MULTI-METHOD CHARACTERIZATION OF LOW-LEVEL RADIOACTIVE WASTE AT TWO SANDIA NATIONAL LABORATORIES ENVIRONMENTAL RESTORATION SITES

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ABSTRACT

This paper discusses the application of multiple methods for characterizing radioactive wastes generated by the Sandia National Laboratories/New Mexico (SNL/NM) Environmental Restoration (ER) Project. Specifically, the wastes were generated during the excavation of buried materials at the Classified Waste Landfill (CWLF) and the Radioactive Waste Landfill (RWL). These waste streams include nuclear weapon components and other refuse that are surface contaminated and components that contain sealed radioactive sources with unknown radioactivity content. Characterization of radioactive constituents in RWL and CWLF waste has been problematic, due primarily to the lack of documented characterization data prior to burial. A second difficulty derives from the limited information that the ER project personnel have concerning weapons component designs and testing that was conducted in the early days of the Cold War. To reduce these uncertainties and achieve the best possible waste characterization, the ER Project has applied both project-specific and industry-standard characterization methods that, in combination, serve to define the types and quantities of radionuclide constituents in the waste. The resulting characterization data have been used to develop the waste profiles needed to meet disposal site waste acceptance criteria.

INTRODUCTION

The CWLF, located in SNL/NM Technical Area II, is a 1.5-acre site that received nuclear weapon components and related materials from about 1950 through 1987. These materials were used in the development and testing of nuclear weapon designs. In March 1998 the SNL/NM ER Project initiated excavation of the CWLF as a voluntary corrective measure to remove buried materials that were suspected of releasing contaminants and potentially affecting groundwater quality. The CWLF excavation project is ongoing. A goal of the project is to maximize the amount of excavated materials that can be demilitarized and recycled. However, some of these materials are radioactively contaminated and, if they cannot be decontaminated, are destined to require disposal as radioactive waste.

The characterization of radioactive constituents in the CWLF waste has been problematic, due primarily to the lack of any documented characterization data prior to burial, and because of the limited information that CWLF project personnel have about the weapons component design and testing that was conducted as much as 50 years ago. In addition, during the first 10 months of the project, wastes could not be characterized using SNL/NM's gamma-ray spectroscopy drum assay system because of an administrative constraint. Specifically, the waste disposal site had not yet certified the system. This situation necessitated developing and relying on process knowledge (PK) of the radioactivity in the components and other materials to characterize the waste. Developing PK to the level that was necessary to sufficiently characterize and certify project-generated waste for disposal required extensive efforts on the part of the project's waste management team.

The RWL is a 0.3-acre site that is also located in TA II approximately 200 yards northeast of the CWLF. It began operations in 1949 to dispose of highly contaminated materials, including waste contaminated with Pu-239 and other alpha emitters, as well as high gamma radiation sources discarded from research activities at SNL/NM and other US Department of Energy sites. The RWL was closed in 1959. In 1996

SNL/NM excavated all radioactive wastes from the RWL as a voluntary corrective measure. Following excavation, the wastes were initially packaged and staged for later disposition, but were not characterized. The containerized waste totaled approximately 4,000 cubic feet.

In January 1999 with remediation work on the CWLF in progress, the project Task Leader assigned a field team to complete a waste elimination campaign on the containerized RWL waste. This included emptying the contents of each container, characterizing the waste, sorting by waste stream, and repackaging for final disposal. The administrative constraint that limited the ability to assay the gamma isotopic content in waste drums was lifted by the time of the RWL waste elimination campaign, thereby ensuring more accurate characterization. However, complete characterization of all RWL waste still presented a challenge because of the unique nature of some waste items encountered during the campaign. The project's approach to characterizing one of these items is presented later in this paper.

