CARD No. 24
Waste Characterization

24.A.1 Background

DOE must provide waste inventory information for use in performance assessments (PA), including the radionuclide content of waste and the physical and chemical components that may affect disposal system performance. DOE must assess the impact that specific waste components have on waste characteristics (40 CFR 194.24(b)), and DOE must provide sufficient overall waste inventory information for use in the PA, specifically for those components deemed important to repository performance. Section 194.24(a) of the Compliance Criteria presents the inventory reporting requirements that DOE must meet to ensure that sufficient information is available for use in performance assessment.

The Compliance Certification Application (CCA) includes the Transuranic Waste Baseline Inventory Report (TWBIR), Revisions 2 and 3, which provides waste characterization information specific to DOE generator sites and identifies how DOE grouped similar wastes from various generator sites to facilitate discussions with regulatory agencies. Previous versions of TWBIR (Revisions 0 and 1) were used to support Sandia National Laboratories (SNL) in conducting earlier performance assessments for the WIPP (e.g., the 1992 PA). Revision 2 was expanded to support DOE's compliance with the 1992 WIPP Land Withdrawal Act (LWA) requirement to provide the total DOE transuranic (TRU) waste inventory.

TWBIR Revision 3 provides additional summary data and other information used by SNL to develop the CCA. TWBIR Revision 3 contains essentially the same data as Revision 2, with the following changes:

- ♦ Radionuclide data were updated.
- ♦ Estimates for complexing agents in TRU solidified waste forms were included.
- ♦ Estimates of nitrate, sulfate, and phosphate content in TRU solidified waste forms were included.
- ♦ An estimate of the cement content in TRU solidified waste forms was included.

Waste described in TWBIR Revision 3 was primarily characterized through sampling and analysis and acceptable knowledge (AK), although real-time radiography (RTR), nondestructive assay (NDA), and headspace gas data are available for some waste streams. See Section 194.24(c)(3) of this CARD for further discussion of these analytical techniques. Characterization by process knowledge (PK) is the identification of waste components based on the processes used to create the waste. EPA defines acceptable knowledge as waste characterization that includes process knowledge and sampling and analysis data. See Section 194.24(c)(3) of this CARD for further discussion of PK and AK.

24.A.2 Requirement

(a) "Any compliance application shall describe the chemical, radiological and physical composition of all existing waste proposed for disposal in the disposal system. To the extent practicable, any compliance application shall also describe the chemical, radiological and physical composition of to-be-generated waste proposed for disposal in the disposal system. These descriptions shall include a list of the waste components and their approximate quantities in the waste. This list may be derived from process knowledge, current non-destructive examination/assay, or other information and methods."

24.A.3 Abstract

EPA expected the compliance application to provide a description of existing waste, list approximate quantities of waste components in each description, and provide similar descriptions for to-be-generated waste, to the extent practicable.

To describe and categorize the entirety of TRU waste that exists at various DOE facilities and to meet the requirements of 40 CFR part 194.24(a), DOE developed a descriptive methodology for grouping waste information from each generator site. The CCA states that there are a total of approximately 970 contact-handled (CH) and remote-handled (RH) TRU waste streams intended for WIPP, of which 569 are individual CH waste streams.[1] DOE also determined that, of the hundreds of radionuclides present within these wastes, only ten are important to performance assessment: ^{241}Am, ^{244}Cm, ^{137}Cs, ^{238}Pu, ^{239}Pu, ^{240}Pu, ^{241}Pu, ^{90}Sr, ^{233}U, and ^{234}U. Of these ten, ^{90}Sr, ^{233}U, ^{137}Cs are important to RH but not CH waste streams. The chemical, physical, and radiological inventories were grouped by DOE and developed in detail from the waste stream profiles from each of the TRU waste generator and/or storage sites (Appendix BIR, Appendix P).

DOE estimates that the total expected inventory volume for CH-TRU wastes will not reach the maximum disposal capacity for the WIPP (calculated to be approximately 168,500 cubic meters or 5,950,000 cubic feet of CH-TRU). DOE employed a scaling approach based on existing and projected waste to project the inventory of a full repository.

EPA reviewed the CCA to determine whether it provided a sufficiently complete description of the chemical, physical, and radiological composition of the existing and to-be-generated wastes proposed for disposal in the WIPP. EPA also reviewed DOE's description of the approximate quantities of waste components (for both existing and to-be-generated wastes). EPA considered whether the CCA's waste descriptions were of sufficient detail to enable the Agency to conclude that DOE did not overlook any component that is present in TRU waste and has significant potential to influence releases of radionuclides. DOE described the waste in Volume 1 and Appendix BIR of the CCA. EPA found that DOE's development of the stored, projected, and disposal inventory is sufficient for PA purposes. EPA also concluded that the use

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[1] Contact-handled TRU waste is defined as TRU waste with a surface dose rate not greater than 200 millirem per hour. Remote-handled TRU waste is defined as TRU waste with a surface dose rate of 200 millirem per hour or greater. WIPP Land Withdrawal Act, Section 2(3) and (12).

of projected waste inventory for scaling the CH-TRU waste inventory to meet the total WIPP capacity was acceptable.

24.A.4 COMPLIANCE REVIEW CRITERIA

EPA expected the compliance application to:

- Provide a description (chemical, radiological, physical) of existing waste.
- List approximate quantities of waste components in each description.
- Provide similar descriptions for to-be-generated waste, to the extent practicable.

As stated in the Compliance Application Guidance for 40 CFR Part 194 (CAG) (p. 30), the physical description of waste may include: the types of items, articles, and materials present in the waste (including void space); a description of physical forms and initial liquids present in the category (both free and bound); and the types and properties of the containers to be used for disposal. The chemical description may include: process chemicals likely to be present in the waste; all added components (neutralizers, stabilizers, solidifies, etc.) and approximate total quantities; and the chemical properties of other items present that could affect performance. The radiological description may include: the species and quantities of the radioisotopes present in the waste; information on the expected distribution of curie loading by container; the surface radiation levels of containers, including types of radiation; and the classification of the waste material, such as CH or RH TRU waste.

The waste description may be rather lengthy, due to the heterogeneous nature of TRU waste and the presence of numerous components that are present in sufficient quantity and have the potential to affect solubility, gas generation, criticality, etc. EPA expected that the waste description would be detailed enough to enable EPA to have confidence that DOE did not overlook any component that is present in TRU waste and has significant potential to influence releases of radionuclides. EPA also expected that the required descriptions would be semi-quantitative, based upon both waste measurement data and acceptable knowledge that are readily available at the waste generator sites and well documented, best-judgment estimates of what will be generated in the future.

24.A.5 DOE METHODOLOGY AND CONCLUSIONS

<u>Chemical, Physical, and Radiological Description of Existing Waste</u>

To describe and categorize the entirety of TRU waste that exists at various DOE facilities and to meet the requirements of 40 CFR 194.24(a), DOE developed a descriptive methodology for grouping waste information obtained from each generator site. DOE first asked every TRU waste generator site to fill out waste profile forms describing the physical, chemical, and radiological constituents in each waste stream that generates or generated TRU waste at that site. Appendix BIR, Appendix P, contains for each waste stream both detailed, site-specific information and summary information (e.g., Appendix BIR, Table 1-2) concerning the chemical, physical, and radiological properties of existing and to-be-generated waste. WIPP waste profile forms for each waste stream at each generator site contain the following information (BIR Chapter 4, p. 4-14):

- Waste stream description.
- Waste stream source description.
- Currently used identification codes, including DOE TRU waste site matrix descriptions (waste matrix descriptions are described below).
- Final waste form assigned by the TRU waste generator and storage sites (final waste forms are described below).
- As-generated waste form volumes and final waste form volumes.
- Estimated minimum, maximum, and average weight of waste components per cubic meter of the final waste form (i.e. iron-base metal and alloys, aluminum-base metal and alloys, cellulosics, etc.).
- Identification of whether the waste is CH or RH TRU waste.
- Final waste form radionuclide inventory (activity of each radionuclide) in curies per cubic meter).
- Chemical constituent content (i.e. hazardous waste code identification).
- Comments provided by the TRU waste generator site and storage sites to further explain the data provided.

This list was derived by the generator sites from acceptable knowledge, current nondestructive examination/assay, or other information and methods. See Section 194.24(c)(4) of this CARD for further discussion of specific characterization methodologies. DOE obtained disposal inventory information from many sources such as the safeguarded materials database. The CCA states that there are a total of approximately 970 CH and RH TRU waste streams intended for WIPP, of which 569 are individual CH waste streams. DOE determined that, of the hundreds of radionuclides present within these wastes, only ten are important to performance assessment: ^{241}Am, ^{244}Cm, ^{137}Cs, ^{238}Pu, ^{239}Pu, ^{240}Pu, ^{241}Pu, ^{90}Sr, ^{233}U, and ^{234}U. Of these ten, ^{90}Sr, ^{233}U, ^{137}Cs are important to RH but not CH waste streams. See Section 194.24(b) of this CARD for further discussion of waste characteristics and components important to PA.

Waste streams were categorized by DOE into waste matrix codes, and the waste matrix codes were grouped into final waste forms, based on similar physical and chemical properties (Section 4.1.3.1, Table 4-2, p. 4-15). The following eleven final waste forms intended for disposal at the WIPP were identified by DOE (Table 4-2):

- Solidified Inorganics
- Salt
- Solidified Organics
- Soils
- Uncategorized Metal
- Lead and Cadmium Metal
- Inorganic Nonmetal
- Combustible
- Graphite
- Heterogeneous and
- Filters.

The chemical, physical, and radiological inventory was also grouped in other fashions by DOE and developed in detail from the waste stream profiles from each of the TRU waste generator and/or storage sites (Appendix BIR, Appendix P). As previously stated, the BIR contains information, called a waste stream profile, on the radiological, chemical and physical properties of existing and to-be-generated waste for each waste stream at each generator site. DOE grouped these individual waste stream profiles into site-specific waste stream profiles, which were further grouped across the DOE generator sites to develop WIPP waste profiles (Figure 4-3, p. 4-19). This categorization is a second type of waste descriptor that is parallel to the categorization by waste material code and final waste form descriptor described above.

Waste groupings (other than contact handled and remote handled designations) by DOE were based on the chemical and physical aspects of the waste, not the radiological content of the waste (Appendix BIR). However, the radiological constituents were identified and quantified (in Ci/m^3 for each waste stream) on each waste profile form, and information from the forms was used by DOE to develop the radiological inventory for the WIPP. Table 4-6 (Chapter 4, p. 4-25) shows the radiological constituents expected in WIPP waste, including the inventory at the estimated time of disposal (year 2033), and anticipated EPA units for each radionuclide. Sanchez et al. (1997) presented the radionuclide content for each waste stream anticipated for shipment to WIPP.

Each WIPP Waste Profile contains information on the physical and chemical waste components (identified as Waste Material Parameters (WMP's) for DOE purposes), as well as radiological waste components, that DOE believes could affect the performance of the repository. DOE's waste material parameters are not identical to waste material forms, but do share similar waste categories (e.g. soils). DOE's waste material parameters are presented as density values. These density values are calculated by multiplying the average density of individual waste streams from a given waste form by the volume of the TWBIR waste stream and then the total volume of the final waste form. Refer to Appendix BIR, TWBIR, Revision 3 (p. 2-3) for DOE's detailed WMP calculation methodology. The approximate maximum, average, and minimum densities for twelve (12) of DOE's waste material parameters were calculated, including iron based metals/alloys, aluminum based metals/alloys, other metal/alloys, other inorganic materials, vitrified materials, cellulosics, rubber, plastics, solidified inorganic matrix, solidified organic matrix, solidified cement, and soils (Appendix BIR, Table 2-2, p. 2-5). WIPP Waste Profiles contain information on the WMPs, i.e., components that DOE determined to have the potential to impact repository performance. DOE identified the quantity of physical waste components such as cellulosics, rubber, etc., in Appendix BIR (see TWBIR Revision 3, pp. ES-1 and ES-2). Table 4-3 shows the anticipated non-radioactive TRU waste inventory for the WIPP based upon the waste profile forms in Appendix BIR, Appendix P.

DOE stated that the information on waste inventory is provided in the waste profile forms and Appendix BIR is adequate to facilitate EPA's waste component assessments. Parts of the CCA addressing the waste categorization process include Chapter 4 and Appendices BIR and WCA. Also, in accordance with 40 CFR 194.24(a), DOE's waste profiles contain specific information on the species and quantities of individual radioisotopes in the waste. Additional information, such as curie distribution per container and surface dose rate, while not explicitly provided in the CCA, can be calculated using the information contained in Appendix BIR, Appendix P.

Description of To-Be-Generated Waste

DOE indicated that to-be-generated waste will be included in those waste streams and final waste forms currently identified at DOE sites (Section 4.1.3, p. 4-12). Therefore, the waste stream descriptors for existing waste also apply to to-be-generated waste. Existing waste stream information was used by DOE in its description of to-be-generated waste.

DOE described its inventory as "stored" and "projected," with the stored inventory generally equivalent to existing waste and projected waste generally equivalent to to-be-generated waste. The projected inventory information was derived from each generator site from the waste stream profile forms, and reflects the site's best determination of the waste expected to be generated (Appendix BIR, TWBIR Revision 3, pp. 1-3 to 1-8). The anticipated inventory is the sum of the stored and projected inventories (Appendix BIR, TWBIR, Revision 3, p. 1-3). Appendix BIR, TWBIR Revision 3, Table 2-1, summarizes DOE's projected and anticipated inventories based on final waste form.

DOE's estimates indicate that the total expected inventory volume for CH-TRU wastes will not reach the maximum disposal capacity of the WIPP for CH-TRU (calculated to be approximately 168,500 m^3 or 5,950,000 ft^3) (Chapter 4.1.3.21, p. 4-21). DOE employed a scaling approach to project the impacts of a full repository. This scaling methodology was not used on remote handled transuranic wastes, because DOE has reported inventory sufficient to meet the RH-TRU waste capacity defined in the WIPP Land Withdrawal Act (LWA) (approximately 7,080 m^3 or 250,000 ft^3). DOE developed a scaling factor based upon the approximately 54,000 m^3 of projected inventory it expected would be generated, as DOE believed that any new waste generated to "fill" the outstanding WIPP space would probably be more similar to the projected rather than existing waste inventory (Appendix BIR, TWBIR Revision 3, p. 2-3). This scaled CH-TRU inventory was described by DOE in TWBIR Revision 3 and was based on the projected TRU waste inventory (e.g., waste components, quantity, type of waste, species and quantity of radionuclides).

As reported in TWBIR Revision 3, the scaling factor calculated by DOE for CH-TRU waste is 2.05. This factor is used in the following formula to project the makeup of the emplaced waste according to the LWA design limitations:

Stored Inventory + (Projected Inventory x 2.05) = Disposal Inventory

24.A.6 EPA COMPLIANCE REVIEW

EPA reviewed the CCA to determine whether it provided a sufficiently complete description of the chemical, radiological and physical composition of the existing and to-be-generated wastes proposed for disposal in the WIPP. EPA also reviewed DOE's description of the approximate quantities of waste components (for both existing and to-be-generated wastes). EPA considered whether the CCA's waste descriptions were of sufficient detail to enable EPA to conclude that DOE did not overlook any component that is present in transuranic waste and has significant potential to influence releases of radionuclides.

Chemical, Physical, and Radiological Description of Existing Waste

EPA concluded that the information presented by DOE in the CCA provides adequate characterization of existing WIPP waste for use in PA. EPA questioned in its March 19, 1997, letter to DOE whether any recently acquired information pertinent to the BIR would result in revision of the BIR and, hence, PA estimates (Docket A-93-02, Item II-I-17). DOE responded that EPA should consider the information contained in the CCA as the inventory description upon which the PA is based for the purposes of the initial compliance determination (Docket A-93-02, Item II-I-24). EPA used the information submitted in the CCA as the inventory description upon which the PA was evaluated.

Descriptions of the chemical, radiological, and physical components of the waste were included in the CCA, Section 4.1, pp. 4-5 through 4-24 and TWBIR Revision 3. EPA concluded on the basis of this information that the CCA adequately described the chemical, radiological, and physical characteristics of each waste stream proposed for disposal at the WIPP. The chemical description included process chemicals likely to be present in the waste, other added components (neutralizers, stabilizers, solidifies, etc.) including approximate total quantities, and the chemical properties of other items present that could impact performance. EPA questioned whether the actual quantity of organic ligands was accurately presented (Docket A-93-02, Item II-I-17). DOE provided supplemental information (Docket A-93-02, Item II-I-24) pertaining to organic ligand use in PA that satisfied EPA's concern that the organic ligand content was sufficiently accounted for (see Section 194.24(b)(3) of this CARD for further discussion). EPA notes that descriptions of the chemical components of the waste streams are provided as cross references to EPA hazardous waste codes and are located in Appendix BIR, Appendix P.

EPA reviewed Chapter 4 of the CCA, DOE's waste stream profile forms in Appendix BIR, and Sanchez et al. (1997) and found these materials to contain sufficiently specific information on the species and quantities of individual radioisotopes in the waste. The radiological description included the species and quantities of the radioisotopes present in the waste and types of radiation. EPA also concluded that DOE appropriately identified the ten isotopes most significant to the PA: ^{241}Am, ^{244}Cm, ^{137}Cs, ^{238}Pu, ^{239}Pu, ^{240}Pu, ^{241}Pu, ^{90}Sr, ^{233}U, and ^{234}U (with ^{90}Sr, ^{233}U, and ^{137}Cs important only to RH waste). These isotopes comprise about 99 percent of the EPA units anticipated within the WIPP waste inventory (see **CARD 31—Application of Release Limits** for an explanation of "EPA units"). EPA determined that other information requested in the CAG, such as estimates of curie distribution per container and surface dose rate, can be calculated using the information contained in Appendix BIR, Appendix P, i.e., the curies/meter estimated for the particular waste stream and adjusted for the container volume size. DOE stated whether a waste stream contained CH- or RH-TRU waste. See **CARD 31—Application of Release Limits** for a discussion of isotope inventory decay calculations. The physical description of waste included the types of items, articles, and materials present in the waste (void space is inferred by waste porosity values used in PA), physical forms, and types of containers used in disposal. Although liquid content was not included, EPA notes that this information will be acquired for each drum using real-time radiography (RTR) (Chapter.4.4.1.2, p. 4-54).

The waste stream profiles presented in Appendix BIR group waste which have similar chemical and physical characteristics (such as rubbers which may actually be many different individual items like gloves, booties, hoses, tubing, etc.) These waste stream profiles contain detailed information on the quantities of each profile component. Therefore, EPA found that the waste stream profiles presented in Appendix BIR adequately described the quantities of waste components.

EPA concluded that the estimates provided in Appendix BIR are the best available information to date. EPA describes these quantities as, "estimates" and "best available information to date" because these quantities are estimates which contain projections of future wastes to-be-generated. EPA recognizes that the inventory numbers may change as DOE analyzes each container of TRU waste for complete radiological and physical waste characterization at the generator and/or storage site prior to being accepted for disposal at the WIPP. EPA also concluded that the estimates provided in Appendix BIR are sufficient for performance assessment purposes. EPA reached this conclusion because the numbers provided in Appendix BIR will serve as maximum limits imposed on the final WIPP inventory. The issue of whether or not that projected inventory increases or decreases as the BIR is updated in the future will be addressed through recertification.

Description of To-Be-Generated Waste

DOE's descriptions of to-be-generated wastes were included in the waste profile forms that comprise Appendix BIR, Appendix P. EPA recognized that these descriptions are the best information currently available regarding individual waste stream projections. EPA noted that future planning by DOE could affect the projected volumes of waste from environmental restoration and decommissioning, as well as quantities of anticipated final waste forms, waste streams, etc., projected for disposal by DOE. EPA also noted that DOE's CAO used a reasonable approach and did not perform a validation of data for to-be-generated waste submitted by the generator sites, with the exception of the completeness and consistency check employed in the data call. EPA believes this approach to be reasonable because it is not possible to validate waste projections that extend 40 years into the future and take into account the generation of waste from facilities that are still in use and are intended to remain in use for the near future. Projected data were only reviewed from a common sense perspective and at the system-wide level and, therefore, it is possible that sites using different assumptions could develop widely different projections. However, EPA concluded that the quantity and nature of waste emplaced in the WIPP between initial certification and recertification will be within the identified inventory envelope. EPA will closely monitor this inventory through site inspections and audits of waste inventory data. Modifications to the projected waste inventory will be accounted for in recertification activities.

EPA concluded that DOE's development of the disposal inventory is sufficient for PA purposes. EPA agrees with DOE that the use of projected waste inventory for scaling the CH WIPP inventory to meet the total WIPP capacity is the most appropriate method.

24.B.1 BACKGROUND FOR SECTION 194.24(b)

To satisfy the requirements of 40 CFR 194.24(b), EPA requires that DOE perform an analysis to identify and assess the impact on long-term performance of those waste characteristics that influence the containment of waste in the disposal system, including those waste components that affect the waste characteristics. A *waste characteristic* is defined by EPA as a property of the waste that has an impact on the containment of waste in the disposal system. A *waste component* is defined by EPA as an ingredient of the total inventory of the waste that influences a waste characteristic (40 CFR 194.2). The inclusion of select waste components and characteristics as parameters or portions of performance assessment models links WIPP waste with the overall evaluation of disposal system performance. DOE uses the term waste material "parameter" differently than the EPA use: which implies inclusion in PA. Wherever possible in this document, EPA has clarified which definition of a waste "parameter" is being used.

Waste components determine waste characteristics and are therefore integral to disposal system performance. For example, the characteristic of gas generation is controlled, in part, by the type and amount of certain waste components present, such as metal waste containers and cellulosics/rubber/plastic material. The presence of these components and a sufficient amount of brine leads to microbial degradation of cellulosics, corrosion of metals, and subsequent gas generation (i.e., CO_2, H_2, CH_4). The resulting gas pressure affects repository pressure, room closure rates, fracture development in associated marker beds, etc., as well as brine inflow and the possibility of waste entrainment in gas during a drilling event (spallings). Radionuclide solubility in Salado and Castile brine partially[2] controls the quantity of radionuclides that are released in brine to ground surface through a direct brine release; radionuclides in brine also serve as the source term to the Culebra for potential long-term transport through this rock unit. All of these factors are important elements of disposal system performance and are modeled in the performance assessment (PA).

24.B.2 REQUIREMENT

(b) "The Department shall submit in the compliance certification application the results of an analysis which substantiates:

(1) That all waste characteristics influencing containment of waste in the disposal system have been identified and assessed for their impact on disposal system performance. The characteristics to be analyzed shall include, but shall not be limited to: solubility; formation of colloidal suspensions containing radionuclides; production of gas from the waste; shear strength; compactability; and other waste-related inputs into the computer models that are used in the performance assessment."

24.B.3 ABSTRACT

EPA expected the compliance application to provide a detailed description of a waste characterization analysis that identifies a list of waste characteristics retained as a result of the analysis and explains the rationale for excluding any other waste characteristics.

DOE first identified those waste characteristics pertinent to the WIPP as part of its screening of features, events, and processes (FEPs). Those FEPs screened into performance assessment served as the basis from which waste characteristics and associated components were identified and further analyzed.

DOE presented the results of its waste characteristic and components analyses pursuant to 194.24(b)(1) in a number of documents. Chapter 4 of the CCA and Appendices MASS, WCA, SOTERM, and SA are the primary sources. DOE developed a thorough list of waste characteristics that could affect the WIPP's performance. DOE indicated that the following characteristics were expected to have a significant effect on disposal system performance and so were used in the performance assessment (i.e., parameters were developed which account for the effects of each):

- ♦ Solubility (including redox state and redox potential).
- ♦ Formation of colloidal suspensions containing radionuclides.
- ♦ Production of gas from the waste (hydrogen, and microbial substrate/ nutrients for methane gas generation).

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[2] Depending on the performance assessment model future, the volume of brine released is as or more important than solubility.

- ♦ Shear strength, compactability (waste compressibility), and particle diameter.

- ♦ Radioactivity in curies of each isotope.

- ♦ TRU radioactivity at closure.

EPA's analysis of the solubility calculations using the Fracture-Matrix Transport (FMT) code indicated that DOE did not take into account the possibility of hydromagnesite as a metastable mineral species in the stability reaction, which would affect the calculated solubility values by lowering the possible range of values. EPA reran these analyses; see EPA Technical Support Document for Section 194.24: EPA's Evaluation of DOE's Actinide Source Term (EPA 1998d). EPA's results indicated that modified solubility values for actinides were required, and the Performance Assessment Verification Test (PAVT) was run using these values. DOE has since performed experiments that identify hydromagnesite as a metastable mineral species.

24.B.4 Compliance Review Criteria

EPA's compliance review criteria pertinent to waste component and characteristics analysis apply to Sections 194.24 (b)(1),(2), and (3). As stated in the CAG (p. 31), EPA expected the compliance application to provide a waste characterization analysis that includes:

- ♦ A detailed description of the analysis performed.

- ♦ A list of waste characteristics retained as a result of the analysis.

- ♦ A list of waste components influencing these characteristics that are retained as a result of the analysis.

- ♦ Identification of all waste-related inputs into computer models.

- ♦ A list of all waste characteristics and components that were considered and excluded, including the rationale for exclusion.

EPA expected that DOE would discuss applications of screening procedures, results of bounding or sensitivity analyses, etc., beginning from the description required by §194.24(a) and leading to the selection of the important or significant waste components that will be limited and controlled to ensure compliance with the disposal regulations. Any measured or assumed waste property that is used either directly or indirectly in PA should be present on the list of waste characteristics and components.

A description of the scope of peer review of the waste characterization analysis required by 194.27(a)(2) was expected to be provided, along with a discussion of reviews of the panel's conclusions regarding the adequacy of the analysis and DOE's follow-up actions. Also, objective evidence supporting decisions (peer review process documentation, conclusions, etc.) and the location of the evidence should be cited in the CCA.

EPA expected the rationale for excluding potentially significant waste components or characteristics from the PA to be clearly stated and explained. Further, the justification for exclusion should be based on clear criteria such as “negligible impact” and basic scientific principles or a detailed technical justification should be provided which clearly enumerated the argument for exclusion.

24.B.5 DOE METHODOLOGY AND CONCLUSIONS

DOE identified those waste-related elements pertinent to the WIPP as part of its screening of features, events, and processes (FEPs). Appendix SCR, Table SCR-2, shows over 100 waste- and repository-induced FEPs that DOE identified as potentially important to the containment capabilities of the WIPP. DOE’s evaluation resulted in many waste-related FEPs being included in the performance assessment, e.g., waste inventory, radionuclide decay, gas generation, and solute transport. Other waste-related FEPs were screened from consideration due to low consequence, low probability, or for regulatory reasons. Such FEPs include heat from radioactive decay, nuclear criticality, and galvanic coupling. Those FEPs included in the performance assessment served as the basis from which waste characteristics and associated components were identified and further analyzed. See **CARD 32—Scope of Performance Assessments** for further discussion of FEP analyses.

DOE presented the results of its waste characteristic and components analyses in a number of documents. Chapter 4 of the CCA and Appendices MASS, WCA, SOTERM, and SA are the primary sources. In addition, DOE submitted supplementary information in response to EPA requests that pertained to DOE’s waste characterization programs (see Section 24.B.6 below).

Appendix WCA, Waste Characterization Analysis, Tables WCA-2 and WCA-3 (pp. WCA-9 to WCA-11), show the waste characteristics that DOE included in the performance assessment. Table WCA-4 (p. WCA-12) identifies waste characteristics that were assessed but not included in the performance assessment.

