate the Th-232 to Th-230 activity ratio. The results yielded Th-232 to Th-230 ratios from 1:0.32 to 1:2.95. A summary of soil sample analyses performed to calculate the ratio of Th-232 to Th-230 activity is presented in the table below. A compilation of the analytical data used to calculate the ratio of Th-232 to Th-230 is presented in Appendix E. The established ratio of Th-232 to Th-230 of 1:3.5 will continue to be used during Phase II of the decommissioning of the site because this is the most conservative (protective) approach. A summary of sample result Th-232 to Th-230 activity ratios for the Kaiser site is provided in Table 14-6 below.

Table 14-6

Measured Th-232 to Th-230 Ratios

Reference	Number of Samples	Minimum Ratio of Th-232:Th-230	Maximum Ratio of Th-232:Th-230	Average Ratio of Th-232:Th-230
ADA 1994	3	1:2.4	1:3.4	NA
ARS 1995	11	1:0.6	1:3.1	1:1.7
Kaiser 1999	24	1:1.5	1:6.4	1:3.4
ES 2002	14	1:0.32	1:3.0	1:2.1

Characterization activities concerning water sample analysis have also shown that the contaminated material is not soluble.

The characterization of the site is complete. Extensive characterization surveys and sample analysis have been reviewed to provide the initial classification of the site open land areas and structural surfaces. The majority of the land area is impacted and classified as Class 1. The only nonimpacted area is the Freshwater Pond parcel based on site history and the adjacent land based on final status survey results. The only identified subsurface structural surface is the spillway. The spillway is classified as impacted Class 1. All additional subsurface structures discovered during excavation in Class 1 open land areas will be classified as Class 1. Reclassification of any areas would be based on final status survey measurements secured as detailed in the following parts of Section 14.0.

14.3 Remedial Action Support Surveys

Segregation of impacted soil during remediation may be aided by an automated system equipped with NaI (or equivalent) gamma detectors. Alternatively, HPTs may segregate impacted soil using portable survey instruments equipped with NaI detectors. Both detection methods have the sensitivity to detect Th-232 (surrogate radionuclide) below the most restrictive threshold value of 3 pCi/g above background. Th-232 is an alpha emitter but is in secular equilibrium with several progeny that emit high-energy photons. Detection of Th-232 is based on the detection of these high-energy photons. Table 14-7 provides MDC values calculated using the guidance provided in NUREG-1575, MARSSIM, for increasing background values. The calculation of MDC is based on the detection of high-energy emitting Th-232 progeny.

Table 14-7
MARSSIM Calculated Minimum Detectable Concentration Values
For Increasing Background (2-inch-by-2-inch NaI Detectors)

Background (cpm)	Minimum Detectable Count Rate (ncpm)	Scan Minimum Detectable Concentration (μR/hr)	Scan Minimum Detectable Concentration (pCi/g Th-232)
3,000	585	1.00	1.0
5,000	756	1.29	1.3
7,000	894	1.52	1.5
9,000	1,014	1.73	1.7
11,000	1,121	1.91	1.9
13,000	1,219	2.08	2.1
15,000	1,309	2.23	2.2
16,000	1,352	2.30	2.3
17,000	1,394	2.37	2.3
18,000	1,434	2.44	2.4
19,000	1,473	2.51	2.5
20,000	1,512	2.58	2.5
21,000	1,549	2.64	2.6

Remedial action support surveys will be performed while remediation is being conducted and will guide the remedial action in a real-time mode. These surveys will be used to determine when a survey unit is ready for the final status survey. The remedial action surveys will rely principally on direct radiation measurement using gamma-sensitive instrumentation. Scan MDC will be determined for remediation survey instrumentation using the same protocol as final status surveys. The determination of a survey unit's readiness for a final status survey will rely on the on-site knowledge of the area (i.e., kriging information and area classification) and the results from the survey instrumentation.

During remediation, excavated material will be characterized into one of the following four categories based on physical description and/or radiological survey:

- Contaminated Soil (or soil-like material) – Soil above the $DCGL_W$ or DCCL value for the processing and Retention Pond areas respectively.
- Acceptable Backfill Soil (or soil-like material) – Soil containing radioactivity above the $DCGL_W$ but below the DCCL value.
- Suspect Contaminated Soil (or soil like material) – Soil which requires additional characterization for the determination of whether it is below the $DCGL_W$ or DCCL value.

- Debris (Structural Surface Survey Material) – Nonsoil material that is oversized (e.g., concrete fragments, bricks, and construction debris). Surveys of debris consist of surveys of structural surfaces for total (fixed) and removable contamination in units of disintegrations per minute per one hundred centimeters squared (dpm/100 cm^2).

Debris is subdivided into two categories: 1) removable debris that can be easily removed from an excavation and 2) permanent structures such as the concrete spillway contained beneath Characterization Grids 1-4 (ALRP). Removable debris will be segregated from soil to the extent practical by visual inspection. Debris buried within the dross and soil mixture will be evaluated in accordance with NRC Fuel Cycle Policy and Guidance Directive FC 83-23 to determine whether they are potential candidates for clearance surveys considering such factors as volumetric contamination and accessibility of surfaces for survey. Clearance surveys may be performed if large, nonporous, solid debris with only surface contamination are uncovered during residue excavation. In this case, clearance surveys for total and loose alpha will be performed on the debris to ensure that released items are released in accordance with NRC Fuel Cycle Policy and Guidance Directive FC 83-23. Otherwise, debris material will be packaged to meet the applicable disposal facility waste acceptance criteria. Permanent structures will be surveyed for unrestricted release in accordance with the guidance provided in the May 2002 DPA for structural surface surveys.