CHARACTERIZING CWLF RADIOACTIVE WASTES

The CWLF project waste management team has designated the following five major radioactive waste streams:

- unclassified soft radioactive waste, consisting of soft, compactible trash such as paper, plastic, and plywood;
- unclassified solid radioactive waste, including scrap metal, other unclassified hardware items, and soil;
- unclassified mixed waste, containing the same materials as unclassified soft or solid radioactive waste, but also containing one or more Resource Conservation and Recovery Act (RCRA) regulated constituents;
- classified radioactive waste, consisting of classified artifacts, usually weapons components, that contain only radioactive contaminants; and
- classified mixed waste, comprising radioactive classified material that also contains RCRA constituents.

These waste streams contain a variety of radionuclides that exist as both surface contamination and as sealed sources and, as such, must be sufficiently characterized to meet disposal site waste certification requirements.

OBSTACLES TO DEFINITIVELY CHARACTERIZING RADIOACTIVE WASTE CONSTITUENTS

Recognizing that the CWLF project personnel were hazardous site remediation specialists and not weapons engineers, the project Task Leader enlisted the assistance of SNL/NM weapons program consultants to assist with identifying various components and the potential hazards associated with them. These hazards include non-fissile radioactive materials that were deliberately incorporated into components to serve various functions. However, some weapons component artifacts suspected to contain radioactive material cannot be identified, even by knowledgeable experts currently working in the weapons program because

- they were originally fabricated decades ago as one-of-a-kind items for testing purposes; or
- the test methods included destructive testing for component integrity, thus contaminating component surfaces and rendering some excavated components physically unrecognizable.

Project personnel have encountered numerous such artifacts that, if the radionuclides cannot be identified by direct analysis such as gamma-ray spectroscopy, require significant effort on the part of project personnel and weapons consultants to characterize by other means, such as PK.

Another obstacle to definitively characterizing CWLF radioactive waste streams lies in the fact that many aspects of weapons component design are classified as confidential or secret restricted data. Although CWLF project personnel have the proper level of security clearance, access to detailed information pertaining to the exact quantities of radioactivity in some components also requires a need to know. For national security reasons, placing knowledge of precise radioactivity quantities into the public domain merely for waste characterization purposes is not warranted. Only approximate or maximum activities of component sources are forthcoming, and are thus conservatively assumed to be present in waste artifacts.

This problem is compounded by the unknown age of the waste artifacts. Many weapon components contain radionuclides with intermediate half-lives ranging from about 12 to 100 years. For waste artifacts that were produced, tested, and buried 12 to 50 years ago, their radioactivity could be reduced by 50 to 95% from the initial quantity as a result of radioactive decay. In these cases the artifact's original activity should be decay corrected. However, since the components in the CWLF were buried as refuse with no expectation of future recovery, there was no need to record the original date of production for the radioactive materials they contained. Thus, decay correction is not possible even if the original activity is known from design specifications.

In addition to the problems associated with characterizing waste artifacts of unknown origin and age (as well as those that contain "restricted data" radioactivity quantities), there is no efficient method to characterize inaccessible internal surfaces of artifacts contaminated with radionuclides that emit no gamma-ray signature. To do so would require disassembling and obtaining representative swipes of every item in the waste stream. Because some waste streams contain thousands of such items, this method represents a costly and time-consuming investment of available project funds and cannot be justified if alternative methods are available.

THE NEED TO DEVELOP AND APPLY PROCESS KNOWLEDGE

Radioactive waste characterization data are ultimately relied upon by both SNL/NM, as the waste generator, and by the receiving waste disposal site to substantiate compliance with disposal site waste acceptance criteria. Therefore, characterization of radioactive waste constituents required heavy reliance on PK in combination with available analytical methods.

Developing PK in the context of the CWLF project is different from that required for a manufacturing process where the constituents of waste stream output are byproducts of known feed materials. PK on the CWLF project is being acquired long after the time of original fabrication of weapon components and is limited by its experimental and classified nature. Thus, PK for this project required extensive consultation and research to develop and, to ensure compliance with waste acceptance criteria, conservatism in its application to waste streams. The waste management team also invested significant effort, not only to collect available component design information, but also to develop and apply assumptions that will result in conservative estimates of radioisotopic content.