<u>Waste Characteristics Retained</u>

DOE indicated that the following characteristics were used in the performance assessment and were expected to have a significant effect on disposal system performance (Appendix WCA, Table WCA-2, pp. WCA-9 to WCA-10):

- ♦ Solubility (including redox state and redox potential).
- ♦ Formation of colloidal suspensions containing radionuclides.
- ♦ Production of gas from the waste (hydrogen, and microbial substrate/ nutrients for methane gas generation).
- ♦ Shear strength, compactability (waste compressibility), and particle diameter.
- ♦ Radioactivity in curies of each isotope.

- TRU radioactivity at closure.

DOE indicated that the following characteristics were used in the performance assessment, but were not expected to have a significant effect on disposal system performance (Appendix WCA, Table WCA-3, p. WCA-11):

- Waste permeability
- Waste porosity
- Microbial nutrients
- Microbial substrate and
- Gas generation.

Assessment of Waste Characteristics and Waste Characteristic Input Parameters

DOE identified several waste characteristics as being potentially important to performance assessment (Appendix WCA, Section WCA.6, pp. WCA-42 to WCA-43) based on consideration of available information, including uncertainties and WIPP system characterization. These analyses were summarized in Appendices WCA, SOTERM, and MASS, and were augmented by DOE's responses to EPA comments. Specifically, EPA's comments on the CCA (Docket A-93-02, Items II-I-01 and II-I-25) led DOE to conduct magnesium oxide-related experiments and additional FMT code analysis.

Solubility

DOE stated that solubility of actinides is among the major characteristics of the radionuclides expected to affect disposal system performance (Appendix WCA, Section WCA.4, pp. WCA-30 to WCA-34). DOE assessed the solubility of thorium, uranium, neptunium, plutonium, and americium (see below). DOE assumed that cesium and strontium are inventory limited (meaning that 100% of these isotopes would be dissolved) due to their high solubilities; therefore, formal solubility values were not derived for these two radionuclides (p. WCA-30).

DOE stated that in the absence of MgO backfill, system pH, CO_2 fugacity, redox conditions, complexing agents, and brine availability all negatively affect radionuclide solubility (Section WCA.4.1, p. WCA-31). DOE assumed, however, that MgO will be present to buffer the pH and mitigate CO_2 fugacity (temperature will also affect solubility (solubility tend to rise with temperature), but DOE contended that temperature will be nearly constant in the repository). DOE assumed that pressure does not affect solubility.

DOE assumed that anoxic conditions will prevail in the system following closure, resulting in lowered redox potential. As a result, reduced states of actinides with numerous oxidation states will likely prevail (Appendix WCA, Section WCA.4.1.1, pp. WCA-31 to WCA-32). DOE assumed that iron within drums will facilitate reducing conditions. DOE concluded that the following oxidation state distribution be used in PA, based upon experimental data as well as published literature (p. WCA-32):

- Thorium (Th): +IV
- Uranium (U): +IV and +VI
- Neptunium (Np): +IV and +V
- Plutonium (Pu): +III and +IV and
- Americium (Am): +III.

DOE concluded that curium exhibits the same chemical behavior and oxidation state as americium. DOE also concluded that half of the realizations in the performance assessment include the lower oxidation states of uranium, neptunium, and plutonium, and half include the higher oxidation state (p. WCA-32).

A summary of experimental data used by DOE to develop actinide solubilities was presented in Appendix SOTERM, Section SOTERM.3.4 (pp. SOTERM-24 to SOTERM-27). DOE used these experimental data to derive actinide solubility variability and distribution and to select a computer code to calculate solubilities. A primary consideration for DOE's selection of a computer model for the WIPP was demonstrating applicability of existing models and data bases to the brine and evaporite systems at the WIPP site (Appendix SOTERM, Section SOTERM.3.2, pp. SOTERM-21 to SOTERM-23). DOE estimated actinide solubilities by using an equilibrium thermodynamics model based on experimental parameterization. The Pitzer formalization was chosen and tailored to be used for the WIPP to determine activity coefficients. DOE indicated that the Pitzer formalism was chosen for several reasons (pp. SOTERM-22):

- The Pitzer formalism contains parameters that represent the contributions to the excess energy from every species interaction.
- The Pitzer parameterization includes an established data base that describes solubility in the $Na\text{-}K\text{-}Mg\text{-}Ca\text{-}H\text{-}Cl\text{-}SO_4\text{-}OH\text{-}HCO_3\text{-}CO_3\text{-}CO_2\text{-}B\text{-}H_2O$ system. This system includes the significant inorganic constituents of WIPP brines.
- The Pitzer formalization is shown to work for electrolytes concentration between 0.8 molal to 8 molal ionic strength. The Pitzer model is developed for and has been shown to work for electrolytes as concentrated as those in the WIPP system will be.

Along with the Pitzer formalism, Appendix SOTERM discussed the use of the FMT computer code (Sections SOTERM.3.5 and SOTERM.3.6, pp. SOTERM-27 to SOTERM-28, and Attachment FMT of Appendix SOTERM). The CCA's FMT code implements the Pitzer formalism and was used to calculate the solubility of the actinide elements in equilibrium with the appropriate solubility-controlling solid(s) in WIPP brines. The FMT calculations were done for three actinides—Am(III), Th(IV), and Np(V)—that served as the chemical analogs for the actinide III, IV, and V oxidation states, respectively. DOE stated that since actinides in the same oxidation state exhibit similar chemical behavior (Appendix SOTERM 3.3), the FMT calculations were applied to all actinides in that particular state. Parameters used in FMT were taken from existing databases, literature and/or determined from experimental data using the NONLIN code (Appendix SOTERM, Attachment 2). NONLIN calculated Pitzer parameters using a non-linear squares fitting program. Appendix SOTERM contains the code user's manuals for NONLIN and FMT. Using the Pitzer Model and FMT, solubilities for each actinide oxidations state analog were calculated by DOE and presented in Appendix SOTERM, Table SOTERM-2 (p. SOTERM-28). DOE also derived uncertainty ranges associated with each radionuclide used in PA based on experimental and calculated solubility data (Bynum 1996a).

The exception to the solubility approach described above was U(VI), for which a concentration of 8.8 x 10-6 molar was selected by DOE as a reasonable estimate of the maximum concentration that might occur in the repository. The solubility approach was not used for U(VI) because DOE stated that the aqueous speciation of U(VI), especially the hydrolyzed species, has not been determined with sufficient accuracy to allow good predictions to be made with the FMT code. The concentration of 8.8 x 10-6 molar was based on an assessment by Hobart and Moore (1996) of U(VI) solubility experiments conducted with brines at pH 10 in the absence of CO_2(g).

Performance Assessment Parameters Related to Solubility

Solubility of actinides in the III, IV, V and VI oxidation states for both the Castile and Salado brines were calculated by DOE with the assumption that pH and f(CO_2) are controlled by $Mg(OH)_2$ - $MgCO_3$ equilibrium.

The solubilities (moles/liter) in Table 1 were used by DOE in PA:

Table 1
Solubilities of the Oxidation State Analogs, in moles/liter, with MgO Backfill
(From Appendix SOTERM, Table SOTERM-2)

		Solubilities for PA Material Name and Oxidation State			
Brine	PA Parameter Name	SOLMOD3 (III)	SOLMOD4 (IV)	SOLMOD5 (V)	SOLMOD6 (VI*)
Salado	SOLSIM	5.82×10^{-7}	4.4×10^{-6}	2.3×10^{-6}	8.7×10^{-6}
Castile	SOLCIM	6.52×10^{-8}	6.0×10^{-9}	2.2×10^{-6}	8.8×10^{-6}

* Not calculated in the FMT model

DOE defined uncertainty limits for actinide concentrations calculated from solubility relationships based on the differences between measured concentrations and those predicted for the solubilities of discrete actinide solids with the FMT or NONLIN computer codes (Bynum

1996b). These differences were measured for a number of experimental studies of the solubilities of different actinide solids in high ionic strength solutions. Based on criteria of data adequacy, Bynum used data only from solubility experiments with +3 and +5 actinides to construct the uncertainty distributions. These uncertainty limits were determined by DOE to range from 1.4 log units above to 2.0 log units below the actinide concentrations calculated from solubility expressions contained in the FMT model. Based on the distribution of uncertainties, DOE determined a mean of 0.18 and median of -0.09 in log units relative to the solubility-based actinide concentrations obtained from the FMT model. These uncertainty ranges were used for each actinide sampled in the PA, that is for Am(III), Pu(III), Pu(IV), in Castile and Salado brines, U(IV) in Salado brine, U(VI) in both Castile and Salado brine, and Th(IV) in Salado brine.

The uncertainties in the actinide solubilities were used to define the range for Latin Hypercube Sampling of the actinide concentrations in the PA, assuming a log cumulative distribution. The results were presented as a function of cumulative probability and probability density functions and parameter valance (log molar) (Parameter Nos. 36-45, Appendix PAR, pp. PAR 124-144). See **CARD 34—Results of Performance Assessments** for further discussion of Latin Hypercube Sampling.

Relative to oxidation state distributions, DOE assumed that the probable oxidation state for Am/Cm is III, Pu is III or IV, Np is IV or V, Th is IV, and U is IV or VI, based on the assumption that reducing conditions would prevail in the repository. DOE also assumed that there would be a 50% chance that repository conditions will allow for higher oxidation states of each actinide and 50% chance that the lower actinide oxidation state will prevail (Appendix WCA, Section WCA.4.1.1, p. WCA-32). Parameter No. 47 (Appendix PAR, p. 148) described this oxidation state variation, which was LHS sampled assuming a uniform distribution, mean of 0.5, median of 0.5, minimum of 0, maximum of 1.0, and standard deviation of 0.29 (these values are unitless).

DOE indicated that the actinide concentrations are calculated using the code ALGEBRA, the results of which are input to codes such as PANEL and NUTS. These values are reported to PANEL and NUTS as the log of the total mobile concentrations, with the fraction that is dissolved and on each colloidal type passed on to the complimentary cumulative distribution function (CCDF) calculations (CCA Appendix SOTERM 3.3).

<u>Formation of Colloidal Suspensions Containing Radionuclides</u>

Colloid formation can enhance the quantity of actinides contained in brine, and was evaluated by DOE as an important group of waste characteristics (with "colloids" as a resulting <u>component</u> that must be considered). DOE determined that four types of colloids may be present in the WIPP repository: Intrinsic colloids, mineral fragment colloids, humic colloids, and microbe colloids (Appendix WCA, Section WCA.4.2, pp. WCA-34 to WCA-36). DOE conducted literature studies and experiments directed by SNL and concluded that intrinsic colloid concentrations for all actinides except for plutonium should be modeled as zero, with plutonium modeled with a 1×10^{-9} concentration factor. DOE also concluded that mineral fragment colloid development would be minimal, and modeled the concentration of mineral fragment colloids using a 2.6×10^{-8} concentration factor (Appendix WCA, Section WCA.4.2, p. WCA-35).

Humic colloids will be present in the repository in soil and humic material and also formed through the degradation of cellulosics, plastics, and rubber. The contribution of humic colloids to repository performance was calculated by quantifying humic-actinide complexation coupled with solubilities of humic substances determined experimentally in WIPP brines, expressed as a ratio of moles of humic-bound actinide to moles of dissolved solids. DOE stated that the range of humic colloid ratios derived from this analysis varied from 4.3×10^{-4} to 6.3 for Castile brine, and 5.3×10^{-5} to 6.3 for Salado brines. A maximum "cap" was also applied by DOE, above which no additional sorption would take place (Appendix WCA, Section WCA.4.2, p. WCA-35). DOE conducted humic colloid experiments at SNL and Florida State University (Appendix SOTERM).

Microbial colloids were also identified by DOE as potentially present in the WIPP disposal system. DOE conducted bioaccumulation and toxicity experiments to assess microbial colloid impact, and concluded that microbial colloids can transport actinides in concentrations well above the estimated solubilities. DOE applied proportionality values ranging from 12 (Np IV and V) to 0.0021(U VI and IV) to the calculated solubilities to determine the quantity of actinides that could be transported in WIPP brines via microbial colloids. A maximum "cap" value was also applied above which no sorption was assumed (Appendix WCA, Section WCA.4.2, p. WCA-36). DOE conducted microbe-related experiments at Batelle National Laboratories and SNL (Appendix SOTERM).

Performance Assessment Parameters Related to Colloids

Colloidal actinide concentrations of mineral fragments and actinide intrinsic colloids were addressed in PA modeling. DOE assumed that the maximum concentration of actinides due to mineral fragment colloids is 2.6E-08 moles of colloidal mineral-fragment bound to Am, Pu, U, Th and Np per liter of dispersion (refer to Table PAR-39, all parameters labeled CONCMIN). Relative to actinide intrinsic colloids, DOE assumed a 1.0E-09 moles actinide intrinsic colloidal per liter of dispersion for Pu, and 0 moles actinide intrinsic colloidal Am, U, Th, and Np per liter of dispersion (refer to Table PAR-39, all parameters labeled CONCINT).

DOE calculated proportionality constants and concentration caps for humic and microbial colloids; these values were used in PA. DOE calculated and used the proportionality constants and concentration caps listed in Table 2 (Table PAR-39):

Table 2
Microbe Colloids (Table PAR-39, all parameters CAPMIC and PROPMIC):

	Proportionality Constant[1]	Cap[2]
Am	3.6	Inventory limited
Pu	0.3	6.8E-05
U	2.1E-03	2.1E-03
Th	3.1	1.9E-03
Np	1.2E+1	2.7E-03

Humic Colloids (Table PAR-39, all parameters CAPHUM, PHUMSIM, and PHUMCIM):

	Proportionality Constant[3]		Cap[2]
	Salado Brine	Castile Brine	Both Brines
III	.008-.19	.065-1.6	1.1E-05
IV	6.3	6.3	1.1E-05
V	5.3E05-9.1E-04	4.3E-04-7.4E-04	1.1E-05
VI	.008-.12	.062-.51	1.1E-05

[1] Moles mobile microbial actinide/moles of dissolved actinide
[2] Cap on total moles mobile actinide/liter
[3] Moles mobile humic-bound actinide/moles of dissolved actinide

In addition to the above parameters, one colloid-related parameter was sampled using the LHS method. PHUMOX3/PHUMCIM, the humic proportionality constant for Pu in the III+ oxidation state, was sampled rather than fixed because experimental data indicated this approach was more appropriate (Appendix PAR, pp. 146-147, Parameter 46). DOE used a log cumulative distribution, with a mean of 1.0, median of 1.37, minimum of 0.056, maximum of 1.6, and standard deviation of 0.47.

Production of Gas From the Waste (Including Microbial Substrate and Nutrients)

DOE stated that gas generation includes hydrogen gas generation, as well as carbon dioxide and methane generation by microbial degradation. The characteristics of gas generation are linked to the waste components of waste steel, microbial substrates such as cellulosics, rubber, and plastics, as well as other microbial nutrients (nitrate and sulfate) that could be present (Appendix WCA, Section WCA.5.1, pp. WCA-36 to WCA-38, Appendix SOTERM, Section SOTERM.2.2.2 and 2.2.3 (pp. 4-17) and Francis and Gillow (1994)).

DOE assumed that hydrogen gas generation will proceed as follows (p. WCA-36):

$$Fe + 2H_2O \rightarrow Fe(OH)_2 + H_2(g)$$

DOE stated that gas generation via corrosion will increase gas pressure in the WIPP repository, which is taken into account in PA modeling (see below). Nonferrous metals will also contribute, but DOE contended that their contribution to total gas pressure would be negligible (Appendix WCA, Section WCA5.1, p. WCA-37).

DOE assumed that organic materials in the absence of nitrate and sulfate will biodegrade through the simplified reaction (p. WCA-32):

$$C_6H_{10}O_5 + H_2O \rightarrow 3CH_{4(g)} + 3CO_{2(g)}$$

DOE assumed that the CO_2 created by microbial decay and other reactions will react with MgO backfill in the WIPP. DOE based gas generation determinations upon literature/empirical data and experimental data. (Chemical conditions Model: Results of the MgO Backfill Efficacy Investigation, April 23, 1997, Sandia National Laboratories)

Performance Assessment Parameters Related to Gas Generation

DOE used LHS in PA for the following gas-generation-related parameters (also see Table 3 below for the associated parameter values):

- Inundated steel corrosion rate (Parameter No. 1, Appendix PAR, pp. PAR-16 to PAR- 17).
- Probability of microbial degradation of plastics and rubbers (in the event of microbial gas generation) (Parameter No. 2, Appendix PAR, pp. PAR-17 to PAR-20).
- Biodegration rate of cellulosics, inundated and humic conditions (Parameter Nos. 3 and 4, Appendix PAR, pp. PAR-21 to PAR-24).
- Factor β for microbial reaction rates (Parameter No. 5, Appendix PAR, pp. PAR-25 to PAR-26).

The probabilities for microbial gas generation reflect DOE's implementation of the Chemical Conditions conceptual model that was reviewed and accepted by the conceptual model peer review panel (Appendix PEER.1, Section 3.21.2.2).

Shear Strength, Compactability (Compressibility) and Particle Diameter

Waste particle diameter, compactability, and shear strength were included in PA. See Section 194.23(c)(4) in **CARD 23—Models and Computer Codes** for a discussion of DOE's selection of model parameter values for these physical waste characteristics. Also see Technical Support Document for Section 194.23: Sensitivity Analysis (Docket A-93-02, ItemV-B-13) and Technical Support Document for Section 194.23: Parameter Justification Report (Docket A-93-02, Item V-B-14). It should be noted that EPA determined that waste particle diameter values required an expert judgment elicitation. The expert panel found that the values used in the performance assessment were acceptable. See **CARD 26—Expert Judgment** for additional information about this expert judgment elicitation.

<u>Performance Assessment Parameters Related to Shear Strength, Compactability (Compressibility) and Particle Diameter</u>

DOE sampled the waste particle diameter and effective shear resistance to erosion using the LHS method. Parameter 31 (Appendix PAR, p. PAR-115) describes the particle diameter of waste material used in the CUTTINGS code for waste blowout during a spallings event (with PA parameter names: BLOWOUT and PARTDIA). DOE assumed, in meters, a mean of 0.0235, median of 0.0028, minimum of .000040, and maximum of 0.20, with a standard deviation of 0.04. DOE also assumed a log-uniform distribution.

DOE also used LHS to define PA input for the effective shear resistance to erosion, with parameter names of BOREHOLE and TAUFAIL in PA (Appendix PAR, p. PAR-117). DOE assumed, in pascals, a mean of 5.03, median of 5.03, minimum of 0.05, maximum of 10.0, and standard deviation of 2.9, with a uniform distribution.

Waste compactability was addressed through the assumption of specific waste permeabilities and porosities. See section 194.23(c)(4) in **CARD 23—Models and Computer Codes** for a discussion of DOE's approach to these parameters. Also see Technical Support Document for Section 194.23: Sensitivity Analysis (Docket A-93-02, Item V-B-13) and Technical Support Document for Section 194.23: Parameter Justification Report (Docket A-93-02, Item V-B-14) Table 3 below shows values used by DOE and presented in Appendix PAR for PA-related LHS parameters.

Table 3

Material/Parameter Name/unit	Description	Mean	Median	Minimum	Maximum	Distribution
Parameter No.1: STEEL/CORRMCO2/ m/s	Rate of anoxic steel corrosion under inundated conditions	7.937 E-15	7.937 E-15	0	1.587 E -14	Uniform
Parameter No. 2: WAS_AREA PROBDEG REPOSIT PROBDEG No units	Index alternative modes of microbial degradation for plastics and rubbers if microbial degradation occurs	n.a.	n.a.	0	2	Delta
Parameter No. 3: WAS_AREA GRATMICI REPOSIT GRATMICI mol/kg*s	Rate of cellulosic biodegradation under anaerobic-brine inundated conditions	4.915 E-9	4.915 E-9	3.17 E-10	9.5129 E -9	Uniform
Parameter No. 4 WAS_AREA GRATMICH REPOSIT GRATMICH mol/kg*s	Rate of cellulosic biodegradation under anaerobic humic conditions	6.342 E-10	6.342 E -10	0.0	1.2684 E -9	Uniform

Material/Parameter Name/unit	Description	Mean	Median	Minimum	Maximum	Distribution
Parameter No. 5 CELLULS FBETA No units	Index that characterizes the stoichiometry used to calculate the microbially generated gas, accounting for interaction with gases reacting with steel and steel corrosion products	0.5	0.5	0	0	Uniform

Radioactivity in Curies of Each Isotope

DOE indicated in Sections 3.1 and 3.2 of Appendix WCA that the radioactivity of each isotope is important to the performance assessment because it directly affects the waste unit factor (number of million curies of TRU isotopes in the WIPP inventory), which is the normalization factor used to calculate allowable releases for each radionuclide (see Table WCA-1 in Appendix WCA).

DOE presented numerous tables in Appendix WCA (WCA-6, Attachments WCA 8.1-8.3) that summarize radioactivity in curies for each isotope. These tables show inventory quantities as presented in the TWBIR, Revision 3, Appendix B. DOE indicated that the waste inventory is dominated by ^{241}Am, ^{238}Pu, ^{239}Pu, ^{240}Pu, ^{242}Pu, and ^{245}Cm, with the combined activity at emplacement of ^{241}Am, ^{238}Pu, ^{239}Pu, and ^{240}Pu being three orders of magnitude greater than the remaining 11 alpha-emitting radionuclides that contribute to the waste unit factor (Table WCA-5). See Section 194.24(a) of this CARD for additional discussion of the waste inventory as presented in the TWBIR, Revision 3.

While the waste unit factor was calculated using only the activity of TRU alpha-emitting waste with a half life of 20 years at the time of repository closure, DOE stated that all radionuclides were considered for inclusion in the source term for PA (Appendix WCA, Section WCA.3.2, p. WCA-16). DOE indicated, however, that many of these are present in such small quantities that “their impact on long-term performance is negligible. . . their total combined inventory in EPA units is much less than one percent so they will have negligible impact on compliance” (p. WCA-16). Therefore, DOE performed a simplifying study to determine those actinides of importance to PA.

DOE considered three release pathways when simplifying the radionuclides considered in the source term: 1) releases of particular waste via cuttings, cavings, and spallings; 2) releases of waste in brine via direct brine release; and 3) long term groundwater release, such as releases to the Culebra (Section WCA.3.2, p. WCA-21). DOE examined the three pathways and concluded that different radionuclides were representative of each because of the “time-scale differences and different release media” (p. WCA-21). The following radionuclides were determined important by DOE (Figure WCA-4):

- Cuttings/cavings/spallings release: ^{238}Pu, ^{239}Pu, ^{240}Pu, ^{241}Pu, ^{241}Am, ^{233}U, ^{234}U, ^{90}Sr, ^{137}Cs, ^{244}Cm.

- Direct Release in Brine: ^{238}Pu, ^{239}Pu, ^{240}Pu, ^{241}Pu, ^{242}Pu, ^{241}Am, ^{243}Am, ^{233}U, ^{234}U, ^{235}U, ^{236}U, ^{238}U, ^{229}Th, ^{230}Th, ^{232}Th, ^{237}Np, ^{243}Cm, ^{244}Cm, ^{245}Cm.

- Long-term groundwater release: ^{239}Pu, ^{240}Pu, ^{242}Pu, ^{241}Am, ^{233}U, ^{234}U, ^{229}Th, ^{230}Th.

DOE indicated that U and Th isotopes are required in direct brine release assessments because, although they comprise negligible fractions of the total EPA unit, they do influence the total quantity of dissolved radionuclides (p. WCA-22). In addition, DOE indicated that although EPA units for ^{90}Sr and ^{137}Cs at the time of the WIPP’s closure are significant, they are not included in direct release of brine because they rapidly decay and result in "negligible impact on the PA from those two isotopes" (p. WCA-26). In addition, DOE indicated that if a direct brine release occurred early after closure, the total brine released would be minimal and the ^{90}Sr and ^{137}Cs would still, therefore, play a minor role in compliance (p.WCA-26).

DOE justified the radionuclide list for the long-term groundwater pathway (releases to the Culebra) based upon the following (Appendix WCA, Section WCA.3.2.3, pp. WCA-26 to WCA-27):

- ^{233}U can be combined with ^{234}U for transport because their half lives are similar.

- ^{229}Th can also be combined with ^{230}Th because they are in a fixed ratio to each other.

- ^{232}Th can be dropped because it is a constant small fraction of EPA unit throughout the 10,000 year regulatory period.

- ^{240}Pu and ^{242}Pu can be combined with ^{239}Pu. long half-lives also indicate a fixed ratio between them.

- ^{238}Pu will have decayed to about 0.5% of its initial inventory after 700 years, and its contribution to EPA unit will be negligible because of the long (>700 year) travel time in the Culebra; it was therefore dropped from consideration.

DOE concluded that the ^{239}Pu and ^{240}Pu dominate the EPA unit during the regulatory time period (p. WCA-27). See **CARD 31—Application of Release Limits** for a discussion of the EPA unit. ^{241}Am is a factor for the first 3,000 years. DOE stated that toward the end of the 10,000 year period, ^{230}Th has grown-in by about 2.5 orders of magnitude, ^{229}Th by about 1.5 orders of magnitude, and ^{234}U by a factor of 3, but these are still small fractions of the EPA unit. DOE also stated that ^{226}Ra grows in during the regulatory period, but "even at 10,000 years would comprise a very small fraction of EPA limit" (p. WCA-27). Table WCA-8 of Appendix WCA presented those radionuclides excluded from all source terms.

<u>Performance Assessment Parameters Related to Radioactivity in Curies of Each Isotope</u>

DOE used the information from the BIR to define the isotope inventory for PA. Refer to Section 194.24(a) of this CARD for discussion regarding the description of this inventory. Also refer to Appendix BIR for discussion of the inventory development using the BIR and use of the Integrated Data Base when developing the cuttings/cavings inventory for each waste stream.

Appendix PAR, Table PAR-41 (pp. PAR-233 to PAR-234) shows isotope inventory information for 58 isotopes in CH and RH waste used in PA. The inventory value in 1995 is presented in total curies; this value is a constant input (i.e., unsampled).

TRU Radioactivity at Closure

Table WCA-6 shows DOE inventory at closure, based upon 1995 assay dates. Appendix WCA indicated that the waste unit factor is 4.07, which assumes a total alpha inventory as of 1995. Chapter 4 of the CCA, however, indicated that the waste unit factor is instead 3.44, which represents inventory decay to the year 2033. DOE stated that the "application of the 1995 decayed values to 2033 does not make a significant different in either EPA unit or the waste unit factor" (p. WCA-15). However, DOE recalculated the waste unit factor and EPA units at closure based upon the 2033 decay date and included pertinent information in Chapter 4 of the CCA and Sanchez et al. (1997). DOE has indicated that the 2033 decay values were used in PA.[3]

Performance Assessment Parameters Related to TRU Radioactivity at Closure

The 4.07 waste unit factor is not listed as an input to PA in Appendix PAR, but the value is used in other codes (e.g., CCDFGF, EPAUNI) and is the multiplier used with the allowable EPA release limits presented in Appendix PAR, Table PAR-40 (pp. PAR-27 to PAR-32). See **CARD 31—Application of Release Limits** for further discussion of the release limit calculations using the TRU radioactivity at closure.

