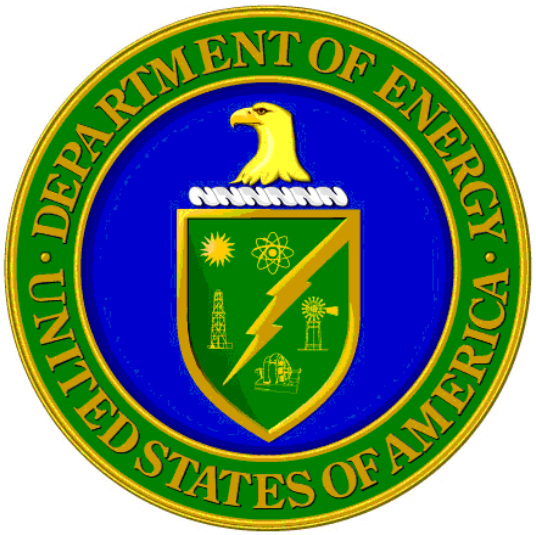
U.S. Department of Energy
Carlsbad Field Office

REMOTE-HANDLED TRU WASTE CHARACTERIZATION PROGRAM IMPLEMENTATION PLAN



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Revision 4

February 7, 2019

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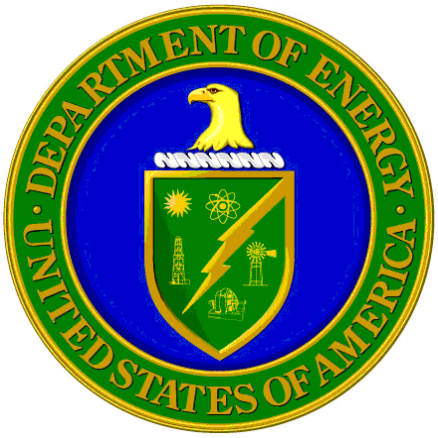

February 7, 2019

Approved by: /signature on file/ Date: February 1, 2019
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CHANGE HISTORY SUMMARY

Revision Number	Date Issued	Description of Changes
4	February 7, 2019	• Added Change History Summary table and formatted document in compliance with requirements of CBFO MP 4.4, *Document Preparation and Control.* • Modified the requirements for analytical batch data reports, incorporate neutron dose-to-curie and correct editorial errors.

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Acronyms and Abbreviations

AK	acceptable knowledge
ANSI	American National Standards Institute
ASTM	American Society for Testing and Materials
BDR	batch data report
CBFO	Carlsbad Field Office
CCA	Compliance Certification Application
CFR	Code of Federal Regulations
CH	contact-handled
CPR	cellulose, plastic, and rubber
CRR	characterization reconciliation report
DA	destructive assay
DOE	U.S. Department of Energy
DQO	data quality objective
DTC	dose-to-curie
EPA	U.S. Environmental Protection Agency
ICP-MS	inductively coupled plasma-mass spectrometry
kg	kilogram
kg/m^3	kilograms per cubic meter
LCS	laboratory control sample
LLD	lower limit of detection
LWA	Land Withdrawal Act
MDA	minimum detectable amount
mrem	millirem
mrem/hr	millirems per hour
MS	matrix spike
MSD	matrix spike duplicate
nCi	nanocuries
nCi/g	nanocuries per gram
NDA	nondestructive assay
NRC	Nuclear Regulatory Commission
OJT	on-the-job training
PA	performance assessment
PAN	passive-active neutron
%R	percent recovery
%RSD	percent relative standard deviation
QA	quality assurance
QAO	quality assurance objective
QAPD	Quality Assurance Program Document
QC	quality control
rem	Roentgen equivalent man
rem/hr	Roentgen equivalent man per hour
RH	remote-handled
RPD	relative percent difference
RTR	real-time radiography

Acronyms and Abbreviations, cont.

SOP	standard operating procedure
SPM	Site Project Manager
TRU	transuranic
VE	visual examination
WCPIP	Waste Characterization Program Implementation Plan
WIPP	Waste Isolation Pilot Plant
WSPF	Waste Stream Profile Form

1.0 INTRODUCTION

Remote-handled (**RH**) transuranic (**TRU**) waste characterization, which involves obtaining radiological and physical data, is a primary component of ensuring compliance of the Waste Isolation Pilot Plant (**WIPP**) with regulatory requirements. This RH TRU Waste Characterization Program Implementation Plan (**WCPIP**) identifies waste characterization requirements and methods to satisfy requirements in Title 40 Code of Federal Regulations (**CFR**) Part 191 (Subparts B and C) and Part 194 (EPA, 1993; EPA, 1996), the U.S. Environmental Protection Agency (**EPA**) final certification decision (EPA, 1998), and the WIPP Land Withdrawal Act (**LWA**) (Public Law 102-579).

Other important aspects of the overall RH TRU waste characterization program that are not covered in this document are:

- WIPP Hazardous Waste Facility Permit
- Transportation requirements specified in the shipping package Safety Analysis Reports for Packaging and associated Certificates of Compliance
- WIPP operations and safety requirements

Implementation of the requirements and methods in this WCPIP will result in a system of controls sufficient to meet the EPA waste characterization requirements for RH TRU waste.

2.0 RH TRU WASTE CHARACTERIZATION PROGRAM REQUIREMENTS AND OBJECTIVES

This section describes the RH TRU waste characterization program requirements and objectives that must be met by RH TRU characterization programs prior to the shipment of RH TRU waste to the WIPP facility. The requirements for the characterization of RH TRU waste that are relevant to the EPA's oversight of the WIPP come from two sources: those established by EPA's certification of the repository and those established by the LWA. The primary purpose of the characterization requirements based on the LWA is to ensure that the U.S. Department of Energy/Carlsbad Field Office (**DOE/CBFO**) operates the repository in accordance with the statutory limits and mission established by the Congress.

In demonstrating compliance with the requirements of 40 CFR §194.24, EPA has specified that DOE quantify the following parameters and the uncertainty associated with their quantification:

- Cellulose, plastics, and rubber (**CPR**)
- Radionuclide content
- Liquids
- Ferrous metals
- Non-ferrous metals

To this end, the RH TRU characterization program presented in this document describes the technical processes necessary to quantify these waste parameters. The following sections

provide a summary of the data quality objectives (**DQOs**) and quality assurance objectives (**QAOs**) developed to assure that the waste acceptance criteria described in section 2.2 are met.

2.1 Data Quality Objectives (DQOs) and Quality Assurance Objectives (QAOs)

DQOs and QAOs serve two separate functions. First, DQOs support decision-making and are developed in order to satisfy the requirements that significant waste components must be tracked and controlled to assure that the TRU waste inventory-related assumptions in the latest performance assessment (**PA**) and performance assessment verification test remain valid. These objectives ensure compliance with legal and regulatory requirements (i.e., they are the bases for decisions on whether compliance is achieved). Second, QAOs are data characteristics used to determine that the quality of data is acceptable. They also support decision-making by assessing the integrity of the data used. In the strictest sense, QAOs are used to assess the quality of analytical data and therefore are quantitative. However, in order to maintain regulatory and programmatic consistency, QAOs may be used with qualitative information. In this case, all of the QAOs (precision, accuracy, representativeness, comparability, and completeness) may not be applicable.

For purposes of implementation of the waste characterization program, DQOs have been developed and are derived directly from a regulatory requirement. Subsequently, QAOs have been developed and are derived from methods used to collect data to satisfy the DQOs. Many times, the regulatory requirement provides a quantitative limit that the total waste inventory must meet. In some cases, the requirement also specifies acceptable methods for assessing compliance with the limit and the amount and nature of documentation needed to demonstrate compliance. The following DQOs must be met for the waste stream to be eligible for disposal at WIPP as an RH TRU waste.

2.1.1 DQO for Defense Waste, High-Level Waste, and Spent Nuclear Fuel Determination

The following is the DQO for meeting regulatory requirements that only waste generated by atomic energy defense activities can be sent to the WIPP. This includes co-mingled waste generated in part by atomic energy defense activities. Commingled waste is waste with part defense-related waste and part non-defense-related waste where it is not feasible to separate into defense and non-defense waste streams. High-level radioactive waste or spent nuclear fuel shall not be disposed of at WIPP.

Purpose for collecting the data:

To determine whether the waste stream was generated by atomic energy defense activities, is not high-level waste, and is not spent nuclear fuel (Regulatory basis: LWA).

Type of data to collect:

Information about the processes used to generate the waste and the purposes for which any materials produced in the processes were used.

Tolerable decision error:

This is a qualitative DQO with no specified decision error tolerance since the characterization program must make the decision based on available information. The characterization program must have documented objective evidence in their acceptable knowledge (**AK**) record that the waste was generated by atomic energy defense activities, is not high-level waste, and is not spent nuclear fuel.

2.1.2 DQOs for Radioactive Properties

The following three DQOs were established for meeting regulatory requirements concerning radioactive properties of the waste.

2.1.2.1 TRU Waste Determination

Purpose for collecting the data:

To determine whether the waste contains more than 100 nanocuries (nCi) of TRU isotopes per gram of waste (Regulatory basis: LWA).

Type of data to collect:

Data on the TRU activity for each waste container shipped to the WIPP.

Tolerable decision error:

The definition of TRU waste does not specify a margin of error or uncertainty. Characterization programs must demonstrate that their methods for determining the TRU isotopes per gram of waste are capable of distinguishing TRU waste from low-level waste for those wastes near 100 nCi per gram (nCi/g). Instruments performing TRU/low-level waste discrimination measurements must have a lower limit of detection **(LLD)** of 100 nCi/g or less.

2.1.2.2 RH Waste Determination

Purpose for collecting the data:

To determine surface dose rate to ensure that it is equal to or greater than 200 millirems per hour (mrem/hr) and less than 1000 Roentgen equivalent man per hour (rem/hr) (Regulatory basis: LWA).

Type of data to collect:

Surface dose rate data for each container of waste.

Tolerable decision error:

The surface dose rate minimum and maximum limits for RH TRU waste are not established with an associated error or uncertainty. The characterization programs must make these measurements with instruments having calibrations meeting the requirements of the DOE/CBFO Quality Assurance Program Document (**QAPD**).

2.1.2.3 Activity Determination

Purpose for collecting the data:

To confirm the total activity for compliance with LWA limits concerning the total waste inventory (i.e., no more than 5.1 million curies of RH TRU waste disposed; 23 curies per liter limit per canister) and to track radionuclides that are important to the calculation of releases (Regulatory basis: LWA, EPA Certification of the WIPP).

Type of data to collect:

Data on the activity of the waste in each container, including the activities and masses of ^{241}Am, ^{238}Pu, ^{239}Pu, ^{240}Pu, ^{242}Pu, ^{233}U, ^{234}U, ^{238}U, ^{90}Sr, and ^{137}Cs.

Tolerable decision error:

The activity requirements for RH TRU waste are not specified with associated precision or accuracy limits. There may be uncertainties associated with the methods for obtaining the data needed. The characterization programs must determine and document the total uncertainty associated with the determination of the activity of the radionuclides in waste to be shipped to the WIPP. For each container, the total activity shall not exceed 23 curies per liter averaged over the volume of the container.

2.1.3 DQOs for Physical Properties

The DOE has identified two DQOs necessary to meet LWA and EPA requirements on reporting, tracking, and controlling physical properties of the waste:

- Liquids DQO
- EPA physical properties DQO

The development of these DQOs is discussed below.

2.1.3.1 DQO for Liquids[1]

Purpose for collecting the data:

To confirm the absence of liquids in excess of 1 percent (Regulatory basis: EPA Certification of the WIPP).

Type of data to collect:

Information on the processes and materials that produced the waste, and information about the specific items in the waste stream.

Tolerable decision error:

The limit on liquids was not specified with an associated error.

[1] For the Compliance Certification Application, the DOE assumed that liquid occurred as free water which was available to participate in gas generation activities (e.g., corrosion, microbial degradation).

2.1.3.2 DQO for Physical Form

Purpose for collecting the data:

To determine the physical form of the waste to delineate the waste stream (e.g., Summary Category Groups S3000, S4000, S5000, and waste material parameters) as required by the final certification rule (Regulatory basis: EPA Certification of the WIPP).

Type of data to collect:

Information on the type and number of containers, waste forms, processes, and materials that produced the waste.

Tolerable decision error:

This DQO provides information that allows the WIPP to track material parameter weights and compare the quantity disposed of to the limits established for the total waste inventory. As such, no errors are specified. Characterization programs must determine the uncertainty in the estimate of the weight of the waste.

2.1.4 Quality Assurance Objectives

The following QAOs are used in the RH TRU characterization program:

- Data precision – A measure of the mutual agreement between comparable data gathered or developed under similar conditions expressed in terms of a standard deviation.
- Data accuracy – The degree to which data agree with an accepted reference or true value.
- Data representativeness – The degree to which data accurately and precisely represent a characteristic of a population, a parameter, variations at a sampling point, or environmental conditions.
- Data completeness – A measure of the amount of valid data obtained compared to the amount that was expected.
- Data comparability – A measure of the confidence with which one data set can be compared to another.

2.2 RH TRU Waste Acceptance Criteria

These criteria serve to ensure that RH TRU waste is disposed of in accordance with EPA requirements. The requirements on which each criterion is based are also listed and originate either from the EPA Certification or the LWA.

2.2.1 Container Acceptance Criteria

Compliance Certification Requirement. Characterization programs will report to the WIPP electronic database the number and types of containers shipped to the WIPP (DOE, 1996, Appendix WCL).

Acceptance Criterion. The limits for metals are a minimum of 2×10^7 kilograms (kg) for ferrous metals and 2×10^3 kg for nonferrous metals. The limits for ferrous and nonferrous metals will be

met by disposed container count and average container material of construction weights. This parameter will be tracked by the WIPP as reported in the WIPP electronic database.

2.2.2 Physical Properties Acceptance Criteria

Compliance Certification Requirement. The total liquid in any container shall not exceed 1 percent by volume of that container (DOE, 1996, Appendix WCL).

Acceptance Criterion. Observable liquid shall be no more than 1 percent by volume of the outermost container at the time of radiography or visual examination (**VE**).

2.2.3 Physical Form

Compliance Certification Requirement. The repository limit for CPR is a maximum of 2.2×10^7 kg (DOE, 1996, Appendix WCL).

Acceptance Criterion. The amount of CPR for debris waste (S5000) will be determined by multiplying the volume of the waste container by the maximum loading density of plastic (620 kilograms per cubic meter [kg/m^3]). Weights up to the net weight of the waste will be assigned using this method. The derived weight will be entered into the WIPP electronic database with a waste material parameter type of "plastic." For soils and gravel (S4000), the net weight of the waste will be entered into the WIPP electronic database with a waste material parameter type of "soil." For homogeneous solids (S3000), the net weight of the waste will be entered into the WIPP electronic database with the waste material parameter type appropriate to the waste (e.g., solidified inorganic material, solidified organic material, cement). For S3000 and S4000 wastes that also contain debris, the characterization programs will estimate the weight of debris in each container of waste. The debris in S3000 and S4000 wastes will be entered into the WIPP electronic database with a waste material parameter type of "plastic." For all Summary Category Groups, weights for plastics in packaging (e.g., drum liners) will be entered into the WIPP electronic database. The total CPR mass in RH TRU waste will be tracked and controlled through the WIPP electronic database such that the repository limit on CPR is not exceeded.

2.2.4 Radiation Surface Dose Rate

Land Withdrawal Act Requirement. The LWA defines "remote-handled transuranic waste" as TRU waste with a surface dose rate of 200 mrem/hr or greater. The LWA prohibits the receipt of TRU waste with a surface dose rate in excess of 1000 rem/hr, and no more than 5 percent by volume of the RH TRU waste received at the WIPP may have a surface dose rate in excess of 100 rem/hr (LWA).