DEVELOPING PROCESS KNOWLEDGE

Development of radioactive waste PK began after commencing excavation by providing weapons component training for all project personnel with security clearances. This training familiarized project personnel with several configurations of major weapon components. It also provided them with limited, nominal, design information, including the types of radionuclides used in various components. Although

useful for identifying the likely types of sealed sources contained in specific weapon component artifacts, this training did not provide much data about the activity associated with each source. Also, it did not equip project personnel with the knowledge to identify individual radionuclides existing as contamination on waste artifact surfaces.

Needing to compensate for these shortcomings and the other obstacles described above, the waste management team realized that to adequately characterize CWLF waste streams, PK would have to be developed during the course of the project as additional experience with waste artifacts was gained. It was decided that the initial approach to characterizing waste artifacts and materials would include:

- direct measurement of gross alpha and beta-gamma contamination levels (in units of disintegrations per minute [dpm] per 100 cm^2) using hand-held friskers;
- collection and analysis of swipes via liquid scintillation counting for removable contamination, particularly tritium; and
- analysis of collected swipes via gamma-ray spectroscopy to confirm gamma isotopic content.

A procedure for collecting and documenting this information, the *TA-II ER Site 2 Classified Waste Landfill Radioactive/Mixed Waste Radiological Characterization Procedure* (1), was developed to ensure consistency in the project's methods for measurement and documentation of results. The swipe results obtained from these methods provided a surface contamination activity concentration (in units of dpm per 100 cm^2) that, when combined with an estimate of the artifact's surface area, yielded a total activity for gross alpha or beta-gamma contamination. This method worked well for estimating total removable radioactivity content, but did not specify the contaminant radionuclide. Nor did it provide any data for waste artifacts containing only fixed contamination or sealed sources.

After several swipe analyses indicated depleted uranium (DU) contamination associated with black or yellow oxides on several artifacts, this initial approach was modified to specify the radionuclide using visual, colorimetric identification of DU as a substitute for gamma-ray spectroscopy analysis of waste drum contents. Another modification employed was to use the ratio of beta-gamma to alpha count rates to discern DU from thorium-232 contamination. For DU, this ratio was determined from repeated field measurements on various waste items to be approximately 1,000 counts per minute beta-gamma to 1 count per minute alpha. For thorium-232 the ratio was about 4:1.

If the contaminant radionuclide was identifiable from one of these methods, it was documented on the waste artifact radiological survey form. However, the project still lacked the capability to identify radionuclides in the form of fixed-only contamination or sealed sources. To remedy this problem, the waste management team decided to adapt the project's large area gamma-ray spectroscopy system (LAGSS), that was being used for measuring contamination in 10 cubic yard soil lots, to perform direct measurement of individual artifacts containing fixed or internal gamma contamination, or sealed gamma sources. This method worked well for qualitatively identifying alpha- and gamma-emitting radionuclides. After a variety of waste artifacts were analyzed using the LAGSS, it became clear that all of the alpha-emitting nuclide contaminants in CWLF waste streams exhibited an accompanying gamma-ray signature. This fact provided assurance that fixed alpha contaminants and sealed alpha sources would be detected via gamma-ray spectroscopy.

Even after adapting the LAGSS to identify gamma-emitting radionuclides, it was difficult to quantitatively estimate the total activity present. This was especially true for artifacts exhibiting high gamma exposure rates that created excessive dead time in the LAGSS' germanium-based detector, and artifacts with other internal components or heavy outer casings of unknown composition that could act as internal shielding material. Also, use of the LAGSS did not provide any data about internal sources containing pure beta-emitting radionuclides.

The combined use of these methods provided a measure of assurance that the activity of about 80% of waste artifacts and related materials in the CWLF waste streams could be qualitatively measured, and about 50% could be quantitatively measured with reasonable accuracy. The cumulative experience gained with the excavation and characterization of waste artifacts from each trench showed a repeating pattern of many similar components and other materials that were contaminated with radionuclides that were specific to that component or material. Thus, even with limited component design information, PK was gradually being developed as part of project operations from repeated measurements on similar components. However, it became clear that to adequately characterize all of the weapon component waste artifacts and related materials, more precise information concerning the radionuclides (and their quantities) associated with sealed sources was needed.