Peer Review

DOE conducted Peer Review of Waste Characterization in June of 1996. The results of the initial Peer Review were included in Appendix PEER.3 of the CCA. The Peer Review Panel concluded that the analysis used to estimate the parameters needed to establish the radionuclide inventory and releases limits was "thorough and systematic" (Appendix PEER.3, p. 6-1). However, the Panel also concluded that the heterogenous source term information was not clearly presented in the reviewed material (which was an earlier version of Appendix WCA). The Panel also concluded that while the median solubility values were reasonable, the uncertainty ranges about the median were too low and were inconsistent with earlier results. Further, the issue of actinide solubility was not adequately addressed in relation to MgO backfill assumptions because of a lack of experimental data. The Panel also stated that experiments pertaining to actinides were well done, but questioned the meaningfulness of the uncertainty given for colloid actinide source term because of the few experiments conducted.

The Panel concluded that Appendix WCA identifies the major gas generation issues, but the fate of microbially generated methane and carbon dioxide (with relation to MgO backfill) was not adequately resolved. Waste compactability and strength studies were not adequately referenced in Appendix WCA, according to the Panel. The Panel concluded that it could not evaluate the treatment of porosity as a waste characterization parameter, but concurred with conclusions regarding waste permeability presented in Appendix PAR. Relative to head space gas generation, the Panel stated that the analyses were well done and conclusions were well founded. The Panel concurred with DOE's assertion that low valence metals will maintain a reducing environment in

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[3] EPA has determined that the actual value of the waste unit factor is 4.28. See **CARD 31—Application of Release Limits** for a detailed discussion of the calculation of the waste unit factor.

the WIPP, but did not believe that DOE's position concerning uptake of organic ligands by transition metals was defensible, due to the lack of experimental data. The Panel concluded that the treatment of cellulosics was sufficient, but the position that transition metal will react with organic ligands should be justified with high-ionic strength experiments (Appendix PEER.3, pp. 6-1 to 6-3).

As a result of the initial Peer Review Panel's concerns, a second Peer Review was performed in December 1996. Each of the concerns cited in the first review was examined by the same Panel in light of supplemental information presented by DOE. The Panel concluded that the information used by DOE to develop the heterogeneous source term was acceptable, but information "that supports this conclusion [was] somewhat fragmented" (Docket A-93-02, Item II-G-14, p. 6). The Panel concurred that DOE's additional experiments pertaining to MgO adequately addressed their concerns regarding median actinide solubility values and MgO chemistry as it pertains to actinide solubility.

The Panel found supplemental information provided by DOE pertaining to gas production to be sufficient to answer questions regarding methane and carbon dioxide. Further, the Panel concluded that DOE's supplemental information answered the Panel's questions regarding waste compactability, waste strength, and waste porosity. The Panel agreed with DOE's argument regarding organic ligand complexation with transition metals, stating that even at the "basic pH in the repository, the availability of transition metals may be enhanced due to the formation of soluble halo complexes, making an even stronger case that base metals control ligand chemistry" (Docket A-93-02, Item II-G-14, p. 12). The Panel concluded that DOE's supplemental argument in Appendix SOTERM regarding organic ligand uptake by transition metals (which was not provided to the first Panel) was sufficient. The Panel stated, "It is the opinion of the Peer Review Panel that all conclusions presented in the initial peer review report have been satisfactorily addressed. . . However, the panel believes that 'conservative' bounding values for the colloid actinide source term may be less scientifically defensible than they are purposed to be" (Docket A-93-02, Item II-G-14, p. 1).

24.B.6 EPA COMPLIANCE REVIEW

EPA reviewed information on waste characteristics and components in a number of technical documents. References were examined, both individually and in concert, to determine whether DOE presented rationale and logical arguments for all characteristic and associated component identifications. EPA considered whether all relevant waste characteristics and components were identified and evaluated. Screening procedures used to determine whether waste characteristics and components were examined for reasonableness and consistency of application. Results of DOE experimental programs, as they pertain to identified characteristics and components, were also examined in detail to determine whether conclusions drawn by DOE, based upon experimental program results, were sound. In addition, DOE's sensitivity analysis and applicable bounding analysis were examined to determine whether the sensitivity analysis included all applicable components, as well as to review the application of sensitivity analysis results. All information was examined relative to the waste inventory and its associated uncertainties (194.24(a)), as well as to the effect of the analyses' results on proposed waste limits (194.24(c)).

The identification of significant waste characteristics was an important step in this process, and the CCA was examined to determine whether a complete list of all possible waste characteristics was identified. Those waste characteristics already included in PA were also examined to assess whether they were important to disposal system performance (i.e., some characteristics are included in modeling to provide a more comprehensive and realistic presentation of system performance, but the sensitivity of system performance to the characteristic or components appears to be minimal).

EPA concluded that DOE generally performed a thorough and well documented analysis, adequately identified all waste characteristics and, except for actinide solubility, appropriately assessed them as PA input parameters. In the case of actinide solubility, EPA believes that DOE assumed an incorrect solubility that controls the mineral phase. However, this error led to the use of higher actinide solubilities than what EPA believes will be the case.

Solubility

Actinides can exist in oxidation states ranging from +3 to +6, depending on the specific actinide under consideration and prevailing redox conditions. The FMT model, which was used by DOE to calculate solubilities of actinide solids, does not include representations of redox processes, hence actinides must be designated as being present entirely in a single oxidation state. This treatment requires that a conceptualization of the redox conditions in the repository be developed based on available information on the inventory and knowledge of relevant redox reactions. After closure, the repository is expected to become anoxic relatively rapidly because of reactions between any available oxygen and iron metal and organic material. Both organic materials and iron metal are expected to be major components of the waste inventory. Additionally, the production of hydrogen by metal corrosion reactions is expected to contribute to creating reducing conditions in the repository. Based on these processes, EPA concurs with DOE that reducing conditions will prevail in the repository after closure.

Consideration of actinide chemistry indicates that the following oxidation states can be expected under reducing conditions: Thorium will be present in the +4 oxidation state, which is the only stable state in the natural environment. Am is expected to be present in primarily the +3 oxidation state. Higher oxidation of Am(+5) and Am(+6) can occur under oxidizing conditions, but is rapidly reduced by naturally occurring reductants and in brines at pH greater than 9 (Felmy et al., 1990). Pu is expected to be present as either Pu(+3) or Pu(+4). Higher oxidation states of Pu (i.e., +5 and +6) can exist under oxidizing conditions, but have been reported to be reduced rapidly by metallic iron (Weiner 1996). Consequently, Pu(+5) and Pu(+6) are not expected to be dominant oxidation states for Pu under the reducing conditions of the repository and abundance of metallic iron. U is expected to exist in both the +4 and +6 oxidation states, the predominance of which could not be ascertained based on current knowledge or uranium chemistry. The predominance of U(+4) requires extremely reducing conditions that, while possible in the repository, cannot be predicted with certainty. Consequently, U is designated in the PA as being present as U(+4) in 50% of the runs and as U(+6) in the other 50%. Likewise, Np is expected to be present as either Np(+4) and/or Np(+5), because the designation of a predominant form could not be made with complete certainty for the repository conditions.

The thermodynamic database for the FMT model contains information for three actinides oxidation states, i.e., Am(III), Th(IV), and Np(V). The solubilities predicted for the Th(IV) solids were used in the CCA also to represent soluble U(IV), Np(IV), and Pu(IV); an approach referred to in Appendix SOTERM as the oxidation state analogy. This approach is reasonable in that it is generally recognized that actinides with the same oxidation state have similar chemical properties because of their similarities in charge density. Also, ThO_2(am), which was used to represent Th(+4), is generally expected to be more soluble than solid forms of U(+4), Np(+4), and Pu(+4), that might be expected to form under repository conditions solubility, making it conservative choice as the basis for the +4 actinide analogy (Felmy et al., 1996; Novak 1996a; Novak 1996b; Novak 1996c). The FMT model contains no data for U(+6), hence it was estimated by an alternative method.

In summary, EPA concurred that the sampling of oxidation distribution states is appropriate, and that the redox conditions of the repository will likely be reducing rather than oxidizing. EPA also agrees that chemical equilibrium models are appropriate for predicting the concentrations of actinides that might be reached in the brines infiltrating into the repository. EPA has conducted a thorough evaluation of the conceptualizations and methodology used by DOE to calculate the solubilities of actinides under equilibrium conditions (EPA 1998d).

One of the primary findings of EPA's evaluation was that DOE considered magnesite (magnesium carbonate) as the primary product of hydrolysis and carbonation of the magnesium oxide backfill rather than the more probable phase of hydromagnesite (hydrated magnesium carbonate). This distinction was considered potentially important because the phase that is considered determines the equilibrium pH and partial pressure of CO_2gas—factors that affect the solubilities of actinide solids. Consequently, EPA conducted an evaluation of actinide solid solubilities for conditions of hydromagnesite equilibria compared to magnesite equilibria; see EPA Technical Support Document for Section 194.24: EPA's Evaluation of DOE's Actinide Source Term (EPA 1998d). The results of this evaluation indicate that although hydromagnesite was probably the most appropriate phase, the solubility values for hydromagnesite equilibria are not greatly different from those obtained for magnesite equilibria.

The PAVT was run using values for hydromagnesite equilibria (see Table 4 below). Since delivering the CCA to EPA on October 29, 1996, DOE has performed experiments that indicate that hydromagnesite is a primary product of reactions between MgO and brines. (Chemical Conditions Model: Results of the MgO Backfill Efficacy Investigation, April 23, 1997, Sandia National Laboratories, Docket A-93-02, Item II-A-39)

Table 4
EPA's Actinide Solubilities Calculated with the Computer Code FMT

Oxidation state	Formation Brine	EPA's FMT Calculated Concentrations (molar)
+6	Salado	8.8×10^{-5}*
+6	Castile	8.8×10^{-5}*
+5	Salado	4.8×10^{-7}
+5	Castile	2.4×10^{-7}
+4	Salado	4.1×10^{-8}
+4	Castile	1.3×10^{-8}
+3	Salado	1.3×10^{-8}
+3	Castile	1.2×10^{-7}

* Concentrations for +6 actinides (i.e., U(VI)) were not calculated from solubilities but were estimated (see below).

During EPA's re-run of the FMT code to calculate actinide solubilities under conditions of equilibrium with different magnesium carbonates phases, errors were identified in the FMT database for some ion-interaction parameters, particularly for Th(IV). Also, in the period of time between the submission of the CCA and EPA's assessment, revisions of the FMT database were made. With the correction of the Th(IV)-related parameters and inclusion of other revisions to the FMT database, the concentrations of actinides obtained from the FMT code by EPA's assessment were generally lower than those presented in the CCA. Consequently, EPA views the concentrations in the CCA as conservative.

The concentration of the +6 actinide, U(VI), was not calculated from solid phase solubility with the FMT model as were the other actinides because solubility and aqueous speciation data for U(VI) were judged by DOE not to be sufficiently reliable for making predictions. As a result, a single concentration of 8.8×10^{-6} molal was selected by DOE to represent U(VI) in the actinide source term model. This concentration is based on an assessment by Hobart and Moore (1996) of U(VI) solubility experiments conducted with brines at pH 10 in the absence of CO_2(g).

EPA questioned the validity of selecting a single concentration for representing U(VI) concentrations in the repository and calculated U(VI) concentrations that might be expected for equilibrium with potential solubility controlling solids such as schoepite, sodium uranate, and calcium uranate. The concentrations calculated for alkaline pH conditions expected in the presence of the MgO backfill were generally lower than the value of 8.8×10^{-6} molal used by DOE. Also, experimental results from Reed and Wygmans (1997) made available since submission of the CCA have indicated that the U(VI) concentrations at equilibrium with as yet unidentified solids are generally lower than 8.8×10^{-6} molal, and consistent with the solubilities expected for sodium or calcium uranate phases. While not conclusive (because of the differences in ionic strengths), additional calculations of U(VI) in a lower ionic strength solution also point to lower solubilities than those used in the CCA PA (Bynum 1997). Based on this cumulative evidence, EPA considered the concentration of U(VI) at 8.8×10^{-6} molal a reasonable upper bound for U(VI) concentrations in the WIPP brines.

EPA also examined the methodology developed by DOE to assign uncertainty limits to the concentrations of actinides predicted from solubility calculations. These uncertainty limits were determined by DOE to range from 1.4 log units above to 2.0 log units below the actinide concentrations calculated from solubility expressions contained in the FMT model. In the PA, actinide concentrations are allowed to range between these upper and lower bounds with a mean value set at the concentration calculated from actinide solubilities. DOE defined uncertainty limits based on the differences between measured concentrations and those predicted for the solubilities of discrete actinide solids based on thermodynamic parameters contained in the FMT and NONLIN computer codes (Bynum 1996b). These differences were measured for a number of experimental studies of the solubilities of different actinide solids in high ionic strength solutions. Based on criteria of data adequacy, Bynum (1996b) used data only from solubility experiments with +3 and +5 actinides to construct the uncertainty distributions. EPA recognizes that the uncertainty distribution calculated in this manner is most relevant to the +3 and +5 actinides. However, this does not necessarily mean that the distribution is arbitrarily narrowed to exclude the uncertainty that might be expected for +4 and +6 actinides. In fact, because the uncertainty distribution is based on direct comparisons between predicted and observed data from actinide solubility experiments, it is expected to provide a reasonable depiction of the uncertainty in calculations of actinide solubilities made with the FMT model.

Formation of Colloid Suspensions

EPA reviewed DOE's characterization and parameterization of microbial, humic, actinide intrinsic, and mineral colloids and identified uncertainties in those two areas. However, EPA concluded that the parameterization for actinide intrinsic and mineral colloids was adequate for use in the PA due to the low sensitivity of colloids in EPA's Sensitivity Analysis. EPA also questioned the specific values for the humic proportionality and cap values (Docket A-93-02, Item II-I-17), but EPA considered these issues in light of the results of the EPA Sensitivity Analysis and determined that the current values within the PA were satisfactory; see EPA Technical Support Document for Section 194.23: Sensitivity Analysis Report (EPA 1998a).

EPA analyzed microbial colloid development and concluded that the microbial colloid proportionally constants used by DOE have ~~significant~~ uncertainties associated with their characterization. EPA also concluded that while the values used in PA could be more appropriate, the Performance Assessment results are relatively insensitive to them.

EPA questioned whether the adsorbed actinides were accounted for in PA, noting that colloidal formation can either enhance or retard actinide movement (Docket A-93-02, Item II-I-17). DOE responded that sorption of this nature was not considered in PA, and the assumption of a lack of sorption was considered a beneficial consequence of Performance Assessment (Docket A-93-02, Item II-I-24). EPA agrees that sorption may occur in the repository and that DOE's approach would result in higher releases than if sorption were considered and is therefore conservative.

Production of Gas from the Waste

See the discussion in **CARD 23—Models and Computer Codes** and EPA Technical Support Document for 194.23: Models and Computer Codes (EPA 1998e) under the topic of the gas generation conceptual model. For discussion of the development of parameters which represent waste characteristics/components such as: gas generation, waste shear strength, compactability, particle diameter, and radioactivity, see EPA Technical Support Document for 194.23: Parameter Justification Report (EPA 1998b).

Peer Review

EPA agreed with the independent Waste Characterization Peer Review Panel's findings regarding heterogenous source term. EPA also agreed with the Panel's finding on waste loading and so questioned DOE on whether or not waste would be loaded randomly as modeled in the PA and the impact if any of non-random loading. (Docket A-93-02, Item II-I-17). DOE's response to the question included CCDF curves for non-random waste loading that were well below EPA's limit and thus supported DOE's contention that it does not matter whether random or non-random waste loading is assumed for the purposes of PA.

EPA agreed with the Panel that DOE's additional experiments pertaining to MgO helped to address concerns regarding median actinide solubility values and MgO chemistry as it pertains to actinide solubility. EPA agreed that supplemental information provided by DOE was sufficient to answer questions regarding CH_4 and CO_2, since the effects of CO_2 production relative to repository pressure build-up and pH buffering are mitigated via the presence of MgO. Further, EPA agreed with the Panel's conclusion that DOE's supplemental information adequately addressed the Panel's questions regarding waste compactability, waste strength, and waste porosity, although EPA also recognized that the actual values for waste strength needed to be modified by EPA in the PAVT. See EPA's Technical Support Document for Section 194.23: Parameter Justification Report for additional information (EPA 1998b).

EPA agreed with the Panel's conclusion that DOE's argument regarding organic ligand complexation with transition metals is sufficient. The Panel concluded that DOE's supplemental argument in Appendix SOTERM (which was not provided to the first Panel) regarding organic ligand uptake by transition metals was sufficient. EPA agreed that Appendices SOTERM and MASS provide a wealth of information not presented in the version of Appendix WCA provided to the first Peer Review Panel. EPA, however, examined the issue of organic ligand complexation thoroughly and concluded that organic ligand complexation was assessed appropriately by DOE. See Section 194.24(b)(3) of this CARD for additional discussion of organic ligand complexation.

24.C.1 REQUIREMENT

(b) The Department shall submit in the compliance certification application the results of an analysis which substantiates:

(2) That all waste components influencing the waste characteristics identified in paragraph (b)(1) of this section have been identified and assessed for their impact on disposal system performance. The components to be analyzed shall include, but shall not be limited to: metals; cellulosics; chelating agents; water and other liquids; and activity in curies of each isotope of the radionuclides present.

24.C.2 ABSTRACT

DOE indicated that the components identified below were expected to have a significant effect on disposal system performance and so were used in PA:

- Ferrous metals
- Cellulose and other chelating agents as they pertain to enhanced actinide mobility
- Radioactivity in curies of each isotope
- $\propto$-emitting TRU radionuclides, $t_{1/2} > 20$ years ($t_{1/2}$ is the half-life)
- Radionuclides
- Solid waste components (cementitious materials)
- Sulfates and
- Nitrates.

Appendix WCA of the CCA includes tables showing waste components used in PA (Tables WCA-1 through WCA-3), as well as a table presenting waste components that were assessed but not included in PA (Table WCA-4).

EPA's review of the values for these waste components showed that they are consistent with inventory values presented in Appendix BIR (see Section 194.24(a) of this CARD for additional discussion of inventory values). EPA evaluated the average and bulk density values used in the PA for cellulosics, plastics, and rubber based upon Appendix BIR values, and found the values used by DOE to be consistent with and therefore supported by Appendix BIR. See EPA Technical Support Document for Section 194.24: WIPP Facility and Waste Characterization (EPA 1998c) for further discussion of EPA's assessment of DOE's inventory values.

The solid waste components which affect compactability and shear strength were considered by DOE when assigning characteristic-related values used in PA. EPA examined the values for related parameters and recommended changes to some (e.g., TAUFAIL). Refer to **CARD 23—Models and Computer Codes** and associated Technical Support Documents for additional information.

24.C.3 COMPLIANCE REVIEW CRITERIA

Refer to Section 194.24(b)(1) of this CARD for criteria pertinent to Sections 194.24(b)(1) through (b)(3).

24.C.4 DOE METHODOLOGY AND CONCLUSIONS

Appendix WCA of the CCA includes tables that present DOE's determination of waste components used in PA (Tables WCA-2 and WCA-3), as well as a table presenting waste components that were assessed but not included in PA (Table WCA-4). See Section 194.24(b)(1) of this CARD for a summary of analyses performed by DOE to identify waste components and characteristics.

Waste Components Retained

DOE indicated that the components identified below in Table 5 were expected to have a significant effect on disposal system performance and were used in PA (Table WCA-2, pp. WDA-9 to WCA-10).

Table 5
Selected Waste Components and Characteristics and Their Effect on PA

Component	Characteristic Affected by the Component	Effect on PA
Ferrous metals	Redox potential and gas generation	Affect actinide oxidation state, actinide solubility/mobility , and gas generation/pressure via hydrogen production
Cellulosics and chelating agents (rubber/plastics)	Microbial substrate: methane generation and colloid development	Increase in gas pressure and actinide mobility
Radioactivity in curies of each isotope	Radioactivity in curies of each isotope	Used in calculating normalized releases
∝-emitting TRU radionuclides, t1/2 > 20 years	TRU radioactivity at closure	Determines waste unit factor
Radionuclides	Redox state and solubility	Actinide mobility
Solid Waste Components	Compactability, shear strength, particle diameter	Effect on creep closure, cuttings, cavings and spallings release
Sulfates	Microbial gas generation; methane production	Increase in gas pressure
Nitrates	Microbial gas generation; methane production	Increase in gas pressure

DOE indicated that the following components were used in PA but were not expected to have a significant effect on disposal system performance (Table WCA-3, p. WCA-11):

- Solid waste components related to waste permeability and porosity.

- Water in the waste.

DOE also considered the effects of sulfates, nitrates, cellulosics, plastics, and rubber as they pertain specifically to CH_4 and CO_2 generation. DOE concluded that while gas would be generated due to the presence of these components, the effects of CO_2 production would be greatly reduced by the impact of MgO backfill and therefore would not significantly affect disposal system performance. However, their impact on gas pressurization due to CH_4 production was still expected to significantly affect disposal system performance (Tables WCA-2 and WCA-3). Section 194.24(b)(2) also required DOE to examine the effects of chelating agents, including organic ligands. DOE evaluated organic ligands and concluded that they would have minimal impact on disposal system performance due to the presence of other metals, such as nickel, which would selectively bind with the organic ligands. As such, DOE excluded organic ligands from consideration in PA; see Section 194.24(b)(3) of this CARD for additional information.

Figure WCA-1 (p. WCA-13) in Appendix WCA shows DOE's interpretation of how waste components and associated characteristics contribute to PA codes. The waste components and/or characteristics identified as being important to system performance are included as parameters in the PA.

Assessment of Waste Components and Waste Component Input Parameters

The following subsections discuss the waste components identified as important to PA, as well as the input parameters to which they relate.

Ferrous Metals

DOE found that the ferrous metal content of steel drums directly affects gas generation via corrosion. Steel drums also contain nonferrous metals that will selectively bind with organic ligands as a result of the corrosion process (Appendix WCA, Section WCA.5.1, p. WCA-36). DOE indicated that additional metals, such as aluminum, may also affect gas generation, but are present in such small quantities that it is not necessary to consider their effect on repository performance (Appendix WCL, p. WCL-4). Refer to Section 194.24(c) of this CARD for discussion of waste limits pertaining to ferrous metals. DOE assumed values for ferrous metal quantity that were both modeled and mandated by minimum waste limits equivalent to the total quantity available in WIPP CH waste containers (Table WCL-1, P. WCL-2).

Performance Assessment Parameters Related to Ferrous Metals

DOE imposed a minimum limit of ferrous metals of 2 E+7 kg to ensure that reducing conditions will prevail in the repository, which is in turn a necessary condition for the modeled actinide oxidation states. In addition, DOE recognized that gas generation via corrosion is dependant upon the bulk density of iron containers as well as the average density of iron-based material in RH and CH wastes. DOE therefore included the following parameters in PA (Appendix PAR, Table PAR-38, p. 223):

- DIRNCCHW, bulk density of iron containers, CH waste: 1.36 E+2 kg/m3.
- DIRNCRHW, bulk density of iron containers, RH waste: 2.59 E+3 kg/m3.
- DIRONCHW, average density of iron-based waste, CH waste: 1.7 E +2 kg/m3.

- DIRONRHW, average density of iron-based waste, RH waste: 1.0 E +2 kg/m3.

<u>Cellulosics and Chelating Agents</u>

DOE concluded that the cellulosics, plastics, and rubber content of waste directly affects CO_2 and CH_4 gas generation (Table WCA-2). DOE therefore limited the quantity of cellulosics that may be emplaced in the WIPP to 2 E+7 kg. This value takes into account the quantity of MgO that must be emplaced in the WIPP to mitigate sufficiently the amount of CO_2 generated due to the presence of cellulosics (Appendix WCL, Section WCL.3, pp. WCL-4 to WCL-5). DOE also recognized that chelating agents would be present in the waste, but concluded that their impact would be minimal due to the presence of metals that would selectively bind with the organic ligands.

DOE identified the principle non-radioactive components to include those affecting gas generation (Section WCA.5.1, pp. WCA-36 to WCA-38)—specifically, cellulosics, iron, plastics, rubbers, nitrates, and sulfates—although DOE contended that the impact of carbon dioxide generation will be mitigated through the addition of MgO via buffering of pH. DOE implied that CH_4 will be a major microbe-generated gas that will contribute to repository pressure, since CO_2 will be sequestered (Tables WCA-2 and WCA-3).

<u>Performance Assessment Parameters Related to Cellulosics and Chelating Agents</u>

DOE limited the quantity of cellulosics that may be present in WIPP waste; refer to Appendix WCL, Section WCL.3 (pp. WCL-4 to WCL-5) for additional information. DOE also recognized that the density of plastics, rubber, and cellulosics for both RH and CH waste affect gas generation values and so are important to PA. DOE included the following parameters in PA (Table PAR-38, p. 223):

- DCELLCHW, average density of cellulosics, CH waste: 5.4 E +1 kg/m3
- DCELLRHW, average density of cellulosics, RH waste: 1.7 E + 1 kg/m3
- DPLASCHW, average density of plastics, CH waste: 3.4 E +1 kg/m3
- DPLASRHW, average density of plastics, RH waste: 1.5 E +1 kg/m3
- DRUBBCHW, average density of rubber, CH waste: 1.0 E + 1 kg/m3 and
- DRUBBRHW, average density of rubber, RH waste: 3.3 E +0 kg/m3.

In addition, the bulk density of plastic liners was used in PA:

- DPLSCCHW, bulk density of plastic liners, CH waste: 2.6 E +1 kg/m3 and
- DPLSSRHW, bulk density of plastic liners, RH waste: 3.1 E +0 kg/m3.

Radioactivity and Radionuclides

DOE concluded that the curie content of waste is a very significant component for PA. Appendix WCA, Section WCA.3, states that actinide activity is important because of how it affects the waste unit factor and the source term. As discussed in **CARD 31—Application of Release Limits**, only TRU radionuclides contribute to the waste unit factor. However, DOE included all radionuclides in the PA source term (p. WCA-16). Curie content was calculated at varying times during the regulatory time period and then used to calculate the potential cumulative curie release.

Inclusion of a radionuclide in the source term required analysis of two different pathways: direct releases and releases to the accessible environment through the subsurface (e.g., Culebra) (Section WCA.3.2, p. WCA-21). DOE selected different radionuclides for these pathways; see Section 194.24(b)(1) of this CARD for additional information regarding DOE's selection process. DOE included 10 isotopes in direct release by cuttings, cavings, and spallings, for which they also calculated curie content (Section WCA.3.2.1, Figure WCA-4):

- ^{238}Pu, ^{239}Pu, ^{240}Pu, and ^{241}Pu
- ^{241}Am
- ^{233}U, ^{234}U
- ^{90}Sr
- ^{137}Cs and
- ^{244}Cm.

DOE included the following radionuclides in direct brine release, for which they also calculated curie content (Section WCA.3.2.2, Figure WCA-4):

- ^{238}Pu, ^{239}Pu, ^{240}Pu, ^{241}Pu, ^{242}Pu
- ^{241}Am, ^{243}Am
- ^{233}U, ^{234}U, ^{235}U, ^{236}U, ^{238}U
- ^{229}Th, ^{230}Th, ^{232}Th
- ^{237}Np and
- ^{243}Cm, ^{244}Cm, ^{245}Cm.

DOE included the following radionuclides in long-term groundwater release, for which they also calculated curie content (Section WCA.3.2.3, Figure WCA-4):

- ^{239}Pu, ^{240}Pu, ^{242}Pu
- ^{241}Am
- ^{233}U, ^{234}U and
- ^{229}Th, ^{230}Th.