Acceptance Criterion. The external radiation fields (dose equivalent rates or dose rates) of individual containers shall be greater than or equal to 200 mrem/hr and less than or equal to 1000 rem/hr at the surface of the container. Containers whose dose rate is greater than or equal to 200 mrem/hr, but when placed into a payload container result in that payload container being less than 200 mrem/hr, can be shipped as RH waste. The total dose equivalent rate and the neutron contribution shall be reported in the WIPP electronic database for each container. The WIPP will track the dose rates and volumes of containers, using the WIPP electronic database, to

ensure that no more than 5 percent by volume of the RH TRU waste received at the WIPP has a surface dose rate in excess of 100 rem/hr.

2.2.5 TRU Alpha Activity Concentration

Land Withdrawal Act Requirement. The LWA defines "transuranic waste" as waste containing more than 100 nCi of alpha-emitting TRU isotopes per gram of waste, with half-lives greater than 20 years.

Acceptance Criterion. Containers shall contain more than 100 nCi/g of alpha-emitting TRU isotopes with half-lives greater than 20 years. The TRU alpha activity concentration for a container is determined by dividing the TRU alpha activity of the waste by the weight of the waste. The weight of the waste is the weight of the material placed into the container (i.e., the net weight of the container). The weight of the waste is typically determined by subtracting the tare weight of the container (including the weight of the rigid liner and any shielding external from the waste, if applicable) from the gross weight of the container. The TRU alpha activity concentration shall be determined by any radiological characterization method used (i.e., dose-to-curie [**DTC**], destructive assay [**DA**], or nondestructive assay [**NDA**]) and be reported to the WIPP electronic database. NDA is defined as measurements that do not affect physical form such as gamma and passive-active neutron (**PAN**) spectrometry.

2.2.6 Radionuclide Activity

Compliance Certification Requirement. The activity of emplaced radionuclides shall be quantified (DOE, 1996, Section 4).

Land Withdrawal Act Requirement. RH TRU waste received at the WIPP shall not exceed 23 curies per liter maximum activity level (averaged over the volume of the canister). The total curies of the RH TRU waste received at the WIPP shall not exceed 5,100,000 curies (LWA).

Acceptance Criterion. The activities and masses of ^{241}Am, ^{238}Pu, ^{239}Pu, ^{240}Pu, ^{242}Pu, ^{233}U, ^{234}U, ^{238}U, ^{90}Sr, and ^{137}Cs shall be established on a container basis for purposes of tracking their contributions to the total WIPP radionuclide inventory. The activities and masses for these 10 radionuclides, including their associated uncertainties expressed in terms of one standard deviation, shall be reported to the WIPP electronic database on a container basis. For any of these 10 radionuclides whose presence can be substantiated from AK information, direct measurement, computations, or a combination thereof, and for which any measured data are determined to be below the LLD for that radionuclide, the characterization program shall report the character string "< LLD" to the WIPP electronic database for the activity and mass of that radionuclide; otherwise a value of zero shall be reported. The total activity and its associated uncertainty shall also be reported and tracked on a per container basis.

2.2.7 Waste Origin

Land Withdrawal Act Requirement. The LWA limits the WIPP mission to the disposal of radioactive waste materials generated by atomic energy defense activities, is not high-level waste, and is not spent nuclear fuel.

Acceptance Criterion. The waste must be generated by atomic energy defense activities.

3.0 RH TRU WASTE CHARACTERIZATION PROGRAM DESCRIPTION

This section provides a summary of the RH TRU waste characterization program, including descriptions of the waste stream delineation, characterization, and AK qualification processes. Additionally, this section describes the RH TRU waste characterization program documents and program quality assurance (**QA**) activities.

As illustrated in Figure 1, RH TRU waste characterization begins with the compilation of available AK information regarding a specific waste stream. As defined in 40 CFR Part §194.8, AK is defined as:

> *Acceptable knowledge means any information about the process used to generate waste, material inputs to the process, and the time period during which the waste was generated, as well as data resulting from the analysis of waste, conducted prior to or separate from the waste certification process authorized by EPA's Certification Decision ….*

AK is used to determine the characteristics of the waste stream by gathering and examining existing knowledge of the waste and generating activities. AK consists of documentation describing the processes associated with the generation of a waste, in addition to the waste stream-specific information required to determine the physical and radiological characteristics of the waste stream. AK information may consist of historic site program records including operating procedures and plans, project reports, and safety and analysis documentation. Waste stream-specific AK information may consist of site waste inventory container documentation, generator databases, and historic waste characterization information.

Initially, sufficient AK information must be assembled to delineate the waste stream and verify that the waste was generated by atomic energy defense activities, as required by the LWA. A waste stream is defined as waste material that is (1) generated from a single process/activity and (2) similar in material, physical form, and radiological properties. The existing information is evaluated to determine if the AK is sufficient to delineate the waste stream and support subsequent characterization activities. If the existing AK is insufficient to delineate the waste stream or discrepancies are identified in the documentation, additional AK information can be developed to augment existing AK through the use of interviews, correlation to similar waste inventories, or collecting additional information through direct examination or sampling and analysis of the waste using methods separate from the waste certification process authorized by the EPA. For example, waste inspection, real-time radiography (**RTR**) quick screen, or grab sampling methods may be employed, and the resulting data included as part of the AK record.

Once sufficient information has been collected to delineate the physical and radiological waste stream properties and establish the defense origin for the waste stream, the characterization methods that will be used to satisfy the DQOs for each container to be included in the waste stream can be developed. These methods may utilize data already compiled in the AK record, data generated by the standard characterization methods described in Section 4.0, and/or data generated by other characterization methods approved by CBFO prior to implementation. A combination of these characterization methods may be utilized to meet a given DQO; however, any AK data used in part or in whole to meet a DQO must be qualified using one of the AK qualification methods described in Section 5.0 as illustrated in Figure 2.

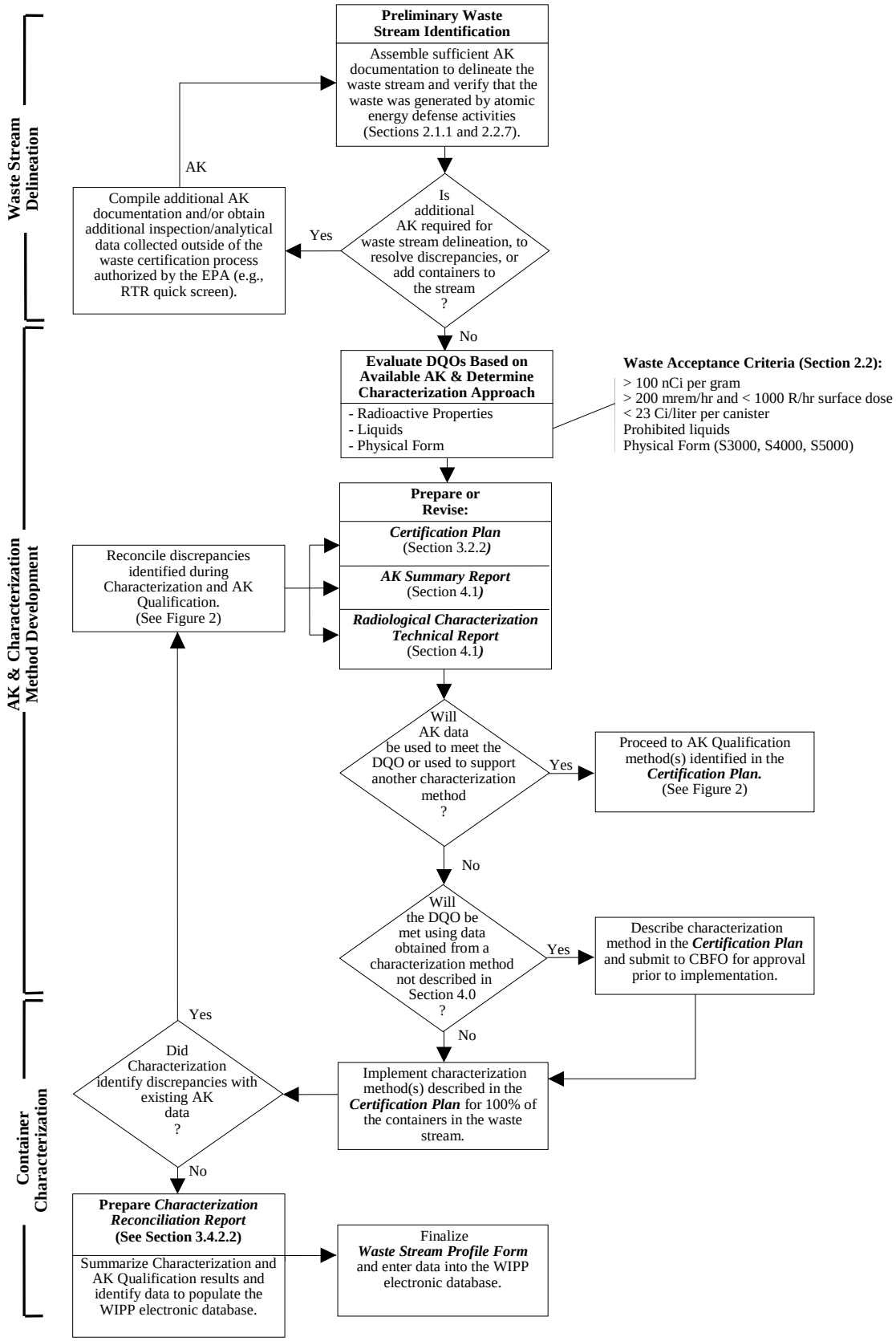

Figure 1. RH TRU Waste Characterization Process

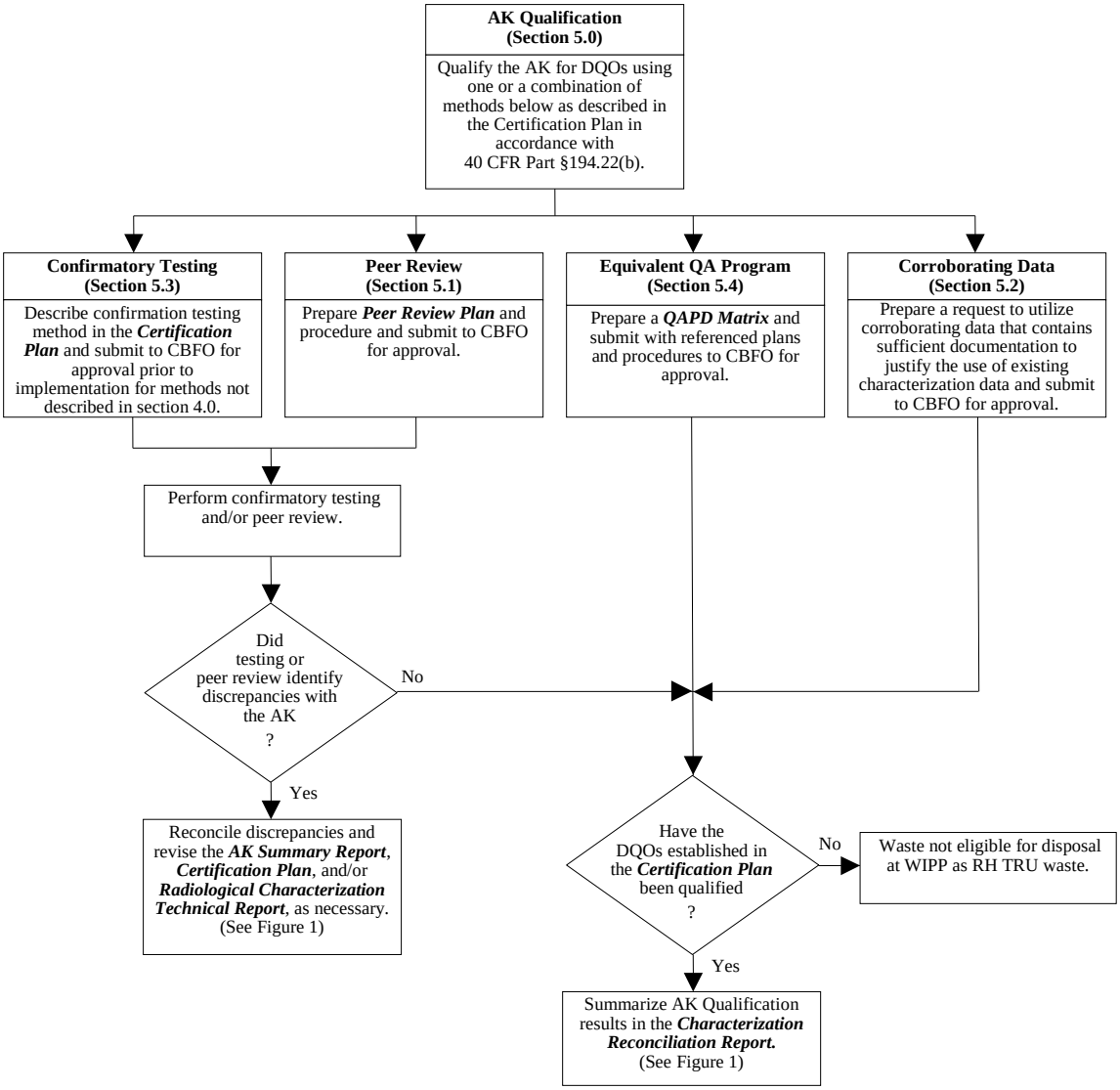

Figure 2. Acceptable Knowledge Qualification Process

The primary reports developed to document the RH TRU waste characterization for a given waste stream include the AK Summary Report, RH TRU Waste Certification Plan (**Certification Plan**), and Radiological Characterization Technical Report. As described in Section 4.1, the AK Summary Report will be prepared to describe existing AK information relating to the generating process(es), material inputs, and the physical and radiological properties of the waste stream. The nature of RH waste (material age, unique dose considerations, availability of AK information, site waste-handling capabilities, and potential opportunities to collect data by measurement), makes it necessary to develop waste stream-specific characterization approaches. In conjunction with the development of the AK Summary Report, a Certification Plan is developed for each waste stream (or related waste streams) to establish the methods selected to generate characterization data and qualify AK data used to meet the DQOs and to describe the QAOs for each of those methods. As described in Section 3.2.2, the Certification Plan will also provide the justification for the selection of the characterization strategy and selection of

methods not included in Section 4.0. As described in Section 4.1, the Radiological Characterization Technical Report will also be developed for each waste stream (or related waste streams) in conjunction with the AK Summary Report and implementation of the radiological characterization methods described in the Certification Plan. This report describes in greater detail the strategy, rationale, and technical aspects of the methods used to meet the radiological DQOs. The Radiological Characterization Technical Report also presents technical results and evaluations performed from the implementation of radiological characterization methods selected for the waste stream containers, as applicable.

If AK information is used in whole or in part to determine that containers included in the waste stream meet the DQO requirements, this AK data shall be qualified using one or more of the methods allowed by 40 CFR Part §194.22(b). The following AK qualification methods are described in Section 5.0:

- Peer review
- Corroborating data
- Confirmatory testing
- Equivalent QA program

As described above, the AK qualification methods selected for each waste stream will be determined by the Site Project Manager (**SPM**) and described in the Certification Plan. CBFO approval is required for all AK qualification methods, with the exception of confirmation testing utilizing the methods described in Section 4.0. If another AK confirmation method is selected, the method will be described in the Certification Plan and submitted to CBFO prior to implementation. As illustrated in Figure 2, QA Equivalency Reports, Peer Review Plans, and/or Corroborating Data Reports will be submitted for CBFO approval depending on the AK qualification method selected and described in the Certification Plan. The contents of these submittals are outlined in Section 5.0.

Once the waste stream characterization and AK qualification activities are complete and the DQOs have been met using the data generated by the activities, a Characterization Reconciliation Report is prepared as described in Section 3.4.2.2. The SPM is responsible for verifying that the DQOs have been met in accordance with the Certification Plan and that the applicable QAOs (accuracy, completeness, representativeness, and comparability) associated with the characterization process have been met. The SPM will also notify AK personnel of any discrepancies identified during the characterization and AK qualification process that would require discrepancy resolution and/or revision to the AK Summary Report.

3.1 Quality Assurance Program

Before characterizing waste for shipment to the WIPP, RH TRU waste characterization programs must establish a QA program governing waste characterization activities that meet the requirements of the DOE/CBFO QAPD. This QA program must be reviewed and approved by CBFO. The QAPD is the quality management document that identifies federal, state, and industry quality requirements applicable to CBFO programs. The QAPD specifically establishes

the QA program requirements applicable to this RH TRU waste characterization program, as specified in 40 CFR §194.22.