Additional requests and justification to the weapon consultants for sealed source activity quantities yielded more data. It was provided in the form of unclassified upper-limit activity values for weapon component parts such as tritium targets and sealed source "rad" tubes. The waste management team used these upper-limit values without decay correction to draw conservative assumptions regarding the quantities of radionuclides such as tritium, nickel-63, and cesium-137 contained in weapon component waste artifacts. Examples of component waste artifacts and their respective radionuclide contaminants are presented below.

Neutron Generators. A neutron generator contains a tube and transformer assembly (TTA) that holds less than 100 millicuries of tritium. Some of this tritium has leaked, creating loose contamination and cross-contaminating other artifacts. At low tritium concentrations encountered on artifact surfaces, the tritium is not field-detectable with a beta-gamma frisker probe. However, a concentrated quantity, such as in the TTA, will produce detectable bremsstrahlung x-rays in the frisker probe.

Thoriated Skins. An alloy of a light metal blended with thorium-232 was integrated with the outer casings of mock weapons that were used for training purposes. The thoriated skins are often degraded from weathering or galvanic corrosion, resulting in skin material breaking into fragments or crumbling into a gray colored granular powder.

"Rad" Tubes. These are glass tube electronic components, each containing up to 12 microcuries of nickel-63. The nickel-63 is firmly fixed to an internal component in the tube and generally does not result in removable contamination. However, there are thousands of these tubes in CWLF waste streams.

Spark Gap Tubes. These are electronic tubes composed of glass and metal encapsulating a ceramic cylinder containing up to 5 millicuries of cesium-137. These tubes are fairly rugged, but occasionally are broken, releasing beta-gamma contamination.

Radium/Tritium Self-Luminous Dials. Instrument dials were sometimes painted with either radium-226 or tritium for visibility under dark conditions. These dials are often missing their sight glass covering or are designed with no covering, thus exposing them to potential contact with other artifacts. The paint of the exposed dials is usually weathered, creating high levels of removable contamination.

These waste artifacts are common to many of the CWLF trenches that have been excavated to date. The project waste streams also include "other materials" such as scrap metal, paper, plastic, wood, and other items that were contaminated directly in weapon component testing prior to burial, or were cross-contaminated from contact with weapon component waste artifacts since burial.

As part of the process of gaining acceptance of the CWLF waste streams for disposal, the project was required to prepare a process knowledge evaluation (PKE) that included a table of all expected

radionuclides and their maximum concentrations in the CWLF waste streams. The waste management team realized that if the maximum radionuclide activity concentrations were derived from compiling the total characterization data accumulated to date, it would also provide a PK basis for characterizing similar, future waste generated.

DERIVATION OF MAXIMUM WASTE STREAM RADIOACTIVITY CONTENT

A survey of the characterization data for the first 30 waste containers revealed that they contained a broad, representative spectrum of items. Each 55-gallon drum contained an average of 35 artifacts or other waste items, and weighed an average of 74 kg. Interestingly, it was observed that each artifact was contaminated with only a single parent radionuclide. To assign maximum activity concentrations in the PKE required knowing what radionuclides appeared most frequently. The survey of the 30 containers yielded the breakdown of the percent of items contaminated by each radionuclide per waste container, as shown in Table I below.

Table I
Percent of Waste Items Contaminated by Radionuclides

Radionuclide	Percent of Items Contaminated In Waste Container
Depleted uranium (including U-238, U-235, U-234) and progeny with a half-life greater than one year[1]	70.00%
Th-232 and progeny with a half-life greater than one year[2]	10.00%
H-3	10.00%
Ni-63	5.00%
Ra-226[3]	2.00%
Am-241	1.00%
Co-60	1.00%
Sr-90[4]	0.50%
Pu-238[4]	0.25%
Pu-239[4]	0.25%
Cs-137	Gap tubes added separately at max. 12 per container