DOE stated that the 10 isotopes listed in cuttings/cavings/spallings releases are appropriate because the release is assumed to occur when containers of CH and/or RH waste are breached during a borehole intrusion. DOE also addressed source term determination under these release scenarios (Sanchez et al., 1997). DOE included eight of the 10 isotopes listed in cuttings/cavings/spallings on this list because they comprise more than 99.9 percent of EPA units for the entire regulatory period, and included the remaining two because they are parent nuclides of significant daughters. DOE also concluded that the addition of the radionuclides that make up the final 1 percent would not affect the WIPP's compliance (Appendix WCA, Section WCA.3.2.1, p. WCA-22).

DOE found that in direct brine releases to ground surface, radionuclides are dissolved in brine. Direct brine releases include several isotopes that have a negligible effect on the total EPA unit, but must be included in the source term because of their influence on the total quantity of dissolved radionuclides. DOE stated that exclusion of ^{90}Sr and ^{137}Cs is appropriate because although these radionuclides constitute a relatively large EPA unit, they decay rapidly and will not affect PA. DOE noted that the half-lives of ^{90}Sr and ^{137}Cs are about 30 years, therefore active institutional controls over 100 years will permit significant decay of these radionuclides prior to an intrusion (Section WCA.3.7.2, pp. WCA-22 to WCA-26). For further discussion of active institutional controls, see **CARD 41 - Active Institutional Controls**.

DOE included both dissolved and colloidal radionuclide components in releases to the Culebra. DOE selected eight radionuclides for long term releases, including those radionuclides that dominate EPA unit for "all but the earliest part of the regulatory period" (p. WCA-27). DOE indicated that ^{239}Pu, ^{241}Am, ^{234}U, and ^{230}Th are transported separately in PA; isotopes of the same element are transported together, unless their half-lives differ greatly. DOE combined ^{233}U and ^{234}U because their half-lives are similar. ^{229}Th was combined with ^{230}Th because they have a fixed relative ratio to one another; ^{232}Th was dropped because it is a small fraction of EPA unit during the regulatory period. ^{240}Pu and ^{242}Pu were combined with ^{239}Pu due to their long half lives and fixed relative ratios. ^{238}Pu will have decayed to about 0.5 percent of its initial inventory after 700 years; DOE stated that its contribution to the EPA unit will be negligible and therefore combined its transport with the other Pu isotopes (Section WCA.3.2.3, pp. WCA-26 to WCA-27).

DOE indicated in Appendix WCA, Section WCA.4, that a number of components affect the characteristics of radionuclide solubility. Specifically, those components that affect the redox environment also control the oxidation state of the actinides (Section WCA.4.1.1). Components such as ferrous metals and biodegradable organic matter, which affect oxygen depletion, also influence the oxidation state of actinides (which exhibit different solubilities). Cellulosics, plastics, and rubbers are important waste components that affect redox environment and actinide solubility through pH enhancement of brine and colloid formation.

DOE recognized that pH and CO_2 fugacity significantly affect radionuclide solubility (Section WCA.4.1.2, p. WCA-32), but also stated that these characteristics would be controlled by the presence of MgO backfill. CO_2 produced by microbial degradation would alter system pH to about 4.5 without MgO; the addition of backfill buffers the pH to approximately 9.4 in Salado brines and 9.9 in Castile brines.

Performance Assessment Parameters Related to Radioactivity and Radionuclides

As discussed under Section 194.24(b)(1) above, DOE included the radioactivity of individual radionuclides in PA calculations. Appendix PAR, Table PAR-40, shows radionuclide parameters such as atomic weight, half life, and EPA release limits for each radionuclide included in the PA. Appendix PAR, Table PAR-41 (pp. PAR-233 and 234), shows the isotopic inventory for radionuclides included in the PA.

Solid Waste Components, Sulfate, Nitrate, and Water

DOE identified a number of waste components (See Table 5 above) that affect such physical characteristics of waste as compactability, shear strength, porosity, and permeability. DOE indicated that compactability and shear strength are waste characteristics which affect PA significantly, while porosity and permeability are waste characteristics which do not significantly affect PA. DOE stated that the presence of sulfate and nitrate influences the amount of gas generation, but claimed that PA results are not sensitive to gas generation. DOE thus bounded limits pertaining to sulfate and nitrate by the total quantity of cellulosics metabolized by microbes. Appendix WAC of the CCA limits the water content of the waste in order to control gas generation resulting from the presence of waste.

Performance Assessment Parameters Related to Solid Waste Components, Sulfate, Nitrate, and Water

DOE included parameters related to waste porosity and permeability (which are affected by all waste components) in PA; see **CARD 23—Models and Computer Codes** for parameter value discussion. DOE also included a fixed value for nitrate and sulfate in PA as stochastic gas generation parameters. DOE included nitrate as a parameter for nitrate (QINT), which represents the initial quantity of nitrate in waste as 2.61 E+7 moles. DOE also included QINT for sulfate as an initial quantity of 6.59 E+6 moles. A specific quantity of water was not included as a specific PA parameter, although the anticipated volume was included in initial brine saturation (parameter SAT_BRN = 1.5%, Table PAR-38). DOE used an initial free water emplacement limit of 1685 m^3, based upon the maximum WAC allowable free liquid (1% of total waste volume).

Additional Performance Assessment Parameters: Total CH and RH Inventory Values

The CCA included the total CH and RH inventories, scaled based upon actual and projected inventories and as controlled by other factors (e.g., limits specified in the Land Withdrawal Act). DOE states in Appendix PAR, Table PAR-38 (p. PAR-233) that the total volume of CH waste is 1.69 E +5 m^3, while the total volume of RH waste is 7.08 E +3 m^3. See Sections 194.24(a) and (g) of this CARD for further discussion of the waste inventory.

24.C.5 EPA COMPLIANCE REVIEW

EPA agrees that ferrous metals are important waste components relative to gas generation, and that iron will be present in abundance in waste containers shipped to WIPP. EPA also concurs with values used in PA for the density of iron. See EPA Technical Support Document for Section 194.23: Parameter Justification Report (EPA 1998b) for EPA's evaluation of parameter values, and EPA Technical Support Document for Section 194.23: Sensitivity Analysis (EPA 1998a) for EPA's sensitivity analysis. EPA also agrees that cellulosics will contribute to gas generation and that chelating agents (organic ligands) will bind to metals other than actinides. EPA's sensitivity analysis indicates that chelating agents and colloids are not important to performance. EPA's Technical Support Document for Section 194.23: Sensitivity Analysis (EPA 1998a) provides EPA's sensitivity analysis for related parameters such as cellulosic and plastic density. EPA Technical Support Document for Section 194.23: Parameter Justification Report (EPA 1998b) discusses DOE's selection of values for these parameters. EPA also notes that iron and cellulosic contents will be determined for each container intended for disposal in the WIPP through process knowledge and radiography and/or visual examination. See Section 194.24(c)(4) of this CARD for further discussion.

EPA agrees that radioactivity in curies of each isotope, alpha-emitting TRU radionuclides (with respect to TRU activity at closure), and radionuclides (with respect to redox state and solubility) are important waste components. EPA's review of the CCA indicated that DOE did not adequately consider the entire waste inventory when determining the total curie content anticipated at closure. DOE provided supplementary information pertaining to this issue in which DOE concurred with EPA that the waste unit factor at closure (2033) was 3.59, not 3.44, as stated in Chapter 4 (p. 4-26). EPA concluded that these values did not result in a significant difference in CCDF curves and did not affect EPA's assessment of the WIPP's compliance. See **CARD 31—Application of Release Limits** for further discussion of the estimated curies of each radionuclide in the disposal system at the time of disposal.

EPA found that the specific actinide activities selected by DOE were consistent with those presented by generator sites (and, in the case of cuttings values, modified in accordance with modifications presented in the BIR), and that values used in PA were appropriately decayed to the closure date. EPA also notes that DOE will determine the activity of the important radionuclides in each waste container through process knowledge and non-destructive assay.

EPA concurs with DOE's assessment that solid waste components, sulfates, and nitrates are potentially important to the WIPP's performance. However, EPA questioned DOE's values of shear strength and particle diameter as related to solid waste components. As a result, EPA required the use of alternative values for these parameters in the PAVT; see **CARD 23—Models and Computer Codes** for EPA's evaluation of the PAVT results and EPA's Technical Support Document for Section 23: Parameter Justification Report (EPA 1998b) for EPA's justification of parameter revisions. EPA concurs with DOE's values for sulfates and nitrates because they are consistent with those presented in the BIR.

Table WCA-4 lists those characteristics and components not considered in PA and identifies where in Appendices SCR and WCA the supporting justification is contained. Based on the review described above, EPA concludes that DOE has considered the effects of each component appropriately.

DOE had reported in Appendix SOTERM that organic ligands are not expected to affect the aqueous speciation of actinides, given anticipated repository conditions, because of competition for the ligands with major solutes in the brine and metal ions derived from corrosion of waste materials. However, the calculations described in Appendix SOTERM were not well documented and could not be reproduced for brines. Consequently, EPA conducted an independent evaluation of the effects of organic ligands by conducting modeling runs to examine the effects of EDTA on the aqueous speciation of Th(IV) and the solubility of ThO_2(am); see EPA Technical Suport Document for Section 194.24: EPA's Evaluation of DOE's Actinide Source Term (EPA 1998d). The solid phase, ThO_2(am), is the expected solubility-controlling phase for Th(IV) in the repository environment. EDTA was considered because it has the greatest affinity for forming aqueous complexes with the actinides compared to acetate, citrate, and oxalate.

The modeling runs indicated that the EDTA concentration would have to increase by at least 1,000 times the maximum concentrations expected for the repository to produce an appreciable change in the aqueous speciation of Th(IV) and solubility of ThO_2(am), and this range was limited primarily to acidic pH conditions. At the pH conditions of 9 to 10 that are relevant to the repository with MgO backfill, the EDTA was complexed predominantly by Ca and Mg ions. These results imply that the organic ligands are unlikely to affect the mobilities of the actinides. Another study, performed independently of the WIPP project, of actinide chemistry at high pH in the presence of various organic ligands, including EDTA, reported results consistent with those described here, i.e., that the ligands do not appear to have a strong effect on the aqueous speciation of actinides because of competition with major ions that are present at much higher concentrations (Hummel 1993).

24.D.1 REQUIREMENT

(b) "The Department shall submit in the compliance certification application the results of an analysis which substantiates:

(3) Any decision to exclude consideration of any waste characteristic or waste component because such characteristic or component is not expected to significantly influence the containment of the waste in the disposal system."

24.D.2 ABSTRACT

DOE provided a listing of those waste characteristics and components that were excluded from consideration in the PA for various reasons, such as negligible impact. EPA examined DOE's exclusion of the specified waste characteristics and components to determine whether DOE excluded them appropriately.

24.D.3 COMPLIANCE REVIEW CRITERIA

Refer to Section 194.24(b)(1) of this CARD for criteria pertinent to Sections 194.24(b)(1) through (b)(3).

24.D.4 DOE METHODOLOGY AND CONCLUSIONS

DOE provided a list of those waste characteristics and components that were excluded from consideration in the PA for various reasons, such as negligible impact (Appendix WCA, Table WCA-4). These characteristics and components included the following:

Characteristic	Component	Reason Excluded
cellulosic radiolysis	radionuclides	negligible effect on total CO_2
explosivity	other organic compounds	no effect
brine radiolysis	radionuclides	negligible effect on actinide valence
galvanic action	nonferrous metals	negligible effect on PA
complexation with actinides	soil/humic material	actinide mobility
buffering action	cement	negligible; reacts w/CO_2 and $MgCl_2$
heat of solution	cement	negligible effect on PA
Ca^{2+} binding-organic ligands	cement	negligible compared to other metals
buffering action	ferrous metals	would reduce actinide mobility
galvanic action	ferrous metals	negligible effect on PA
binding to organic ligands	ferrous alloy components	can reduce actinide mobility
redox reactions	nonferrous metals	negligible compared to iron
binding to organic ligands	nonferrous metals	can reduce actinide mobility
complexation with actinides	organic ligands	negligible effect on PA
gas generation	Al, other non-ferrous metals	negligible effect relative to steels
microbial nutrients, CO_2 generation	phosphates	negligible due to MgO-CO_2 reaction
microbial nutrients CH_4 generation	phosphates	negligible

heat generation	RH-TRU	negligible
electrochemical processes	sulfate, nitrate, phosphate	negligible

Organic ligands were identified by DOE as components that could potentially affect actinide solubility, but were screened out of PA because DOE concluded that there would be sufficient non-actinide metals in the WIPP waste inventory to complex organic ligands preferentially over actinides (Appendix SOTERM, Section SOTERM.5, pp. SOTERM-36 to SOTERM-41).

DOE presented information pertaining to organic ligands in Appendix SOTERM (Section SOTERM.5), and also presented summary information concerning organic ligands in a July 30, 1997, meeting with the Environmental Evaluation Group (EEG) that EPA observed (DOE 1997k). In this meeting, DOE reiterated that the Peer Review Panel agreed with DOE that organic ligands as chelating agents will have a negligible effect on repository performance. DOE stated that WIPP-specific information was used by DOE, including very conservative inventory estimates of the primary organic ligand of concern, i.e., EDTA. EDTA is the primary ligand of concern because it was used far more than any other organic ligand and it is highly reactive DOE also stated that it assumed: 1) all organic ligand inventory values (e.g., EDTA from Rocky Flats inventory) were included in TRU waste, but not other waste (e.g., low-level); 2) no thermal treatment would be performed to remove EDTA; and 3) no degradation or sorption of EDTA or other organic ligands would occur. DOE's conclusions showed no significant effect of organic ligands on the solubility of actinides, even when a bounding analysis was performed assuming EDTA calculations well above those used in PA (Docket A-93-02, Item II-D-115).

24.D.5 EPA COMPLIANCE REVIEW

Table WCA-4 lists those characteristics and components not considered in the performance assessment, and references locations in Appendices SCR and WCA where supporting justification is contained. EPA concludes that exclusion of the characteristic or component was appropriate because DOE considered the effects on repository performance of each component appropriately.

EPA evaluated DOE's assumptions, calculations and experimental results and had questions pertaining to assumptions and conclusions made by DOE that were posed in EPA's December 19, 1996, letter to DOE (Docket A-93-02, Item II-I-01). EPA's concerns centered around DOE's exclusion of the affects of organic ligands (in particular EDTA) on repository performance because EPA found DOE's justification for exclusion to appear technically weak. In particular, DOE did not: 1) appropriately justify the inventory assumptions regarding EDTA; 2) explain clearly why complexation with actinide species would not occur; and 3) justify clearly the assumptions that sufficient nonferrous metal ions (such as Nickel) would be available to preferentially complex with the EDTA thus excluding complexation with the actinide species For example, EPA required DOE to provide additional information pertaining to computer codes used to calculate equilibrium constants for organic ligands. DOE responded that the results of this modeling were not used in PA, although experimental data were used (Docket A-93-02, Item II-I-24). The CCA states that complexation calculations were performed for a single organic ligand, EDTA, and 99.8% of the EDTA was complexed by nickel that is present in the system through liberation via steel corrosion. However, the CCA does not discuss the assumption of nickel (or other metal) availability, except to say that "significant amounts of uncorroded metal in the repository (could be present) throughout the 10,000-year regulatory period" (p. SOTERM-19).

EPA found that the mechanisms concerning organic ligands' behavior that DOE postulated came from fundamental principals existing in relevant literature and is particularly well established. EPA performed a bounding analysis assuming EDTA volumes up to approximately 1000 times that used by DOE. This analysis showed that the solubility of the modeled actinide was unaffected by EDTA quantity at repository pH and pCO_2 (EPA 1998d). EPA therefore concludes that DOE's treatment of organic ligands in the PA is adequate.

24.E.1 BACKGROUND FOR 194.24(c)(1)

As specified in § 194.24(b)(2) of the Compliance Criteria, DOE was required to conduct an analysis that identifies waste components important to PA. Section 194.24(c) addresses the identification of waste limits associated with these critical components, as well as how the limits are included in PA (§ 194.32) and compliance assessments (§ 194.54). In addition, DOE must specify how waste components will be quantified, tracked and controlled, and how quality assurance is applied.

Waste identification, quantification, tracking, and control are critical elements of DOE's waste characterization program. Activities performed by DOE to demonstrate compliance with 194.24(c) describe the progression from characterization of the WIPP waste at the generator site, through waste control, waste tracking, and WIPP inventory identification and management.

Waste limits are mandatory quantities of waste components, such as cellulosics and metals, that must be emplaced in the WIPP to ensure conformance to inputs used in the PA. Either upper or lower component quantities have been established for waste components whose quantities must be controlled to ensure that waste emplaced within the WIPP is consistent with the input assumptions used in PA. Refer to Section 194.24(b)(2) of this CARD for a discussion of the waste components identified by DOE. The final rule requires that upper and lower limits be based on the total inventory proposed for disposal such that the results of a PA will comply with the containment requirements of 40 CFR 191.13 when these values are used. As waste is emplaced in the WIPP, a running total must be kept of each waste component. In this fashion, DOE may track the quantity of each waste component that has been emplaced in the repository so that the upper limits will not be exceeded or, alternatively, that the total emplaced quantity of any waste component will not be precluded from eventually reaching its lower limit.

24.E.2 REQUIREMENT

c) "For each waste component identified and assessed pursuant to paragraph (b) of this section, the Department shall specify the limiting value (expressed as an upper or lower limit of mass, volume, curies, concentration, etc.), and the associated uncertainty (i.e., margin of error) for each limiting value, of the total inventory of such waste proposed for disposal in the disposal system. Any compliance application shall:

(1) Demonstrate that, for the total inventory of waste proposed for disposal in the disposal system, WIPP complies with the numeric requirements of §194.34 and §194.55 for the upper or lower limits (including the associated uncertainties), as appropriate, for each waste component identified in paragraph (b)(2) of this section, and for the plausible combinations of upper and lower limits of such waste components that would result in the greatest estimated release."

24.E.3 ABSTRACT

EPA expected the CCA to specify the limiting value of a given waste component, note whether it is an upper or lower limiting value, and provide the uncertainty associated with each value. EPA also expected DOE to provide: plausible combinations of upper and lower limits and a rationale for these limits; the results of modeling code runs; the demonstration of numeric compliance; and the greatest release estimates.

DOE identified four waste component groupings that require limitations. These waste component~~s~~ groupings and their limiting values are:

- Ferrous metals (iron)—minimum of $2x10^7$ kilograms
- Cellulosics, rubber, and plastic—maximum of $2x10^7$ kilograms total
- Free water emplaced with waste—maximum of 1684 cubic meters and
- Nonferrous metals (metals other than iron)—minimum of $2x10^3$ kilograms

DOE did not provide the associated uncertainty for the waste component limits in the CCA and plausible combinations of lower and upper waste limits (and associated uncertainties). DOE stated that the waste component limits are fixed values with no associated uncertainties. DOE also stated that the plausible combinations of upper and lower limits are equivalent to the fixed values selected and included in this manner in the PA calculations. DOE asserted that the combination of selected limits that resulted in the greatest estimated release was used in the analysis.

EPA evaluated the waste limits provided by DOE and determined that the appropriate components requiring limitation were identified and that the applied waste limits were sufficient. EPA believes that DOE adequately addressed questions raised by the Agency regarding uncertainties, the presentation of upper/lower limits, and plausible combinations of these limits. EPA found that the CCA adequately described model code runs, maximum calculated releases, and release estimates. EPA determined that while the waste limit values were not direct inputs into the PA, the waste components were closely associated with other input parameters that, in effect, captured the limitation intended by the waste limit.

24.E.3 COMPLIANCE REVIEW CRITERIA

As stated in the CAG (pp. 31-32), EPA expected the compliance application to:

- ♦ Specify the limiting value of the waste component.
- ♦ Note whether the limiting value is an upper or lower limiting value.
- ♦ Provide the associated uncertainty with each waste component limiting value.

EPA expected the waste related inputs to computer models identified pursuant to § 194.24(b)(1) to be clearly related to the waste components identified under § 194.24(b)(2). Further, this relationship should result in the specification of delimiting values for each of the waste components (maxima or minima, as appropriate), so that there is a clear connection between the waste related code inputs used to model performance and the components of the waste inventory.

For example, actinide solubility is modeled using assumptions about various components of the inventory (chelating agents, buffers, acids, bases, salts, etc.) that may influence solubility. Fulfillment of this requirement for the waste characteristic of actinide solubility would involve the specification of the limiting value for solubility, with the range of the components affecting solubility that are expected to be part of the total inventory.

EPA also expected any compliance application to provide:

- ♦ A description of the plausible combinations of upper and lower limits of waste and their associated uncertainties.
- ♦ A rationale for the selection of these combinations.
- ♦ The results of a modeling run of the code, using values as input parameters corresponding to values of waste components fixed at the limiting values.
- ♦ A demonstration that the results of the analysis show that the disposal system complies with the numeric requirements under these conditions.
- ♦ Documentation that the combination of the selected limits result in the greatest estimated release.

24.E.4 DOE METHODOLOGY AND CONCLUSIONS

<u>Identification of Waste Component Limiting Values</u>

Section 4.2.2 (p. 4-27) and Table 4-10, and Appendix WCL (Table WCL-1) of the CCA specified the four waste component groupings that DOE believed required limiting values, expressed as mass or volume for four waste component groupings. Maximum or minimum

limiting values were identified. These waste components groupings, their limiting values, and their designations were:

- Ferrous metals (iron), minimum of $2x10^7$ kilograms.

- Cellulosics, plastics and rubber: maximum of $2x10^7$ kilograms total.

- Free water emplaced with waste, maximum of 1684 cubic meters.

- Nonferrous metals (metals other than iron), minimum of $2x10^3$ kilograms.

DOE stated that ferrous iron was required to ensure oxygen reducing conditions within the repository, and that the quantity of iron in WIPP containers would be sufficient for this purpose. The established ferrous iron limit is therefore consistent with the quantity of ferrous iron of which WIPP waste containers are comprised (WCL.2, p. WCL-4). The cellulosic/plastic/rubber limit was imposed to ensure that the emplaced quantity would not exceed the reaction capabilities of MgO backfill, which will be emplaced to mitigate the effects of CO_2 generation via cellulosic, rubber, and plastic degradation (WCL.3, p. WCL-5). Free water limits are consistent with the WIPP WAC restriction of less than 1% by volume (WCL.5, p. WCL-6, and DOE 1996c). Nonferrous metal limitations were imposed to ensure availability of non-ferrous metals for preferential binding with organic ligands (WCL.2, p. WCL-4).

Uncertainty

The limiting value is expressed as an upper or lower limit of mass, volume, curies, or concentration. The limiting values identified are minimum or maximum threshold limits for the waste material parameters based on PA requirements for the disposal system. (Docket A-93-02, Item II-G-02). For example the amount of ferrous components in the disposal system must be sufficient to ensure a reducing environment. (See CCA Appendix WCL, pp. WCL-4 and WCL-5 for a general discussion of the limiting factors) Examples of assumptions and the qualitative uncertainties that were made in developing limiting values are found in the CCA, Appendix SOTERM, p. 35. DOE stated that the waste component limits are fixed values with no associated uncertainties. DOE also stated that the plausible combinations of upper and lower limits are equivalent to the fixed values selected and included in the CCA PA calculations. Therefore, DOE asserted the combination of selected limits that result in the greatest estimated release was used in the analysis.

Plausible Combinations of Upper and Lower Limits

The CCA did not specifically address plausible combinations of upper and lower limits of waste components and associated uncertainties and the rationale for the selection of these combinations. In response to an EPA completeness comment regarding the absence of this information (Docket A-93-02, Items II-I-24 and II-I-28), DOE stated that the plausible combinations of upper and lower limits are equivalent to the fixed values selected and included in the CCA PA calculations. Therefore, DOE asserted that the combination of selected limits that result in the greatest estimated release was used in the analysis.

Compliance with Numeric Requirements

Chapter 6, Section 6.5, shows the results of PA code runs that included waste-related parameters. Appendix PAR does not explicitly identify numeric values for the waste limits specified by DOE for ferrous iron, non-ferrous material, water, and cellulosics/plastics/rubber, but does include parameters closely related to these components. See Section 194.24(b)(2) of this CARD for a summary of DOE's parameterization of waste components. Figures 6-35 to 6-41 of Chapter 6 show that the disposal system complies with the numeric requirements. Figures 6-35 to 6-37 show the individual CCDF curves for the three replicate runs performed. The curves on these figures closest to EPA's containment requirement limit are those that represent the combination of conditions—including waste-related parameters—that result in the maximum calculated releases. See **CARD 23 —Models and Computer Codes** and **CARD 34—Results of Performance Assessments** for a detailed discussion of modeling results.

24.E.5 EPA COMPLIANCE REVIEW

Identification of Waste Component Limiting Values

EPA found that DOE identified four waste component grouping limits in Chapter 4.2.2 and Table 4-10, as well as Appendix WCL, Table WCL-1. See Section 194.24(b) of this CARD and EPA Technical Support Document for 194.23: Sensitivity Analysis (EPA 1998a) for a discussion of how EPA assessed waste components and their effect on PA. EPA concluded that DOE identified those waste components that required limits, and that the limits are reasonable and quantifiable. Limitations on cellulosics, rubber, and plastics are reasonable because they based upon a quantity of MgO backfill that will effectively react with CO_2 that is generated by the biodegradation of those waste components. EPA concurred that the quantity of iron from the waste containers is an appropriate and easily traceable minimum waste limit, and also recognizes that iron within waste will provide additional iron and other components. The WAC limits will ensure that water within the waste is less than 1% by volume.

EPA concurred that limits on radionuclides are not explicitly warranted at this time. Solid waste component limits are not practical because of the difficulty in measuring these quantities and their high degree of associated uncertainty, nor does the PA indicate the need to limit the solid waste form to ensure compliance. EPA's sensitivity analysis indicated that the PA is not particularly sensitive to humic and organic ligand parameters modeled, therefore limitations on these components are not warranted. See EPA Technical Support Documents for Section 194.23 (EPA 1998a and 1998b). EPA also notes that information gleaned through the waste characterization process will provide additional detailed information pertaining to waste inventory, and that modification of waste limits in the PA could be imposed as part of the recertification process if necessary.

Uncertainty

DOE did not provide the uncertainty associated with the waste component limits in the CCA. In DOE's responses to an EPA comment regarding the absence of associated uncertainties (Docket A-93-02, Item II-I-17, Enclosure 1), DOE stated the waste component limits are fixed values, and fixed values do not have uncertainties associated with them (Docket A-93-02, Items II-I-24 and II-I-28). EPA agrees with this position because the limiting value itself may be used to represent the "upper end" of an uncertainty value. This approach captures the intent of EPA's criterion because the uncertainty will be captured in the measurement or estimate of the quantity of each waste component and the fixed limit essentially will serve as an upper confidence limit. EPA reviewed several CCA Appendices, including SOTERM, SA, WCA, and WCL, to ascertain how DOE addressed uncertainty prior to determining the limiting values. DOE built uncertainty into all of its waste characterization and PA activities. For this reason, EPA determined that DOE sufficiently accounted for uncertainties associated with the limiting values.