The area containing the Characterization Grids 1-4 (ALRP) is known to contain a concrete spillway. As shown in Figure 4-1, the spillway starts slightly west of Characterization Grid 1 and runs from west to east. The spillway turns north at Characterization Grid 4 and proceeds toward the Retention Pond. The spillway is considered a permanent structure and will be surveyed as a Class 1 structure.

Additional subsurface structures may be encountered during excavation. The structures will first be categorized as permanent or removable. If the structures are permanent, a final status survey of structural surfaces will be performed. Since thorium is highly insoluble, it is not anticipated that structures will be volumetrically contaminated. However, subsurface culverts and/or piping may be encountered. Structures with internal surfaces will receive final status surveys of both external and internal surfaces. Consideration will be given to nonaccessible surfaces. Residues, sediments, and/or liquids encountered will be collected and held for sampling. Based on the results of the sample analysis, the material will be dispositioned accordingly. Gas proportional detectors will be used to survey structural surfaces when possible. The final and clearance survey protocols for structures are detailed in subsequent parts of Chapter 14.0. Soil and/or soil like material surrounding structures will be segregated in accordance with this plan.

Based on survey DCCL, $DCGL_W$, and ADCL values, survey instrumentation threshold values will be determined. The lower bound threshold is the value below which surveyed soil is acceptable backfill soil. The upper bound threshold is the value above which surveyed soil is contaminated soil. The two threshold values will be conservatively set based on empirical data (e.g., the lower bound threshold value will be set at the average net counts per minute [ncpm] value corresponding to the $DCGL_W$ less one standard deviation and the upper bound threshold will be set at the average plus one standard deviation) to ensure that soil is acceptable backfill or that soil is contaminated. The average ncpm value will be derived from empirical data and will be continually checked as survey and analytical data are collected. Soil surveyed with results between the two threshold values will be stockpiled as suspect contaminated soil and will be sampled for laboratory analysis to determine if the soil is acceptable backfill or contaminated.

14.4 Final Status Survey Design

14.4.1 Survey Objective

The objective of this survey is to demonstrate that residual radioactivity levels meet the site release criteria.

14.4.2 Basic Design

14.4.2.1 MARSSIM's Wilcoxon Rank Sum Test

The final status survey will use systematic grid sampling to determine the average radionuclide concentration in a survey unit and gross gamma scans to screen for elevated areas. At least the minimum number of samples (N/2) will be taken in each survey unit. Since the radionuclides of interest occur naturally in background, the minimum number of samples (N/2) from the reference background area will also be used to complete the Wilcoxon Rank Sum (WRS) Test.

Minimum Number of Samples (N/2)

When using the WRS test, the minimum number of samples (N/2) is the number of samples required in the survey unit and in the reference background area. Hence "N" is the total number of samples required to complete the WRS test. Paramount to determining the minimum number of samples is the determination of the relative shift, delta over sigma (Δ/σ). Delta is equal to the DCGL minus the lower bound gray region (LBGR) value. The LBGR value is arbitrarily set at one-half the DCGL value to start the determination. Sigma is an estimate of the variability in a set of sample analysis results from a survey unit. The estimate of sigma used is based on the standard deviations in Th-232 activity measured in survey units during the final status sampling of the adjacent land remediation final survey (0.42). Sigma may be increased if the spatial variability of contaminants within a given survey unit is expected to be greater than 0.42. Since the Th-232 activity concentration of 3.0 pCi/g will be used as the surrogate DGCLw, Δ is equal to 3.0 – 1.5, or 1.5. Delta divided by the sigma of 0.42 results in a relative shift of 3.57 which is rounded to 3.5 for the purpose of determining the required number of samples. The number of samples can be calculated using the following formula or looked up in Table 5.3 of MARSSIM:

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

where:

$Z_{1-\alpha}$ = percentile represented by selected value of α, Table 5.2 of MARSSIM
$Z_{1-\beta}$ = percentile represented by selected value of β, Table 5.2 of MARSSIM
P_r = value obtained from Table 5.1 of MARSSIM

Based on a relative shift of 3.5, the following number of samples are required to meet the DQOs:

Size of Survey Unit	Class	DQOs for α and β	Number of Sampling Locations
$\geq$ 10 m^2 <2,000 m^2	1	0.05, 0.05	9
$\geq$ 2,000 m^2 and <10,000 m^2	2	0.05, 0.05	9
$\geq$ 10,000 m^2	3	0.05, 0.05	9

Likewise, for surveys of the backfill material the number of samples is 9 corresponding to a relative shift of 3.5, based on the DCCL value of 31.1, the LBGR of 15.6 and a sigma estimate of 4.4 pCi/g.