Notes:
[1] The progeny of U-238 with half-life greater than one year are Th-230, Ra-226, and Pb-210.
[2] The progeny of Th-232 with half-life greater than one year are Ra-228 and Th-228.
[3] The listed value of 2.00% of items in a waste container applies only to artifacts with concentrated Ra-226 contamination, such as artifacts with radium painted dials. Ra-226 is also a progeny of U-238 with half-life greater than one year. Therefore the derivation of Ra-226 concentration in waste containers is an additive function from two sources of waste items.
[4] Sr-90, Pu-238, and Pu-239 have not been detected as contaminants on waste items at the CWLF to date, but are included in this profile because SNL landfill inventory records indicate that they may be present.

The waste characterization survey reports for the items in these containers were reviewed to determine the typical maximum activity per waste item by radionuclide. These data, presented in Table II below, were obtained from direct gamma-ray spectral analysis of individual items using the LAGSS, or from analysis of samples by the SNL/NM Radiation Protection Sample Diagnostics Program (RPSD), or from component design specifications.

Table II
Waste Item Maximum Activity by Radionuclide

Radionuclide	Typical Max. Activity/Item (pCi)	Radionuclide	Typical Max. Activity/Item (pCi)
U-238[1]	2.45 E+08	H-3[4]	1.00 E+11
U-235[1]	4.66 E+06	Ni-63[5]	4.80 E+07
U-234[1]	1.10 E+08	Ra-226[6]	2.47 E+07
Th-230[2]	7.35 E+07	Am-241	2.93 E+06
Ra-226[2]	7.35 E+07	Co-60	3.42 E+06
Pb-210[2]	7.35 E+07	Sr-90[7]	1.27 E+06
Th-232	8.22 E+05	Pu-238[7]	4.99 E+07
Ra-228[3]	7.81 E+05	Pu-239[7]	5.95 E+07
Th-228[3]	7.81 E+05	Cs-137[8]	5.00 E+09

Notes:

[1] For waste contaminated with depleted uranium, the U-235 and U-234 activities are calculated using known ratios to the U-238 activity that are typical of depleted uranium at SNL/NM. U-235 activity is at 1.9% and U-234 is at 44.7% of the U-238 activity (from the TA II RWL approved PKE and direction of Arthur Shanks SNL/NM, 10/98).

[2] Progeny of U-238 (DU) with half-life greater than one year are assumed to be in secular equilibrium with the parent, at an average of 30% of the parent activity. This value was determined from a review of parent-progeny activity ratios detected via gamma-ray spectral analysis of eight typical DU-contaminated waste items from the TA II CWLF.

[3] Progeny of Th-232 with half-life greater than one year are assumed to be in secular equilibrium with the parent at 95% of parent activity.

[4] H-3 materials typically are contained in sealed sources with a maximum of 100 mCi H-3 per source, and one source per H-3 contaminated waste item (from Ruth Berger SNL/NM, Spring/98).

[5] Ni-63 materials are typically contained in sealed source tubes with a maximum of 12 µCi per source (per Earl Graff SNL/NM, 9/98) and a maximum of 4 tubes per Ni-63-contaminated waste item, totaling a maximum of 48 µCi of Ni-63 per waste item.

[6] In addition to Ra-226 existing in equilibrium activity as a progeny of U-238, it is also a contaminant in concentrated form on certain artifacts containing luminous dials or other internal sources. The stated value is an average for such artifacts.

[7] Sr-90, Pu-238, and Pu-239 have not been detected as contaminants on waste items at Site 2 to date, but are included in this profile because SNL landfill inventory records indicate that they may be present. In the absence of ER Site 2-specific contamination data, the maximum activity contents per item for these radionuclides were back calculated from the concentrations identified in the TA-II RWL PKE.

[8] Cs-137 materials are known from process knowledge to be contained in spark gap tubes. Maximum number of gap tubes allowed per 55-gallon drum = 12. Maximum activity of Cs-137 per gap tube = 5 mCi (per Mike Lucas SNL/NM, 10/98).