Plausible Combinations of Upper and Lower Limits

EPA questioned whether the CCA addressed compliance with numeric requirements, plausible combinations of upper and lower limits of waste components and associated uncertainties, the rationale for the selection of these combinations, results of modeling run of the code, results of the analysis, and the combination of the selected limits resulting in the greatest estimated release. EPA stated its concerns in a March 19, 1997, letter to DOE (Docket A-93-02, Item II-I-17). DOE responded to EPA's questions by stating that: 1) the results of the WCA, SA, CCDFs and PAs established fixed-value repository-scale WCLs; and 2) these fixed-value limits also addressed Section 194.24(c)(1) requirements because the fixed limits represent the combination which would result in the greatest postulated releases (Docket A-93-02, Items II-I-24 and II-I-28). DOE also stated that the plausible combinations of upper and lower limits are equivalent to the fixed values selected and included in the CCA PA calculations. Therefore, DOE asserted the combination of selected limits that result in the greatest estimated release was used in the analysis.

Compliance with Numeric Requirements

EPA found that the results of modeling, including waste-related parameters, were included in Chapter 6 of the CCA. EPA noted, however, that the PA did not include the specific waste limit values as PA input parameters, although other parameters capture the intent of these limitations. For example, the PA codes were not explicitly designed to use the ferrous and non-ferrous metal limit values as an input parameter. However, EPA concluded that the calculated quantity of ferrous iron was reasonable and traceable, and that DOE's calculated waste limit quantities were included in other parameters that were input to PA. For example, Appendix WCA states that reducing conditions will be maintained through the reaction of iron in WIPP waste containers themselves. EPA concluded, given the quantity of ferrous iron in waste containers identified by DOE, that a number of parameters used in the PA—including the oxidation state distribution parameter (Appendix PAR, p. PAR-148)—incorporated the effects of reducing conditions. Also, the quantity of drums (Parameter ID 3132, p. PAR-235) is input to PA, as is the fixed volume of the repository.

Since the density of waste containers relative to ferrous and nonferrous metals was established by DOE (Table 4-4) and is input to PA (see Section 194.24(b)(2) of this CARD for specific values), the combination of fixed PA repository volume, drum content, and waste density captures the effect that ferrous metals would have on PA. EPA found that DOE, by using a reasonable cellulosic/plastic/rubber microbial degradation rate and including MgO within PA, adequately captured the effects of cellulose in the repository. A specific quantity of water was not included as a separate PA parameter, but the anticipated volume of water was incorporated in the initial brine saturation parameter (parameter SAT_BRN = 1.5%, Table PAR-38).

EPA examined the CCA (Chapter 6, Appendix SA) and found that Figures 6-35 through 6-41 present the results of PA, including input as a result of waste-related analysis, and show that the disposal system complies with EPA's numeric requirements. EPA found that Figures 6-35 through 6-37 show the individual CCDF curves for the three replicate runs performed. EPA noted that the curves on these figures that are closest to EPA containment requirement limit are those that represent the combination of conditions—including waste-related parameters—that result in the maximum calculated releases. See **CARD 23—Models and Computer Codes** and **CARD 34—Results of Performance Assessments** for further discussion of modeling results.

24.F.1 REQUIREMENT

(c) "For each waste component identified and assessed pursuant to paragraph (b) of this section, the Department shall specify the limiting value (expressed as an upper or lower limit of mass, volume, curies, concentration, etc.), and the associated uncertainty (i.e., margin of error) for each limiting value, of the total inventory of such waste proposed for disposal in the disposal system. Any compliance application shall:

(2) Identify and describe the method(s) used to quantify the limits of waste components identified in paragraph (b)(2) of this section."

24.F.2 ABSTRACT

EPA expected DOE to identify the method(s) that will be used to quantify each waste component. Chapter 4 presents several waste characterization methods to identify the physical, chemical, and radiological properties of the waste. Specifically, DOE proposed to use NDA (i.e., PANS), non-destructive examination (NDE) (i.e., RTR), VE, headspace gas sampling and analysis, and solid waste sampling and analysis as the methods to quantify various waste components (Section 4.4). The first three methods, which involve radiological and physical waste characterization, are most important to compliance with § 194.24 because they pertain to waste components for which limits have been set. The last two methods involve chemical waste characterization for hazardous waste components. DOE stated that hazardous components did not have an impact on the WIPP's performance relative to radiological standards, and so set no limits for these components.

DOE identified waste characterization methods used to quantify waste components in: the CCA, Chapter 4.4; the TRU QAPP, Chapters 9 and 10 and Section 5.4.2; and the Transuranic Waste Characterization Sampling and Analysis Methods Manual (Methods Manual), Methods 310.1 and 310.2.

EPA reviewed DOE's proposed waste characterization information and methods to quantify waste components. EPA also reviewed site-specific procedures at LANL and RFETS during

DOE waste characterization certification audits and Performance Demonstration Programs (PDPs). DOE's waste characterization methods apply solely to CH-TRU waste. DOE did not specify waste characterization methods for RH-TRU waste in the CCA.

24.F.3 COMPLIANCE REVIEW CRITERIA

As stated in the CAG (pp. 32-33), EPA expected the compliance application to specify:

- The waste characterization method (e.g., process knowledge, non-destructive assay, non-destructive examination, visual inspection, statistical sampling and analysis, etc.) that is being or will be used to determine the quantity of each waste component.

- How each method will be used to quantify the amounts of listed waste components prior to disposal.

- The procedure followed and the scale to which the method is applied (e.g., individual waste container, batch, statistical sample of drums, etc.).

- The instrumentation used and its sensitivity.

- The parameter measured and how it is related to the waste component in question.

EPA also expected the compliance application to describe how the data obtained by each method meet or exceed any quality assurance indicators or data quality indicators that were assumed or derived relative to waste-related inputs to the PA. Discussions of quantification methods may be referenced in documentation of existing quality assurance or methods documentation. Finally, EPA expected the CCA to demonstrate DOE's ability to quantify each of the listed waste components (for purposes of control, at the precision and accuracy adequate to assure that limiting values will not be exceeded in the inventory shipped to WIPP). See additional requirements at Section 194.24(c)(5) of this CARD. DOE must show that the proposed methods can be performed, using the current technology, at the precision and accuracy necessary to quantify the waste components. The quantification results must then be summed and tracked against the limiting values to ensure that the limits will not be exceeded.

24.F.4 DOE METHODOLOGY AND CONCLUSIONS

As discussed in Section 194.24(b)(2) above, DOE identified waste components expected to have a significant effect on disposal system performance (Appendix WCA, Tables WCA-2 and WCA-3) that were used in PA. Several radionuclides were among those components. DOE also identified waste components that were not expected to have a significant effect on disposal system performance. Finally, DOE identified waste components for which limits were required (Appendix WCL, Table WCL-1):

- Ferrous metals (iron)—minimum of $2x10^7$ kilograms.

- Cellulosics/plastic/rubber—maximum of $2x10^7$ kilograms.

- Free water emplaced with waste—maximum of 1684 cubic meters.

- Nonferrous metals (metals other than iron)—minimum of $2x10^3$ kilograms

See Section 194.24(c)(1) above for further discussion of waste component limits.

Methods Used to Quantify Each Waste Component

In Chapter 4.4 (p. 4-44), DOE proposed to use NDA methods (i.e., PANS & gamma spectroscopy), NDE (i.e., RTR), and VE, as the methods to quantify various waste components.

- RTR is a nondestructive, semi-quantitative technique that involves x-ray scanning of waste containers to identify and verify waste container contents (including cellulosics, plastics, and rubbers).

- VE is a semi-quantitative method that confirms/determines the matrix parameter category and waste material parameter weights through visual examination of wastes. It is used to quantify waste components such as cellulosics, plastics, and rubbers.

- NDA, a nonintrusive technology, employs radiation detection techniques to determine the waste's isotopic content and activity.

The first three methodologies pertain to waste components for which DOE set limits and that DOE must identify through radiological and physical waste characterization. DOE emphasized NDA for radiological waste characterization and RTR and VE for physical waste characterization.

In Chapter 4.2.2 (p. 4-29) and Appendix BIR (Chapter 1, pp. 17-20; Chapter 2, pp. 6-7; Appendix M, pp. 1-3), DOE provided ferrous metal calculations based on the amount of ferrous metal contained in the drum shell itself multiplied by the number of drums expected to be emplaced in the repository. DOE demonstrated through these calculations that the ferrous metals (iron) content will not fall beneath the minimum limit of $2x10^7$ kilograms. Therefore, DOE asserted that additional quantification is not necessary and did not further discuss quantification of ferrous metals in the CCA, other than tracking of the number of drums to be emplaced.

Chapter 4.4.1 (p. 4-50) indicated that RTR and VE are qualitative methods for physical waste characterization that will be employed to quantify physical waste components, including cellulosics, plastics and rubbers. These methods are "qualitative" because they do not actually measure the quantity in question. The methods merely identify materials by name and quantity (i.e., "3 Tyvek protective suits"). This information is then compared to known "quantitative" information (i.e., a Tyvek suit consists of 250g of cellulosic material and 80g of ferrous metal) to come up with a quantitative measure of the waste component groupings. Chapter 4, Sections 4.4.1.2 (p. 4-54) and 4.4.1.3 (p. 4-55), refer to QA guidelines in Chapter 10 (radiography) and Section 5.4.2 (VE) of the TRU QAPP (DOE 1996a), and Methods 310.1 (radiography) and 310.2 (VE) in the Transuranic Waste Characterization Sampling and Analysis Methods Manual (DOE 1996b). The QAPP (Chapter 10, pp. 1 to 6) describes radiography and VE as qualitative and semi-quantitative because the information gathered is “qualitative”, but it can be used to “quantify” the waste component groupings as described above.

In Chapter 4.2.2 of the CCA (p. 4-29), DOE based the limit on water on the maximum amount of water allowed (1% of total waste volume) by the WAC and the CH-TRU design basis of the repository (168,485 m^3). DOE calculated that the water content will not exceed the maximum limit of 1684 m^3. DOE asserted that additional quantification is not necessary because the effect of water in the waste is a function of the percentage of water and not the absolute quantity of water. DOE did not further discuss quantification of water in the CCA, although DOE will identify free liquid content during radiography and VE.

DOE provided information pertaining to nonferrous metal limits in Chapter 4.2.2 (p. 4-29) and Appendix BIR (Chapter 1, pp. 17-20; Chapter 2, pp. 6-7; Appendix M, pp. 1-3). DOE derived the quantity of nonferrous metals (i.e., metals other than iron) from the amount of nonferrous metal impurities in the drum shells and the total number of drums expected to be emplaced in the repository. DOE asserted that a minimum limit of $2x10^3$ kilograms of nonferrous metals will be exceeded. Therefore, DOE stated that quantification beyond tracking the number of drums to be emplaced in the WIPP is not necessary.

Sections 4.4.2 and 4.4.2.1 (pp. 4-55 to 4-57) identify NDA as a methodology to quantify radionuclides and their activity. Chapter 4.4.2 (p. 4-55) refers to the TRU QAPP for QA guidelines for NDA (DOE 1996a, see Chapter 9).

<u>How Each Method Will Be Used to Quantify the Amounts of Waste Components</u>

DOE described how radiography and VE will be used to quantify the amounts of waste components in the following documents: Chapter 4.4.1, 4.4.1.2, and 4.4.1.3 (pp. 4-50 to 4-55); Chapter 10 (radiography) and Section 5.4.2 (VE) of the TRU QAPP (DOE 1996a); and Methods 310.1 (radiography) and 310.2 (VE) in the Transuranic Waste Characterization Sampling and Analysis Methods Manual (DOE 1996b).

Radiography is used to determine the physical form of the waste (i.e., matrix parameter category, waste inventory, TRUPACT-II Content (TRUCON) Code, Item Description Code (IDC), waste packaging configuration) and the weight of the waste materials in order to quantify waste components such as cellulosics, plastics and rubbers or free liquid. The results of radiography are verified through VE, or VE can be performed in lieu of radiography.

DOE described how NDA will be used to quantify the radionuclides and their activity in Chapter 4.4.2 and 4.4.2.1 (pp. 4-55 to 4-57) and described QA requirements for NDA in the TRU QAPP.

All waste containers will undergo NDA techniques which allow an item to be tested without altering its physical or chemical form. NDA techniques approved for use on WIPP containers can be classified as active or passive. Passive NDA methods measure spontaneously emitted radiations produced through radioactive decay of isotopes inside the waste containers. Active NDA methods measure radiations produced by artificially generated reactions in waste material.

Most active NDA is based on the observation of gamma or neutron radiation that is that is emitted from a target isotope when that isotope undergoes a transformation resulting from an interaction with stimulation radiation provided by an external source.

Procedure Followed and Scale

The CCA does not identify procedures for radiography and VE, but Chapter 4.4.1.2 and 4.4.1.3 (p. 4-54 to 4-55) state that QA requirements are identified in the TRU QAPP (DOE 1996a) and procedures are identified in the Transuranic Waste Characterization Sampling and Analysis Methods Manual; see Methods 310.1 (radiography) and 310.2 (VE) (DOE 1996b).

Site-specific VE and radiography procedures were reviewed by DOE at LANL during the waste characterization certification audit of May 1997 and follow-up audit of August and September, 1997. Also, DOE reviewed procedures at the RFETS during the audit of June 1997 (radiography only; VE was not in the scope of this audit) (DOE 1997 RFETS audit). A follow-up audit for RFETS to include both radiography and VE will be conducted.

DOE identified the scale to which VE and radiography will be applied in the CCA, Chapter 4.4 (pp. 4-49 to 4-55); and the QAPP, Chapter 10 and Section 5.4.2. DOE stated that radiography will be performed on all retrievably stored waste containers. As a quality control check on radiography, DOE indicated that VE will be performed on a statistically selected number of waste containers (DOE 1996a, Section 5.4.2, p. 8). VE will be performed on 100 percent of the newly-generated waste because VE is cost-effective and an accurate way to keep records of what goes into a waste drum as it is filled versus employing methods like radiography after the fact. Therefore, radiography will not be performed on newly generated waste. Retrievably stored waste that is repackaged will be treated as newly-generated waste.

DOE provided the following description of radiography procedures in its Methods Manual (DOE 1996b, p. 310.1-1):

> Waste containers are moved into the shielded vault, X-rays are projected through the container onto a fluorescent screen/image intensifier, and the resultant image is transferred by a camera to a remotely located television screen. A description of the contents of the waste container is video recorded and documented on a data form. The description should clearly identify all discernable waste items, residual and packaging materials, and/or [DOE] waste material parameters whenever possible so that waste can be classified according to the [DOE] waste material parameters specified in Table 1. This classification based on radiography information will be confirmed by visual examination (Procedures 310.2 of this Methods Manual).

DOE provided the following description of visual examination in its Methods Manual (DOE 1996b, p. 310.2-1):

> The transuranic (TRU) waste that is designated for the Program is visually examined, weights determined or estimated, and video recorded. A description and estimated or measured weights of the contents of each waste container is also recorded on

audio/video tape and a visual examination data form. The description should clearly identify all discernible waste items, residual materials, packaging materials, or waste material parameters so that all the waste in each container can be classified according to the waste material parameters. . . Opening individual bags/packages may be necessary in order to ensure the quality of the examination data. If individual bags/packages are not opened, estimated weights of waste items, residual materials, packaging materials, or waste material parameters within the bags/packages are recorded. If it is necessary to open individual bags/packages, then actual weights of waste items, residual materials, packaging materials, or waste material parameters are recorded.

The CCA does not identify procedures for NDA, but the QAPP (DOE 1996a) provides QA guidelines which must be met in site-specific NDA procedures. In addition, the QAPP (Chapter 9, p. 8) recommends the use of American Society for Testing and Materials (ASTM) procedures and Nuclear Regulatory Commission (NRC) standard practices and guidelines.

DOE reviewed site-specific NDA procedures for the passive active neutron (PAN) system at LANL during the waste characterization certification audit of May 1997. DOE conducted follow-up audits for the gamma system (commonly referred to as FRAM, the Norwegian name for the system software) at LANL in August and September 1997. DOE reviewed RFETS NDA procedures for the passive/active drum counter (PADC) during the RFETS Performance Demonstration Program of November 1996, and the RFETS audit of July 1997 included the mobile Canberra NDA unit. DOE typically uses PAN and segmented gamma scanning (SGS) devices to measure radioactivity.

DOE specified the degree to which each method would be applied in the CCA. NDA will be performed on 100% of the waste containers. Sections 4.4 (p. 4-49) and 4.4.2 (pp. 4-55 to 57); and the QAPP, Chapter 9 for NDA.

<u>Instrumentation Used and Sensitivity</u>

DOE described the equipment and facilities typically found in a radiography system in the Methods Manual, Method 310.1, Section 5.0, Apparatus and Materials (DOE 1996b). DOE described the equipment typically associated with radiation containment facilities for VE in the Methods Manual, Method 310.2, Section 5.0, Apparatus and Materials. The radiography equipment and facilities at RFETS, and the radiography and VE equipment and facilities at LANL were examined by DOE during the previously noted audits. The CCA did not discuss sensitivity of instruments, since analytical instrumentation for which instrument sensitivities would apply are not used.

As described in the Methods Manual (DOE 1996b, pp. 310.1-3), a typical radiography system consists of the following equipment and facilities:

- Shielded room that is properly ventilated and lighted

- X-ray head and associated equipment

- Drum turntable dolly assembly
- Fluoroscopic screen and accessories
- Closed-circuit television equipment and monitors
- Safety interlocks and
- Data management system.

DOE discussed NDA instrumentation in the CCA, Chapter 4.4.2.1 (pp. 4-56 to 4-57) and the QAPP, Chapter 9 (DOE 1996a). Chapter 4.4.2.1 and the QAPP list NDA instrument systems that can be classified as belonging to one or more of four types of measurement categories. DOE indicated that the list of instrument systems is neither complete nor limiting, but shows the breadth of choices available. DOE proposed to use any type of NDA instrument system, modification, combinations or hybrids as long as the quality assurance objectives (QAOs) can be met. NDA instrumentation at RFETS and LANL was examined by DOE during the previously noted PDP exercises and audits.

As described in the Methods Manual (p. 310.2-3) (DOE 1996b), sites develop radiation containment facilities for VE and provide the following equipment:

- Drum, waste bag, and waste handling equipment
- Video cameras and audio equipment
- Mass balances and calibration standards
- Bag opening unit
- Data input station and
- Safety equipment.

DOE discussed the minimum detectable concentration (MDC) for NDA, also known as the detection limit, in the QAPP, Section 9.1. The MDC corresponds to a level of activity that is practically achievable with a given instrument, analytical method and analyte/matrix combination. The MDC considers not only the instrument characteristics (background and efficiency), but all other factors and conditions which influence the measurement. The MDC is 60 nCi/g.

As described in Chapter 4.4.2.1 (p. 4-56), typical NDA instrumentation includes:

- Gamma ray measurements
  - low-and high-resolution spectroscopy using a sodium iodide and intrinsic germanium detector, respectively

- transmission-corrected gamma ray measurement using a segmented gamma ray scanner and
- transmission-corrected gamma ray measurement using a computed tomographic gamma ray scanner.

♦ Passive neutron measurements

- passive neutron coincidence counter
- advanced matrix-corrected passive neutron counter (add-a-source) and
- shielded neutron-assay probe totals counter

♦ Passive and active neutron measurements

- americium-lithium source-driven coincident counter
- californium delayed-neutron counter (shuffler)
- neutron generator differential die-away counter and
- combined thermal and epithermal neutron counter.

♦ Thermal neutron capture

- californium delayed-neutron counter
- neutron generator differential die-away counter and
- combined thermal and epithermal neutron counter.

<u>Parameter Measured and How Parameter is Related to Waste Component</u>

DOE identified the measurement taken and how the measurement is related to the waste component in the CCA and the QAPP. Specifically, radiography and VE will identify the waste matrix category and DOE's waste material parameters (WMPs), and estimate the weights of the WMPs as stated in the CCA, Sections 4.4.1.2 and 4.4.1.3 (pp. 4-53 to 55); the QAPP, Chapter 10 and Section 5.4.2; and the Methods Manual, Methods 310.1 and 310.2, respectively. For radiography and VE, waste material parameters are waste components (including cellulosics, plastics and rubbers) as stated in the CCA, Section 4.4 as well as the QAPP, Chapter 10 and Section 5.4.2; and the Methods Manual, Methods 310.1 and 310.2, respectively. Specifically, NDA will measure the presence of individual radionuclides and their associated activity, as stated in the CCA, Section 4.4.2 (pp. 4-55 to 57) and the QAPP, Chapter 9.0. Radionuclides and their activities were considered waste components by DOE as stated in the CCA, Section 4.4, Appendix WCA (Tables WCA-2 and WCA-3), and the QAPP, Chapter 9.0.

<u>How Data Meet Or Exceed QA Indicators Or Data Quality Indicators</u>

DOE discussed in the Methods Manual (Section 10, pp. 8-9) how the data obtained by radiography and VE meet or exceed any QA indicators or data quality indicators that have been assumed or derived relative to waste related modeling inputs. For VE and radiography, DOE provided procedure performance information and data in the Methods Manual, Methods 310.1 and 310.2 (respectively), Section 10.0 - Procedure Performance, Tables 5 and 4 (respectively).

For NDA, DOE generates procedure performance data during the Performance Demonstration Program (PDP), which is a quality assurance program initiated by DOE to test and certify the ability of NDA instrumentation to detect actinide sources in various matrices. See Section 194.24(c)(5) of this CARD for information on the PDP program. See "Performance Demonstration Program for Nondestructive Assay for the TRU Waste Characterization Program, Scoring Report - April 1996 Distribution" (commonly referred to as the NDA PDP Cycle 1 Report) for details on NDA PDP procedure performance data (DOE 1996e).

Demonstration of the Ability to Quantify Each Waste Component

DOE's ability to quantify cellulosics, plastics, and rubber by VE and radiography was addressed during generator site audits. The LANL audits of May 1997 and August 1997 included VE and radiography. The RFETS audit of July 1997 included only radiography; VE was not in the audit's scope. A follow-up audit for RFETS to include both radiography and VE will be conducted in the future. DOE concluded as a result of the audits that the sufficiency of RFETS and LANL's VE and/or radiography programs was adequately demonstrated. For further discussion of DOE's audits, see EPA Technical Support Document for 194.24: WIPP Facility and Waste Characterization, especially attachments in Item III-B-18 (EPA 1998c).

DOE's ability to quantify radionuclides and their activities by NDA was also addressed during audits of generator sites. DOE conducted NDA audits at LANL in May, August, September, 1997, and conducted a PDP Cycle 2 exercise at RFETS in November 1996 and an audit of NDA at RFETS in July 1997. DOE concluded that the certification for NDA at LANL could be authorized as a result of these audits, but NDA at RFETS could not be authorized. For further discussion of DOE's audits, see EPA Technical Support Document for Section 194.24: WIPP Facility and Waste Characterization, especially attachments in III-B-18 (EPA 1998c).

DOE did not provide waste characterization methods specific to RH-TRU waste in the CCA.   The waste characterization discussions in Chapter 4 of the CCA apply to CH-TRU waste, not RH-TRU waste, except for the CCA's Table 4-13 (p. 4-49), which is entitled "Applicable CH- and RH-TRU Waste Component Characterization Methods."

24.F.5 EPA Compliance Review

As discussed in Section 194.24(b)(2) of this CARD, DOE identified the waste components expected to have a significant effect on disposal system performance and used in PA. Ten radionuclides are among those components identified by DOE as very important to PA (Appendix WCA). These ten radionuclides are:

- ^{238}Pu, ^{239}Pu, ^{240}Pu, and ^{241}Pu
- ^{241}Am
- ^{233}U, ^{234}U
- ^{90}Sr

- ^{137}Cs and

- ^{244}Cm.

Seven of the ten radionuclides are specific to CH-TRU waste, and three are specific to RH-TRU waste. The seven CH-TRU waste radionuclides are ^{238}Pu, ^{239}Pu, ^{240}Pu, ^{241}Pu, ^{241}Am, ^{234}U and ^{244}Cm. The three RH-TRU waste radionuclides are ^{137}Cs, ^{90}Sr and ^{233}U.

As discussed in Section 194.24(c)(1) of this CARD, DOE identified waste components for which limits were required. The waste components with limiting values are:

- Ferrous metals (iron)—minimum of 2x10^{7} kilograms.

- Cellulosics/plastic/rubber—maximum of 2x10^{7} kilograms.

- Free water emplaced with waste—maximum of 1684 cubic meters.

- Nonferrous metals (metals other than iron)—minimum of 2x10^{3} kilograms.

The discussion below addresses EPA's review of the methods that DOE will use to quantify waste components and their limits.

Method Used to Quantify Each Waste Component

EPA reviewed the CCA, Chapter 4.2.2 (p. 4-29) and Appendix BIR (Chapter 1, pp. 17-20; Chapter 2, pp. 6-7; Appendix M, pp. 1-3) for the calculations provided by DOE regarding ferrous metal content. The amount of ferrous metal contained in the repository was calculated according to the total number of drums expected to be emplaced in the repository. DOE demonstrated through these calculations that the ferrous metals (iron) content will not fall below the minimum limit of 2x10^{7} kilograms. Therefore, EPA agrees with DOE's assertion that further quantification is not necessary, particularly since DOE must track the number of waste containers emplaced in the WIPP.

EPA reviewed the CCA, Chapter 4.4.1, 4.4.1.2, and 4.4.1.3 (p. 4-50 to 4-55) for a description of radiography and VE as physical waste characterization methodologies to quantify waste components (including cellulosics, plastics and rubbers). EPA also reviewed the QAPP, (DOE/CAO-94-1010) for QA guidelines in Chapter 10 (radiography) and Section 5.4.2 (VE), and the Transuranic Waste Characterization Sampling and Analysis Methods Manual (Methods Manual, DOE/WIPP-91-043) for procedures in Methods 310.1 (radiography) and 310.2 (VE). After performing these reviews, EPA determined that DOE adequately identified radiography and VE as the appropriate physical waste characterization methodologies to quantify waste components (including cellulosics, plastics and rubbers).

EPA reviewed the CCA, Section 4.2.2 (p. 4-29) for the water calculation based on the maximum amount of water allowed (1% of total waste volume) per the WAC and the CH-TRU design basis of the repository (168,485 cubic meters). DOE demonstrated through this calculation that the water content will not exceed the maximum limit of 1684 cubic meters. Therefore, EPA agrees with DOE's assertion that a method of quantification other than RTR and VE maintenance of this WAC limit is not necessary.

EPA reviewed the CCA, Section 4.2.2 (p. 4-29) and Appendix BIR (Chapter 1, pp. 17-20; Chapter 2, pp. 6-7; Appendix M, pp. 1-3) for the nonferrous metal calculations based on the amount of nonferrous metal contained in the materials of construction of a drum and the number of drums expected to be emplaced in the repository. DOE demonstrated through these calculations that the nonferrous metals (metals other than iron) content will not fall below the minimum limit of $2x10^3$ kilograms. Therefore, EPA agrees with DOE's assertion that a method of quantification is not necessary, although EPA believes that DOE must track the number of waste containers emplaced in the WIPP.

EPA reviewed DOE's CCA, Sections 4.4.2 (p. 4-55) and 4.4.2.1 (pp. 4-56, 57) for NDA as the radiological waste characterization methodology to quantify radionuclides and their activity. EPA also reviewed the QAPP, (DOE/CAO-94-1010) for QA guidelines in Chapter 9 for NDA. After performing these reviews, EPA determined that DOE adequately identified NDA as the radiological waste characterization methodology to quantify radionuclides and their activity because NDA can quantify the radioisotopes in the waste stream destined for WIPP.