The number of samples in the above table includes a factor to increase the number of required samples by 20 percent, as recommended by MARSSIM, to allow for lost or unusable data. The number of required samples may be further increased to increase the power level of the statistical tests. Additional sampling locations may also be necessary if characterization data and remedial action surveys and sampling indicate that there is greater than expected spatial variability (σ)of sample results within specific survey units.

14.4.2.2 Discrete Soil Sampling

The results of discrete soil sampling will be used to verify that the average soil concentration is less than the appropriate $DCGL_W$ or DCCL values. Regardless of the survey unit classification (Class 1, Class 2, or Class 3), a predetermined minimum number of samples will be collected in each survey unit. A random-start triangular grid pattern will be used in Class 1 and Class 2 survey units. This sampling pattern is generally the most efficient means of identifying small areas of elevated activity. The distance between the grid nodes (L) will be determined by

$$L = [A/(0.866 \times n)]^{½}$$

where A is the survey unit area to be covered by the grid pattern and n is the number of samples.

The random start point will be selected by use of readily available random point generators such as provided by the spreadsheet Excel. Sample points will be located by use of a global positioning system (GPS) or equivalent survey equipment.

14.4.2.3 Scanning

Scanning surveys will be used to identify small areas of elevated activity. The percentage of the survey unit to be covered by scans will be based upon the survey unit classification in accordance with the following table.

Table 14-8

Survey Unit Classification	Scanning Coverage
Class 1	100 percent coverage
Class 2	10 to 100 percent Systematic and Judgmental
Class 3	Judgmental

One hundred percent coverage means that the entire surface area of the survey unit has been covered by the field of view of the detector. The scanning coverage for Class 1 areas will be 100 percent. The scanning coverage for Class 2 areas will be adjusted based on the level of confidence supplied by existing data. Whenever less than 100 percent of the survey unit is scanned, the Data Manager will determine the degree of scan coverage and which areas are to be scanned based on the information available at the time of survey. For example, if the potential for contamination in a section of the survey unit is higher than the rest, i.e., the section that borders a Class 1 survey unit, this section may receive 100 percent coverage, while the remaining section may receive 50 percent systematic coverage. If the survey unit has an equally unlikely potential for contamination, e.g., isolated with no previous history of contamination, a systematic coverage at 25 percent coverage may be appropriate.

14.4.2.4 Null Hypothesis

The null hypothesis (H_o) to be tested is that the residual contamination exceeds the remedial objective (release criteria are not met) and the alternative hypothesis (H_A) is that the residual contamination meets the remedial objective (release criteria is met).

14.4.2.5 Decision Error Rates

There are two types of decision errors as shown below:

		DECISION/OUTCOME OF STATISTICAL TEST	
		Reject H_o	Accept H_O
TRUE CONDITION OF SURVEY UNIT	Meets remedial objective (below $DCGL_W$)	No decision error (probability = 1 -α)	Incorrectly fail to release survey unit Type II error (probability = β)
	Exceeds remedial objective (exceeds $DCGL_W$)	Incorrectly release survey unit Type I error (probability = α)	No decision error (probability = 1 - β)

Examination of this table highlights the importance of limiting the Type I error rate (or α) in terms of protection of human health and the environment. The DQO selected for α is 0.05. The DQO selected for β is 0.05.

14.5 Use of a Surrogate Radionuclide

Characterization activities have verified that the primary radionuclides of concern are isotopes of thorium. Th-232 and Th-228 are part of the natural thorium decay chain and have been verified to be in secular equilibrium (i.e., the activity of Th-228 is equal to that of Th-232). Another isotope of thorium, Th-230, has been identified as a primary radionuclide of concern. Although Th-230 is part of the natural uranium decay chain, no uranium has been identified. However, in the estimated 55 years since Th-230 was separated from the uranium decay chain, some Ra-226, a member of the decay chain below Th-230, has grown in. The relationship of Th-230 activity to that of Th-232 has been established in previous characterization of the site. The relationship of Th-230 activity is 3.5 times Th-232 activity. Not all of the radionuclides present can be identified by real-time gamma surveys or by gamma spectroscopy of soil samples--the most efficient and cost-effective measurements. In addition, each of the radionuclides contributes to the total dose to varying degrees of magnitude. In order to save both time and resources, it is desirable to select a surrogate radionuclide to demonstrate compliance for all the radionuclides and to guide remediation activities. Th-232 has been selected as the surrogate radionuclide.

14.6 Establishing Background

Appendix F contains the reference area, surface soil, and background data consisting of two different reference areas located approximately 1 mile apart. The results of 30 different sampling locations in each reference area presented in the *Adjacent Land Characterization*, Kaiser Aluminum Specialty Products, Appendix A, Estimate of Volume of Off-Site Contaminated Soil, Adjacent Land Characterization Report, ADA, March 1999. These data were also used for the background determination during the Kaiser Adjacent Land Area Remediation Project. Based on a review of the data in both reference areas, there appears to be no significant variability between the two reference areas that were sampled. The mean Th-232 concentration in the reference area located on the nonimpacted northwest Kaiser property is 0.94 +/- 0.11 pCi/g at the 95 percent confidence level, and mean Th-232 concentration in a reference area located approximately 1 mile away is 1.06 +/- 0.10 pCi/g at the 95 percent confidence level. The reference area data standard deviations were 0.30 and 0.28 respectively. According to NUREG 1727, "When there may be significant difference in backgrounds between different areas, a Kruskal-Wallis test...can be used to determine whether there are, in fact, significant differences in mean background concentrations among potential reference areas." Based on the agreement between the mean of both reference areas, it is not necessary to conduct a Kruskal-Wallis test on the reference area data, because there is no significant variability between the two reference areas that have been sampled. The established background value was 1.1 pCi/g Th-232.