3.2 Program Documents

The RH TRU waste characterization program includes a hierarchy of documents that will guide and control characterization activities and QA activities.

3.2.1 Waste Characterization Program Implementation Plan

This WCPIP describes the activities to be undertaken by the characterization program to characterize RH TRU waste in compliance with the criteria in 40 CFR Part 194. The QA criteria of 40 CFR §194.22 are met by compliance with the QAPD. This WCPIP includes both management and technical aspects of program implementation, as well as data requirements and characterization requirements that each TRU waste characterization program must meet in characterizing RH TRU waste intended for disposal at the WIPP.

3.2.2 TRU Waste Characterization Program Documentation

Each participating TRU waste characterization program shall develop and implement program documentation that addresses the requirements specified in this WCPIP. This documentation shall include or reference the appropriate management and technical criteria of the program, as well as qualitative or quantitative criteria for determining that program activities are being satisfactorily performed. The documentation shall also include a QA plan that addresses the applicable requirements of the QAPD.

The RH TRU waste characterization program shall be described in an RH TRU Waste Certification Plan (**Certification Plan**) developed to meet the requirements of 40 CFR Part 194. The Certification Plan shall be approved by CBFO prior to the certification of any RH TRU waste from the TRU waste characterization program. The required QA plan shall be approved by the CBFO and may be incorporated into the Certification Plan or other CBFO-approved program document. Likewise, either or both plans may be incorporated as separate and distinct sections in existing Certification Plans and QA plans if deemed appropriate by the participating TRU waste characterization program.

The Certification Plan shall be prepared to describe the process for certification of the waste stream, including a description of the characterization methods selected for the waste stream as described in Section 4.1, and AK qualification method(s) described in Section 5.0. A Certification Plan shall be prepared for each waste stream (or related streams) that presents the overall characterization strategy for the waste stream. At a minimum, the Certification Plan will include the following:

- Description of AK qualification and/or characterization methods selected to meet the DQOs, including the justification for the selection of the methods.
- Description of the QAOs for the selected methods.

- Detailed description for any characterization and testing method not included in the WCPIP. The description of the method must be sufficient to allow for CBFO approval prior to implementation of the method.

- Summary of the program documents to be prepared during the characterization and/or qualification methods selected for the waste stream.

Program documents must be approved by CBFO prior to implementation. CBFO will notify EPA upon approval of program documents and implementing procedures relevant to a future request for a change (Baseline Inspection request, Tier 1 Change request, etc.). EPA's comments on documents that are related to compliance with the regulations should be incorporated prior to an official evaluation (Baseline Inspection, Tier 1, etc.). These requirements apply to the following documents (program documents) noted with an asterisk [*] are not approved by CBFO:

- AK Summary Reports* (Section 4.1)

- Certification Plans (Section 5.0)

- Radiological Characterization Technical Reports (Section 4.1)

- AK source documents and review summaries* (Section 4.1)

- Auditable list of AK source documents for each waste stream* (Section 4.1)

- RH TRU Waste Correlation and Surrogate Summary Form* (Section 4.1)

- Peer Review Plans/Reports (Section 5.1)

- Corroborating Data (Section 5.2)

- Equivalent QA Program Reports (Section 5.4)

- Sampling plans and post-sampling and analysis memorandum (Section 4.3.4.1)

- AK Accuracy Reports* (Section 3.4.2.2)

- Measurement batch data reports (**BDRs**) (Section 3.4.3)

- Waste stream profile forms (**WSPFs**) (Section 3.4.2.1)

- Characterization Reconciliation Reports* (Section 3.4.2.2)

- Nonconformance Reports* (Section 3.4.2.3)

- Certification Plans with confirmation testing methods not described in Section 4.0 (Section 5.3)

- Any plans prepared for obtaining data that may be later used in AK or radiological characterization

- Modification to an implemented characterization or qualification method that has been presented to EPA as part of a Baseline, Tier 1, or Tier 2 request including, but not limited to, peer review, QA equivalency, corroborating data, or confirmation testing

- Any other documents associated with the waste stream for which CBFO is seeking approval

3.3 Assessment and Oversight

Specific assessment actions will be taken during the program to ensure all parties are adhering to the requirements of this WCPIP. These actions include periodic audits as well as management and independent assessments conducted in accordance with the QAPD. Corrective actions shall be taken when conditions adverse to quality are identified.

Audits shall include management and technical aspects of the program outlined in this WCPIP. Corrective actions shall be taken if any condition adverse to quality is detected during an audit or assessment. The cause of any adverse condition, identified by any means, that affects compliance with the quality assurance/quality control (**QA/QC**) requirements specified in this WCPIP shall be promptly determined and action taken to preclude its recurrence. The identification, cause, and corrective actions for conditions not complying with the quality requirements for the program must be documented and reported to appropriate levels of management.

In addition to approval of this program-specific documentation, the TRU waste characterization program must pass an initial site certification audit where adequate and effective implementation of these programs is assessed.

Each RH TRU characterization program that is characterizing waste to the requirements of the WCPIP is recertified by the CBFO annually. A recertification consists of, but is not limited to, reviewing (if applicable):

- RH TRU characterization program documents that are written and approved to the latest WCPIP
- Program implementation as determined by a site certification audit
- Reports from surveillances conducted during the past year

To ensure that the characterization program complies with the WCPIP, audits are conducted by the CBFO. An initial audit is conducted for each program performing waste characterization activities prior to the formal acceptance of the WSPFs and/or any waste characterization data supplied by program personnel. This formal acceptance is referred to as site certification. Audits are performed at least annually thereafter, including the possibility of unannounced (not regularly scheduled) audits. These audits verify that the characterization program has implemented a QA program for all characterization activities. After CBFO approval of the RH TRU characterization program documents, the EPA may perform an audit or an inspection in

conjunction with CBFO of the characterization program to verify that a QA program and a waste characterization program have been properly implemented.

3.4 Data Management

This section contains the data management requirements applicable to waste characterization and AK qualification data generated by the characterization program using the methods described in Sections 4.1 and 5.0.

3.4.1 Data Review and Validation

The RH TRU characterization programs will implement the data generation and management processes described in this section. All measurement data generated using the methods listed in Section 4.1 must be reviewed and approved by qualified personnel prior to being reported. At a minimum, the data must be reviewed by a technical reviewer and approved by the SPM.

3.4.1.1 Acceptable Knowledge

The SPM reviews the AK Summary Report, Radiological Characterization Technical Report, and relevant supporting documentation (e.g., source documents, discrepancy reports, and RH TRU Waste Correlation and Surrogate Summary forms) generated through the AK process to determine if the AK documentation is complete and if the information contained therein is adequate to characterize the waste stream. The SPM reconciles AK characterization with the required DQOs and documents the reconciliation. This reconciliation ensures that the characterization methods selected provide documented evidence that the waste containers in the waste stream meet the DQOs.

3.4.1.2 Measurement Methods and Data Validation Requirements

A testing BDR for data validation and QA purposes is required when Section 4.0 radiography, radioassay, DTC, or VE are used to characterize waste. A testing BDR (or equivalent) includes data pertaining to radiography, radioassay, DTC, or VE for up to 20 waste containers or samples.

An analytical BDR for data validation and QA purposes is required when Section 4.0 radiochemistry is used. An analytical BDR (or equivalent) includes data pertaining to analysis for up to 20 samples, excluding QC samples.

A sampling BDR for data validation and QA purposes is required when sampling is performed. A sampling BDR (or equivalent) includes sampling data for no more than 20 samples that were collected for analysis by radiochemistry, excluding QC samples. Analytical and sampling data may be combined into one BDR for reporting purposes.

All measurement data must be reviewed and approved by qualified personnel prior to being reported. At a minimum, the data must be reviewed by an independent technical reviewer. This review shall be performed by an individual other than the data generator who is qualified to have performed the initial work. The independent technical reviewer shall verify, at a minimum, the following information, as applicable:

- Data generation and reduction were conducted in a technically correct manner in accordance with the methods used (procedure with revision).
- Data were reported in the proper units.
- Calculations have been verified by a valid calculation program, a spot check of verified calculation programs, or 100 percent check of all hand calculations.
- Values that are not verifiable to within rounding or significant difference discrepancies must be rectified prior to completion of independent technical review. What constitutes a significant discrepancy is waste stream-specific and will be determined and documented on a case-by-case basis.
- The data have been reviewed for transcription errors.
- The testing, sampling, or analytical data QA documentation for BDRs is complete and includes, as applicable, raw data, calculation records, chain-of-custody forms, calibration records (or references to an available calibration package), and QC sample results. Corrective action will be taken to ensure that all BDRs are complete and include all necessary raw data prior to completion of the independent technical review.
- QC sample results are within established control limits and, if not, the data have been appropriately dispositioned using the nonconformance process described in Section 3.4.2.3.
- Radiography tapes have been reviewed (independent observation) on a waste container basis at a minimum of once per testing batch or once per day of operation, whichever is less frequent.
- Field sampling records are complete. Incomplete or incorrect field sampling records will be subject to resubmittal prior to completion of the independent technical review.
- The appropriate QAOs have been met.

All data must be approved by the SPM. The SPM shall verify, at a minimum, the following information:

- Data generation-level independent technical review, validation, and verification have been performed as evidenced by the completed review checklists and appropriate signature release. Batch data review checklists are complete.
- BDRs are complete and data are properly reported (e.g., data are reported in the correct units).
- Data meet all applicable QAOs.

To ensure that data of known and documented quality are generated, each participating measurement facility shall implement a documented facility QA program. Any measurement technique used for RH TRU waste must be performed in accordance with calibration and operating procedures controlled by the characterization program. Laboratory procedures must contain applicable quality controls. Facility QA programs shall specify qualitative and quantitative acceptance criteria for the QC checks of this program, and corrective actions to be taken when these criteria are not satisfied. Only appropriately trained and qualified personnel shall be allowed to perform data validation/review.

3.4.2 Reconciliation with Data Quality Objectives and Quality Assurance Objectives

Reconciling the results of waste characterization to the DQOs and QAOs provides a way to ensure that data support the waste acceptance criteria. Reconciliation with the DQOs and QAOs will be completed and approved by the SPM.

3.4.2.1 Reconciliation

The reconciliation process involves a review of each DQO, including a listing of the compliance methods used to meet that DQO and a determination documenting that the information is sufficient to meet the QAOs associated with the characterization objective. If any nonconformances are identified during this process, they shall be identified and documented.

Reconciliation must be completed prior to submittal of the WSPF except for the surface dose rate measurements used to establish the dose rate for the container. This measurement must be taken and entered into the WIPP electronic database prior to the waste being accepted for transportation to the WIPP.

Each SPM will ensure that all data generated and used in decision-making meet the DQOs provided in Section 2.1 and the QAOs identified in Section 4.0 for the specific method employed.

For each waste stream or waste stream lot characterized, the SPM shall determine if sufficient data have been collected on a waste stream or container basis, as required. If the SPM determines that sufficient data have not been collected to make the determinations described above, additional data collection efforts must be undertaken. The reconciliation of a waste stream or waste stream lot shall be performed prior to submittal of the WSPF to CBFO for the waste stream. Once a waste stream or waste stream lot is fully characterized, the SPM will submit the completed WSPF and Characterization Reconciliation Report (**CRR**) for the waste stream or waste stream lot to CBFO for approval. Written approval of the WSPF must be obtained prior to shipment of the waste stream or waste stream lot to the WIPP. For each WSPF submitted for approval, CBFO will verify that each submittal (i.e., WSPF and CRR) is complete and will notify the originating characterization program in writing of the WSPF approval. The WSPF shall contain the following:

- WSPF Number
- Generator Site
- Technical Contact/Phone Number
- Generator Site EPA ID
- Summary Category Group
- Waste Stream Name and Description
- Number of containers
- BDR numbers supporting waste stream characterization
- AK Summary Report Number
- SPM signature/date

3.4.2.2 Reconciling Compiled AK Information

The SPM reviews the AK Summary Report in accordance with the requirements of the WCPIP, BDRs and, if applicable, supplemental data collected during repackaging using an approved technique, to determine if the AK record is reconciled and is adequate to characterize the waste stream or waste stream lot and satisfy the relevant DQOs. The SPM will review the qualification data to ensure the DQOs have been met for the waste stream in accordance with 40 CFR 194.22 by review of the appropriate QAOs identified for the qualification method used. Discrepancies between the AK record and confirmatory test results identified during this reconciliation process must be resolved and documented. The discrepancy resolution process may involve a reevaluation of the AK record, reassignment of waste stream parameters, and a revision to the AK Summary Report.

The SPM will review the AK Summary Report, confirmatory test data, and identified AK discrepancies and prepare an AK Accuracy Report. AK accuracy will be determined by assessing the percentage of waste containers that require reassignment to a new Summary Category Group or new waste stream based on the reevaluation of AK, or on obtaining testing, sampling, and/or analysis data. It will also identify the percentage of containers for which there are significant discrepancies in radionuclide information between the AK record and measured values. What constitutes a significant discrepancy will depend on site- and waste stream-specific considerations. If AK accuracy falls below 90 percent, the site shall notify the CBFO and the EPA of this condition. AK Accuracy Reports will be prepared following the characterization of all the containers in the waste stream, or updated at least annually for waste streams generated on an on-going basis.

The SPM shall document the reconciliation of AK qualification and characterization data. The SPM reviews the qualified AK characterization information and the corresponding required DQOs and documents this review in an RH TRU waste CRR. At a minimum the CRR shall include:

- Specification of applicable site and waste stream
- A listing of each DQO
- Data from the AK record that addresses each DQO
- AK source document references that support/provide the data
- A listing of AK record discrepancy resolutions, if any, that are relevant to each DQO
- Documentation, including specific references, of how the AK data for each DQO were qualified, such as BDRs, corroborative data, proceedings of a peer review, etc.
- Radiography and/or visual examination summary to document that prohibited liquids are absent from the waste and to confirm AK concerning the physical properties of the waste
- A summary presentation of radiological measurement data used to meet the DQOs and to confirm AK
- A complete AK summary (unless previously submitted)

- A complete listing of all container identification numbers used to generate the WSPF, cross-referenced to each BDR
- Signature of the SPM

The SPM also verifies that the applicable QAOs (accuracy, completeness, representativeness, and comparability) associated with the AK process have been met. If changes to the AK Summary Report or other program documents are required, AK personnel will be notified and the changes properly documented.

3.4.2.3 Nonconformances

The status of work and the WCPIP activities at each TRU waste site shall be monitored and controlled by the SPM. This monitoring and control shall include nonconformance identification, documentation, and reporting.

A nonconformance is a deficiency in characteristic, documentation, or procedure that renders the quality of an item or activity unacceptable or indeterminate. Nonconforming items and activities are those that do not meet the WCPIP requirements, procurement document criteria, or approved work procedures. Nonconforming items shall be identified by marking, tagging, or segregating. TRU waste characterization programs shall reconcile and correct nonconforming items as appropriate, in accordance with the QAPD. Disposition of nonconforming items shall be identified and documented. The TRU waste characterization program standard operation procedures (**SOPs**) shall identify the person(s) responsible for evaluating and dispositioning nonconforming items.

Management at all levels shall foster a "no-fault" attitude to encourage the identification of nonconforming items and processes. Nonconformances may be detected and identified by anyone performing WCPIP activities, including:

- Project staff – during field operations, supervision of subcontractors, data validation and verification, and self-assessment.
- Laboratory staff – during the preparation for and performance of laboratory testing; calibration of equipment; QC activities; laboratory data review, validation and verification; and self-assessment.
- QA personnel – during oversight activities or audits.

A nonconformance report shall be prepared for each nonconformance identified. Each nonconformance report shall be initiated by the individual(s) identifying the nonconformance. The nonconformance report shall then be processed by knowledgeable and appropriate personnel. For this purpose, a nonconformance report shall be prepared including or referencing, as appropriate, results of laboratory analysis, QC tests, audit reports, internal memoranda, or letters.