Procedure Followed and Scale

EPA reviewed the CCA and determined that DOE does not provide procedures for radiography and VE within the CCA. However, the CCA, Section 4.4.1.2 (p. 4-54) and Section 4.4.1.3 (p. 4-55) refers to the QAPP, (DOE 1996a) for QA guidelines in Chapter 10 (radiography) and Section 5.4.2 (VE), and the Transuranic Waste Characterization Sampling and Analysis Methods Manual (DOE 1996b) for procedures in Methods 310.1 (radiography) and 310.2 (VE) which were reviewed by EPA and found to be adequate. EPA based its determination of adequacy on the level of detail contained in the descriptions found in the QAPP and the Methods Manual. Though the level of detail does not reach that of actual implementable procedures, the detail is such that each site will be able to develop site specific procedures which, when audited and inspected against the QAPP and the Methods Manual, will be adequate for the performing radiography and VE.

EPA reviewed procedures for VE and radiography at LANL during DOE's waste characterization certification audit of May, August, and September, 1997. EPA concludes that LANL adequately demonstrated VE and radiography for selected waste streams. EPA's determination that radiography and VE were demonstrated adequately is based on: 1) direct inspection of ongoing radiography and VE activities; 2) detailed technical review of support documents such as operating procedures, log books, and training records; and 3) direct interviews with operations personnel, operations supervisors, and operations managers. Also, EPA reviewed a site-specific procedure during the RFETS audit of June 1997 (radiography only; VE was not in the scope of this audit because the site was not prepared to have this method audited and inspected for purposes of certification.). Although the RFETS radiography procedure appeared adequate, EPA was not performing a certification inspection and so a follow-up audit for RFETS to include both radiography and VE will be conducted in the future. EPA plans to attend the RFETS follow-up audit to further examine radiography and to examine VE.

EPA reviewed the CCA, Chapter 4.4, 4.4.1.2, and 4.4.1.3 (p. 4-49 to 4-55), and the QAPP, Chapter 10 and Section 5.4.2, for radiography and VE (respectively), and determined (based on a thorough technical review) that DOE adequately provided the scale to which the methods are applied.

EPA reviewed Chapter 9 of the QAPP, which provides quality assurance (QA) guidelines to be met in site-specific NDA procedures, and found the QA guidelines for NDA to be adequate. However, EPA noted that DOE did not provide specific NDA procedures.

EPA reviewed NDA procedures at LANL for the passive/active neutron system during DOE's waste characterization certification audit of May 1997, and for the gamma system during follow-up audits of August and September 1997. EPA concluded that LANL adequately demonstrated NDA for selected waste streams. EPA's determination that NDA was demonstrated adequately is based on: 1) direct inspection of ongoing NDA activities; 2) detailed technical review of support documents such as operating procedures, log books, and training records; and 3) direct interviews with operations personnel, operations supervisors, and operations managers. EPA also reviewed NDA procedures for the passive/active drum counter at the RFETS PDP of November 1996, and for the mobile Canberra NDA unit at the RFETS audit of July 1997.

The NDA methods at LANL demonstrated their ability to detect individual radionuclides for the debris waste stream inspected. LANL's NDA methods have not yet demonstrated the ability to detect individual radionuclides for the entire spectrum of waste streams and waste matrices expected to be encountered at LANL. DOE has not sufficiently demonstrated the ability to detect individual radionuclides at RFETS. EPA concluded that DOE has sufficiently demonstrated that NDA can identify and quantify radionuclides and their activity at LANL for legacy debris waste. DOE has neither demonstrated nor certified through its PDP program that radionuclides can be assayed in any waste matrices other than legacy debris waste, for which combustible debris waste was used as an example.[4]

EPA questioned DOE's NDA protocols, requesting protocols for determining: measurements; equipment; analytical methods; and ranges of correction/calibration factors for NDA (Docket A-93-02, Item II-I-17). DOE responded that they do not specify what methods or measurements must be met, only that generator sites follow QAPP requirements, thus providing necessary analytical flexibility to the sites (Docket A-93-02, Item II-I-24). EPA reviewed the Chapter 4.4 (p. 4-49) and 4.4.2 (pp. 4-55 to 57) and the QAPP, Chapter 9, for NDA and

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[4] Specifically, DOE demonstrated a process to adequately develop and implement waste characterization capabilities at LANL for several waste streams in the category of "retrievably stored (legacy) debris waste." This group of waste streams, characterization system, and process is cited in a DOE approval to certify memorandum from George Dials (WIPP) to G. Thomas Todd (LANL), dated September 12, 1997 (Docket A-93-02, Item II-I-70).

determined that as long as QAPP requirements are met DOE adequately provided the scale to which the methods are applied.[5]

Instrumentation Used and Sensitivity

EPA agrees with DOE that there is no analytical instrumentation associated with the physical waste characterization methodologies of radiography and VE used to identify waste components. EPA reviewed DOE's description of the equipment and facilities typically found in a radiography system in the Methods Manual, Method 310.1, Section 5.0, Apparatus and Materials. EPA also reviewed DOE's description of the equipment typically associated with radiation containment facilities for VE in the Methods Manual, Method 310.2, Section 5.0, Apparatus and Materials. EPA determined that these descriptions provided by DOE are adequate because they provided a detailed technical description which matched the actual equipment found during site inspections. In addition, EPA examined the radiography equipment and facilities at RFETS (VE was not in the scope of the audit), and the radiography and VE equipment and facilities at INEEL during the previously noted audits. EPA determined that these facilities and equipment may be adequate because they may accurately provide the information which is required to meet the 194.24 requirements. EPA agrees with DOE that since there is no analytical instrumentation associated with radiography and VE because they are only semi-quantitative methods, DOE is not required to provide a discussion of instrument sensitivities.

EPA reviewed Chapter 4.4.2.1 (pp. 4-56, 57) and the QAPP, Chapter 9 (p. 9), for DOE's discussions of NDA instrumentation. EPA also examined the NDA instrumentation used at RFETS and LANL during the previously noted PDP and audits. The LANL NDA instrumentation was adequate. Although the RFETS NDA instrumentation appeared adequate, a follow-up audit will be conducted in the future at RFETS to address NDA issues. EPA will inspect the follow-up audit at RFETS to further examine NDA. See EPA Technical Support Document for Section 194.24: WIPP Facility and Waste Characterization (EPA 1998c) for further explanation of why LANL NDA instrumentation was adequate. EPA concludes that DOE, through audit results, has adequately described instrumentation at RFETS and LANL. EPA observations of audits have not been performed at other generator sites.

EPA reviewed the CCA and determined that DOE does not provide a discussion of instrument sensitivities for NDA within the CCA. EPA reviewed the QAPP, Section 9.1, for DOE's discussion in the QAPP of the minimum detectable concentration (MDC), also known as the detection limit, for NDA. Although DOE did not provide a discussion of instrument sensitivities for NDA, DOE has required that all NDA instrumentation be sensitive enough to meet or exceed the MDC. EPA determined the MDC requires a minimum sensitivity given the variety of NDA instruments used by DOE, and the MDC meets the intent of EPA's request in the CAG regarding instrument sensitivities.

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5 As discussed below in Sections 194.24(c)(3) and (4), EPA will conduct independent evaluations at the waste generator sites to verify demonstration of the required waste characterization systems and processes.

Parameter Measured and How Parameter is Related to Waste Component

EPA reviewed Chapter 4.4.1.2 and 4.4.1.3 (pp. 4-53 to 55); the QAPP, Chapter 10 and Section 5.4.2; and the Methods Manual, Methods 310.1 and 310.2, for discussion of DOE's waste matrix parameters measured using VE and radiography and how they are related to the relevant waste components. EPA determined that DOE provided adequate information that radiography and VE will identify the DOE matrix parameter category and waste material parameters (WMPs) and estimate the weights of the WMPs.

EPA reviewed Chapter 4.4.2 (pp. 4-55 to 57) and the QAPP, Chapter 9.0, for DOE's discussion of the parameters measured using NDA (i.e., radionuclides and their activity) and how they are related to the relevant waste components. EPA determined that DOE provided adequate information that NDA will measure radionuclides and their activity, although EPA questions the current ability of DOE's generator sites to demonstrate that individual radionuclides and their activities can be measured for different waste matrices, as discussed previously in "Procedures Followed and Scale." For example, LANL's process for developing NDA methods—which will be able to detect individual radionuclides for legacy debris waste streams—includes meeting QAPP requirements, having a DOE approved AK package covering the waste characterized for shipment, and having passed a PDP cycle with a matrix which is representative of the waste matrix expected (through acceptable knowledge) to be encountered in the waste characterized for shipment. LANL's NDA methods have not yet demonstrated the ability to detect individual radionuclides for the entire spectrum of waste streams and waste matrices expected to be encountered at LANL.

How Data Meet Or Exceed QA Indicators Or Data Quality Indicators

EPA determined that DOE did not provide procedure performance information regarding VE and radiography in the CCA as requested in the CAG. EPA reviewed the Methods Manual for procedure performance information for VE and radiography in Methods 310.1 and 310.2 (respectively), Section 10.0 - Procedure Performance, Tables 5 and 4 (respectively). EPA determined that DOE sufficiently described how the data obtained by radiography and VE meet or exceed any quality assurance indicators or data quality indicators that have been assumed or derived relative to waste related inputs to PA.

EPA reviewed the CCA and determined that DOE did not provide NDA procedure or performance data within the CCA as requested in the CAG. For NDA, DOE generates procedure performance data during the PDP. See "Performance Demonstration Program for Nondestructive Assay for the TRU Waste Characterization Program, Scoring Report - April 1996 Distribution," (DOE 1996e) (commonly referred to as the NDA PDP Cycle 1 Report) and "Performance Demonstration Program for Nondestructive Assay for the TRU Waste Characterization Program, Scoring Report - November 1996 Distribution," (DOE 1997a) (commonly referred to as the NDA PDP Cycle 2 Report) for details of NDA PDP procedure performance data. EPA reviewed the PDP Cycle 1 and 2 Reports for NDA procedure performance data. EPA determined that by providing adequate procedure and performance data, DOE sufficiently described how the data obtained by NDA could meet or exceed any quality assurance indicators or data quality indicators that have been assumed or derived.

Demonstration of the Ability to Quantify Each Waste Component

EPA conducted inspections of DOE's audits of generator sites' waste characterization to verify DOE's ability to develop, implement and demonstrate systems and processes to quantify waste components using VE and radiography. EPA determined that DOE demonstrated the ability to quantify waste components by VE and radiography during the LANL audits of May 1997 and August 1997, and potentially by radiography at RFETS during an audit in July 1997 (VE was not in the RFETS audit scope). This ability was demonstrated by having operators: 1) radiograph a drum typical of the waste stream being certified; 2) record the quantity and type of material components observed; and 3) report these waste component quantities in accordance with established, audited, and inspected procedures. A follow-up audit for RFETS for VE will be conducted in the future. EPA will attend the RFETS follow-up audit to further examine radiography and VE systems and processes. See EPA Technical Support Document for Section 194.24: WIPP Facility and Waste Characterization (EPA 1998c) for further discussion of radiography and VE demonstrations.

EPA conducted inspections of DOE's audits of generator sites' waste characterization to verify DOE's ability to quantify waste components using NDA. During the LANL waste characterization certification audit of the PAN system in May 1997, EPA identified issues regarding software quality assurance, and inadequate isotopic identification prior to using the PAN system. The LANL PAN system cannot identify individual radionuclides, but can quantify radionuclide activity after the radionuclide is identified by another waste characterization method such as gamma spectroscopy. AK appears necessary either to focus the gamma spectrum of interest in the FRAM gamma spectroscopy system, provide expected waste matrix information to allow for correction in NDA methods, or at least as a QC check on NDA, radiography, and VE data. Inadequate isotopic identification prior to using the PAN reduces the PAN system's ability to quantify radionuclide activity accurately. During DOE's follow-up audit of the gamma system at LANL (commonly referred to as FRAM, the Norwegian name for the system software) in August 1997, issues were identified with software quality assurance, calibration, equipment set-up, and the inability of the FRAM system to identify the radionuclide Neptunium (Np). Since the FRAM did not identify Np and the PAN system relies upon the isotopics provided by the FRAM, the PAN system did not quantify Np.

EPA attended DOE's follow-up audit of LANL in September 1997, at which the software quality assurance, calibration, equipment set-up, and FRAM issues previously noted were adequately addressed. During DOE's audit in July 1997 of the mobile Canberra NDA unit at RFETS, EPA identified issues regarding software quality assurance. An RFETS follow-up audit will be conducted in the future to address these NDA issues. EPA will attend the RFETS follow-up audit to further examine NDA. See EPA Technical Support Document for Section 194.24: WIPP Facility and Waste Characterization (EPA 1998c) for further discussion of NDA demonstrations.

EPA inspected audits that included NDA at only two generator sites, RFETS and LANL. LANL conclusively demonstrated their NDA system's ability to detect individual radionuclides for a debris waste stream. However, LANL's NDA systems have not yet demonstrated the ability to detect individual radionuclides for all varieties of waste streams and waste matrices expected to be encountered at LANL. Furthermore, RFETS could not conclusively demonstrate their NDA system's ability to detect individual radionuclides.

RH-TRU Waste

EPA determined that the CCA did not identify any waste characterization methods for RH-TRU waste, nor did it discuss specifically how DOE will quantify the RH-TRU waste. Chapter 4 addresses only contact-handled transuranic (CH-TRU) waste, with the exception of Table 4-13 (p. 4-49), "Applicable CH- and RH-TRU Waste Component Characterization Methods." There was no discussion in the CCA of the applicability of traditional CH-TRU waste characterization methods to RH-TRU waste. Therefore, EPA is not able to certify that DOE has demonstrated that the WIPP will comply with the radioactive waste disposal regulations for any RH-TRU wastes.

24.G.1 REQUIREMENT

(c) "For each waste component identified and assessed pursuant to paragraph (b) of this section, the Department shall specify the limiting value (expressed as an upper or lower limit of mass, volume, curies, concentration, etc.), and the associated uncertainty (i.e., margin of error) for each limiting value, of the total inventory of such waste proposed for disposal in the disposal system. Any compliance application shall:

(3) Provide information which demonstrates that the use of process knowledge to quantify components in waste for disposal conforms with the quality assurance requirements found in § 194.22."

24.G.2 ABSTRACT

EPA expected the compliance application to: provide information used in connection with control of the use of process knowledge; cite objective evidence substantiating the degree of implementation of quality assurance for each generator site that is approved to use process knowledge for characterization; and provide an implementation plan for application of quality assurance requirements to process knowledge at remaining sites.

DOE provided process knowledge/acceptable knowledge (PK/AK) documentation in Chapter 4 and Appendix WAP. DOE also includes PK/AK information in the QAPP, which DOE submitted to update and supplement the CCA. The QAPP is an updated version of Appendix WAP, Appendix C10, that was modified to include specific reference to radionuclides. DOE defined the PK/AK process for waste characterization to include three general activities:

- ♦ Compiling PK/AK documentation into an auditable record, including mandatory and supplemental PK/AK information, as defined by DOE in the Quality Assurance Program Plan.

- ♦ Confirming PK/AK information with waste analysis results by comparison of PK/AK characterization with those obtained through sampling and analyses, including resolution of discrepancies.

- ♦ Auditing of PK/AK records (audit steps are also discussed in Appendix WAP, Appendix C11, "WIPP Generator Waste Audit Program").

The QAPP identifies the system of controls DOE proposes to implement for PK/AK characterization. DOE has prepared a training program for site personnel responsible for assessing PK/AK information and resolving discrepancies. DOE required each generator site to follow the requirements of the QAPP, and DOE asserted that this three-step process leads to consistent characterization of waste among DOE generators sites using PK/AK.

DOE indicated that generator site PK/AK programs must be approved and certified through DOE's internal audit process prior to shipment to the WIPP. When the CCA was submitted in October of 1996, no generator or storage sites had received the DOE/Carlsbad Area Office's (CAO) certification of their AK process. In September 1997, CAO certified certain waste characterization activities at LANL, including approval of their PK/AK process. RFETS and INEEL have undergone pre-certification audits. DOE will audit each site according to audit procedures and schedules to be developed by DOE to ensure that each site meets QAPP requirements.

EPA's review of PK/AK documentation for LANL provided in the CCA indicated that it was adequate for all constituents except radioactive constituents.

24.G.3 COMPLIANCE REVIEW CRITERIA

As stated in the CAG (p. 31), EPA expected the compliance application to:

- ♦ Provide information, including standardized guidance or directives, training documents, etc., used in connection with control of the use of process knowledge.

- ♦ Cite (and make available for field review) objective evidence substantiating the degree of implementation of quality assurance (such as audit reports, status of corrective actions, etc.) for each generator site that is approved to use process knowledge for characterization.

- ♦ Provide an implementation plan for application of quality assurance requirements to process knowledge at remaining sites.

24.G.4 DOE METHODOLOGY AND CONCLUSIONS

EPA and DOE agree that acceptable knowledge (AK) includes information regarding the physical form of the waste, the base materials composing the waste, the nature of the radioactivity present, as well as the process generating the waste. That is, acceptable knowledge includes process knowledge, waste analysis data, and facility records of analyses performed. DOE documentation, including DOE's Quality Assurance Program Plan (DOE 1996a) and the CCA (e.g. Section 4.4, p. 4-44, Appendix WAP), have been updated to include the term acceptable knowledge rather than process knowledge. However, for continuity with the rule language, acceptable knowledge and process knowledge are used as the acronym PK/AK, with the understanding that DOE characterized waste using the broader characterization techniques associated with acceptable knowledge.

Process Knowledge/Acceptable Knowledge (PK/AK) Information

DOE provided PK/AK documentation in Chapter 4, Section 4.4.1.1 (pp. 4-50 to 4-53), and Appendix WAP, Appendix C9. DOE also included PK/AK information in Chapter 4 of the QAPP (pp. 1-18); the QAPP is an updated version of Appendix WAP, Appendix C10, that has been modified to include specific reference to radionuclides. DOE defined the PK/AK process for waste characterization to include three general activities (Chapter 4.4.1.1, p. 4-50):

- ♦ Compiling PK/AK documentation into an auditable record, including mandatory and supplemental PK/AK information, as defined by DOE in the Quality Assurance Program Plan (Chapter 4, pp. 1-18), and in Appendix WAP, Appendix C9 (pp. C9-3 to C9-6).

- ♦ Confirming PK/AK information with waste analysis results by comparison of PK/AK characterization with those obtained through sampling and analyses, including resolution of discrepancies.

- ♦ Auditing of PK/AK records. (Audit steps are also discussed in Appendix WAP: Appendix C11, the WIPP Generator Waste Audit Program).

Step 1 includes the assembly of acceptable knowledge documentation. DOE identified in the QAPP, Chapter 4 (p. 3 and Figure 4-1), the processes that generator sites must follow to assemble PK/AK information, and specific criteria that must be met. Criteria that must be met in establishing a PK/AK information record include compilation of data into auditable records, correlation of facility waste management to specific waste stream information, correlation between waste streams with regard to time of generation and processes, and development of a reference list that identifies documents, databases, QA protocols, and other sources of AK information.

DOE established the process for assembling and using acceptable knowledge in the QAPP, Chapter 4 (pp. 5 through 6), and required each generator site to develop procedures for assembling, assessing, and confirming PK/AK data (QAPP, Chapter 4, p. 3). Written procedures must outline the methods used to assemble PK/AK records, including origin of documentation, use, and limitations. DOE also identified priorities for AK data assembly (QAPP, Chapter 4, p. 3) and mandatory characterization requirements (e.g., identification of DOE waste material parameters, physical waste form, etc.). These procedures should address how nonconforming items are identified and managed, and should include procedures for confirmation of PK/AK with sampling and analysis data. Generator sites must assemble the following PK/AK information for each waste stream (QAPP, Chapter 4, p. 11):

- Areas/building from which the waste stream was or is generated.

- Waste stream volume and period of generation.

- Waste generating processes described for each building or area.

- Process flow diagrams.

- Material inputs or other information that identifies the chemical and radionuclide content of the waste stream and physical waste form.

Supplemental, nonmandatory information may also be assembled from process design documents, standard operating procedures, and site personnel (QAPP, Chapter 4.0, pp. 11-12).

Step 2 deals with confirmation of PK/AK waste characterization with that derived from sampling and analysis. As described in Section 194.24(c)(2) of this CARD, DOE will characterize each drum of waste intended for disposal at WIPP using NDA, NDE (e.g. RTR), VE, headspace gas analysis, and PK/AK. A limited number of drums will also undergo solid waste sampling. Chapter 4.2.2 of the QAPP (pp. 5-10) identifies DOE's processes for performing PK/AK confirmation. Generator sites are to compare the results of sampling and other characterization activities (e.g., NDA) with results derived from PK/AK and resolve any discrepancies. Chapter 4 of the QAPP (pp. 13-18) identifies AK program controls for confirmation of AK and resolution of discrepancies.

Step 3 addresses CAO audits of each generator site's PK/AK program (Section 4.5, pp. 15-18). Initial audits of the PK/AK program at each generator site will be conducted to verify that the required procedures have been established and are acceptable. DOE states, "The audits will be used to ensure the consistent compilation, application, and interpretation of acceptable knowledge information throughout the DOE complex and to evaluate the completeness and defensibility of site-specific acceptable knowledge documentation related to hazardous waste determinations" (QAPP, p. 15). DOE states that "subject" waste will not be shipped to the WIPP until CAO approval is granted (QAPP, p. 18).

The QAPP identifies the system of controls DOE proposes to implement for PK/AK characterization. DOE has prepared a training program for site personnel responsible for assessing PK/AK information and resolving discrepancies. Additionally, the QAPP identifies management controls for segregating nonconforming items discovered during PK/AK characterization from waste to be shipped to the WIPP. Confirmation of acceptable knowledge is also considered a waste management control (QAPP, p. 13).

DOE asserted that this three-step process leads to consistent characterization of waste using PK/AK among generator sites (Appendix WAP, p. C9-3), and that application of the same data quality indicators at each site leads to consistent application of PK/AK at the generator sites (QAPP, p. 4-51). (DOE also stated that PK/AK documentation provides qualitative information that cannot be assessed according to specific data quality objectives (DQOs) and quality assurance objectives (QAOs) that are used for analytical techniques, such as precision of data in quantitative terms.)

Quality Assurance Requirements for Process Knowledge/Acceptable Knowledge at Approved Sites

Generator site PK/AK programs must be approved and certified by CAO audits prior to any waste shipment to WIPP (DOE 1996a). When the CCA was submitted in October of 1996, no generator or storage site had been granted approval of their PK/AK process. In September 1997, DOE certified certain waste characterization activities at LANL, including approval of their PK/AK process. RFETS and INEEL have undergone pre-certification audits.

DOE identified quality assurance requirements that are to be met by each generator site and are included in each site certification audit. In Chapter 4, Section 4.4.1.1 (p. 4-50), DOE stated that the sites must comply with the following data quality indicators (characteristics) for PK/AK documentation in order to ensure that the PK/AK process is consistently applied: 1) precision; 2) accuracy; 3) completeness; 4) comparability and 5) representativeness. CAO will conduct an audit of each generator and storage site prior to certifying the site for shipment of TRU waste to the WIPP facility. This initial audit will establish an approved baseline that will be reassessed annually during follow-up audits.

Implementation Plan for Certifying Remaining Sites

DOE required that each DOE site intending to ship waste to WIPP be certified relative to PK/AK, following the requirements of the QAPP, Section 4. DOE will audit each site following audit procedures and schedules to be developed by DOE to ensure that each site meets QAPP requirements.

24.G.5 EPA COMPLIANCE REVIEW

Process Knowledge/Acceptable Knowledge (PK/AK) Information

Prior to 40 CFR 194, waste characterization at DOE facilities was not emphasized. DOE states in Appendix WAP that AK is used to delineate waste streams to facilitate further characterization, to make hazardous waste determinations for debris waste, and to determine if homogeneous solids and soil/gravel are hazardous wastes. (CCA, Appendix WAP, p. C-21). With respect to 191/194 requirements, AK will be used to determine the radionuclide content as a basis for radioassay, and the combustible and metal content will be used to determine the radionuclide content as a basis for radiography and/or visual examination. In section 4 of the QAPP, DOE states that acceptable knowledge records must include the following information for each waste stream:

- Areas and buildings from which the waste stream was generated
- Waste stream volume and time period of generation

- ♦ Waste generating process described for each building
- ♦ Process flow diagrams
- ♦ Material inputs or other information that identifies the chemical and radionuclide content of the waste stream and the physical waste form (Appendix WAP, pp. C-3 to C-5)

In addition the following supplemental information may also be provided for AK records:

- ♦ Process design documents
- ♦ Standard Operating Procedures
- ♦ Preliminary and final safety analysis reports and technical safety requirements
- ♦ Waste packaging logs
- ♦ Site databases
- ♦ Information from site personnel
- ♦ Standard industry information
- ♦ Previous analytical data relevant to the waste stream
- ♦ Material Safety Data Sheets or other packaging information
- ♦ Sampling and analysis data from comparable or surrogate waste streams
- ♦ Laboratory notebooks that detail the research processes and raw materials used in experiments.

If the mandatory information is not available for a given waste stream, that waste stream cannot be shipped to WIPP on the basis of AK alone. Sites may submit additional sampling and analytical data to provide the required waste characterization data (Appendix WAP, p. C-3). Each site is required to prepare written procedures outlining the specific methodology used to assemble AK records, including document origination, how documents will be used, and any limitations associated with the information (Appendix WAP, p. C-7). The generator sites must also develop procedures that describe how AK is evaluated and how discrepancies in the documentation are resolved (Appendix WAP, p. C-8). All AK information is confirmed; each generator site must establish procedures for re-evaluating AK if radiography or visual examination results in the assignment of a different waste matrix code. The generator site procedures must describe how waste is reassigned, AK re-evaluated, and appropriate characterization codes assigned. (Appendix WAP, p. C-9). EPA finds that DOE's AK process is well documented and sufficiently rigorous to provide the basis upon which more detailed characterization will be made.

DOE provided extensive information pertaining to the waste characterization process, including that in Appendix WAP of the CCA, the QAPP (CCA Reference #210) and Methods Manual (CCA Reference #210). EPA has examined this information and has participated in site audits wherein the waste characterization process was observed and evaluated in detail; for further information, see EPA Technical Support Document for 194.24: WIPP Facility and Waste Characterization, especially the attachments in Item III-B-18 (EPA 1998c).

Quality Assurance Requirements for Process Knowledge/Acceptable Knowledge at Approved Sites

EPA ascertained the status of PK/AK at generator sites by inspecting DOE's site certification audits (EPA 1998c). EPA inspected CAO's waste characterization certification audit of LANL in May 1997, which included LANL's PK/AK process, procedures, and output. LANL prepared a PK/AK report as an example of the product which could be produced following their AK package development process (EPA 1998c; see especially "Audit Report for LANL" in Item III-B-18). EPA reviewed the report during the audit. DOE/CAO auditors' checklists and interviews included PK/AK for radiological waste characterization. The PK/AK information included the identification of radioisotopes, but LANL had not conducted the confirmation step at the time of the audit. LANL's follow-up audit was performed the week of August 18, 1997. Audit results indicated that LANL had to address additional issues (including conduct of the confirmation step for PK/AK radionuclide information and NDA data) before certification relative to PK/AK could be obtained from DOE. LANL addressed these issues during a second follow-up audit that took place September 10-12, 1997. In October 1997, DOE certified certain waste characterization activities at LANL, including approval of the PK/AK process.