14.7 Area Classifications

All of the areas have undergone either a characterization study or historical site assessment that is used as the basis for the initial determination of the area classification established in this section. The former Freshwater Pond area currently is not impacted. However, DPs call for use of this area (after closure) as a material processing area. Therefore, all areas in the Pond Parcel with the exception of the clean backfill cover have been designated as impacted for purposes of classification and survey. In addition, gamma surveys will be performed in areas adjacent to the dross pond to confirm that elevated gamma levels measured during the ALRP were due to gamma contribution from the pond.

Definitions

Class	Definition	Survey Unit Size
1 Land Areas	Areas known or expected to have radionuclide concentrations above the $DCGL_W$	Up to 2,000 m^2
2 Land Areas	Areas known or expected to have radionuclide concentrations above normal background concentrations but that are not expected to be above the $DCGL_W$	2,000 to 10,000 m^2
3 Land Areas	Areas that are not expected to have radionuclide concentrations detectable above normal background concentrations	No limit
1 Structural Surfaces	Areas known or expected to have radionuclide concentrations above the $DCGL_W$	Up to 100 m2 of floor area
2 Structural Surfaces	Areas known or expected to have radionuclide concentrations above normal background concentrations but that are not expected to be above the $DCGL_W$	100 to 1,000 m2
3 Structural Surfaces	Areas that are not expected to have radionuclide concentrations detectable above normal background concentrations	No limit

Initial Area Classifications

Area	Description	Classification
Processing Area (Fresh Water Pond)	Area currently occupied by a Freshwater Pond which will be used for processing/stockpiling excavated materials (≈9 survey units).	1
Former Retention Pond Area Bottom	Area formerly occupied by the dross Retention Pond and Reserve Pond, post excavation of dross (≈21 survey units).	1
Former Retention Pond Area	Area formerly occupied by the dross Retention Pond and Reserve Pond, backfilled with below-criteria material in 2-foot survey lifts (≈21 survey units per lift).	1
Former Operational Area	The triangular parcel of land north of 41st Street and south of the Union Pacific Railroad right-of-way in which plant processes and operations occurred.	1
Spillway/Other Permanent Structures	Structures (such as the spillway) located where thoriated material is known to exist. The total area of these structures cannot be determined until uncovered by excavation.	1

14.7.1 Process for Reassignment of Area Classifications

All areas will not have the same potential for residual contamination and, accordingly, will not need the same level of survey coverage to achieve the established release criteria. The initial area classifications are based on a combination of characterization data and historical information. Additional information obtained during the remediation process may lead to the determination that the initial classifications established should be revised to be consistent with the definitions given.

14.7.2 Classification Upgrades

Any area classification may be upgraded (e.g., from Class 2 to Class 1) by the Data Manager based on the receipt of additional survey or measurement information that justifies the need for such action.

14.7.3 Classification Downgrades

Any area classification may be downgraded (e.g., from Class 1 to Class 2) by the Data Manager based on the receipt of additional survey or measurement information that justifies the lower classification provided that the approval of the Kaiser RSO and the NRC is obtained.

14.7.4 Documentation of Classification Changes

All changes to the initial area classifications will be documented and included in the final soil remediation documentation.

14.8 Selection of Survey Units

Each impacted area will be divided into a number of survey units based on the classification defined above. Selection of the survey units will be based on areas having similar operational history or similar potential for residual radioactivity to the extent practical. Survey units also will have relatively compact shapes unless an unusual shape is appropriate for the site operational history or site conditions.

14.9 Field Instrumentation

The gamma-emitting progeny of the surrogate radionuclide Th-232 emit high-energy photons and are easily detected using survey instruments equipped with NaI scintillation crystal detectors. Scanning for gross gamma activity will be used to guide remediation activities and as part of the final status survey when remediation is complete. The following survey instruments (or equivalents) as appropriate will be used to scan soil:

Manufacturer and Meter	Manufacturer and Detector Model	Detector Type	Use
Ludlum 2221	Ludlum 44-10 2"-x-2" NaI scintillator	Sodium Iodide (unshielded)	Scans for Gamma-Emitting Radionuclides

Use of these field instruments or acceptable equivalents are evaluated against the goal of achieving MDCs of less than 75 percent of the $DCGL_W$ for direct measurements and/or scanning measurements. MDCs were calculated for scanning instruments using the method provided in MARSSIM for calculating MDCs that control both Type I and Type II errors (i.e., elimination of false negatives and false positives) as follows:

$$\text{Scan MDCR}_{\text{surveyor}} = \frac{\text{MDCR}}{\sqrt{p}\,\epsilon_i}$$