From these data the maximum expected activity concentration in units of picocuries per gram of each radionuclide in a typical waste container was calculated, using the derived equation below.

(Eq. 1) $A_{R\text{-}max} = (A_R / \text{item}) \times (35 \text{ items} / \text{55-gal drum}) \times (F_{IR}) \times (\text{55-gal drum} / 7.4 \text{ E+04 g waste})$

where: $A_{R\text{-}max}$ = typical max. activity (pCi) of radionuclide per gram of waste

A_R = typical max. activity of a given radionuclide measured on an item, (pCi), from Table II

F_{IR} = fraction of waste items contaminated with a given radionuclide, (item fraction divided by total items in a container), from Table I

For Ra-226, the calculation of maximum expected concentration in a waste container includes both of the typical maximum activity values listed in Table II, and both of the percent items contaminated in a waste container from Table I. Using equation 1 to determine each Ra-226 source contribution and then summing them produces the following:

$$A_{Ra\text{-}226\text{-}max} = [(7.35 \text{ E+07 pCi}_{Ra\text{-}226} / \text{item}) \times (35 \text{ items} / \text{drum}) \times (0.70 \text{ items}_{Ra\text{-}226/} / \text{total items}) \times (1 \text{ drum} / 7.4 \text{ E+04 g waste})] + [(2.47 \text{ E+07 pCi}_{Ra\text{-}226} / \text{item}) \times (35 \text{ items} / \text{drum}) \times (0.02 \text{ items}_{Ra226/} / \text{total items}) \times (1 \text{ drum} / 7.4 \text{ E+04 g waste})]$$

$$= 2.46 \text{ E+04 pCi}_{Ra226} / \text{ g waste}$$

Given the assumption that CWLF waste streams contain, on average, the same distribution of radionuclides as stated in Table I, the maximum expected activity concentration for each radionuclide contaminant in these waste streams can be calculated using equation 1. The results of these tabulations are presented in Table III below.

Table III
Maximum Waste Stream Activity Concentration by Radionuclide

Radionuclide	Max. Activity Concentration in CWLF Rad/Mixed Waste (pCi/g)
U-238	8.11 E+04
U-235	1.54 E+03
U-234	3.64 E+04
Th-230	2.43 E+04
Ra-226	2.46 E+04
Pb-210	2.43 E+04
Th-232	3.89 E+01
Ra-228	3.69 E+01
Th-228	3.69 E+01
H-3	4.73 E+06
Ni-63	1.14 E+03
Am-241	1.39 E+01
Co-60	1.62 E+01
Sr-90	3.00 E+00
Pu-238	5.90 E+01
Pu-239	7.04 E+01
Cs-137	8.11 E+05

Deriving these waste concentrations provided the waste management team with a conservative upper bound against which future generated waste could be assessed, and added to the basis of available PK for CWLF waste streams.

CHARACTERIZING RWL RADIOACTIVE WASTES

By the start of the RWL stored waste elimination campaign, characterization data produced by the waste drum assay system was certified for waste acceptance purposes by the disposal site. Thus, the RWL containerized waste was assayed for both gamma and alpha emitters via gamma-ray spectroscopy using the SNL/NM waste drum assay system in combination with other analytical methods. Some of the PK acquired and applied to characterization of CWLF waste streams was also applied to the RWL wastes. For example, the RWL waste included items such as capacitors and thermal batteries that, from experience with similar items at the CWLF, were known to be unclassified and to contain lead and reactive compounds, respectively. This PK was useful for sorting these items into the correct waste stream. The combination of direct assay, swipe sampling and analysis, and PK enabled the project to accurately characterize virtually all of the RWL waste.

However, several of the staged RWL waste containers included unique items that could not be characterized by PK because they did not resemble any previously identified component. Nor could these items be directly assayed by gamma-ray spectroscopy because they contained concentrated amounts of activity, creating unacceptable dead time in the drum assay system's detectors. The chosen method for characterizing one of these items is discussed below.