The nonconformance report must provide the following information:

- Identification of the individual(s) identifying or originating the nonconformance
- Description of the nonconformance

- Method(s) for correcting the nonconformance (corrective action)
- Schedule for completing the corrective action
- An indication of the potential ramifications and overall usability of the data, if applicable
- Any approval signatures specified in the nonconformance procedures

The SPM shall oversee the nonconformance report process and be responsible for developing a plan to identify and track all nonconformances. Documentation of nonconformances shall be made available to the SPM. Completion of the corrective action for nonconformances must be verified by the site QA Manager (or designee).

The characterization program must implement a corrective action to remedy the nonconformance prior to management, storage, or disposal of the affected waste at the WIPP.

3.4.3 Data Reporting

The following are the minimum requirements for raw data generation and management of testing, sampling, and analytical data:

- All raw data shall be signed and dated in reproducible ink by the person generating them. Alternately, unalterable electronic signatures may be used.
- All data must be recorded clearly, legibly, and accurately in field and laboratory records (e.g., bench sheets, logbooks), and include applicable sample identification numbers (for sampling and analytical labs).
- All changes to original data must be lined out, initialed, and dated by the individual making the change. Original data must not be obliterated or otherwise disfigured so as not to be readable. Data changes shall only be made by the individual who originally collected the data or an individual authorized to change the data.
- All data must be transferred and reduced from field and laboratory records completely and accurately.
- All field and laboratory records must be maintained as QA records.
- Data must be organized into a standard format for reporting purposes, as specified in sampling, testing, and analytical procedures.
- All electronic and video data must be stored appropriately to ensure that waste container, sample, and associated QC data are retrievable.

Data must be reported on a batch basis. A batch is defined, for the purpose of the program, as a suite of waste containers or samples undergoing measurement or sampling using the same testing, analytical, or sampling equipment, with a maximum of 20 containers or samples. Each measurement/testing facility is required to submit BDRs for each batch on standard forms (either hard copy or electronic equivalent), as provided in approved characterization program-specific documentation.

BDRs shall consist of the following:

- Testing facility name, testing batch number, batch report date, container or sample numbers included in that testing batch, technical reviewer signature, and signature release by the SPM
- Background and performance data or control charts for the relevant time period (if applicable)
- Separate testing report sheet for each container in the testing batch that includes:
  - Method used for measurement (i.e., procedure identification)
  - Date of measurement
  - For radioassay or DTC BDRs, activities and masses of individual radioisotopes present and their associated uncertainties (curies and grams), as appropriate for the measurement/testing
  - If for radiography or VE BDRs, parameters of interest (such as Summary Category Group, absence of prohibited liquids)
- QC documentation
- References to or copies of associated nonconformance reports, if any
- Data review checklists
- Operator signature and date
- Independent technical reviewer signature and date

Associated uncertainty shall be included in the measurement/testing BDR or other QA record or database. When associated uncertainty is reported differently on the testing report sheet than in the WIPP electronic database, the method of expressing associated uncertainty shall be specified on the testing report sheet or associated procedures.

Analytical data must be reported on a batch basis. A batch is defined, for the purpose of the program, as a suite of samples undergoing analysis or radiochemistry, with a maximum of 20 samples (excluding QC samples). Each measurement/testing facility is required to submit analytical BDRs for each analytical batch on standard forms (either hard copy or electronic equivalent), as provided in approved characterization program-specific documentation.

Analytical BDRs shall consist of the following:

- Analytical facility name, analytical batch number, batch report date, sample numbers included in that analytical batch, technical reviewer signature, and signature release by the SPM
- Background and performance data or control charts for the relevant time period
- Testing report for all samples in the batch that includes:
  - Method used for measurement (i.e., procedure identification)
  - Date of measurement

- QA documentation, including, as applicable, raw data calculation records, chain-of-custody forms, calibration records (or references to available calibration documentation)
- Reference to or copy of associated nonconformance reports, if any
- Data review checklists
- Operator signature and date
- Independent technical reviewer signature and date
- Sampling BDRs for radiochemistry shall contain the following:
- Sampling facility name, sampling batch number, batch report date, sample numbers included in that sampling batch, technical reviewer signature, and signature release by the SPM
- Table of contents
- Identification of the sample matrix (e.g., sludge, swipe, salt, plastic, metal)
- Sample type (e.g., duplicate, blank)
- Method used for measurement (i.e., procedure identification)
- Waste container identification number (if applicable)
- Date of sampling
- Analyses requested and laboratory
- Sample number
- Sample size
- Sample location
- Sampling personnel identification
- Chain-of-custody record
- Sampling equipment numbers (if applicable)
- Cross-reference of sampling equipment numbers and cleanliness survey records
- Sampling data sheets
- Reference to or copy of associated nonconformance reports, if any
- Data review checklists
- Operator signature and date
- Independent technical reviewer signature and date

Sampling and analytical batch reports may be combined, but all required information must be contained in the combined report.

3.4.4 Data and Records Retention

The following nonpermanent records shall be maintained at the measurement facilities or shall be forwarded to the site project office for maintenance, and shall be documented and retrievable by batch number, in accordance with the QAPD:

- BDRs
- Raw data, including instrument readouts, calculation records, and QC results
- Applicable instrument calibration reports

3.4.5 Data Reporting to WIPP

Characterization programs shall transmit required characterization data to WIPP using the approved electronic database. The electronic database is equipped with edit/limit checks to ensure that the data representing the waste containers are in compliance with this WCPIP. Before shipping RH TRU waste containers from a WIPP-accepted waste stream, the characterization program shall transmit the required waste characterization data to WIPP via the electronic database. WIPP will not accept any waste shipments for disposal if the waste container information has not been correctly submitted and approved by the Data Administrator. The User's Manual provides the information needed by TRU waste characterization programs to perform tasks associated with transmittal of the container's characterization information to WIPP. The reporting requirements for waste components to the WIPP electronic database are contained in Section 2.2 of this WCPIP.

4.0 RH TRU WASTE PROGRAM CHARACTERIZATION METHODS

The following sections describe the methods available for characterizing RH TRU waste streams. In addition to a description of the AK characterization process, physical and radiological analysis and examination methods are described, as well as the QAOs for each characterization method.

CBFO has identified characterization methods to generate the data needed to support the RH TRU waste characterization program DQOs. The primary method is the compilation of AK information described in Section 4.1. AK information may be historical, or currently generated under a non-certified program (such as quick-scan radiography or analysis of grab samples by an unapproved laboratory). In addition, Sections 4.2 and 4.3 present physical and radiological testing/examination characterization methods that can be used in conjunction with AK to characterize RH TRU waste streams.

4.1 Acceptable Knowledge

AK consists of information about the materials and processes that generated a waste and the procedures and policies that were used to package and manage the waste. AK includes, but is not limited to, information about the physical form of the waste, the base materials composing the waste, the radiological characteristics of the waste, and the process that generated the waste. Implementation of the AK process involves the collection, review, and compilation of this information into an auditable AK record. AK information used in whole or in part to meet the

DQO requirements must then be qualified using one of the methods described in Section 5.0. This information is then presented in AK Summary Reports and Radiological Characterization Technical Reports for each waste stream, providing a summation of the AK and other characterization method information and a roadmap to the relevant information contained in the AK record.

As described in Section 3.0 and illustrated in Figure 1, RH TRU waste characterization begins with the compilation of available AK information regarding a specific waste stream. AK consists of the waste stream-specific information assembled to delineate the waste stream, describe the generating process, verify that the waste was generated by atomic energy defense activities, and support subsequent physical and radiological characterization of the containers to be included in the waste stream. If the existing AK is insufficient to delineate the waste stream or discrepancies are identified in the documentation, additional AK information can be developed to augment existing AK through the use of interviews, correlation to similar waste inventories, or collecting additional information through direct examination or sampling and analysis of the waste using methods separate from the waste certification process authorized by the EPA. Specific AK documentation that may be collected include, but are not limited to, the following:

- Published and unpublished documents and controlled databases.
- Internal procedures and notes such as logbooks, correspondence such as memoranda, letters, telephone logs, interviews, and e-mails
- Engineering documents
- Documents that describe facilities and processes involved, missions, time periods of operation, types of waste generated (waste material parameters), and physical and radionuclide inputs into the process
- Historic NDA, radiochemistry, and nondestructive examination data
- Process descriptions and flow diagrams
- Packaging logs and video tapes
- Material Safety Data Sheets
- Procurement records

Discrepancies identified in the AK record relating to any of the WCPIP DQOs must be resolved for the waste to be eligible for disposal at WIPP. The resolution must be documented and included as a source document in the AK record and identify the affected waste stream(s), identify all relevant AK source documents, state the nature of the discrepancy, and make conservative assignments unless otherwise justified.

If correlations and similarities between contact-handled (**CH**) TRU and RH TRU waste generated at the same site or between wastes generated at different sites can be demonstrated, include characterization information for these wastes as part of the RH TRU waste stream AK information to meet the required DQOs, as applicable. Such correlations must be described in the AK Summary Report and documented in a RH TRU Waste Correlation and Surrogate

Summary Form that includes the following information:

- Identification of the generator/storage site
- Applicable RH TRU waste stream
- Identification of the correlating or surrogate waste
- Source of information used for physical form, liquid, and/or radiological characterization information
- Justification for the use of the correlation/surrogate information

The result of the AK process is an auditable record and an AK Summary Report. The AK process and AK Summary Report contents shall be described and implemented by a SOP developed for the TRU waste characterization program. The auditable record consists of the documents that contain the source material used to make decisions regarding waste characterization. This can include documents that establish a parameter that addresses the DQOs, demonstrate limitations of AK information, or demonstrate the absence of a parameter. The AK Summary Report is a narrative that describes in detail the characteristics of the waste stream and how each of the DQO requirements is satisfied by the available documentation. The AK Summary Report will be annotated so that it is possible to identify the source document for each requirement covered in the AK Summary Report.

The AK Summary Report is a narrative that describes the delineation of the waste stream and presents the characterization data available to address DQO requirements, as applicable. The AK Summary Report serves as the roadmap to the auditable AK source documentation record and will be annotated so that it is possible to identify the specific source document(s) for the required AK elements presented in the AK Summary Report. AK data used in part or in whole to meet a DQO (except for the defense determination) must be qualified using one of the qualification methods in Section 5.0. The AK Summary Report includes the following:

- A description of the physical form of the waste. This description will identify the waste as debris, soil/gravel, or homogeneous solid. The waste stream description will be sufficiently detailed to allow the reader to understand the types of items that are expected in the waste stream.
- Relevant radiological information to delineate the waste stream. This may include the results of measurements (field or laboratory), radionuclide inventory records, safeguards information, modeling studies, and other assessments used to determine the expected radionuclide characteristics of the waste stream.
- Language specifically addressing liquids and describing the policies or procedures that were or will be used to exclude or remove liquids. Based on the source documents summarized in the AK Summary Report, a characterization program must be able to document that the containers in the waste stream contain no prohibited liquids and/or the characterization method to be used to assure the absence of prohibited liquids.
- Description of the AK information and source of data used to delineate the waste stream, including the defense waste determination and justification that the waste is not or does not contain spent nuclear fuel or high-level waste

- Facility location, description, and mission
- Types and quantities of RH TRU waste generated
- Description of waste generating processes and activities
- Area and building of generation
- Waste stream volume and period of generation
- Waste generating activities
- Physical waste stream description, including material inputs related to physical form and potential for liquids
- Summary category group and waste material parameters
- Summary of generator's historic radiological characterization information
- Summary of DQOs and the qualification of AK information described in the Certification Plan
- Resolution of discrepancies identified during subsequent characterization and qualification activities
- Use of correlating or surrogate information generated for other materials or waste streams

As described in section 3.0, a Radiological Characterization Technical Report is prepared for each waste stream (or related waste stream) in conjunction with the AK Summary Report. This report presents the methodology and technical approach to be used for the radiological characterization for the waste stream. The Radiological Characterization Technical Report serves as the roadmap to the calculation packages that contain the specific characterization evaluation and related results for the methodology selected. The Radiological Characterization Technical Report includes the following:

- Detailed description of the technical approach, including characterization methodology and technical justification for the selection of the methodology
- Description of radiological materials and operations contributing to the waste stream contamination (type of fuels, reactors, fuel composition, burnup, etc.)
- Presentation of the generator AK information utilized for the radiological characterization method(s) selected for the waste stream
- Specific identification of additional data to be generated to characterize waste containers or qualify AK
- Presentation of method(s) and data used to qualify AK data used for characterization
- Total uncertainty analysis based upon the propagation of uncertainties present in all aspects of the determination of the isotopic content of the waste stream
- Presentation of waste stream-specific radiological parameters that address the required radiological DQOs
- Use of correlating or surrogate information generated for other materials or waste streams

Characterization program personnel responsible for compiling AK, characterizing RH TRU waste streams using the AK process, and assessing the AK characterization shall be qualified and trained in:

- The WCPIP
- The characterization program nonconformance and corrective action process

Specifically, characterization program AK personnel are responsible for the following:

- Obtain site-specific understanding of physical and radiological properties of the waste streams, e.g., CH and RH companion streams, if applicable
- Identify and compile AK source documents that will be used to characterize the waste
- Use compiled information to characterize the waste and document any and all pertinent information
- Compile AK information to demonstrate compliance with the applicable DQOs
- Obtain AK record(s) used by the radiological characterization team to ensure inclusion of the record(s) as AK source documents
- Assign unique tracking numbers to AK source documents
- Write AK source document summaries, identifying the relevant information and noting any limitations associated with source documents
- Maintain an auditable list of the AK sources collected for the waste stream
- Resolve discrepancies in or between AK source documents. Include the documentation of the resolution in the AK record.
- Based upon compiled information, delineate waste streams and assign waste stream numbers
- Support the SPM in the development of appropriate AK qualification methods
- Compile the AK information into an auditable record
- Develop an AK Summary Report for each RH TRU waste stream, as described above
- Support the SPM with the development of the Waste Stream Profile Form

The RH TRU characterization program is responsible for maintaining records of the training provided to personnel responsible for compiling AK.

AK Quality Assurance Objectives

To ensure the consistent application of the AK process, characterization programs must comply with the following data quality requirements for AK documentation. These data quality requirements, expressed as QAOs, are applied to the AK process, not necessarily to the data being collected in the process.

Precision QAO – Precision is the agreement among a set of replicate measurements without assumption of the knowledge of a true value. The qualitative determinations, such as compiling and assessing AK documentation, do not lend themselves to statistical evaluations of precision. Therefore, precision requirements are not established for AK.

Accuracy QAO – Accuracy is the degree of agreement between an observed sample result and the true value. AK accuracy will be determined by assessing the percentage of waste containers that require reassignment to a new Summary Category Group or new waste stream based on the reevaluation of AK or on obtaining testing, sampling and/or analysis data. The sites shall, in addition, develop a methodology to compare radionuclide information from AK confirmation with the information in the AK record and address significant discrepancies. What constitutes a significant discrepancy will depend on site- and waste stream-specific considerations. If AK accuracy falls below 90 percent, the site shall notify the CBFO and the EPA of this condition. The DOE and EPA will examine these documents for adequacy during audits and inspections.

Completeness QAO – Completeness is an assessment of the number of waste streams or number of samples collected compared to the number of samples determined to be useable through the data validation process. The AK record shall contain 100 percent of the information required for each container in the waste stream. The usability of the AK information will be assessed for completeness during audits.

Comparability QAO – Data are considered comparable when one set of data can be compared to another set of data. Comparability is ensured by the characterization program meeting the training requirements and complying with the minimum standards outlined for procedures that are used to implement the AK process.

Representativeness QAO – The degree to which sample data accurately and precisely represent characteristics of a population. Representativeness is a qualitative parameter that will be satisfied by ensuring that the process of obtaining, evaluating, and documenting AK information is performed in accordance with the minimum standards established in an AK procedure.

4.2 Physical Characterization Methods

4.2.1 Visual Examination

VE is used to identify or confirm waste parameters, including physical form and the absence of prohibited liquids. Prohibited liquids include:

- Observable liquid exceeding 1 percent by volume of the outermost container at the time of visual examination.