Where MDCR is the minimum detectable count rate in counts per minute (cpm), ϵ_i is the instrument efficiency (cpm/μR/hour), and p is the surveyor efficiency. The value of p has been estimated to be between 0.5 and 0.75. The value of 0.5 is conservative. In addition:

$$MDCR = s_i \times (60/i)$$

$$s_i = d' \sqrt{b_i}$$

where si is the minimal number of net source counts required for a specified level of performance for the interval i, in seconds; d' is the value selected from MARSSIM Table 6.5 based on the required true positive and false positive rates; and bi is the number of background counts in the intervali. The value of d' used to calculate the detector sensitivity values is 1.38, corresponding to an alpha of 0.05 and beta of 0.40. This value of d' will result in less than 5 percent false negatives and about 40 percent false positives. Typical scan MDCs using the MARSSIM two stage scan methodology for survey instruments equipped with 2-inch-by-2-inch NaI detectors are summarized in Table 14-7 for increasing background count rates. Static and scan MDCs for surface contamination detectors are presented in Chapter 14.0 and Appendix D of the May 2002 DPA.

For surface contamination scanning and static measurements, the radionuclides of concern and/or their progeny emit alpha and/or beta particles that are easily detected using survey instruments equipped with gas proportional detectors and scalers. Scanning for gross alpha or gross beta activity will be used as part of status surveys of structural surface survey units to ensure elevated areas of activity are not missed. In addition, static counts of structural surfaces at predetermined sample points are used to assess total contamination of structural surfaces. The following survey instruments (or equivalents) will be used to scan structural surfaces:

Manufacturer and Meter	Manufacturer and Detector Model	Detector Type	Use
Ludlum 2224	Ludlum 43-89 Dual Phosphor Alpha/Beta Detector	Zinc Sulfide Scintillator	Scans and Static Counts for Alpha and Beta Emitting Radionuclides
Ludlum 2221	Ludlum 43-68 Gas Proportional	Gas Proportional	Scans and Static Counts for Alpha and Beta Emitting Radionuclides

Use of these field instruments or acceptable equivalents are evaluated against the goal of achieving MDCs of less than the $DCGL_w$s for direct measurements and/or scanning measurements. MDCs will be calculated for scanning instruments using the method provided in MARSSIM for calculating MDC that controls both Type I and Type II errors (i.e., elimination of false negatives and false positives) as follows:

Alpha Scan

There are two equations based on the MARSSIM two-stage scan methodology used to determine the alpha scanning MDC depending on the background level. For a typical alpha background level of less than 3 cpm, the probability of detecting a single count while passing over the contaminated area is:

$$P(n \geq 1) = 1 - e^{\frac{-GEd}{60v}}$$

where:

P(n ≥ 1)	= probability of observing a single count,
G	= activity (dpm),
E	= 4π detector efficiency (cpd),
d	= width of detector in direction of scan (cm), and
v	= scan speed (cm/s).

Increase the value of G until the corresponding probability equals the desired confidence level, e.g., 95 percent. For a background level of 3 cpm to about 10 cpm, the probability of detecting two or more counts while passing over the contaminated area is:

$$P(n \geq 2) = 1 - \left(1 + \frac{(GE + B)d}{60v}\right)\left(e^{-\frac{(GE+B)d}{60v}}\right)$$

where:

P(n ≥ 2)	= probability of observing two or more counts,
G	= activity (dpm),
E	= 4π detector efficiency (cpd),
B	= background count rate (cpm),
d	= width of detector in direction of scan (cm), and
v	= scan speed (cm/s).

Increase the value of G until the corresponding probability equals the desired confidence level, e.g., 95 percent.

Beta Scan

Based on the MARSSIM two-stage scan methodology, the beta scanning MDC at a 95 percent confidence level is calculated using the following equation which is a combination of MARSSIM Equations 6-8, 6-9, and 6-10:

$$MDC_{scan} = \frac{d'\sqrt{b_i}\left(\frac{60}{i}\right)}{\sqrt{p} \cdot E_{tot} \cdot \frac{A}{100\,cm^2}}$$

where:

MDC_{scan} = MDC level in dpm/100 cm^2,
d' = desired performance variable (usually 1.38 corresponding to alpha and beta errors of 0.05),
b_i = background counts during the residence interval,
i = residence interval in seconds,
ρ = surveyor efficiency (0.5 – 0.75, 0.5 is conservative),
A = detector probe physical (active) area in cm^2, and
E_{tot} = total detector efficiency for radionuclide emission of
= E_i x E_s,
where:
E_i = 2π instrument efficiency in counts per disintegration (cpd) and
E_s = source (or surface contamination) efficiency.

Note: Es values can be determined or the default values provided in NUREG-1507 can be used as follows: 0.25 for all alpha energies and beta maximum energies between 0.15 and 0.4 MeV, 0.5 for all beta maximum energies greater than 0.4 MeV.