EPA also participated in a RFETS audit, during which issues pertaining to PK/AK were raised. A RFETS follow-up audit will be conducted. A PK/AK certification audit will be held at INEEL as well. As of May 1998 both RFETS and INEEL have received waste characterization certification from DOE including PK/AK process approval, but no other DOE generator sites have undergone recertification or certification audits for PK/AK. See EPA Technical Support Document for Section 194.24: WIPP Facility and Waste Characterization (EPA 1998c) for further discussion of PK/AK audits that EPA observed. EPA also participated in all audits of the quality assurance process; see Section 194.22(a)(2)(i) in **CARD 22—Quality Assurance** for a discussion of audit results and EPA's evaluation of DOE's waste characterization quality assurance program.

24.H.1 BACKGROUND FOR 40 CFR 194.24(C)(4)

DOE must apply waste component limits for the waste emplaced in the disposal system. Section 194.24(c)(1) above describes the waste limits for important waste components and how these waste limits were established. Section 194.24(c)(4) requires the implementation of a system of controls that will be used to ensure that critical waste components for which waste limits have been established are appropriately traced to confirm that the total amount of each component will not exceed these limits. Section 194.24 (e)(1) and (e)(2) requires that the total quantity of emplaced waste must not exceed the estimated upper-bound limits for waste components and will not fall below the estimated lower-bound limits for waste components, which is linked to

§194.24(c)(4) in that the specified system of controls will ensure that the total quantity of emplaced waste will meet the limiting requirements.

24.H.2 REQUIREMENT

(c) "For each waste component identified and assessed pursuant to paragraph (b) of this section, the Department shall specify the limiting value (expressed as an upper or lower limit of mass, volume, curies, concentration, etc.), and the associated uncertainty (i.e., margin of error) for each limiting value, of the total inventory of such waste proposed for disposal in the disposal system. Any compliance application shall:

(4) Provide information which demonstrates that a system of controls has been and will continue to be implemented to confirm that the total amount of each waste component that will be emplaced in the disposal system will not exceed the upper limiting value or fall below the lower limiting value described in the introductory text paragraph (c) of this section. The system of controls shall include, but shall not be limited to: Measurement; sampling; chain of custody records; record keeping systems; waste loading schemes used; and other documentation."

(e) "Waste may be emplaced in the disposal system only if the emplaced components of such waste will not cause:

(1) The total quantity of waste in the disposal system to exceed the upper limiting value, including the associated uncertainty, described in the introductory text to paragraph (c) of this section; or

(2) The total quantity of waste that will have been emplaced in the disposal system, prior to closure, to fall below the lower limiting value, including the associated uncertainty, described in the introductory text to paragraph (c) of this section."

24.H.2 ABSTRACT

EPA expected the compliance application to: describe the system for maintaining centralized control over the waste characterization activities; describe the mechanism for maintaining chain of custody over waste and waste records; describe controls currently in place for receipt of waste at the WIPP; describe the record keeping/accounting system for controlling limited waste components for verification of emplacement of waste; and provide the current WIPP Waste Acceptance Criteria (WIPP WAC) document and identify all (WIPP WAC) requirements or controls that are relevant to compliance with 40 CFR Part 194.

Sections 194.24(e)(1) and (2) require DOE to ensure that the total quantity of emplaced waste in the disposal system will not exceed the upper limiting value for waste components and will not fall below the lower limiting value for waste components. These requirements are applicable to all waste proposed for emplacement in the WIPP.

In Chapter 4.4 (pp. 4-44 to 49) of the CCA, DOE described the system of controls for waste characterization activities. The TRU waste characterization program is conducted by the generator sites and is implemented in accordance with the requirements of the QAPP and WAC. DOE stated that implementation of the TRU waste characterization program at DOE sites requires that all waste characterization activities be conducted in accordance with approved documentation that describes the management, operations and QA aspects of the program. DOE also indicated that conformance with applicable regulatory (Federal and State), programmatic and operational requirements is monitored by DOE/Carlsbad Area Office (CAO) audit and surveillance program. There are two phases in the waste characterization controls of WIPP waste screening, as described in Appendix WAP, Section C-5 (pp. C-37 to 42): Phase I, which entails Waste Stream Screening and Verification at generator sites before waste is shipped to the WIPP; and Phase II, which entails controls implemented at the WIPP site.

DOE indicated that data and documents associated with waste characterization are managed in accordance with standardized records management practices. DOE stated in Appendix WAP, Section C-5 (pp. C-46 to 47) that the following records will be maintained for waste characterization purposes as part of the WIPP operating record: completed Waste Stream Profile Forms and accompanying documentation (including the WWIS Characterization Data Report); completed waste receipt checklists; WWIS Container Emplacement Report; and audit reports and corrective action reports from DOE/CAO audits of the sites. In Appendix WAP, Section C-5 (pp. C-42 to 47), DOE provided information on controls currently in place for receipt of waste at the WIPP. DOE did not provide information on shipment surveys for either RH or CH-TRU waste in the CCA. However, DOE included CH and RH-TRU waste shipment survey information in the RCRA Part B Permit Application submitted to the New Mexico Environment Department (DOE 1996d).

In Section 4.3.2 (pp. 4-35 to 39) and the WIPP Waste Information System Software Design Description (WWIS SDD), DOE provided descriptions of documentation, data fields, and features of the WWIS. The WWIS, as described by DOE, is the record keeping and accounting system for controlling limited waste components for verification of waste emplacement. The WWIS is a computerized data management system used by the WIPP to gather, store, and process information pertaining to TRU waste destined for or disposed at the WIPP. DOE indicated (Chapter 4.3.2) that the WWIS tracks waste components and associated uncertainties against their upper and lower limits and provides notification before the waste component limits are exceeded, in accordance with 40 CFR 194.24(e)(1) and (2). In Section 4.3.2 (pp. 4-36 and 39), DOE stated that there are 130 data fields associated with the WWIS.

EPA reviewed DOE’s description of system controls, chain of custody information, controls in place to track WIPP waste, waste record keeping and accountability systems, and WIPP WAC requirements and controls. EPA noted that Chapter 4.4 (pp. 4-48 to 4-49) discusses the waste stream profile form (WSPF). However, the WSPF (as provided in Appendix WAP, Figure C-4, p. C-130) does not include radiological waste characterization information beyond “material inputs or other information identifying radionuclide content.” EPA also noted that the WWIS is not fully functional (i.e., tested at WIPP and at LANL for manual data entry, but not tested for manual data entry at other generator sites or for electronic data entry at any generator sites).

24.H.3 COMPLIANCE REVIEW CRITERIA

As stated in the CAG (p. 34), EPA expected the compliance application to:

- ♦ Describe the system for maintaining centralized control over the waste characterization activities and authorization of grants to generator sites to characterize and ship waste to WIPP.
- ♦ Describe the mechanism for maintaining chain of custody over waste and waste records from the point of characterization to the point of disposal.
- ♦ Describe controls currently in place for receipt of waste at the WIPP, including: provisions for records and shipment surveys, acceptance and emplacement of waste, and provisions for dealing with non-conforming waste/waste records. cite applicable procedures.
- ♦ Describe the record keeping/accounting system for controlling limited waste components for verification of emplacement of waste.
- ♦ Provide the current WIPP Waste Acceptance Criteria (WIPPWAC) document and identify all (WIPPWAC) requirements or controls that are relevant to compliance with 40 CFR Part 194 (i.e., those criteria specifically related to performance).

EPA expected any evidence that substantiates compliance to be provided as part of any compliance application, or when cited in the CCA, to be available for inspection. This includes evidence that substantiates that waste components for which inventory limits were set in accordance with §194.24 (c) are monitored, controlled, and accounted for in a systematic and traceable manner. The waste proposed for disposal includes waste that undergoes treatment or repackaging, remote-handled and contact-handled wastes, and to-be-generated waste. The WIPP WAC addresses many varied requirements including those of DOT and NRC. For the purposes of waste characterization, EPA is interested in only those WAC limits which relate to limits placed on components which affect compliance.

Sections 194.24(e)(1) and (2) require DOE to ensure that the total quantity of emplaced waste in the disposal system will not exceed the upper limiting value for waste components and will not fall below the lower limiting value for waste components. This requirement is applicable to all waste proposed for emplacement in the WIPP.

24.H.4 DOE METHODOLOGY AND CONCLUSIONS

System for Maintaining Centralized Control Over Waste Characterization Activities

In Chapter 4.4 (pp. 4-44 to 49) of the CCA, DOE described the system of controls over waste characterization activities. The TRU waste characterization program is conducted by the generator sites and is implemented in accordance with the requirements of the Quality Assurance Program Plan (QAPP) (DOE 1996a) and Waste Acceptance Criteria (WAC) (DOE 1996c). The sites must follow the sampling and measurement methods as specified in DOE's Transuranic Waste Characterization Sampling and Analysis Methods Manual (Methods Manual) (DOE 1996b). See Section 194.24(c)(2) of this CARD for a discussion of DOE's sampling and measurement methods.

In Chapter 4.4 (pp. 4-47 to 48), DOE stated that implementation of the TRU waste characterization program at DOE sites requires that all waste characterization activities be conducted in accordance with DOE approved documentation that describes the management, operations, and QA aspects of the program. Generator sites develop programs to control their TRU waste characterization, certification (which includes characterization), and transportation processes. Site-specific TRU waste certification plans document how compliance with the WAC and QAPP are accomplished. Site certification will be granted by the CAO manager contingent upon final approval of the following documentation: TRU waste certification plan (including QA); QAPjPs; TRU package transporter; packaging QA plan; and performance in Performance Demonstration Programs (PDPs). See Section 194.24(c)(5) of this CARD for a description of the PDPs, governing documents of the PDPs, and status of current implementation of PDPs.

In Chapter 4.4 (pp. 4-47 to 49), DOE stated that conformance with applicable regulatory, programmatic, and operational requirements is monitored by the DOE/Carlsbad Area Office (CAO) audit and surveillance program. Generator sites must undergo a site certification audit by CAO, during which the adequacy and effective implementation of these programs are assessed. If deficiencies are identified, sites must develop and implement corrective actions until the site can pass a certification audit. The initial audit is conducted at a generator site prior to formal acceptance of that site's waste stream profile forms (WSPFs) and waste characterization data. This formal acceptance is referred to as site certification. The audits verify that the generator site has implemented a QA program for all certification activities. Additionally, certification audits examine the technical adequacy of equipment, procedures, and personnel for activities associated with waste characterization. Each generator site must go through recertification by the CAO annually. Recertification consists of reviewing the following: site-specific program documents; program implementation; reports from audits and surveillances; performance in shipping; and performance in PDPs. See Section 194.24(c)(5) of this CARD for a discussion of additional requirements for the PDPs.

There are two phases in the waste characterization controls of WIPP waste screening. In Appendix WAP, Section C-5 (pp. C-37 to 42), DOE provided information on these two phases. Phase I entails Waste Stream Screening and Verification, which is a three-step process that will occur before waste is shipped to the WIPP. First, an initial audit of the site will be conducted by DOE/CAO as part of the audit program before the WIPP will begin the process of accepting waste from a site. The audit will provide on-site verification of characterization procedures, data package preparation and record keeping. Second, WIPP personnel will review the waste characterization data package for completeness and accuracy as part of the Waste Stream Profile Form (Appendix WAP, Figure C-4, p. C-130) approval process. Third, waste characterization data on the WSPF will be entered manually or electronically into the WIPP Waste Information System (WWIS). The WWIS is discussed below under "Record Keeping/Accounting System for Controlling Limited Waste Components." WIPP staff verify that all of the required elements of a waste characterization data package are present and that the data meet acceptance criteria required for compliance. CAO's approval or rejection to ship a waste stream to the WIPP is the outcome of Phase I. Phase II—Waste Shipment Screening and Verification—is discussed below.

Mechanism for Maintaining Chain of Custody

DOE described records management and storage in Appendix WAP, Section C-5 (pp. C-46 to C-47). The storage of the WIPP's copy of the manifest, waste characterization data, WSPFs, and other related records will be identified on a records inventory and disposition schedule. DOE stated that data and documents that are part of the WIPP operating record are stored in accordance with the following guidelines: active records must be stored when not in use; quality records must be kept in a one-hour, fire-rated container or a copy of a record must be stored separately and sufficiently remote from the original; and unauthorized access to the records is controlled by locking the storage container or controlling personnel access to the storage area.

DOE stated in Appendix WAP, Section C-5, that the following records will be maintained for waste characterization purposes as part of the WIPP operating record: completed WSPFs and accompanying documentation (including the WWIS Characterization Data Report); completed waste receipt checklists; WWIS Container Emplacement Report; and audit reports and corrective action reports from DOE/CAO audits of the sites. The WWIS data will be backed up every 24 hours, and the backup data will be archived. The security and integrity of the WWIS database are supported by physical as well as electronic barriers. The audit process will provide on-site verification of characterization procedures, data package preparation and record keeping. These records will be maintained for each TRU mixed waste container managed at the WIPP. Records will be managed in accordance with the CAO Quality Assurance Program Description (QAPD) record management requirements. The QAPD identifies requirements for the generation, indexing, classification, receipt, storage, preservation, disposition, and retrieval of QA records.

Controls Currently in Place for Receipt of Waste at the WIPP

In Appendix WAP, Section C-5 (pp. C-42 to 47), DOE described controls in place for receipt of waste at the WIPP, which constitutes Phase II—Waste Shipment Screening and Verification. Phase II, like Phase I, is a three-step process. First, WIPP personnel determine the completeness and accuracy of the Hazardous Waste Manifest. Upon receipt of a waste shipment, WIPP personnel will revise and sign the manifest before the driver departs. Second, WIPP personnel will verify completeness of the waste shipment by checking the unique, bar-coded identification number found on each TRU waste container. The bar-coded identification number will be checked against the WWIS, which maintains waste container information. Third, any irregularities or discrepancies in the waste shipment will be identified and resolved. If there are discrepancies, the generator will be told to resolve them. Any waste container information not provided during Phase I will be supplied electronically to the WWIS. Approval or rejection of the waste shipment for disposal at the WIPP is the outcome of Phase II. In CCA, Section 4.3.1, DOE provided a waste loading scheme discussion. See Section 194.24(d) below for information pertaining to waste loading.

The CCA did not contain shipment surveys for CH-TRU waste because no waste shipments have taken place. However, DOE included CH-TRU waste shipment survey information in the

RCRA Part B Permit Application submitted to the New Mexico Environment Department (DOE 1996d). The RCRA Part B Permit Application, Chapter D, Section D-10a(3)(b), "CH TRU Waste Handling," states that CH-TRU waste will arrive by tractor-trailer at the WIPP facility in sealed TRUPACT-II shipping containers. The TRUPACT-II containers will undergo security and radiological checks and shipping documentation reviews. A forklift will remove the TRUPACT-II containers from the trucks and transport them a short distance through an air lock into the CH Bay of the Waste Handling Building (WHB). The outer containment vessel lid of the TRUPACT-II containers will be lifted and an external survey of the inner vessel will be performed. The contamination surveys will consist of surface sampling (swipes) and radioactivity counting. An overhead bridge crane will be used to remove the CH-TRU waste containers from the TRUPACT-II containers. Additional surveys will be conducted on the containers. If the TRUPACT-II containers or the CH-TRU waste containers are found to be contaminated in excess of DOE's free release limits (i.e., 20 disintegrations per minute alpha or 200 disintegrations per minute beta/gamma), the TRUPACT-II or CH-TRU waste container may be decontaminated if the contamination falls within the criteria for small area spot decontamination (i.e., less than or equal to 100 times the free release limit and less than or equal to 6 square feet 0.56 square meters). If a large area of contamination is discovered during unloading, the waste will be left in the TRUPACT-II container and the shipping container resealed. The TRUPACT-II container will then be returned to the shipper, shipped to another DOE site for management, or shipped to a non-DOE facility for decontamination.

The CCA also did not contain shipment surveys for RH-TRU waste because no waste shipments have taken place. However, DOE provided RH-TRU waste shipment survey information in the RCRA Part B Permit Application. The RCRA Part B Permit Application, Chapter D, Section D-10a(3)(c), "RH TRU Waste Handling," states that the RH-TRU waste will arrive at the WIPP facility in a shielded road cask loaded on a tractor-trailer or in a railroad cask loaded on a railcar (DOE 1996d). Upon arrival, radiological checks, security checks, and shipping documentation reviews will be performed. Inside the RH Bay of the WHB, the shielded cask will be unloaded from the tractor-trailer or railcar via a bridge crane. The outer cask lid will be removed and the inner cask lid prepared for removal. The shielded cask will be moved into the unloading room of the hot-cell complex and positioned under the hot-cell unloading port, the cask-seal collar will be mated to the unloading port, the inner cask lid will be removed, and the RH-TRU waste canister will be lifted into the hot cell. In the hot cell, trained operators will remotely take sample swipes from the canisters. The swipe samples will be removed from the hot cell via the shielded transfer drawer and will be checked for contamination. If a canister is contaminated or physically damaged, it will be decontaminated or overpacked prior to transfer to the underground repository.

Record Keeping/Accounting System for Waste Components

DOE identified ten radionuclides important to the long-term performance of WIPP: ^{241}Am, ^{244}Cm, ^{137}Cs, ^{238}Pu, ^{239}Pu, ^{240}Pu, ^{241}Pu, ^{90}Sr, ^{233}U, and ^{234}U. Of these ten, ^{90}Sr, ^{233}U, and ^{137}Cs are important to RH but not CH waste streams. In addition, DOE identified four important waste components that must be tracked because limits were required for compliance (Appendix WCL, Table WCL-1). The waste components with limiting values are:

- Ferrous metals (iron): minimum of $2x10^7$ kilograms.
- Cellulosics/plastic/rubber: maximum of $2x10^7$ kilograms.
- Free water emplaced with waste: maximum of 1684 cubic meters.
- Nonferrous metals (metals other than iron): minimum of $2x10^3$ kilograms

In Chapter 4.3.2 (pp. 4-35 to 39) and the WIPP Waste Information System Software Design Description (WWIS SDD) (DOE 1997n), DOE described the WWIS, including documentation, data fields and features. The WWIS is the record keeping and accounting system for controlling limited waste components for verification of waste emplacement. The WWIS is a computerized data management system used by the WIPP to gather, store, and process information pertaining to TRU waste. The WWIS collects information into one source and provides data in a uniform format whose accuracy is verifiable. The WWIS is used to store all information pertaining to characterization, certification, and emplacement of waste at the WIPP. It has features such as automatic limit, range and QA checks, automatic report generation, and the ability to track compliance with 40 CFR part 194.24 requirements.

The WWIS also tracks waste components and associated uncertainties against their upper and lower limits and provides notification before the waste component limits are exceeded, in accordance with 40 CFR parts 194.24(e)(1) and (2). The records contained within the WWIS will be reviewed periodically by DOE management to track performance against the established limits. Additionally, the emplaced inventory will receive close scrutiny during any EPA audit/inspection or recertification.

DOE stated that the following reports associated with the WWIS are sufficient to document the software lifecycle (pp. 4-35 to 4-36):

- WWIS Evaluation and Recommendations (associated with DOE 1997c, DOE 1997d, DOE 1997e)
- WWIS Software Quality Assurance Plan (DOE 1997f).
- WWIS Software Verification and Validation Plan (DOE, 1997g).
- WWIS Software Requirements Specification document (DOE 1997h).
- WWIS Software Design Description (DOE 1997i).
- WWIS Software Configuration Management Plan (DOE 1997j).
- WWIS Security Plan.
- Contingency Plan—WIPP Wide-Area Network.

- Risk Analysis Report—WIPP Wide-Area Network.

Chapter 4.3.2 (pp. 4-36 and 4-39) stated that there are 130 data fields associated with the WWIS and referenced Appendix WAP, Appendix C13, for this information. Appendix WAP, Appendix C13, described the data fields associated with the WWIS. DOE updated the WWIS SDD and the data fields associated with the WWIS in 1997 (DOE 1997i). The CCA lists the following data fields (including waste material parameters) as relevant to compliance:

- Assay characterization method
- Assay date
- Disposal date
- Nondestructive examination
- ^{239}Pu fissile gram equivalent
- Radionuclide activity
- Radionuclide activity uncertainty
- Radionuclide mass
- Radionuclide mass uncertainty
- TRU alpha activity
- TRU alpha activity uncertainty
- Verification data
- Verification method
- Visual examination of container
- WAC certification data
- Waste Material Parameters (WMPs)
- Waste Matrix Code (WMC).

DOE referred to the WWIS SDD (DOE 1997i) in Chapter 4.3.2. The WWIS SDD communicates software design information about the system's application software by relating requirements for implementation to a description of software structure, components, interfaces and data. Section 2 of the WWIS SDD describes how the system has been structured and the purpose and function of each entity. The five design entities are: characterization, certification, shipment, disposal, and administration. For the characterization, certification and shipment entities, there is a function to “perform edit/range checks on data.” DOE has the capability to generate reports that contain waste-related information. DOE demonstrated during the WWIS Test of September 1997 that current fields include checks for components such as weight of cellulosics in kilograms, and the total capacity of CH waste in cubic feet or cubic meters. For the certification entity, there is a WAC exception function. For the disposal entity, several reports (i.e., bar code batch processing errors, nuclide, waste emplacement, headspace gas concentration) will be generated. DOE has provided the reporting schedule. For the administration entity, there are numerous reference tables (i.e., material parameters, nuclide, assay method, etc.) and several reports (i.e., reference tables, change log short, and change log long). Section 5 of the WWIS SDD contains the internal details of each design entity, including a description of the data elements associated with each entity. According to the WWIS SDD, the WWIS also has the capability to perform decay analysis using RADAC software and to perform regulatory reporting (i.e., by radionuclide, biennial).

WIPP Waste Acceptance Criteria (WIPP WAC) and Identification of All Requirements or Controls that are Relevant to PA

DOE included the WIPP WAC (DOE 1996c) as a reference to the CCA and identified the container-based limits imposed by the WAC, as well as the waste characterization requirements detailed in the WAC (Chapter 4.2.3, pp. 4-30 to 4-34, and Chapter 4.4, pp. 4-44 to 4-49). Chapter 4.2.3 summarizes the container-based limits imposed by the WIPP WAC in Table 4-12, including limitations on fissile gram equivalents per 55 gallon container, limitations on ^{239}Pu equivalent activity, waste container surface dose rates, RH waste thermal power, RH waste curies per liter, liquid in waste, explosives, compressed gas, pyrophoric materials, and polychlorinated biphenyls (PCBs).

24.H.5 EPA COMPLIANCE REVIEW

System for Maintaining Centralized Control Over Waste Characterization Activities

EPA determined that Chapter 4.4 (pp. 4-44 to 4-49) provided an adequate description of the system for maintaining centralized control over waste characterization activities. During the May 1997 waste characterization certification audit at LANL, EPA observed DOE/CAO auditors and determined that they sufficiently examined the qualifications, responsibilities, and activities of waste characterization records center personnel, as well as the records themselves. In addition, during the WWIS demonstration of June 1997, EPA observed the system’s security, data backup and archiving functions and reviewed the associated documentation. During the WWIS test of September 1997, which occurred simultaneously at WIPP and LANL, EPA observed the reporting for nuclides and waste container data and the calculation of total cellulosics (including plastics and rubber).

EPA also inspected the waste characterization certification audits at RFETS (June 1997) and LANL (May, August, and September 1997), as well as the PDPs at LANL (June 1997) and RFETS (November 1996). These are the only audits and PDPs that EPA inspected. EPA verified at the audits and PDPs that DOE had an adequate system for maintaining centralized control over waste characterization activities. See EPA Technical Support Document for Section 194.24: WIPP Facility and Waste Characterization (EPA 1998c) for further discussion of the audits and PDPs; see Section 9 of this document for further discussion of the WWIS.

Chapter 4.4 (pp. 4-48 to 4- 49) discusses the waste stream profile form (WSPF). However, the WSPF (as provided in Appendix WAP, Figure C-4, P. C-130) does not include radiological waste characterization information beyond "material inputs or other information identifying radionuclide content." The WSPF provides a location for sampling and analysis data, but does not provide a location for NDA data. NDA data are a critical part of the waste characterization program, and a location must be provided for it on the WSPF.

EPA determined that Chapter 4.4 (p. 4-49) did not provide an adequate description of the radiological waste characterization portion of the audit process, and that the audit checklist (as presented in Appendix WAP, Appendix C11) does not include a radiological waste characterization portion. This situation is a compliance concern because the quantity of radioactive material directly affects the results of PA and therefore must be recorded and tracked accurately. Through EPA's inspection of the waste characterization certification audits at LANL (May, August and September 1997), EPA reviewed DOE/CAO auditors' checklists and observed the auditors during interviews, and determined that the auditors sufficiently examined LANL's waste characterization program as it relates to radiological waste characterization. See EPA Technical Support Document for Section 194.24: WIPP Facility and Waste Characterization, especially attachments in III-B-18 (EPA 1998c), for further discussion of the LANL inspection.

Mechanism for Maintaining Chain of Custody

EPA reviewed the records management and records storage information that DOE provided in Appendix WAP for evidence of a clear chain of custody, Appendix WAP, Section C-5 (pp. C-46, 47), and found the information to be adequate. During the May 1997 waste characterization certification audit at LANL, EPA observed that the LANL waste characterization records center exceeds the records management and storage guidelines required by DOE of WIPP waste documents. See EPA Technical Support Document for Section 194.24: WIPP Facility and Waste Characterization, especially attachments in III-B-18 (EPA 1998c) for further discussion of records management and storage.

Also during the May 1997 waste characterization certification audit at LANL, EPA observed DOE/CAO auditors through their audit checklists and interviews, and determined that the auditors sufficiently examined the LANL waste characterization records center personnel qualifications, responsibilities, and activities, as well as the records themselves. In addition, during the WWIS demonstration of June 1997, EPA observed the WWIS security, data backup and archiving functions and reviewed the associated documentation. EPA also found that the WWIS demonstrated the physical ability to perform the functions which DOE requires and was thus found adequate for its intended purpose. See EPA Technical Support Document for Section 194.24: WIPP Facility and Waste Characterization (EPA 1998c) for further discussion of records maintenance and the WWIS.

Controls Currently in Place for Receipt of Waste at the WIPP

EPA reviewed the CCA to determine if DOE provided adequate information on controls currently in place for receipt of waste at the WIPP. In Appendix WAP, Section C-5 (pp. C-42 through C-47), DOE provided details on the Phase II - Waste Shipment Screening and Verification, although DOE did not cite applicable procedures. However, EPA determined that DOE has sufficient controls in place for waste receipt given that waste receipt is still not scheduled and thus plenty of time is available to develop and implement the specific procedures which will be reviewed through audits and inspections.

DOE did not provide information on shipment surveys for CH-TRU and RH-TRU waste in the CCA. However, DOE included adequate CH-TRU and RH-TRU waste shipment survey information in the RCRA Part B Permit Application submitted to the New Mexico Environment Department (DOE 1996d). Refer to RCRA Part B Permit Application Chapter D, Section D-10a(3)(b), CH TRU Waste Handling, and Section D-10a(3)(c), RH TRU Waste Handling, respectively.

Record Keeping/Accounting System for Waste Components

EPA reviewed the CCA and determined that DOE provided generally an adequate descriptions of the WWIS in general including documentation, data fields and features in Chapter 4.3.2 (pp. 4-35 to 4-39) and the WIPP Waste Information System Software Design Description (WWIS SDD) (DOE 1997i). Although, DOE did not submit documentation that the WWIS had been implemented and could be functionality tested in order to support compliance related inspections. EPA submitted a request for additional WWIS information (i.e., automatic limits, range and QA checks; automatic report generation) in the completeness comment letter dated December 19, 1996 (Docket A-93-02, Item II-I-01). DOE responded on May 2, 1997 to EPA's completeness comment by referencing the information already provided in the CCA (Docket A-93-02, II-I-28). EPA determined that DOE provided no additional information on the WWIS in its response and therefore did not demonstrate that the WWIS was functional.