VE involves operators looking at every item that goes into a container either by witnessing the packaging (in person or by remote viewing) or viewing visual records of that packaging. The examination will be recorded on a signed data form accompanied by visual evidence such as video/audiotapes, photographs, or some other form of unalterable media. In lieu of a video/audiotape or other unalterable media, two trained operators may look at every item and

document their examination on a signed data form. It may not be possible to see through inner containers because of discoloration, dust, or because inner containers are sealed. In these instances, documented AK (records signed by the packager), may be used to identify the Summary Category Group and verify the absence of prohibited liquids without further qualification. It is acceptable to load waste containers into larger containers (e.g., loading cans into drums or drums into canisters) without visual recordings as long as there is traceability and documentation of the loading and any additional packaging materials that have been added (such as bags or straps). No additional waste material may be added during these loading activities.

At a minimum, the VE data to be entered on the VE data form must include:

- Container number
- Container's waste stream designation
- Operator(s) performing the VE
- Description of the container contents including waste material parameters that are present
- Determination of whether the waste matches the waste stream description in the AK summary report
- Determination of whether prohibited liquids are present
- Description of packaging including any liners used
- Fill percentage (required to implement DTC).
- Information regarding waste matrix properties, if required by the TRU waste site program, to implement radiological characterization methods
- Date of VE
- Videotape or equivalent media identification number (if applicable)
- Videotape or equivalent media start and stop time (if applicable)
- Title and revision number of the VE procedure used
- Signature of first trained operator
- Signature of second trained operator (if not using recording media)

The characterization program must have a training program that provides VE operators with both on-the-job training (**OJT**) and formal training. VE operators must be instructed in the site-specific waste generating practices and expected packaging configurations of RH TRU waste. The OJT must be conducted by an experienced and qualified VE operator. The training programs will be site-specific due to differences in equipment and waste configurations. For example, the particular physical forms and packaging configurations at each site will vary, so operators must be trained on types of RH TRU waste that are generated, stored, and/or characterized using VE at that site. VE personnel must be requalified every two years.

Although the site-specific training programs will vary, the sites that use VE must have a training program containing the following required formal training elements:

- Project requirements
- Container identification and labeling
- Applicable state and federal regulations
- Site-specific instruction

The site must have a site-specific training program, including OJT, addressing the following aspects of waste characterization with VE, as applicable to the waste characterization being conducted using VE:

- Identification of summary category groups
- Identification of waste material parameters
- Identification of packaging configurations
- Identification of liquids

Each VE facility must designate a VE expert. The VE expert must be familiar with the RH TRU waste-generating processes that have taken place at the site, all the types of RH TRU waste being characterized at that site using VE, and the data that are collected from VE operations. The VE expert must be responsible for the overall direction and implementation of VE at that facility. The characterization program must specify in site documentation the selection, qualification, and training requirements of the VE expert.

To become qualified, VE operators must, at a minimum:

- Successfully pass a comprehensive exam based on training enabling objectives. The exam will address the VE training and implementation requirements. A minimum score of 80 percent is required to pass the comprehensive exam.
- Demonstrate capability in the presence of the site VE expert during OJT.

Operators must be requalified at least every two years, based on evidence of continued satisfactory performance. Unsatisfactory performance is defined as the failure to identify a prohibited item during OJT or a score of less than 80 percent on the comprehensive exam. Retraining and demonstration of satisfactory performance are required before an operator is again allowed to perform VE for the WIPP program.

VE Quality Assurance Objectives

The following QAOs apply to the VE method:

Precision QAO – Precision is maintained by reconciling any discrepancies between two operators (or between the operator and the independent technical reviewer) with regard to the identification of important waste characteristics (i.e., physical form of the waste and absence of prohibited liquids) within a single container. Any container with unreconciled discrepancies cannot be shipped to the WIPP.

Accuracy QAO – Accuracy is maintained by requiring operators to pass a comprehensive examination with a score of 80 percent and demonstrate satisfactory performance in the presence of the VE expert during their initial qualification and subsequent requalification.

Representativeness QAO – The contents placed in a container will be described on the data forms.

Completeness QAO – The relevant waste information must be collected. This information must be documented on a videotape and/or data form, or other unalterable media.

Comparability QAO – Comparability is ensured by the characterization program meeting the training requirements and complying with the minimum standards used to implement this characterization process. In some instances, waste will be contained in opaque containers and not all items will be visible to the operator (e.g., sealed paint cans or 5-gallon buckets). If these containers are not opened during VE, source documents must be available in the AK record that allow the operator to identify the contents of the closed containers.

If a characterization program intends to use records of visual examination performed prior to implementation of this WCPIP to demonstrate compliance with a DQO, it must demonstrate that the information collected regarding the waste stream and individual containers is sufficient to meet the QAOs and the programmatic DQOs that can be satisfied using VE.

If a characterization program intends to use records of visual examination that does not meet the QAOs of this section, then site plans for qualification of VE data require CBFO approval to assure consistency with RH TRU waste characterization program objectives. The plan must demonstrate compliance with the AK qualification requirements of Section 5.0.

4.2.2 Radiography

Radiography may be used to assess the physical form of the waste and verify the absence of prohibited liquids. Prohibited liquids include:

- Observable liquid exceeding 1 percent by volume of the outermost container at the time of radiography.

Radiography involves the use of penetrating radiation to examine the contents of containers. The examination will be recorded on a signed data form accompanied by visual evidence such as videotape or other unalterable media.

Radiography shall consist of a qualitative evaluation of the waste container contents and shall be recorded on videotape (or another equivalent unalterable medium). A radiography data form shall be used to document the data that are collected by a trained radiography operator. Characterization programs that use radiography must use controlled procedures that identify all data that must be collected during radiography and entered on the radiography data form. At a minimum, the radiography data to be entered on the radiography data form must include:

- Container number
- Container waste stream designation

- Operator(s) performing the radiography
- Description of container contents including waste material parameters that are present
- Determination of whether the waste matches the waste stream description in the AK summary report
- Determination of whether prohibited liquids are present
- Description of packaging, including any liners used
- Fill percentage (required to implement DTC)
- Information regarding waste matrix properties, if required by the TRU waste characterization program, to implement radiological characterization methods
- Date of radiography
- Videotape or equivalent media identification number
- Title and revision number of the radiography procedure used
- Signature of trained operator

At the beginning of each day, prior to performing radiography on any waste containers, the radiography equipment must be checked by observing a known test target to verify image quality. A videotape recording (or a recording on an equivalently unalterable media) shall be made of the test target and each waste container scan. Independent replicate scans shall be performed on one waste container per day or once per testing batch, whichever is less frequent. Independent observations of one scan (not the replicate scan) shall also be made once per day or once per testing batch, whichever is less frequent, by a qualified radiography operator other than the individual who performed the first examination. The radiography data form shall be used to document the data that are collected. Characterization programs that use radiography must have trained radiography operators who can scan the waste container, generate the recorded image, interpret the image, and complete the radiography data form. A second trained operator is necessary for the independent observation.

The characterization program shall have a training program that provides radiography operators with both OJT and formal training. Radiography operators shall be instructed in the specific RH TRU waste-generating practices and typical packaging configurations. The OJT shall be conducted by an experienced, qualified radiography operator prior to qualification of the training candidate. Because of differences in equipment, waste configurations, and the types of data being collected during radiography, the training programs will be site-specific. For example, certain sites use digital radiography equipment, which is operated differently than real-time radiography equipment. In addition, the waste and packaging configurations at each site will vary; therefore, radiography operators shall be trained on the types of RH TRU waste that are representative at that site.

Although the site-specific training programs will vary based on the data that are being collected using radiography, sites that use radiography shall have a training program including the following required formal training elements:

- Project requirements
- Applicable state and federal regulations
- Basic principles of radiography
- Radiographic image quality and calibration
- Radiographic scanning techniques
- Radiography of waste forms
- Standards, codes, and procedures for radiography
- Site-specific instruction

Each site that uses radiography must have a site-specific training program that addresses the following aspects of waste characterization using radiography:

- System operation
- Identification of packaging configurations
- Identification of summary category groups
- Identification of waste material parameters
- Identification of liquids

A radiography test container shall be examined as part of the radiographer qualification. The radiography test container shall include items representative of the physical properties of the waste streams at the site and prohibited liquids. The summary category group and liquids shall be successfully identified by the operator as part of the qualification process. Qualified radiography operators shall, at a minimum:

- Successfully pass a comprehensive exam based on training enabling objectives. The comprehensive exam will address radiography operation, documentation, characterization, and procedural elements stipulated in this WCPIP. A minimum score of 80 percent is required to pass the comprehensive exam.
- Perform practical capability demonstration in the presence of the appointed site radiography subject matter expert (this person is an experienced radiography operator who is qualified as an OJT trainer).

Operators shall be requalified at least every two years, based on evidence of continued satisfactory performance (primarily audio/videotape reviews). Unsatisfactory performance is defined as the failure to identify prohibited liquid in a test container or a score of less than 80 percent on the comprehensive exam. Retraining and demonstration of satisfactory performance are required before an operator is again allowed to operate the radiography system for the purposes of this WCPIP.

Radiography Quality Assurance Objectives

The following QAOs shall apply to the radiography method:

Precision QAO – Precision is maintained by reconciling any discrepancies between two operators (during Independent Observation and Replicate scans) with regard to the identification of important waste characteristics (i.e., physical form of the waste and absence of prohibited liquids) within a single container.

Accuracy QAO – Accuracy is obtained by using a target to tune the image for maximum sharpness and by requiring operators to successfully identify prohibited liquid in a training container during their initial qualification and subsequent requalification.

Representativeness QAO – All of the relevant contents in a container selected for radiography will be described.

Completeness QAO – All of the relevant waste information must be assembled and must show that each of the containers in the waste stream belongs to the waste stream. This information must be documented on videotape or other equivalent media and data form.

Comparability QAO – Comparability is ensured by meeting the program training requirements and complying with the minimum standards used to implement the radiography process.

If a characterization program chooses to use records of radiography performed prior to implementation of this WCPIP to demonstrate compliance with a DQO, it must demonstrate that the information collected regarding the waste stream and individual containers is sufficient to meet the QAOs and the overall programmatic DQOs that can be satisfied using radiography.

If a characterization program chooses to use records of radiography performed prior to implementation of this WCPIP that do not meet the QAOs listed in this section, the program is required to have their plan to qualify radiography data approved by CBFO to assure consistency with RH TRU waste characterization program objectives. The plan must demonstrate compliance with the AK qualification requirements of Section 5.0.

4.2.3 Count Containers

The counting of containers will be accomplished by information provided in the WIPP electronic database. Information collected by counting containers will be used to calculate amounts of ferrous and nonferrous metals. No method description or associated QAOs are provided for this method. This will be performed by WIPP based on shipment data input into the WIPP electronic database by the characterization programs for each shipment.

4.3 Radiological Characterization Methods

CBFO has identified several acceptable methods that are involved in the radiological characterization of RH TRU waste to satisfy the DQOs for disposal at the WIPP. Generally, more than one of these methods is required for the characterization of the waste. The method or methods may vary from generator site to generator site because of differences in the extent and nature of the information available on the radiological characteristics of the waste, in the radiological nature of the waste, in the activities and processes involved in the waste generation, and whether or not the waste is already packaged.

When characterization programs decide to use any of the following methods to characterize waste, they will be required to determine the applicability of the method and the sampling and analysis required to support the selected method(s). The methods, supporting analyses and results of the characterization shall be documented in the Radiological Characterization Technical Report as described in Section 4.1.

4.3.1 Determination of Absolute Concentrations in Waste

For waste streams that have reasonably homogeneous characteristics of radionuclide concentrations and density, such as soil, sludge, and liquids, sampling and analysis may be used to derive the absolute concentrations of the radionuclides required for characterization. A representative number of samples may be needed to demonstrate the homogeneity of the waste stream and to derive the average concentrations of the radionuclides of interest. The data shall be analyzed to determine average concentrations. The variability in the data shall be used to determine uncertainties in the average concentrations. AK information may be required to support the conclusion that a particular waste stream is homogeneous. If adequate AK information is available, modeling may be used to develop the concentration of radionuclides that are not separately identified in normal radio-counting techniques.

If the radionuclide concentration data are to be used in the characterization of the homogeneous waste, then a sampling plan, as described in Section 4.3.4 is required. The sample collection and sample analyses shall be conducted in accordance with guidance in Section 4.3.4.

Existing sampling and analytical data may be used, if the data can be qualified in accordance with the requirements of Section 5.0. The Radiological Characterization Technical Report shall include the justification for the use of the existing data as representative of the waste stream and as appropriate for the intended use of the data.

The QAOs for the sampling and destructive analysis methods are addressed in Section 4.3.4.

4.3.2 Dose-to Curie Conversion

The curie content of RH TRU waste containers can be derived based on an external gamma dose rate measurement This process, referred to as dose-to-curie (**DTC**), can be used to establish radionuclide activity, total activity, and activity per container, when used in conjunction with scaling factors that represent the radionuclide distribution in the waste.

The DTC method requires a dose rate measurement of the waste container to derive the quantity of either the primary gamma-emitting or neutron-emitting radionuclide(s) in the container based on the average gamma or neutron dose rate. The activities of the remaining radionuclides in the waste are then derived by the use of conversion factors, commonly termed scaling factors. The dose rate measurement shall be made using a calibrated instrument. The correlations to convert from a gamma or neutron dose rate to a radionuclide concentration are derived from radiation transport modeling using shielding computer programs such as MicroShield® (for gamma only) or MCNP5. The external dose rate can be correlated to the total activity of the primary gamma- or neutron-emitting radionuclides in the container by taking into account such factors as matrix and container geometry. The activities of the other radionuclides are calculated from the gamma or neutron activity using scaling factors.

Scaling factors can be developed from modeling, sampling and analysis, process information, and/or other forms of AK. For some RH TRU wastes, the scaling factors can be calculated based on fuel characteristics and computer modeling (from a program such as ORIGEN) as discussed in Section 4.3.5. Representative sampling and analysis may also be used to derive scaling factors as discussed in Section 4.3.4. Another alternative is to use process inventory information to develop scaling factors. The scaling factor development should consider potential partitioning of the key gamma radionuclide and the scaled radionuclides in the process operations and the deposition on the waste. For example, ^{137}Cs may be separated from the actinides by fuel examination activities involving water where the ^{137}Cs would be more soluble in water than the actinides. The radionuclide scaling factor derivation shall be documented in the Radiological Characterization Technical Report.

The DTC correlations shall be developed and applied as follows:

- The dose rate shall be determined at a distance of a minimum of one meter from the outer surface of the waste container, at the predetermined height of the container.
- The DTC correlation shall be developed as a function of the waste density for each radionuclide contributing to 95 percent of the measured dose rate. In order to determine the waste density, the fill height of each container shall be known.
- The DTC correlation shall consider the waste type (i.e., metal, concrete, or organic) and waste height effects (other than its effect on density), if such parameters are determined to be significant.
- The DTC correlation shall include the shielding effect of the container wall(s) and shall account for any significant scatter from shield walls adjacent to the container being measured.
- The dose rate per unit activity outside a RH TRU container shall be calculated through straightforward shielding analysis techniques. These techniques include discrete ordinates, Monte Carlo, and point-kernel methods that have been implemented in numerous computer programs. Some of the more common programs implementing these methods are MCNP5 and MicroShield®.
- The DTC correlation shall be used with the measured dose rate to estimate the activity(ies) in the waste container of the primary gamma radionuclide that is the basis of the scaling factor.

Specific procedural steps for conducting the radiation survey of the exterior of the waste container for the purpose of DTC measurements shall be developed. General programmatic requirements are provided below.

- A suitable gamma or neutron radiation detector for measuring the dose rate outside the loaded waste container shall be used.
- The detector's response function (e.g., mrem/hr) shall be consistent with that used in the calculation of the dose rate.
- The detector shall not be subject to saturation in high radiation fields and shall have the capability for remote reading.