Alpha or Beta Static Counts

Minimum counting times for static counts of total and removable contamination will be chosen to provide a MDC that is a fraction (25 – 75 percent) of the survey unit-specific acceptance criteria. MARSSIM equations have been modified to convert to units of dpm/100 cm^2. Count times are determined using the following equation. Static counting MDCs at a 95 percent confidence level are calculated using the following equation which is an expansion of NUREG-1507, Equation 6-7 (Strom & Stansbury, 1992):

$$MDC_{static} = \frac{3 + 3.29\sqrt{B_r \cdot t_s \cdot (1 + \frac{t_s}{t_b})}}{t_s \cdot E_{tot} \cdot \frac{A}{100}}$$

where:

MDC_{static} = minimum detectable concentration level in dpm/100 cm^2,
B_R = background count rate in counts per minute,
t_B = background count time in minutes,
t_S = sample count time in minutes,
A = detector probe physical (active) area in cm^2, and

E_{tot} = total detector efficiency for radionuclide emission of
= $E_i \times E_s$,
where:
E_i = 2π instrument efficiency in counts per disintegration (cpd) and
E_s = source (or surface contamination) efficiency.

Note: Es values can be determined or the default values provided in NUREG-1507 can be used as follows: 0.25 for all alpha energies and beta maximum energies between 0.15 and 0.4 MeV, 0.5 for all beta maximum energies greater than 0.4 MeV.

14.10 Laboratory Analysis

With the exception of radiation badge service, laboratory analytical services are expected to be provided by Outreach of Broken Arrow, Oklahoma. In the event that Outreach is not available, Kaiser will select another qualified analytical laboratory.

Soil samples will be analyzed by gamma spectroscopy. The MDC value required for each gamma spectroscopy analysis is 25 percent of the release criteria for Th-232. Characterization survey results confirm that Th-232 is in secular equilibrium with its short-lived progeny Ac-228 and Th-228. Th-232 activity will be identified based on the Ac-228 activity (primary gamma energy of 911.1 keV). The Th-228 activity will be calculated by multiplying the Th-232 activity by 1. The Th-230 activity will be calculated by multiplying the Th-232 activity by 3.5.

A minimum of five of the QC samples taken as part of the final status survey will also be analyzed by alpha spectroscopy for Th-232, Th-230, and Th-228. The data will be used to confirm the activity ratio of Th-232 to Th-230 of 1:3.5. The required MDC for the alpha spectroscopy analysis will be 0.5 pCi/g.

14.11 Sampling and Measurement Technique

A combination of the following techniques may be used to achieve the desired survey requirements for an area.

14.11.1 Surface Scans

Depending on the area classification (Class 1, Class 2, or Class 3), scanning coverage will range in accordance with Table 14-8, Section 14.4.2.3. When scanning soil, the detector is held close to the ground (1 to 2 inches) and moved in a serpentine pattern. A scan rate of 0.5 m per second will be used. In the scanning mode, the audio response will be used to prevent lack of detection of an elevated area due to meter response time. The "two-stage" scan methodology will be utilized.

14.11.2 On Site Gamma Spectrometry

An on-site gamma-ray spectroscopy system may be utilized to provide qualitative and quantitative analysis of the Th-232 content in waste samples and final status survey screening samples.

14.11.3 Soil Sampling

14.11.3.1 Surface Sampling

Surface soil sampling will be conducted to evaluate the average remaining activity concentration of a survey unit. Surface samples will be collected from the top 15 cm (6 inches) of soil that correspond to the soil mixing or plow depth in several environmental pathway models. Grass, rocks, sticks, and foreign objects will be removed from the soil samples to the degree practical at the time of sampling. If there is reason to believe these materials contain activity, they will be retained as separate samples.

14.11.3.2 Core Sampling

Core samples will be collected after backfilling of below-release criteria material is complete. For purposes of a final status survey, the entire backfilled retention pond area will be considered as a unit and divided into survey units based on m2, i.e., Class 1 survey units of less than 2,000 m^2. A random start, triangular grid pattern will be used to take the required number of samples (N/2) in each survey unit. The sample will consist of a core sample through the approximate 3-meter layer of placed material and 6 inches of the excavation bottom. The entire core will be scanned using a 2-inch-by-2-inch NaI detector in a low background area sufficient to achieve a scan-MDC of less than 3 pCi/g Th-232. The core will be subdivided as follows: the bottom 6 inches of excavation bottom will be separated, mixed, and containerized. The remaining 3 meters will be subdivided into three consecutive 1-meter segments in accordance with Appendix E of the NMSS Decommissioning Standard Review Plan. Each 1-meter segment will be mixed and containerized. All four segments (one 6-inch and three 1-meter) will be analyzed by gamma spectroscopy for Th-232. The MDC required will be 3 pCi/g.

14.12 Final Status Survey Implementation

The final status survey will be used to select/verify survey unit classification and to demonstrate that the objectives have been achieved. Two situations that require final status surveys are detailed in this section. The first involves the final status survey of remediated areas (e.g., the Retention/Reserve Pond Area), and the second involves the final status survey of the processing area. The surveys will be performed using gamma-sensitive instrumentation and analytical analyses described above.

14.12.1 Postremediation Surveys

The final status survey units will be defined and marked. When remediation activities in a survey unit are completed, the following will be performed.

14.12.1.1 Gamma Scans

A gamma scan as defined by classification will be performed in accordance with the area classification. For the Retention Pond area, each 2-foot-thick lift that is placed in an excavation will receive a 100 percent scan to ensure that there are no areas that exceed theelevated measurement comparison.