CHARACTERIZING THE RADIUM "SEED"

One of the waste containers staged at the RWL exhibited a gamma exposure rate that created a radiation area near the container. The source of this radiation was determined to be a small sealed source measuring only a few millimeters in diameter. The source remained sealed, as evidenced by the complete absence of contamination in the other debris in the container that was in contact with source. This source was qualitatively analyzed in the field using a Microspec2 multi-channel analyzer coupled to a one-inch sodium-iodide detector at a distance sufficient to prevent saturation of the detector. The gamma photopeak spectrum of the seed was compared to a spectrum from a SNL/NM sealed calibration source known to contain Ra-226. The photopeaks (Ra-226 and progeny) of the two spectra matched perfectly. Quantifying the activity of this source required obtaining field measurements with an ion chamber and applying this data to an established thumb rule formula that uses the specific gamma constant for Ra-226, as shown below.

The field measured gamma exposure rate at one meter from the unshielded source was 6.0 milliroentgen per hour, or 0.006 roentgen per hour (R/hr). Using the measured exposure rate and knowing from the comparison of gamma spectra that the source radionuclide was Ra-226, the activity of the source was determined by:

(Eq. 2) $X / t = \Gamma A / r^2$ (2)

where: X / t = the measured gamma exposure rate from a point source (R / hr)
= 0.006 as measured with an ion chamber with the beta window closed

Γ = the gamma radiation level from one curie of a specified radionuclide, i.e., the specific gamma constant or specific gamma-ray emission ($R\text{-}m^2$ / hr-Ci)
= 0.825 for Ra-226 with progeny in equilibrium (3)

A = the activity of the source (Ci)

r = the distance at which the exposure rate is measured (m)

Solving for "A" we have:

0.006 R / hr = $(0.825\ R\text{-}m^2$ / hr-Ci) (A) / 1 m^2

A = 0.00727 Ci = 7.27 mCi

CONCLUSIONS

With the certification of the SNL/NM waste drum assay system, the CWLF project now employs this and other industry standard characterization methods to the maximum extent possible to directly measure radioactivity content. The direct measurement methods include:

- acquiring gamma-ray spectra of waste drums using the SNL/NM waste drum assay system to specify gamma and alpha radionuclide activity;
- collecting representative swipes of artifact surfaces for analysis of pure beta particle emitters by liquid scintillation counting; and
- direct frisk measurement of beta-gamma and alpha contamination levels as backup data for the gamma-ray spectroscopy and liquid scintillation analysis results.

However, the project continues to generate wastes whose radioactivity content cannot be efficiently ascertained using these methods. For these wastes, the PK that the waste management team has accumulated to date is vital to providing conservative estimates of radioisotopic activity content and assurance that the waste meets applicable disposal site acceptance criteria.

The following suggestions may prove useful to waste managers encountering significant quantities of radioactive wastes that contain unknown types and quantities of radioactive materials.

- When faced with a waste data knowledge deficit, adopt a characterization approach that includes multiple methods to eliminate a large percentage of uncertainties concerning waste stream source terms.

- Establish waste characterization methods and procedures as early as possible, but allow flexibility to evolve characterization methods to improve definition of waste stream constituents and minimize uncertainty.

- Seek opportunities to couple various characterization methods such as direct frisk, colorimetry, and analytical systems that are being used for unrelated purposes (e.g., the CWLF LAGSS). Doing so can help establish correlation between types of waste items and constituent radionuclides in waste

streams, thus improving definition of the radioactive waste source term. It can also improve confidence that if larger-scale characterization methods become available (e.g., gamma-ray spectroscopy drum assay system), they will provide accurate radioisotopic profiles.

- For classified waste of unknown age, use unclassified, upper-limit values of radionuclide activity as a conservative substitute for more exact, but restricted, data.

- Deriving maximum expected radionuclide activity concentrations from representative waste packages can be useful for establishing detailed patterns in characterization data, and provides a basis for tracking any deviation from the expected character of the waste.

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ACKNOWLEDGEMENTS

This work was supported by the United States Department of Energy under contract DE-AC04-94AL85000. Sandia is a multi-program laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy.

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