- Measurements shall only be made within the calibrated range of the instrument.
- For the purpose of this procedure, the background dose rate shall be as low as practicable.
- The background radiation dose rate shall be measured prior to the RH TRU container and that background dose rate shall be recorded.
- The position of the detector relative to the waste container and any intervening shielding shall be consistent with that used in the calculation of the expected gamma dose rate.
- Measurements shall be made at two or more equally spaced polar positions about the container.
- The average value of the measurements shall be used for the DTC conversion calculation of radionuclides in the container.
- For each batch of containers, a duplicate set of dose rate measurements shall be made and documented.

In addition, measurement facilities must document the following attributes:

Background – The measured container dose rate must be at least three times greater than the background. Average background shall be subtracted from the average measured container dose rate.

Lower Limit of Detection (**LLD**) – Any measurement device used for TRU/low-level discrimination must have an LLD that is less than or equal to that which corresponds to 100 nCi/g of TRU radionuclides.

Total Uncertainty– The total uncertainty must be determined and documented for the DTC method.

DTC Quality Assurance Objectives

The following QAOs are applied for the DTC method:

Precision QAO – Not applicable.

Accuracy QAO – Accuracy is achieved through the use of standardized and benchmarked radiation transport computer codes such as MCNP5 or MicroShield®.

Representativeness QAO – Representativeness of the DTC correlation is achieved through the use of an appropriate model of the actual physical drum dose rate configuration. Representativeness is demonstrated through the documentation and independent review of the DTC correlation.

Completeness QAO – Completeness of the DTC correlation is achieved by basing it on calculations that span the full range of important parameter values (such as density) that are expected to be encountered with the actual RH TRU containers.

Comparability QAO – Not applicable.

The following QAOs are applied for the dose rate measurement:

Accuracy QAO – Calibration shall be established and maintained within the recommendations of the manufacturer of the dose-rate instrument used and shall be documented.

Precision QAO – Precision is reported as relative percent difference (**RPD**). The RPD is derived from analysis of the dose rate duplicate. The RPD shall not exceed 40 percent.

Representativeness QAO – Not applicable.

Completeness QAO – Not applicable.

Comparability QAO – Not applicable.

4.3.3 Nondestructive Assay of Waste Containers

4.3.3.1 Passive-Active Neutron Systems

Nondestructive assay includes neutron assay devices such as passive-active neutron (**PAN**) systems. PAN systems, when used in conjunction with adequate AK, can be used to establish TRU activity, total activity, isotopic activity, and activity per waste container. NDA may be used in conjunction with AK information in a documented study that provides the needed relationship between NDA and the radionuclide characteristics of the waste. The PAN can quantify specific fissionable and/or neutron-emitting radionuclides which can be correlated to other radionuclides by scaling factors.

Scaling factors can be developed from modeling, sampling and analysis, process information, and/or other forms of AK. For some RH TRU wastes, the scaling factors can be calculated based on fuel characteristics and computer modeling (from a program such as ORIGEN) as discussed in Section 4.3.5. Representative sampling and analysis may also be used to derive scaling factors as discussed in Section 4.3.4. Another alternative is to use process inventory information to develop scaling factors. Scaling factor development should consider potential partitioning of the scaled radionuclides between the process operations and the deposition on the waste. The radionuclide scaling factor derivation shall be documented in the Radiological Characterization Technical Report.

4.3.3.2 Gamma Spectrometry Assay Systems

Gamma spectroscopy system can be used in several contexts, either as a general tool for determining relative radionuclide contributions to the gamma dose rate (isotopic distribution), for estimating scaling factors, or as a specific measurement technique to quantify radionuclides in the waste.

First, the general process may be used to determine the relative abundance of gamma-emitting radionuclides to determine the contribution to the measured dose rate by the primary gamma-emitting radionuclide. This allows the quantification of the key gamma-emitting radionuclide in the container. The activity of the primary gamma-emitting radionuclide is then correlated to other radionuclides by scaling factors.

The general process may also be used to determine a scaling factor in the container for a primary radionuclide such as ^{137}Cs and an actinide such as ^{241}Am. The ^{137}Cs activity in the container would be determined by a DTC method. The ^{241}Am/^{137}Cs scaling factor determined from the gamma spectrometry measurement of the waste container would be used to derive the ^{241}Am activity in the container. The calculated ^{241}Am activity is then correlated to the TRU and other reportable radionuclides by scaling factors. This option would be used where the ^{137}Cs scaling factors do not exhibit a constant relationship to the reportable radionuclides.

4.3.3.3 General Requirements

Assay systems that provide data for the characterization of RH TRU waste must be controlled under formal measurement control programs, as required by the QAPD. RH TRU waste typically contains higher concentrations of gamma-emitting radionuclides such as ^{137}Cs and ^{60}Co. The corresponding external radiation fields (dose equivalent rates or dose rates) present measurement challenges for performing both gamma and neutron assay devices, although some equipment has been successfully used in the past.

In support of the above requirements, the characterization program must evaluate, document, and technically justify the following determinations.

Lower Limit of Detection – The LLD for each NDA system must be determined. Instruments performing TRU/low-level waste discrimination measurements must have an LLD of 100 nCi/g or less. Site-specific environmental background and container-specific interferences must be factored into LLD determinations. The LLD and minimum detectable activity (**MDA**) are similarly defined as that level of radioactivity which, if present, yields a measured value greater than the critical level with a 95 percent probability, where the critical level is defined as that value which measurements of the background will exceed with 5 percent probability. The LLD is expressed as a concentration (the activity divided by the waste mass) while the MDA is expressed in units of activity. In general, the term MDA is used to describe the statistically derived activity below which the true activity of an individual radionuclide in a sample cannot be determined. It therefore represents the highest activity of a particular radionuclide that may probably be in a sample within the statistical bounds of the conditions under which the measurement was made. Because the MDA is a measurement-based parameter, it is not feasible to calculate MDAs for radionuclides that are not determined primarily by measurement, e.g., ^{90}Sr. In such cases, the characterization program shall derive the equivalent of an MDA, i.e., a reporting threshold for a radionuclide(s), when it is technically justified. This value may be based on decay kinetics, scaling factors, or other scientifically based relationships and must be adequately documented in the characterization program records. For purposes of reporting radionuclide data in the WIPP electronic database, this value will be the equivalent of an MDA.

Total Uncertainty – The method used to calculate the total uncertainty for the quantities in Section 2.2.5 (TRU Alpha Activity Concentration) and 2.2.6 (Radionuclide Activity) must be documented and technically justified for each CBFO-certified NDA system. Compliance with this requirement will be evaluated by CBFO.

Calibration Procedures and Frequencies – Each NDA measurement system shall be calibrated before initial use. During calibration or recalibration, system correction factors shall be established and algorithms adjusted such that the value of percent recovery (**%R**) is

set equal to 100% (i.e., the system is calibrated to 100%R). The range of applicability of system calibrations must be specified in the characterization program procedures. The matrix/source surrogate waste combinations used for calibration shall be representative of the:

- Activity range or gram loading
- Relevant waste matrix characteristics (e.g., densities, moderator content, container size) planned for measurement by the system

Calibration shall be performed in accordance with consensus standards, when such standards exist. If consensus standards are not used, full documentation of the calibration technique must be provided to and approved by CBFO prior to performing WIPP-related assays. Primary calibration standards shall be obtained from suppliers maintaining a nationally accredited measurement program. When primary standards are not available, the standards used shall be correlated with primary standards obtained from a nationally accredited measurement program.

Calibration Verification – Notwithstanding the need to calibrate individual components for replacement, changes, or adjustments (e.g., energy calibration of a detector), verification of NDA measurement system calibration shall be performed after any one of the following occurs:

- Major system repairs and/or modifications
- Replacement of the measurement system's components (e.g., detector, neutron generator, or supporting electronic components that have the capacity to affect data)
- Significant changes to system software
- Relocation of the system.

Calibration verification shall consist of demonstrating that the affected operating system modality (whether gamma, passive neutron, or active neutron) is within the range of acceptable operation. Secondary standards or sources can be used for the calibration verification if their performance has been correlated with the calibration standards. These secondary standards or sources may either be a single source or a collection of sources in a geometrically stable configuration and matrix, with suitably long-lived radionuclides. These may be used to confirm proper operation when compared to a previously collected baseline set of measurements that have demonstrated the reproducibility of response for the source(s) and configuration. If a verification of the measurement system's calibration or other test demonstrates that the system's response has significantly changed, recalibration of the system shall be performed.

Calibration Confirmation – In order to confirm that the calibration of the NDA system was correctly established, the accuracy and precision of the system are determined after each calibration or recalibration by performing replicate measurements of a non-interfering matrix. Calibration confirmation replicate measurements shall be performed on containers of the same nominal size as those in which actual waste is assayed and according to approved waste assay procedures. The number of replicate measurements to be performed shall be

documented and technically justified. The replicate measurements shall be performed using nationally recognized standards, or certified standards derived from nationally recognized standards that span the range of use. The standards used to calculate accuracy shall not be the same as those used for the system calibration. Accuracy is reported as %R. Accuracy shall be ± 10%. The justification for an accuracy greater than 10% will be documented. For gamma systems, the accuracy shall be calculated for each useable gamma energy line over the calibration range. The accuracy for each line shall be <10%. The justification for not using certain gamma lines due to matrix density, filter density, or attenuation will be documented. Precision is reported as percent relative standard deviation (**%RSD**). The %RSD shall not exceed the values listed in Table 4.1 for the corresponding number of replicate measurements in a non-interfering matrix. Measurement facilities may develop alternate limits for accuracy and precision subject to approval by CBFO prior to certification of waste.

Table 4.1. Upper Limits for %RSD vs. Number of Replicates

Number of Replicates	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Max %RSD	1.8	6.6	10.0	12.3	14.0	15.2	16.2	17.1	17.7	18.3	18.8	19.3	19.7	20.0

The values listed are derived from the measured standard deviation of the replicate measurements using $\frac{s}{\mu} \bullet 100\% < \sqrt{\frac{(0.292)^2 \bullet \chi^2_{0.05,n-1}}{n-1}} \bullet 100\%$ where s is the measured standard deviation, n is the number of replicates, μ is the true value, $\chi^2_{0.05,n-1}$ is the critical value for the upper 5% tail of a one-sided chi-squared distribution with n-1 degrees of freedom, and 0.292 corresponds to a 95% upper confidence bound on the true system precision limit of 29.2%.

NDA QC Requirements

To ensure that data of known and documented quality are generated, each measurement facility shall implement a documented facility QA program. Any NDA technique used for TRU waste must be performed in accordance with calibration and operating procedures that have been written, approved, and controlled by the site or testing facility. Laboratory procedures must contain applicable quality controls. Facility QA programs shall specify qualitative and quantitative acceptance criteria for the QC checks of this program and corrective action measures to be taken when these criteria are not satisfied.

Nondestructive Assay Training – Only appropriately trained and qualified personnel shall be allowed to perform NDA and data validation/review. Standardized training requirements for NDA personnel shall be based upon existing industry standardized training requirements (e.g., American Society for Testing and Materials [ASTM] C1490, *Standard Guide for Selection, Training and Qualification of Nondestructive Assay (NDA) Personnel*; American National Standards Institute [ANSI] N15.54, *Radiometric Calorimeters – Measurement Control Program*) and shall meet the specifications in the QAPD. Requalification of NDA personnel shall be based upon evidence of continued satisfactory performance and must be performed at least every two years.

Software QC Requirements – All computer programs and revisions thereof used for NDA shall meet the applicable requirements in the QAPD.

The assay procedures cited in various ASTM and ANSI standards and Nuclear Regulatory Commission (**NRC**) standard practices and guidelines are recommended for use at all testing facilities.

Background Measurements – Background measurements must be performed and recorded daily, unless otherwise approved by CBFO. Contributions to background due to radiation from nearby radiation-producing equipment, standards, or wastes must be carefully controlled or more frequent background checks must be performed.

Instrument Performance Measurements – Performance checks on calibrated and operable gamma and neutron NDA instruments must be performed and recorded once per operational day. Performance checks shall include efficiency checks (when applicable), matrix correction checks and, for spectrometric instruments, peak position and resolution checks.

Both radioactive sources and surrogate waste matrix containers (both non-interfering and interfering) are used. At least once per operational week, an interfering matrix must be used to assess the long-term stability of the NDA instrument's matrix correction. Surrogate waste containers must reflect the type of waste (e.g., debris, sludge) currently being assayed. To verify calibration, radioactivity standards must be selected such that, over a six-month period, the operating range of the assay system is tested in each applicable surrogate waste matrix. The use of interfering and non-interfering matrices provides a realistic assessment of the assay system's performance over time, and will assist measurement personnel in detecting potential problems relative to the matrices currently assayed by the measurement system.

Interfering surrogate matrix containers must be constructed in such a way that the waste characteristics do not change over time.

Radioactive sources should be long-lived, easy to position relative to the detector, and of sufficient radioactivity to obtain good results with relatively short count times.

Data Checks

Background and performance measurements shall be reviewed and evaluated at least weekly to determine continued acceptability of the assay system and to monitor performance trends. If daily performance checks result in data that are outside the acceptable range, the required responses in Table 4.2 shall be followed.

Table 4.2. Range of Applicability

	Acceptability Range	Required Response
Acceptable Range	Data[b] $2\sigma^a$	No action required.
Warning Range	$2\sigma^a$ < Data $3\sigma^a$	The performance check standard shall be run no more than twice. If the rerun performance check results in data within ± 2σ, then the additional performance checks shall be documented and work may continue. If the system does not fall within ± 2σ after two performance checks, then the required response for the Action Range shall be followed.
Action Range	Data> $3\sigma^a$	Work shall stop and the occurrence shall be documented and appropriately dispositioned (e.g., initiating a nonconformance report). The NDA system shall be removed from service pending successful resolution of all necessary actions, and all assays performed since the last acceptable performance check are suspect, pending satisfactory resolution. Recalibration or calibration verification is required prior to returning the system back to service.

[a]σ - The standard deviation is only based on the reproducibility of the data check measurements themselves. This is not total measurement uncertainty.

[b]Absolute Value

NDA Quality Assurance Objectives

The following QAOs apply to the NDA method:

Precision QAO – Precision is reported as %RSD. The %RSD shall not exceed the values listed in Table 4.1.

Accuracy QAO – Accuracy is reported as %R. Accuracy will not exceed ±10% on a non-interfering matrix.

Representativeness QAO – Representativeness is ensured through assay of each waste container when NDA is used to satisfy DQOs.

Completeness QAO – Required completeness is 100%. All NDA data used to satisfy a DQO must be valid and usable.

Comparability QAO – Comparability is ensured by the characterization program meeting the training requirements and complying with the minimum standards used to implement the NDA process.

4.3.4 Sampling to Confirm or Derive Radionuclide Distributions

Representative sampling of actual waste materials or of surrogate materials can be used to develop the radionuclide distribution for use in the DTC or Direct Assay methods. The sampling may involve the acquisition of a small portion of the actual waste or it may involve the removal of the contamination on the waste or surrogate surfaces such as work areas, tools, equipment and

floors by the use of what is termed a swipe or smear. The sampling results may be used by themselves to develop radionuclide ratios for all of the radionuclides required for the characterization of the waste. Alternatively, the sampling results may be used in conjunction with modeling to develop the required ratios. Such a case, for example, would be where two isotopes (e.g. $^{239}Pu/^{240}Pu$) cannot be separated in a typical alpha spectrometry measurement, but their relative contributions may be determined from calculations using available AK information. The sample results may also be used to confirm the ratios derived from analytical modeling.

Existing sampling and analytical data may be used, if the data can be qualified in accordance with the requirements of Section 5.0. The Radiological Characterization Technical Report shall provide the justification for the use of the existing data as representative of the waste stream and as appropriate for the intended use of the data.

4.3.4.1 Sampling Plan

For TRU waste characterization programs that plan to use analytical results from sampling to develop either radionuclide ratios or concentrations, a sampling plan shall be prepared and documented for each RH TRU waste stream, or portion thereof. The sampling plan is a critical component in the development of representative samples and shall be developed using the guidance provided in EPA QA/G-5S, *Guidance on Choosing a Sampling Design for Environmental Data Collection for Use in Developing a Quality Assurance Project Plan*. The characterization program shall consider the best means for obtaining samples that are representative of the RH TRU content of a particular waste stream. The sampling plan shall be submitted to CBFO for review and approval.