14.12.1.2 Grids

The sample grid and starting location will be established.

14.12.1.3 Sample Number

The required number of samples will be taken and analyzed as described above.

14.12.1.4 Data Evaluation

The data will be evaluated as described below.

14.12.2 Postremediation Surveys for Returned Overburden Material

When remediation activities in a survey unit that required the excavation of substantial overburden soil are completed, the following will be performed:

- The bottom of the excavation will be surveyed as detailed in 14.12.1.1 above.
- A 2-foot layer of acceptable (below 31.1 pCi/g) backfill material will be placed in the excavation.
- A gamma scan as defined by classification will be performed.
- The sequence of 2-foot layers of acceptable backfill and subsequent survey will be repeated as necessary to fill excavation (prior to placement of off-site backfill).

Once the excavation is filled with below-criteria material:

- the sample grid and starting location will be established,
- the number of core samples required will be taken and analyzed, and
- the data will be evaluated as described below.

14.13 Data Evaluation

Data will be reviewed by the Data Manager to ensure that the requirements are implemented as prescribed and that the results of the data collection activities support the objectives of the survey, or permit a determination that these objectives should be modified.

14.13.1 Preliminary Data Review

The Data Manager will review QA and QC reports, prepare graphs of the data, and calculate basic statistical quantities to analyze the structure of the data and identify patterns, relationships, or potential anomalies. The survey data shall be reviewed as it is collected. The preliminary data examination includes the following:

- Evaluation of data completeness.
- Verification of instrument calibration.
- Verification of sample identification and traceability back to sampling location.
- Measurement of precision using duplicates, replicates, or split samples.
- Measurement of bias using reference materials or spikes examination of blanks for contamination.
- Assessment of adherence to method specifications and QC limits.
- Evaluation of method performance in the sample matrix.
- Applicability and validation of analytical procedures for site-specific measurements.
- Assessment of external QC measurement results and QA assessments, including the results of analytical laboratory QA/QC reports related to the analysis of final status survey samples.

14.13.2 Data Evaluation and Conversion

For comparison of survey data to $DCGL_{WS}$ or DCCLs, the survey data from field and laboratory measurements will be converted to $DCGL_{W}$ or DCCL units. The Data Manager will ensure data measurements retain traceability to NIST and conversion factors are appropriate for the radiation quantity. The preliminary data reports will be reviewed to ensure adequate measurement sensitivity is being achieved and to resolve any detector sensitivity problems. Analytical reports will be reviewed for proper MDC values. The results of analytical results will be reported whether the result is above or below the reported MDC value so that the MDC value is not used in the data assessment. Preliminary scan data will also be reviewed against the percent coverage requirement of the survey unit.

An evaluation will be made to determine that the data are consistent with the underlying assumptions made for survey plan statistical procedures. The basic statistical quantities that will be calculated for the survey unit are the following:

- Mean
- Standard deviation
- Median
- Minimum
- Maximum

The parameter of interest is the mean concentration in the survey unit. The two-sample statistical test (WRS Test) will be used. The two-sample WRS Test will evaluate whether the median of the data is above or below the $DCGL_W$ or DCCL.

Summary of Statistical Tests

Survey Result	Conclusion
Difference between maximum survey unit measurement and minimum reference area measurements is less than $DCGL_W$/DCCL	Survey unit meets release criterion
Difference of survey unit average and reference area average is greater than $DCGL_W$ /DCCL	Survey unit does not meet release criterion
Difference between any survey unit measurement and any reference area measurement greater than $DCGL_W$/DCCLor the difference of survey unit average and reference area average is less than $DCGL_W$ / DCCL	Conduct WRS Test and elevated measurement comparison

The null hypothesis is assumed to be true unless the WRS test indicates that it should be rejected in favor of the alternative. The result of the hypothesis test determines whether or not the survey unit as a whole is deemed to meet the release criterion. The WRS test will be applied as outlined in the following steps.

1. Adjusted reference area measurements will be obtained by adding the $DCGL_W$ or DCCL to each reference area measurement.

2. The m adjusted reference area sample measurements and the n sample measurements from the survey unit will be pooled and ranked in order of increasing size from 1 to N, where N = m + n.

3. If measurements are tied in rank, each of the tied values will be assigned the same average rank of that group of tied measurements.

4. The ranks from the reference area will be summed as W_r.

5. The value of W_r will be compared with the critical value given in MARSSIM Table I.4 for the appropriate values of m and n at the required Type I error decision rate ($\alpha = 0.05$). If W_r is greater than the critical value, the null hypothesis that the survey unit exceeds the release criterion was rejected.