At a minimum in the development and design of the sampling plan, the following shall be considered:

- The purpose and use of the sampling data (i.e., DQOs and QAOs).
- The sampling approach that will be employed based on an evaluation of the activities and facilities that generated the waste, the practicality of obtaining representative samples, the availability of waste, and the form, distribution, and type of waste comprising the RH TRU waste stream.
- The form, distribution, and type of waste comprising RH TRU waste.
  - The variety in operations and the nature of the generation of RH TRU waste are such that a single method of sampling the waste cannot be applied across the DOE complex.
  - The method used to collect the sample must be representative of the waste.
  - RH TRU material embedded in concrete or other solids may require samples to be obtained from within the matrix.
- The use of surrogate samples such as swipes or smears of actual waste materials or work surfaces within the facility where the wastes were generated. The justification for the use of surrogate samples shall be documented.

- The number, types and locations of samples as required to meet the established accuracy goal and to demonstrate representativeness and/or account for potential variations in the distribution within the waste.
- The sample collection, handling and identification.
- The analytical methods to be used and the specific radionuclides to be measured.

The guidance provided in EPA QA/G-9S, *Data Quality Assessments: Statistical Methods for Practitioners*, shall be used in analyzing results of the sampling program. This post-sampling and analysis will be documented in a memorandum prepared for the SPM. The post-sampling analysis memorandum will contain the following:

- Review of objectives
  - Review of sampling program objectives
  - Review of sampling program QAOs
- Preliminary Evaluation of Data
  - Derivation of radiological characterization parameters from sample data
  - Derivation of statistical parameters
- Perform Statistical Analyses
  - Evaluate adequacy of the number of samples
  - Evaluate performance against QAOs
  - Perform other statistical tests, as required
- Verify Assumptions of Statistical Analyses
  - As applicable for the methods and analyses performed
- Draw Conclusions from the Data
  - Summarize results of sampling program and QAOs
  - Summarize radiological characterization parameters derived from sampling program

In addition, the post-sampling memorandum shall contain a description of the actual sampling event including any deviation from the original sampling plan. Significant or substantial deviation should be flagged and their potential effect evaluated.

Sampling Quality Assurance Objectives

The following QAOs are applied for the sampling activities:

Precision QAO – Not applicable.

Accuracy QAO – Accuracy shall be achieved by the development of an appropriate sample design in the sampling plan approved by CBFO and by collecting an adequate number of samples such that the one-sigma uncertainty in the mean value of the sample-generated scaling factor is within a factor of two. A more stringent accuracy criterion may be established for absolute concentration measurements on homogeneous materials.

Representativeness QAO – Project-specific QAOs shall include methods to ensure representativeness and shall be described in each sampling plan. The specification of a factor of two in the one-sigma uncertainty in the mean provides an indication that the sampling plan is representative.

Completeness QAO – Completeness will be ensured by meeting the QAO for a minimum set of radionuclides as specified in the sampling plan.

Comparability QAO – Not applicable.

4.3.4.2 Sample Collection

The methods used to collect samples of RH TRU waste shall be such that the samples are representative of the waste from which they were taken. However, the diversity of RH TRU waste, as well as the dissimilarity of storage facilities (tanks, drums, hot cells, storage wells, underground caissons, etc.) and sampling equipment associated with them, preclude a detailed description of any specific sampling plan in this WCPIP. Consequently, the burden of responsibility for developing a technically sound sampling plan rests with the TRU waste characterization program at each site.

To minimize the quantity of waste derived from sampling, laboratories conducting the analytical work may require no more sample than is required for the analysis, based on the analytical methods. However, a sufficient number of samples shall be collected to adequately represent waste being sampled. All sampling will comply with the QC requirements specified in this section.

Sampling equipment shall be cleaned or purchased clean. Sampling equipment, at least that portion that contacts the waste during sampling, shall be verified to be free of radiological contamination prior to use. This can be verified by normal radiological control survey techniques. The results of cleanliness surveys of sampling equipment shall be traceable to sampling equipment batches.

Chain-of-custody on field samples (including field QC samples) will be initiated immediately after sample collection or preparation. Sample custody will be maintained by ensuring that samples are custody-sealed during shipment to the laboratory. If custody sealing is not practical due to radiological considerations associated with the sample, the generator site may implement administrative controls to ensure that samples are not tampered with. After samples are accepted by the analytical laboratory, custody is maintained by assuring the samples are in the possession of an authorized individual, in that individual's view, in a sealed or locked container controlled by that individual, or in a secure controlled-access location. Sample custody will be maintained until the sample is released by the SPM or until the sample is expended. The sampling plan or site-specific procedures shall include a copy of the sample chain-of-custody form and instructions for completing sample chain-of-custody forms. This form will include provisions for each of the following:

- Signature of individual initiating custody control, along with the date and time.
- Documentation of sample numbers for each sample under custody.

- Sample numbers will be referenced to a specific sampling event description that will identify the sampler(s) through signature, the date and time of sample collection, type/number of containers for each sample, sample matrix, preservatives (if applicable), requested methods of analysis, place/address of sample collection, and the waste container number (if applicable).
- For off-site shipping, method of shipping transfer, responsible shipping organization or corporation, and associated air bill or lading number.
- Signatures of custodians relinquishing and receiving custody, along with date and time of the transfer.
- Description of final sample container disposition, along with signature of individual removing sample container from custody.
- Comment section.
- Documentation of discrepancies, breakage, or tampering.

All samples and sampling equipment will be identified with unique identification numbers. Sampling equipment will be identified with unique equipment numbers to ensure that all sampling equipment is traceable to equipment cleanliness survey records.

All samples will be uniquely identified to ensure the integrity of the sample and to identify the generator/storage site and date of collection. Because of the high radiation dose rates associated with samples of RH TRU waste, traditional sample tags or labels may be impractical and are not required.

Sample Collection Quality Assurance Objectives

The following QAOs are applied for the sample collection:

Accuracy QAO –Sampling accuracy in terms of the absence of cross-contamination will be measured. Sampling equipment will be verified as clean by the use of standard radiological control survey methods.

4.3.4.3 Radiochemistry Analysis

This section describes the requirements for obtaining characterization data for RH TRU wastes using radiochemistry measurement techniques or destructive assay.

Analysis will be performed in accordance with the following:

- The samples shall be evaluated using radiochemistry, including alpha spectrometry, gamma spectrometry, or other appropriate methods to determine the relative activity levels of primary radionuclides. Mass spectrometry should be considered for the measurement of isotopes that are not separated in normal radiochemistry techniques.
- The minimum detectible activity levels and measurement uncertainty shall be recorded for each sample.
- The sample analysis should provide data on the activity of as many of the reportable radionuclides as possible.

- It may not be possible to measure activities for each of the reportable radionuclides by sampling. Some radionuclide activities may be less than the LLD or could be masked by other radionuclides. In such cases calculations shall be used to augment the sample results.

Depending on the medium and the target analyte, the sample preparation can involve considerable processing (e.g., the use of strong acids and solvents for sample digestion and separation). Following separation, purification, and appropriate preparation, the sample is assayed for alpha, beta, or gamma radiations, and the instrument outputs are converted to meaningful data by applying calibration and sample-specific correction factors. Radiochemistry techniques can provide isotopic distributions, gross activities, and radionuclide-specific concentrations.

Each laboratory used for TRU waste assay by DA shall demonstrate that the analytical methods are appropriate to assay the specific wastes for which they are proposed. These methods must contain the following general provisions:

- Assay standards must be prepared and used as indicated in the standard test methods.
- The sample taken from the waste must be representative and traceable to its specific waste batch or waste container.
- The test result for each sample must be associated with a specific lot, batch number, or container.

All methods will be preceded by radiochemical separation and/or preparation for measurement. The QAOs listed below and Table 4.3 present a list of laboratory control requirements that must be met unless the laboratory has an established QA program with alternative QAOs that provide acceptable analytical quality control.

Radiochemistry Quality Assurance Objectives

QAOs for radioassay methods are as follows:

Precision QAO – Precision is reported as RPD. The RPD is derived from analysis of laboratory duplicates. The RPD shall not exceed 40% or laboratory acceptable precision criteria.

Accuracy QAO – Accuracy is reported as %R. The %R is derived from analysis of laboratory control samples and matrix spikes. The %R shall not exceed the parameters listed below, or laboratory acceptable precision criteria:

- 75% to 125% for laboratory control samples
- 50% to 150% for matrix spikes

Representativeness QAO – Not applicable.

Completeness QAO – Completeness shall be expressed as the ratio of the number of samples that are analyzed with valid results to the total number of samples that are submitted for analysis. This ratio shall not be less than 0.9. Valid results for radiochemistry data are those that were obtained when the laboratory or testing facility demonstrated that the instrumentation and method were in control.

Comparability QAO – Not applicable.

Table 4.3. Quality Control Requirements for Radiochemistry

QC Sample	Minimum Frequency	Acceptance Criteria	Corrective Action
Laboratory control samples (LCS)	One per analytical batch	75% to 125%R	See Laboratory Control Sample[a]
Method blank	One per analytical batch	Site-specific statistical control limits	See Method Blanks[b]
Laboratory duplicate	One per analytical batch	RPD 40 or laboratory precision criteria	See Laboratory Duplicate[c]
Matrix spike (MS)	One per analytical batch for ICP-MS, as required by the test performed	50 to 150%R or laboratory method criteria	See Matrix Spike and Matrix Spike Duplicate[d]
Matrix spike duplicate (MSD)	One per analytical batch, as required by the test performed	50 to 150%R RPD 40 or laboratory method criteria	See Matrix Spike and Matrix Spike Duplicate[d]
Radioisotopic tracers	Every sample	Site-specific statistical control limits	See Radioisotopic Tracer[e]

[a]**Laboratory Control Sample (LCS)**: An LCS is analyzed at least once per analytical batch. If a solid matrix with established control limits is used as the LCS, the established limits may be used for the acceptance criteria. The control limits will meet the criteria in Table 4.4.

[b]**Method Blanks**: A method blank is analyzed at least once per analytical batch. It contains all reagents in proportions equal to those in the samples and is carried through the analytical procedure to identify if contamination is present. Acceptance criteria for method blanks are established for each site; if they are expressed as statistical control limits they shall meet the requirements in Table 4.4. Criteria may be absolute values, multiples of background variation, fractions of activity concentrations observed in samples, or other appropriate units.

[c]**Laboratory Duplicate**. A laboratory duplicate is analyzed at least once per analytical batch. A laboratory duplicate is a separate aliquot from the same field sample carried through the entire analytical procedure. The RPD or laboratory precision criteria between duplicate results are compared.

[d]**Matrix Spike and Matrix Spike Duplicate:** Duplicate MSs on individual field samples are performed for inductively coupled plasma-mass spectrometry (**ICP-MS**) analysis at a minimum frequency of one pair (MS plus MSD) per analytical batch. The MSDs are preferred for any analytical procedure not using radioactive tracers. The MS and MSD results are acceptable if the criteria given above for %R and RPD are met.

[e]**Radioisotopic Tracer**: Some methods require that all samples, blanks, LCSs, and laboratory duplicates be spiked with radioisotopic tracers to determine chemical recoveries, counting efficiencies, or a combination thereof. Acceptance criteria for method blanks are established for each site; if they are expressed as statistical control limits they shall meet the requirements in Table 4.4.

Table 4.4 Statistical Control Limits

	Acceptability Range	Required Response
Acceptable Range	Data[b] $2\sigma^a$	No action required.
Warning Range	$2\sigma^a$ < Data $3\sigma^a$	The QC measurement shall be run no more than twice. If the rerun QC measurement results in data within ± 2σ, then the QC measurements shall be documented and work may continue. If the system does not fall within ± 2σ after two QC measurements, then the required response for the Action Range shall be followed.
Action Range	Data > $3\sigma^a$	Work shall stop and the occurrence shall be documented and appropriately dispositioned (e.g., initiating a nonconformance report). The measurement system shall be removed from service pending successful resolution of all necessary actions, and all assays performed since the last acceptable QC measurement are suspect, pending satisfactory resolution.

[a]σ – The standard deviation is only based on the reproducibility of the data check measurements themselves.

[b]Absolute value

4.3.5 Modeling to Confirm or Derive Radionuclide Distributions

As an alternative to, or in addition to sampling, radionuclide distributions may be determined by modeling and/or calculations. Calculations of radionuclide activities are performed by considering their production and depletion during irradiation and radioactive decay and any removal in reprocessing or separations processes. Production of a radionuclide can continue after irradiation as a result of decay of another parent radionuclide. Sophisticated computer programs, such as ORIGEN, exist to calculate these radionuclide production and depletion effects. If the waste is to be characterized by modeling and/or calculations, the following requirements apply:

- The computer codes to be used shall be controlled under an appropriate software quality assurance program that tracks the installation and use of the codes, and requires comprehensive verification and validation prior to use.
- Calculations shall be performed using methods, including computer programs, which account for the pre-irradiation composition of the fuel or target used to produce the TRU radionuclides, the exposure of this fuel or target during irradiation, and the change in radionuclide activities following irradiation.
- The appropriate cross-sections shall be used or generated for each irradiation condition.
- The irradiation energy spectrum shall be known or calculated. The characteristics of the energy spectrum affect the effective cross-sections for fission and transmutation. For many reactor types, these calculations have been performed and cross-section libraries exist.
- The fuel or target exposure history shall be used in the radionuclide generation and depletion calculation. RH TRU waste in a particular waste stream may have been

produced as the result of numerous campaigns involving differing exposure and decay times and differing fuel properties.

Alternatively, in order to avoid calculating each campaign, a strategy may be developed to perform a set of calculations that represent the entire range of conditions leading to the generation of the RH TRU waste. The span of the evaluated parameters is considered AK information and will be compiled and documented for the waste under the AK process.

Modeling Quality Assurance Objectives

QAOs for modeling are as follows:

Precision QAO – Not applicable.

Accuracy QAO – Accuracy will be achieved by demonstrating that the modeling results compare to sample results within a factor of two.

Representativeness QAO – Composition and burnup information for a minimum of 50% of the radioactive materials identified in the AK record involved in the generation of the waste shall be included in the modeling.

Completeness QAO – Not applicable.

Comparability QAO – Not applicable.

4.3.6 Total Uncertainty Analysis

For each waste container, the one-sigma uncertainty shall be estimated for the following parameters:

- Activity for each reportable radionuclide
- TRU alpha activity concentration
- TRU alpha activity
- Total ^{239}Pu equivalent activity
- Total ^{239}Pu fissile gram equivalent
- Total decay heat
- Total volumetric activity

The total uncertainty shall be expressed in terms of one standard deviation. The derivation of the uncertainty shall be documented and submitted to CBFO for review and approval.

Sources of uncertainty depend on the specific method used to determine the reportable radionuclide activities and other reportable parameters. These typically include the following:

- Measurement uncertainty
- Uncertainty inherent in the modeling and/or computer codes used to characterize the waste stream
- Uncertainty in the inputs to the model and/or computer code

- Uncertainty in the physical configuration modeled or analyzed
- Waste stream variability due to variations in the materials and operations contributing to the waste stream
- Sampling uncertainty

The documentation of the total uncertainty shall list the identified sources of uncertainty. The uncertainty due to each source shall be estimated. This may be based on statistical analysis of data, reported values, engineering judgment, sensitivity studies, and/or other analyses. Contributors that are shown or judged to be insignificant may be neglected in the subsequent determination of the overall uncertainty.

Uncertainties due to each potential source shall be statistically propagated to produce an estimate of the overall uncertainty. Such propagation may include one or more of the following techniques:

- Combining, through quadrature, the standard deviations in statistically independent parameters
- Random sampling from probability distribution functions estimated for each parameter
- Mathematical integration of probability distribution functions for each parameter

Care should be taken to identify and consider the effects of potential biases and statistical dependencies in determining the total uncertainty.