Both the measurements at discrete locations and the scans will be used to identify elevated areas within a survey unit. Analytical results of soil samples will be used to complete the elevated measurement comparison. If residual radioactivity is found in a localized area of elevated activity - in addition to the residual radioactivity distributed relatively uniformly across the survey unit - the unity rule discussed above will be used to ensure that the release criterion has been met as follows:

$$\frac{\delta}{DCGL}+\sum_{x+1}^{n}\frac{(\delta_{EMC}-\delta)}{DCGL_{EMC}}\leq 1$$

where:

δ = is the average concentration of Th-232 over the entire survey unit
δ_{EMC} = the average concentration of Th-232 over the elevated area x within the survey unit
DCGL = the $DCGL_w$ or 31.1 for Th-232
$DCGL_{EMC}$ = (area factor for elevated area x) X (DCGL)
x = refers to one of the elevated areas within the survey unit
n = the total number of elevated areas within the survey unit

If there is more than one elevated area, a separate term will be included for each area. The result of the EMC will be used as a trigger for further investigation. The investigation may involve taking further measurements to determine that the area and level of the elevated residual radioactivity are such that the resulting dose or risk meets the release criterion. The investigation will provide adequate assurance, using the DQO process, that there are no other undiscovered areas of elevated residual radioactivity in the survey unit that might otherwise result in a dose or risk exceeding the release criterion. In some cases, this may lead to reclassifying a survey unit--unless the results of the investigation indicate that reclassification is not necessary.

14.13.3 Investigation Levels

The Data Manager will use radionuclide-specific investigation levels to indicate when additional investigations may be necessary. Investigation levels will also serve as a QC check to determine when a measurement process begins to get out of control. A measurement that exceeds the investigation level may indicate that the survey unit has been improperly classified or it may indicate a failing instrument. When an investigation level is exceeded, the first step will be to confirm that the initial measurement/sample actually exceeds the particular investigation level. This may involve taking further measurements to determine that the area and level of the elevated residual radioactivity are such that the resulting dose or risk meets the release criterion. Depending on the results of the investigation actions, the survey unit may require reclassification, remediation, and/or resurvey. The following table lists the investigation levels which will be used by the Data Manager.

Postremediation Survey Investigation Levels

Survey Unit Classification	Flag Direct Measurement or Sample Result When:	Flag Scanning Measurement Result When:
Class 1	$>DCGL_{EMC}$ / DCCLor $> DCGL_W$ / DCCL and the mean of the survey unit is greater than 0.75 of the $DCGL_W$ / DCCL	$>DCGL_{EMC}$ or >DCCL
Class 2	$> DCGL_W$	$> DCGL_W$ or >MDC
Class 3	> 0.5 of the $DCGL_W$ + background	$> DCGL_W$ or >MDC

If the data suggest that the survey unit was misclassified, the original DQOs will be redeveloped for the correct classification. The sampling design and data collection documentation will be reviewed for consistency with the DQOs.

14.14 Final Status Survey Report

A report will be prepared to document the final conditions of the site. The report will include information concerning the following:

- An overview of the results of the survey.
- A discussion of any changes that were made in the survey from what was proposed in the Soil Remediation Plan.

- A description of the method by which the number of samples was determined for each survey unit.

- A summary of the values used to determine the number of samples and justification for these values.

The survey results for each survey unit including the following:

- The number of samples taken for the survey unit.

- A map or drawing of the survey unit showing the reference system and random-start systematic sample locations.

- The measured sample concentrations.

- The statistical evaluation of measured concentrations.

- Judgmental and miscellaneous sample data sets reported separately from those samples collected for performing the statistical evaluation.

- A discussion of anomalous data including any areas of elevated direct radiation detected during scanning that exceeded the investigation level or measurement locations in excess of the $DCGL_W$ or DCCL.

- A statement that a given survey unit satisfied the $DCGL_W$ or DCCL and the elevated measurement comparison, if any sample points exceeded the $DCGL_W$ or DCCL.

- A description of any changes in initial survey unit assumptions relative to the extent of residual radioactivity.

- A discussion of a survey unit reclassification including applicable data.

References

1. ADA Consultants, Inc., April 1, 1994, Radiological Survey Report, Kaiser Aluminum & Chemical Corporation, Tulsa, Oklahoma.

2. Advanced Recovery Systems, 1995, Volume II, Plate 1, Field Characterization Report, Appendix F.

3. Advanced Recovery Systems/Nuclear Fuel Services, Inc., April 25, 1995, Kaiser Aluminum Specialty Products, Field Characterization Report, Tulsa, Oklahoma.

4. Earth Sciences Consultants, Inc., February 2002, Final Status Survey Report, Adjacent Land Area, Tulsa, Oklahoma Facility.

5. Earth Sciences Consultants, Inc., May 2002, Revised May 2003, Decommissioning Plan Addendum, Tulsa Facility, Tulsa, Oklahoma, Kaiser Aluminum & Chemical Corporation, Baton Rouge, Louisiana.

6. Kaiser, August 1998, Adjacent Land Remediation Plan for Kaiser Aluminum & Chemical Corporation, Tulsa, Oklahoma.

7. NMSS Decommissioning Standard Review Plan Appendix E – Rev 0, September 2000, Implementing the MARSSIM Approach for Conducting Final Radiological Survey.

8. Nuclear Regulatory Commission, July 1998, Draft NUREG-1549: Decision Methods for Dose Assessment to Comply with Radiological Criteria for License Termination.

9. NUREG-1507, December 1997, Minimum Detectable Concentrations with Typical Radiation Survey Instruments for Various Contaminants and Field Conditions.

10. NUREG/CR-1575, August 2000, MARSSIM, Rev. 1