- Most of the sources of uncertainty are likely to be random in nature. However, some sources may not be random and may introduce bias into the determination of the total uncertainty. These typically are the result of simplifying analysis assumptions or assumptions and limitations inherent in the model and/or computer code, but may result from any of the identified sources of uncertainty. The magnitude of such biases should be estimated and documented.

Statistical dependencies among parameters used to determine the total uncertainty can have a significant effect on the estimated total uncertainty. Such dependencies typically arise from:

- Common factors used to determine the reported parameter. As an example, the TRU activity is determined by summing the activities of all of the TRU radionuclides. The activities of the TRU radionuclides are calculated from their individual scaling factors multiplied by a common factor, the ^{137}Cs activity. Due to this common factor, the uncertainties in the individual TRU radionuclide activities cannot be combined in quadrature in order to determine the TRU uncertainty.
- Strong covariances among reportable radionuclides (e.g., as in the above example, if there is a strong correlation between two TRU radionuclides, then the uncertainties in the individual TRU radionuclide activities cannot be combined in quadrature).
- Use of the same data to determine more than one parameter used in the total uncertainty determination.

Potential sources of dependencies shall be identified and documented. Significant dependencies shall be explicitly considered in the determination of the total uncertainty.

4.3.7 Surface Dose Rate

Surface dose rate measurements consist of radiation surveys to determine compliance with some of the requirements listed in this WCPIP. For the radiological waste characterization, this method may specifically be used only for the RH determination.

Measurements must be conducted to determine surface dose rates of RH TRU waste containers. Dose rate surveys will be performed only by trained and qualified personnel using properly calibrated instruments appropriate for the types, levels, and energies of the radiation encountered, and appropriate for the existing conditions in which the instruments will be used. Surveys for radiation must be performed as specified by the Radiological Control Organization, Radiological Work Permits, or other technical documents. The Radiological Control Organization should review the adequacy of dose rate measurement systems when facility or operational changes occur. Records must be maintained to document changes in monitoring equipment, techniques, and procedures. Characterization programs shall determine the uncertainty associated with dose rate measurements.

Assessment of container surface dose rates shall include a sufficient number of measurements to characterize the radiation present and to determine compliance with the surface dose rate DQO. Surface dose rate measurement results shall be reviewed by the cognizant radiological supervisor. The review shall ensure that all required measurements have been performed and that the documentation is accurate and complete. Surface dose rate measurements shall be recorded on appropriate standard forms and include the following common elements:

- Date and time of the measurement
- General and specific location of the measurement
- Name of the person performing the measurement
- Pertinent special information needed to interpret measurement results (e.g., unusual background levels, special survey distances)
- Survey maps illustrating where measurements were performed and the results
- For each batch of containers, a duplicate set of dose rate measurements shall be made and documented

For RH TRU wastes, the SPM shall review the container data packages to verify that the maximum contact radiation dose rate (beta + gamma + neutron) at any point on the RH TRU container is equal to or greater than 200 mrem/hr and no greater than 1000 rem/hr.

Surface Dose Rate Quality Assurance Objectives

The following QAOs apply to surface dose rate methodologies:

Precision QAO – Precision is reported as RPD. The RPD is derived from analysis of the dose rate duplicate. The RPD shall not exceed 40%.

Accuracy QAO – The manufacturer typically specifies a flat energy response of 10 to 20% across the applicable energy range. Repeatability of the measurement should be within about 10% at the higher gamma dose rates.

Representativeness QAO – The measurement is applied to the entire waste container.

Completeness QAO – 100% of the measurements needed to determine surface dose rate are performed and useable.

Comparability QAO – Not applicable.

4.3.8 Gravimetric or Dimensional Measurements

For unique waste streams where the activity on or within a waste stream is identified as discreet pieces of irradiated materials, such as fuel pin or target test specimens, gravimetric or dimensional measurements may be used to establish the activity content of the waste container or to confirm AK information for the same measurements. In the gravimetric method, each piece of the irradiated material placed into the waste container would be weighed to determine the total mass of the irradiated materials in the drum. In the dimensional measurement method, dimensional measurements needed for a volumetric determination would be measured and coupled with AK information on the density of the irradiated material to calculate the mass of the discreet piece. Information from the AK record may be used to establish such items as cladding thickness or pellet diameter.

The mass measurements must be coupled with information on the radionuclide activity distributions within each piece to establish the total TRU activity, total activity, and total individual radionuclide activities per waste container. The radionuclide activity distributions can be developed from modeling, process information, and/or other forms of AK. The modeling includes the development of the radionuclide distributions from calculations based on fuel characteristics and computer modeling (from a program such as ORIGEN) as discussed in section 4.3.5.

Gravimetric systems that provide data for the characterization of RH TRU waste must be controlled under formal measurement control programs, as required by the QAPD.

To ensure that data of known and documented quality are generated, the characterization program shall implement a documented QA program. Any gravimetric technique used for TRU waste must be performed in accordance with calibration and operating procedures that have been submitted to and approved by CBFO.

Gravimetric or Dimensional Measurement Quality Assurance Objectives

The following QAOs are applied for the gravimetric or dimensional measurement:

Precision QAO – Measurement equipment shall be maintained according to manufacturer's recommendation. Balance shall be calibrated and maintained according to manufacturer's recommendation.

Accuracy QAO – Balance readout shall be 2 percent of the check weight. The length measurement shall be 0.1 of an inch verified by a second operator.

Representativeness QAO – Not applicable.

Completeness QAO – Every quantity of fuel test specimen loaded into container is measured.

Comparability QAO – Not applicable.

The following QAOs are applied for the gravimetric and dimensional method:

Accuracy QAO – Fuel test specimen design and irradiated information is used for individual fuel test specimen pins in combination of the length and gravimetric measurement. Scaling factors are developed from isotope depletion code such as ORIGEN.

Precision QAO – Not applicable.

Representativeness QAO – The design information has to be representative for each specific fuel test specimen quantity loaded into container.

Completeness QAO – Every quantity of fuel test specimen loaded into container is measured.

Comparability QAO – Not applicable.

5.0 QUALIFICATION OF AK INFORMATION

As described in Section 3.0, AK information used directly, in whole or in part, in the determination that containers included in the waste stream meet the DQO requirements must be qualified, including any information including characterization data generated prior to the characterization program establishing an approved QA program that implements the requirements of the CBFO QAPD. The CBFO QAPD incorporates the EPA-required QA elements from ASME NQA-1-1989 edition, ASME NQA-2a-1990 addenda, part 2.7, of ASME NQA-2-1989 edition, and ASME NQA-3-1989 edition (excluding Section 2.1 (b) and (c) and Section 17.1) as required by 40 CFR §194.22. A QA program meeting these requirements must be applied to waste characterization activities performed under this WCPIP. 40 CFR §194.22 also allows qualification by CBFO QA of information generated prior to the establishment of a compliant QA program. AK information may be qualified by one or a combination of the following four methods:

- Peer review, conducted in a manner compatible with NUREG-1297, *Peer Review for High-Level Nuclear Waste Repositories*, February 1988
- Corroborating data[2]
- Confirmatory testing

[2] Revision 2 of the WCPIP reflects implementation of RH waste characterization processes approved by EPA except for the use of corroborating data to qualify AK information discussed in Section 5.2. Upon receiving DOE's approval of this process, but before its implementation at an RH site, EPA will review relevant process documentation. This will include a report discussing the use of the corroborating data selection process, type and nature of corroborating data to be used, and other primary information. The RH waste characterization site will address EPA comments prior to implementation of the process that EPA will verify during a baseline inspection or Tier 1 evaluation for approval.

- Evidence of a QA program that is equivalent in effect to ASME NQA-1-1989 edition, ASME NQA-2a-1990 addenda, part 2.7, of ASME NQA-2-1989 edition, and ASME NQA-3-1989 edition (excluding Section 2.1 (b) and (c) and Section 17.1)

For all qualification methods, the following shall be considered:

- Qualifications of personnel or organizations generating the data
- Technical adequacy of the equipment and procedures used to collect and analyze the data
- Environmental conditions under which the data were obtained (if germane)
- Quality and reliability of the measurement control program under which the data were generated
- Extent to which data demonstrate properties of interest (e.g., physical or radiological)
- Extent to which conditions generating the data may partially meet requirements of the ASME NQA-1-1989 edition, ASME NQA-2a-1990 addenda, part 2.7, of ASME NQA-2-1989 edition, and ASME NQA-3-1989 edition (excluding Section 2.1 (b) and (c) and Section 17.1).
- Prior uses of the data and associated verification processes
- Prior peer or other professional reviews of data and their results
- Extent and reliability of the documentation associated with the data
- Extent and quality of corroborating data or confirmatory testing results
- Degree to which data generating processes where independently audited

Implementation requirements for the use of these methods are described below.

5.1 Peer Review

Peer reviews conducted to qualify AK characterization information must comply with the following requirements:

- RH TRU waste characterization programs must develop a peer review procedure that complies with the requirements of NUREG-1297, *Peer Review for High-Level Nuclear Waste Repositories*, February 1988.
- The characterization program must obtain CBFO approval of the peer review procedure and the peer review plan prior to conducting the peer review.
- The peer review scope must explicitly define the waste characterization DQOs and QAOs that the peer review panel will be evaluating. The peer review scope must explicitly require the peer review panel to determine whether the data being reviewed satisfy the defined DQOs and QAOs.

The peer review shall be audited and approved by CBFO during each peer review process, and prior to shipping RH TRU waste that has been characterized using data qualified by peer review to the WIPP.

5.2 Corroborating Data

Corroborating data that could be used to qualify AK information includes, but is not limited to:

- Characterization data from a related waste source or from a different time period of generation.
- Data from a related RH or CH waste source.
- Direct analytical results from samples taken from the stream that are not adequate to address a given requirement in Section 4.2 or 4.3 (e.g., too few samples), but sufficient to meet the DQOs for other characterization parameters.
- Data from a similar waste process generated at a different site or facility.
- Data from similar source material (e.g., fuel test specimen or process input materials).
- Data that establishes the efficacy of a mathematical model.

Corroborating data will generally be either lacking a fully implemented QAPD QA program or not supported by the documentation necessary to complete a demonstration of an effectively equivalent QA program under Section 5.4. In order for corroborating data to be used to qualify AK information, the characterization program must present sufficient detail that establishes the quality and reliability of the data. For example, data generated by a laboratory that did not implement NQA-1 or DOE quality assurance programs would be acceptable if that laboratory operated under a regime of quality assurance and control measures that provide defensibility of the data. Corroborating data from other reliable and accredited sources such as government agencies, national laboratories, universities, or peer reviewed journals could be acceptable sources of qualification information.

The use of corroborating data will be described in a report (e.g., Radiological Technical Report) that will describe the source of the data, define the AK information that the data are intended to qualify, present or summarize the data, justify the use of the data, describe the reasons why the data are considered reliable, and explain any limitations associated with the data.

5.3 Confirmatory Testing

Use of the characterization methods included in Section 4.0 for AK qualification shall be described in the Certification Plan described in Section 3.2.2. If a characterization program proposes to qualify AK information by confirmatory testing methods other than those described in Section 4.1, the Certification Plan must be approved by CBFO prior to implementation. Other methods that could be proposed include, but are not limited to:

- Qualification of existing VE or radiography audio/videotapes by the review of a percentage of the tapes by qualified operators.
- Qualification of existing radiological characterization data by analyzing representative samples of the waste.

- Qualification of existing waste container packaging records by VE or radiography of a representative subpopulation of the waste.
- Qualification of existing radiological sampling and analytical information by the use of confirmatory modeling (e.g., ORIGEN).

A combination of methods can be used to meet a DQO and shall be defined in the Certification Plan.

Characterization programs that propose to use other methods to qualify AK information must submit a confirmation testing approach to CBFO for review and approval. This approach will be included in the Certification Plan and must include:

- A description of the waste stream or waste stream lots to which the plan applies.
- An explicit description of the waste characterization DQOs and QAOs that will be satisfied with the data being qualified.
- A description of the proposed method, including the percentage of waste containers that will be subject to the method proposed.
- A description of how the tested subpopulation will be representative of the waste stream or waste stream lot.
- Quantitative acceptance criteria for determining that the AK information in question can be qualified as characterization information.

Prior to shipping waste to the WIPP that has been characterized using data qualified via the proposed method under this section, the proposed method shall be audited and approved by the CBFO.

5.4 Equivalent QA Program

To qualify AK information using an equivalent QA program, the characterization program must be able to demonstrate that the program in use at the time the data were generated implemented requirements equivalent in effect to the applicable requirements of ASME NQA-1-1989 edition, ASME NQA-2a-1990 addenda, part 2.7, of ASME NQA-2-1989 edition, and ASME NQA-3-1989 edition (excluding Section 2.1 (b) and (c) and Section 17.1). "Equivalent in effect" is defined as a program that results in confidence that the data generated is what it is purported to represent, although the data need not exactly match all of the QAPD requirements. For example, if individual training records for certain individuals cannot be recovered but evidence demonstrates that the program had a qualification and training program in place at the time, then it can be surmised that the historical program was equivalent in effect to the QAPD and that the training records existed but are unrecoverable. Implementation of the QA program on the waste characterization program that generated the AK information must be auditable. Examples of the type of records that should be identified and retrieved include:

- Evidence that the organization performing the work identified persons or organizations responsible for verifying quality with sufficient independence from cost and schedule considerations (e.g., organizational charts and QA policies).
- Training records for waste characterization and verification personnel.

- Assessment records (audits and surveillances).
- Nonconformance and corrective action records (if no nonconformances are identified, evidence that a process was in place to address nonconformances had they occurred).
- Procurement documentation for items and services that could affect the quality of the characterization data.
- Approved QA plans and programs.
- Standard operating procedures used for characterization and QA activities.
- Document control records that demonstrate that documents were reviewed and approved in accordance with procedural requirements.
- Calibration records.
- Software qualification records.
- Documented and verifiable evidence that a records program was in existence that required records important to quality be controlled, stored, maintained, and retrievable.

Some records may have exceeded their specified retention time and may have been destroyed in accordance with the requirements of the QA program.

Characterization programs proposing to use the equivalent QA program method for qualifying AK information as characterization data shall submit a "procedure matrix" providing a crosswalk that identifies the plans and procedures that implemented the applicable requirements of ASME NQA-1-1989 edition, ASME NQA-2a-1990 addenda, part 2.7, of ASME NQA-2-1989 edition, and ASME NQA-3-1989 edition (excluding Section 2.1 (b) and (c) and Section 17.1). Those ASME NQA elements that are determined to not be applicable to RH TRU waste characterization activities will be identified on the matrix along with a description of why the element is not applicable. The characterization program shall also submit plans and procedures referenced on the matrix for CBFO review during audits or upon request by CBFO. The matrix and associated plans and procedures should include the applicable document revisions that were in effect when the AK information was originally generated; exceptions must be noted and justified (e.g., a prior or post revision with a declaration from a knowledgeable individual that the missing revision was essentially the same would be sufficient evidence of acceptability).

Prior to shipping waste that has been characterized using data qualified under an equivalent QA program to the WIPP, the documentation demonstrating an equivalent QA program was implemented shall be audited and approved by CBFO.

6.0 REFERENCES

DOE (U.S. Department of Energy), 1996, Compliance Certification Application (**CCA**), DOE/CAO-1996-2184, U.S. Department of Energy, Carlsbad Area Office, Carlsbad, NM.

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EPA (U.S. Environmental Protection Agency), 1996, 40 CFR Part 194: Criteria for the Certification and Re-Certification of the Waste Isolation Pilot Plant's Compliance with the 40 CFR Part 191 Disposal Regulations; Final Rule, *Federal Register*, Vol. 61, No. 28, pp. 5224 – 5245, February 9, 1996, Office of Air and Radiation, Washington, D.C.

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EPA (U.S. Environmental Protection Agency), 2002a, Guidance on Choosing a Sampling Design for Environmental Data Collection for Use in Developing a Quality Assurance Project Plan, EPA QA/G-5S, Office of Environmental Information, Washington, D.C.

EPA (U.S. Environmental Protection Agency) QA/G-9S, *Data Quality Assessments: Statistical Methods for Practitioners*

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