Subsequently, in September 1997, DOE demonstrated for EPA the operation of the WWIS at LANL. EPA observed that the WWIS provides checks for repository-based limits (i.e., cellulosics in kilograms, total capacity of contact-handled (CH) waste in cubic feet or cubic meters). During the WWIS test, which occurred simultaneously at the WIPP and LANL, EPA also observed the nuclide reporting, waste container data reporting, and calculation of total cellulosics (including plastics and rubber). See EPA Technical Support Document for Section 194.24 (EPA 1998c) for further discussion of the features of the WWIS.

The following WWIS documents were reviewed by EPA and found to be adequate because they contained complete and technical descriptions of the system and its function which were subsequently verified by inspection:

- WWIS Evaluation and Recommendation

- WWIS Software Quality Assurance

- WWIS Software Verification and Validation Plan
- WWIS Software Requirements
- WWIS Software Design Description
- WWIS Software Configuration Management Plan
- WWIS Security Plan
- Contingency Plan - WIPP Wide-Area Network and
- Risk Analysis Report - WIPP Wide-Area Network.

EPA determined by reviewing the documents listed above and by actually inspecting the system in operation that the WWIS tracks individual waste material parameters (i.e., cellulosics) and their weights.

When EPA conducts audits or inspections to verify compliance with 40 CFR 194.24, EPA will review DOE's system of controls for the following items that DOE has committed to track:

- The total quantity of waste (volumetrically)
- The quantity of the four important waste components for which DOE has identified limits
- Radionuclide activity for the ten radionuclides important to long-term performance
- Radionuclide activity uncertainty
- Radionuclide mass
- Radionuclide mass uncertainty
- TRU alpha activity
- TRU alpha activity uncertainty
- Verification data
- Verification method
- Visual examination of container
- WAC certification data

- Waste Matrix Code (WMC).

- General location of the waste in WIPP

DOE stated that several reports (i.e., bar code batch processing errors, nuclide, waste emplacement, headspace gas concentration) will be generated, and provided a schedule for these reports. According to the WWIS SDD, Section 2.6 (p. 26), the WWIS also has the capability to perform decay analysis using RADAC software and to do regulatory reporting (i.e., by radionuclide, biennial), but little detail beyond a mention of these features was provided in the CCA. See EPA Technical Support Document for Section 194.24 (EPA 1998c) for further discussion of waste information tracking and the WWIS.

EPA reviewed the CCA and determined that DOE adequately referenced and summarized the WIPP WAC in the CCA. EPA concluded that Chapter 4.2.3 (pp. 4-30 to 34) and 4.4 (pp. 4-44 to 49) adequately discussed the WIPP WAC and provided the container-based limits imposed by the WAC, as well as the waste characterization requirements detailed in the WAC.

24.I.1 BACKGROUND

See Section 194.24(c)(1), Background, for background information pertinent to this section.

24.I.2 REQUIREMENT

(c) "For each waste component identified and assessed pursuant to paragraph (b) of this section, the Department shall specify the limiting value (expressed as an upper or lower limit of mass, volume, curies, concentration, etc.), and the associated uncertainty (i.e., margin of error) of each limiting value, of the total inventory of such waste proposed for disposal in the disposal system. Any compliance application shall:

(5) Identify and describe such controls delineated in paragraph (c)(4) of this section and confirm that they are applied in accordance with the quality assurance requirements found in §194.22."

24.I.3 ABSTRACT

EPA requires DOE to provide the following quality assurance (QA) information for the system of controls in any compliance application. EPA expected DOE to provide a description of all Performance Demonstration Programs (PDPs) used to certify the capability and comparability of measurements at waste generation sites, and to provide standardized waste characterization methodologies, if not provided under §194.24(c)(2). EPA also expected DOE to cite objective evidence of the status of current implementation methods or procedures. Finally, EPA expected that the CCA would include documentation of QA for waste characterization activities from the point of generation (for to-be-generated waste) to the point of emplacement and disposal at the WIPP.

DOE completed Cycles 1, 2, and 3 of the PDP program at DOE TRU waste generator sites. EPA reviewed DOE documentation pertaining to these activities, including the PDP plan and results reports, and participated in the Cycle 2 PDP at RFETS and the Cycle 3 PDP at LANL.

24.I..4 COMPLIANCE REVIEW CRITERIA

As stated in the CAG (p. 34), EPA expected the compliance application to:

- Describe all Performance Demonstration Programs (PDPs) used to certify the measurements capability and comparability of waste generation sites.
- Provide all governing documents for PDPs.
- Cite (and make available for field review) objective evidence of the status of current implementation of PDPs (schedule of past and planned tests, reports on test rounds conducted, etc.).
- Provide or cite (and make available for field review) standardized Methods Manuals, Sampling and Analysis Procedures manuals, etc., that are used to standardize waste characterization methodologies, if not provided under §194.24(c)(2).
- Cite (and make available for field review) objective evidence (e.g., audit reports, certification reports, etc.) of the status of current implementation methods/procedures.

See Section 194.22(a)(2)(I) in **CARD 22—Quality Assurance** for additional discussion of quality assurance for waste characterization activities. EPA expected to see documentation of quality assurance for waste characterization activities from the point of generation (for to-be-generated waste) to the point of emplacement and disposal at the WIPP.

24.I.5 DOE METHODOLOGY AND CONCLUSIONS

Performance Demonstration Program (PDP) Descriptions

DOE described the Performance Demonstration Program (PDP) for NDA in Chapter 4.3.3.1 (p. 4-40) and 4.4 (p. 4-44). The PDP for NDA is designed to ensure compliance with the Quality Assurance Objectives identified in the QAPP by providing a test program that each generator site must pass prior to waste shipment. The PDP is crucial because it is the only means of qualifying some of the NDA equipment (which is state-of-the-art and first-of-a-kind in most cases). The PDP is a multiple (approximately 12)-cycle program that tests a site's NDA abilities to detect radionuclides from various source standards in different waste matrices. The Carlsbad Area Office (CAO) is the reviewing and approving authority for the PDP. All DOE facilities intending to dispose of their waste at the WIPP must participate in the PDP and pass all individual tests within each PDP cycle. The CAO uses the PDP to assess, evaluate, and approve DOE facilities for waste measurement and characterization before the waste is shipped to the WIPP.

As indicated in Chapter 4.3.3.1, the PDP describes the detailed elements that comprise the program, including test materials and analysis required. The PDP also identifies the criteria used for the evaluation of laboratory performance and the responsibilities of the personnel involved in the PDP. DOE indicated that PDP radioactive source standards used in the PDP tests encompass the range of activities (masses) anticipated in waste characterization. The PDP standards address activity ranges relative to waste acceptance criteria (WAC) limits, QAPP QAOs, and NDA method detection limits. The isotopes analyzed under this program include, but are not limited to, ^{238}Pu, ^{239}Pu, ^{240}Pu and ^{241}Am. The PDP uses fifty-five gallon drums which can receive various inserts designed to simulate waste matrices. These inserts may be interfering, moderating, reflecting, benign, or any variety of combinations. (Chapter 4.4.3.3.1, pp. 4- 42 and 4-43). As a site passes a particular PDP cycle, the site has demonstrated its ability to accurately assay waste contained in a matrix for which the PDP test matrix was representative. In the case of LANL which has passed PDP Cycle 3 - a combustible waste matrix, LANL has demonstrated that its equipment can accurately assay radionuclides in a combustible matrix.

DOE indicated in Section 4.3.3.1, that measurement performance must be demonstrated by the successful analysis of samples by all participating facilities on a semiannual basis. PDP samples are analyzed using methods that the facility will use for the analysis of the WIPP waste and that meet the QAPP specifications. PDP scoring is pass/fail. To pass the PDP, the facility must pass all individual tests. Waste analyses will be performed only by measurement facilities and instruments that have demonstrated acceptable performance in the PDP (Section 4.3.3.1, p. 4-43).

PDP Documents

DOE did not include the PDP Plan for NDA in the CCA. However, DOE later provided the PDP Plan for NDA (DOE 1995). DOE has since updated the PDP Plan for NDA (DOE 1997b). DOE has provided results of Cycle 1 and Cycle 2 PDPs (DOE 1996e and DOE 1997a).

Objective Evidence of the Status of Current Implementation of PDPs

In the CCA, DOE did not include the status of current implementation of PDPs at the generator sites. However, DOE has since provided PDP status information. NDA PDP Cycle 1 was completed in April 1996; Cycle 2 was completed in December 1996; and Cycle 3 was completed in June 1997. DOE presented the results of Cycle 1 at the September 1996 Technical Exchange meeting held in Washington, D.C., and the results of Cycle 2 at the January 1997 NDA/NDE Waste Characterization conference held in Salt Lake City, Utah (DOE 1996e and DOE 1997a). DOE will provide the Cycle 3 report upon completion of the report. These reports indicate that LANL for the passive-active neutron system (PAN) system and INEEL for the Stored Waste Examination Pilot Plant (SWEPP)/PAN system passed both Cycles 1 and 2, and RFETS passed on its PAN measurement system, but not its segmented gamma scan system. Results of Cycle 3 are pending.

Standardized Waste Characterization Methodologies

DOE did not include the manuals required for waste characterization in the CCA. However, DOE did provide EPA with the Methods Manual (DOE 1996b) in the CCA and the QAPP (DOE 1996a), which are used to standardize waste characterization methodologies. Although the Methods Manual includes methods for visual examination (Method 310.1) and radiography (Method 310.2), it does not include methodology for NDA. The QAPP does not contain specific radiological waste characterization procedures, however, it provides QA guidelines for AK, VE, NDA and radiography that can be found in the QAPP Chapter 4, Section 5.42, Chapter 9 and Chapter 10 (respectively).

Objective Evidence of the Status of Implementation of Methods/Procedures

DOE did not include the status of current implementation of methods/procedures in the CCA. Instead, information regarding the implementation of methods/procedures was made available to EPA as part of waste characterization certification audits at LANL and RFETS. Information was also obtained during the NDA PDPs at RFETS and LANL.

Other Waste-Related Quality Assurance Activities

DOE did not provide documentation in the CCA of QA for waste characterization activities from the point of generation (for to-be-generated waste) to the point of emplacement and disposal at the WIPP. Instead, DOE implemented a QA program by preparing several QA procedural documents and conducting audits. These QA documents, which are described further in **CARD 22—Quality Assurance**, are the CAO Quality Assurance Program Document, the TRU Waste Quality Assurance Program Plan (QAPP) and site-specific Quality Assurance Project Plans (QAPjP). DOE's QA requirements for TRU waste characterization are contained in the QAPP. The QAPP is applicable to all DOE TRU waste generator sites that anticipate characterizing TRU waste. The QAPjPs are developed at each generator and storage site. These documents describe the characterization activities that are performed in conformance with the QA requirements specified in the QAPP (DOE 1997b).

24.I.6 EPA COMPLIANCE REVIEW

Performance Demonstration Program (PDP) Descriptions

EPA reviewed Sections 4.3.3.1 (p. 4-40) and 4.4 (p. 4-44) of Chapter 4. EPA also acquired the updated PDP Plan for NDA (DOE 1997b) and Cycle 1, Cycle 2, and Cycle 3 PDP results (DOE 1996e, DOE 1997a, and DOE 1997m). EPA concluded that the supplements provided adequate information regarding the PDP for NDA.

PDP Documents

DOE did not provide the PDP Plan for NDA in the CCA. The PDP Plan for NDA (Revision 0, March 1995) was provided by DOE upon EPA's request (DOE 1995). Since then, an updated version of the PDP Plan for NDA (DOE 1997 Revision 1, April 1997) has been provided to EPA. In addition, Cycle 1, Cycle 2, and Cycle 3 results have been provided to EPA. EPA concluded that the necessary PDP documents have been provided.

Objective Evidence of the Status of Current Implementation of PDPs

EPA reviewed the CCA, Section 4.3.3 (p. 4-40) and determined that it does not include the status of the current implementation of PDPs at the generator sites. Although DOE does not provide the status of the current implementation of PDPs in the CCA, DOE has provided PDP status information to EPA. NDA PDP Cycle 1 was completed in April 1996; Cycle 2 was completed in December 1996; and Cycle 3 was completed in June 1997 at LANL. DOE presented the results of Cycles 1 and 2 at the September 1996 Technical Exchange meeting held in Washington, D.C., and at the January 1997 NDA/NDE Waste Characterization conference held in Salt Lake City, Utah, respectively. DOE has separately provided both the NDA PDP Cycle 1 and Cycle 2 Reports (DOE 1996e and 1997a). Although EPA did not participate in Cycle 1, EPA has participated in Cycle 2 at RFETS and in Cycle 3 at LANL. EPA plans to participate in the future NDA PDPs. EPA concluded that it has observed evidence of the implementation of the PDPs at a limited number of the generator sites.

Standardized Waste Characterization Methodologies

EPA determined that the CCA does not include the manuals required for waste characterization. Although DOE does not provide in the CCA the Methods Manual and the QAPP, which are used to standardize waste characterization methodologies, these two documents have been provided by DOE upon EPA's request. The Methods Manual does not include methods for NDA, but does include methods for VE and radiography, Methods 310.1 and 310.2 (respectively). The QAPP does not contain specific radiological waste characterization procedures, but does provide radiography procedures that can be found in QAPP Chapter 10. EPA concluded that standardized NDA methodologies have not been provided, but EPA also recognized that standardization of these procedures was not the intent of DOE. Instead, DOE provided QAPP guidelines that each generator site must meet regardless of the NDA technology used so that generator sites can have flexibility to analyze waste with different techniques, as appropriate. EPA will use its inspection authority to examine the particular technology implemented at each site. These inspections will be performed to determine that adequate and thorough procedures are developed and implemented and that, once implemented, these procedures will lead to an ability to NDA waste with the rigor required to continue to demonstrate compliance with 40 CFR part 194 requirements. See Section 194.24(c)(2) of this CARD for information regarding the methods used to quantify the limits of waste components.

Objective Evidence of the Status of Implementation of Methods/Procedures

EPA determined that the CCA does not identify the status of implementation of methods/procedures. Instead, EPA ascertained the status of methods/procedures through participation in the NDA PDPs at RFETS in November 1996 and at LANL in June 1997. In addition, EPA has ascertained the status of methods/procedures through participation in DOE/CAO waste characterization certification audits at LANL in May, August, and September 1997 (including NDA, AK, VE and radiography) and at RFETS in July 1997 (radiography only;

NDA, VE and AK will be included in the fall 1997 follow-up audit). EPA also reviewed DOE's Cycle 1, Cycle 2, and Cycle 3 Reports. EPA concluded, based on observation of PDP activities and review of DOE PDP documents, objective evidence of the status of the PDP has been provided. See EPA Technical Support Document for Section 194.24: WIPP Facility and Waste Characterization (EPA 1998c) for further discussion of waste characterization methodology and procedures at the generator sites.

Other Waste-Related Quality Assurance Activities

DOE did not provide documentation of QA for waste characterization activities from the point of generation (for to-be generated waste) to the point of emplacement and disposal at the WIPP. However, EPA was able to examine DOE's QA program, which consists of QAPD, QAPP, QAPjPs at LANL , and an audit program. EPA found that a well functioning and audited/inspected QA program with approved implementation documents (QAPD, QAPP, and QAPjPs) provides a high level of assurance that actual operating procedures for future activities will be properly developed. EPA will use its inspection authority to ensure that QA procedures are developed and implemented to cover the quantification and tracking of waste and waste information from "cradle to grave." EPA reviewed the QAPD, QAPP, and available QAPjPs as part of its inspection of DOE audits. In addition, EPA inspected DOE's waste characterization certification audits at LANL in May, August, and September 1997 and at RFETS in July 1997, as well as the NDA PDPs at RFETS in November 1996 and at LANL in June 1997. DOE's QA program was evaluated by EPA during activities performed under 40 CFR 194.22; see **CARD 22—Quality Assurance**.

EPA confirmed through inspections that the system of controls—and in particular, the measurement techniques—are adequate to characterize waste and ensure compliance with the limits of waste components, and also that a QA program had been established and executed at LANL in conformance with NQA requirements. Moreover, DOE demonstrated that the WWIS is functional with respect to LANL— i.e., that procedures are in place at LANL for adding information to the WWIS system, that information can be transmitted from LANL and incorporated into the central database, and that data in the WWIS database can be compiled to produce the types of reports described in the CCA for tracking compliance with the waste limits. Therefore, EPA determines DOE to have demonstrated compliance with Section 194.24(c)(5) for legacy debris waste at LANL. EPA does not find, however, that DOE has demonstrated compliance with these requirements for any other waste generator site.

24.J.1 BACKGROUND FOR SECTION 194.24(d)

DOE has the option of implementing procedures to control the spatial distribution of TRU waste within the disposal system. 40 CFR 194.24(d). Otherwise, DOE must assume random emplacement of waste in the disposal system for purposes of performance and compliance assessments. Either way, DOE must ensure that actual waste emplacement conforms with the loading conditions assumed in performance and compliance assessments. 40 CFR 194.24(f). Because these criteria are closely related, EPA has combined discussion of them here.

The spatial distribution of the TRU waste within the disposal system is modeled in the PA cuttings release calculations. In the borehole intrusion scenario, contact-handled transuranic (CH-TRU) or remote-handled transuranic (RH-TRU) waste may be brought to the surface when a drill bit penetrates containers of waste within the disposal system. The release could be calculated as the product of the volume (in cubic meters) and the radionuclide concentration (EPA units per cubic meter) of the wastes removed from the penetrated drums. DOE could implement a waste loading plan to control preferentially the emplacement and distribution of TRU waste in order to limit radionuclide releases in the PA in the event of a drilling intrusion.

24.J.2 REQUIREMENT

(d) "The Department shall include a waste loading scheme in any compliance application, or else performance assessments conducted pursuant to § 194.32 and compliance assessments conducted pursuant to § 194.54 shall assume random placement of waste in the disposal system."

(f) "Waste emplacement shall conform to the assumed waste loading conditions, if any, used in performance assessments conducted pursuant to §194.32 and compliance assessments conducted pursuant to §194.54."

24.J.3 ABSTRACT

EPA examined the CCA to determine whether DOE provided a final plan for waste loading that addresses the emplacement of radioactive waste and implements any assumptions about the distribution of the waste that were used in the performance assessment. EPA expected DOE to cross-reference the waste distribution assumptions from the waste loading plan with the waste distribution assumptions used in the PA. Finally, EPA examined DOE's description of how the planned distribution of waste (as assumed in the PA) would be achieved. This discussion should identify both the acceptance criteria for implementation and the controls that will be in place to assure proper implementation of the plan.

DOE assumed that the location of each borehole intrusion within the waste disposal region is sampled randomly and that each penetration could encounter either CH-TRU or RH-TRU waste. For calculating direct releases of radioactive waste to the accessible environment, DOE assumed that containers are randomly placed in the WIPP from the various 569 waste streams that comprise CH-TRU waste. DOE then assumed that a penetrating drill bit would pass vertically through three drums (since the drums will be stacked three-high), and that each drum could contain a different waste stream (based on the distribution of waste streams presented in the Transuranic Waste Baseline Inventory Report (Appendix BIR, TWBIR, Revision 3)).

DOE then calculated the complementary cumulative distribution functions (CCDFs) by estimating cumulative radionuclide releases to the accessible environment for 10,000 different possible futures (starting 100 years after closure). DOE used the results of these calculations to determine whether random emplacements of waste containers in the WIPP was important and thus, whether a load management plan was necessary to support the assumptions used in PA.

In response to comments made by EPA in a letter dated March 19, 1997, DOE submitted additional analyses to address the possible impact of nonrandom loading on spallings or cuttings and cavings releases. DOE considered releases to be conditional on (1) the occurrence of a single intrusion, 100 years after decommissioning, into the highest-activity waste stream containing at least 810 drums, and (2) the association of maximum-volume spallings or cuttings and cavings events under a borehole intrusion scenario.

EPA reviewed DOE's methodology for determining whether a final plan for waste loading to control the emplacement of waste and implement any assumptions about the distribution of the waste was necessary. EPA also reviewed DOE's methodology for addressing waste loading and determined whether DOE cross-referenced the resultant waste distribution assumptions from the waste loading plan with the waste distribution assumptions used in the PAs. EPA also reviewed the CCA to determine whether the waste distributions within the waste disposal system were accurately modeled in DOE's methodology for determining whether a final plan for waste loading was necessary. Lastly, EPA reviewed DOE's supplemental analyses concerning the possible effects of nonrandom loading.

24.J.4 COMPLIANCE REVIEW CRITERIA

If DOE does not opt to assume random emplacement of waste in conducting performance assessments and compliance assessments, EPA expected that the compliance application would:

- Provide a final plan for waste loading that addresses the emplacement of waste and implements any assumptions about the distribution of such waste that were used in the descriptions of performance assessments, and provide a cross-reference to waste distribution assumptions made in the performance assessments.

- Address the requirement of §194.24(f) in the emplacement plan by describing how the planned distribution will be achieved, with specification of acceptance criteria for implementation and the controls that will be in place to assure proper implementation of the plan.

If random placement is assumed in the performance assessments, documentation should be submitted that addresses how it will be achieved in actual emplacement (CAG, p. 35).

24.J.5 DOE METHODOLOGY AND CONCLUSIONS

DOE elected to assume that radioactive waste would be emplaced in the WIPP in a random fashion (Chapter 4.3.1, p. 4-35). DOE therefore did not provide a waste loading plan to describe how the planned distribution of waste would be achieved. DOE incorporated the assumption of random waste loading in its performance and compliance assessments (pursuant to §§ 194.32 and 194.54, respectively).

DOE's discussion of load management and assumed waste distribution within the waste disposal system is provided in Chapter 4.3.1 (pp. 4-34 to 4-35). The conceptual and computational models and methodologies used to perform the system-level consequence analysis of waste distribution within the waste disposal system are discussed in Chapter 6.4.12.3 and 6.4.12.4 (pp. 6-137 to 6-140). The sensitivity and uncertainty analyses are presented in Appendix SA (pp. SA-1 to SA-15). DOE's supplemental analyses concerning the possible effects of nonrandom loading are provided in a May 2, 1997, response (Docket A-93-02, Item II-I-28 Enclosure 1, p. 8-18) to EPA's March 19, 1997 request for additional information on the WIPP CCA (Docket A-93-02, Item II-I-17).

DOE's methodology for determining whether a load management plan was necessary to control waste distribution within the waste disposal system incorporated the following steps. First, DOE assumed that the location of each borehole intrusion within the waste disposal region is sampled randomly and that each penetration could encounter either CH-TRU or RH-TRU waste (Chapter 6.4.12.3). This was done in the analysis by separating a plan view of the area of the WIPP footprint into 144 regions and requiring each intruding borehole to penetrate only one region. The probability of intersecting each location is equal to 1/144 (about 0.00694), and slight variations in the size of the regions were disregarded as unimportant (Chapter 6.4.12.3, p. 6-183).

DOE stated that each of the 144 regions contains both excavated and unexcavated areas at the repository horizon (Section 6.4.12.3, p. 6-184). A borehole entering the Salado Formation has approximately a 20 percent chance of entering an excavated region and approximately an 80 percent chance of passing through an unexcavated region. Boreholes that penetrate excavations may penetrate CH-TRU waste, RH-TRU waste, or panel closures that contain no waste. For long-term releases, all penetrations into excavations are treated by DOE as if CH-TRU waste is penetrated, and the RH-TRU waste inventory is averaged into the CH-TRU waste inventory for source-term determination. For cuttings and cavings direct releases, DOE stated that there is an approximately 12 percent chance that RH-TRU waste canisters are penetrated and an 88 percent chance that CH-TRU waste is penetrated, corresponding to the relative plan-view areas of each waste type (Chapter 6.4.12.3, p. 6-184).

The quantity of radionuclides will vary from container to container (Appendix BIR, Appendix P). Radioactivity in containers may vary by several orders of magnitude depending on the quantity of radionuclides (Sanchez et al., 1997). DOE compiled information about waste radioactivity on several different levels. The waste-stream level includes information about waste activities from different processes at the generator sites that generate TRU waste. This level maintains separate waste stream characteristics for 569 CH-TRU waste streams and approximately 401 RH-TRU waste streams. Because the RH-TRU waste is approximately 1.5 percent of the total EPA units (not activity) of CH-TRU waste, all the RH-TRU waste was grouped together into one equivalent or average RH-TRU waste stream. DOE assumed that the variability in this small fraction is negligible (Chapter 6.4.12.4, p. 6-189 to 6-190, and Sanchez et al., 1997).

The waste-generator site level inventory includes information projected over the life of TRU waste generation at a site. DOE identified 21 generator sites for the WIPP (Chapter 6.12.4) and provided data for existing waste and estimated data for future (to-be-generated) waste. This information was compiled from the Transuranic Waste Baseline Inventory Database (TWBID), an electronic version of the TWBIR, Revision 3 (Appendix BIR). Direct releases caused by the mechanisms of cuttings and cavings access discrete and relatively small portions of the waste, and estimates of the quantity of radioactivity released to the accessible environment from these mechanisms may be sensitive to variability in the quantity and location of radioactive material within the waste.

DOE calculated the radioactivity of cuttings and cavings releases using data from the waste-stream level in the following manner (Chapter 6.4.12.4, p. 6-189 to 6-190). Containers were assumed to be placed in the WIPP from the various waste streams in a random manner. Because waste containers will be stacked three-high for disposal, a drill bit is assumed to penetrate three containers. The direct-release consequence resulting from a drill bit hitting the edges of containers and generating releases from more than three containers is assumed to be similar to the consequence of penetrating three containers only. Each of the three containers penetrated by the drill bit can come from different waste streams and have different activities associated with them. The waste streams penetrated are randomly sampled according to the relative quantity of waste in each waste stream (Chapter 6.4.12.4 3, p. 6-189 to 6-190).

DOE stated that the code CUTTINGS_S calculates the volume of repository material brought to the surface by the mechanisms of cutting and cavings (Chapter 6.4.12.4, p. 6-190). Of the volume of the repository removed, approximately 40 percent is waste material; the rest is void space, backfill, and drum packing material. DOE assumed that one-third of the released waste material comes from each of three containers assumed to be intersected (Chapter 6.4.12.4, p. 6-190). The activity of the release to the surface by cuttings and cavings was determined as the sum of the products of one-third the release volume times the three randomly sampled waste streams that are intersected. If random sampling determined that the borehole penetrates RH-TRU waste, 100 percent of the material removed is assumed to be waste and the activity of the release is equal to the volume calculated by CUTTINGS_S times the activity of RH-TRU waste (Chapter 6.4.12.3 and 6.4.12.4, pp. 6-183 to p. 6-19).

DOE then calculated the CCDFs presented in Chapter 6.5, Figures 6-35 to 6-41, by estimating cumulative radionuclide releases to the accessible environment for 10,000 different possible futures (starting 100 years after closure). In Chapter 4.3.1 (pp. 4-34 and 4-35), DOE showed how the results of these calculations determined whether random emplacements of the waste containers in the WIPP was important and, thus, whether a load management plan was necessary to support the assumptions used in PA. DOE concluded that "the CCDF is not affected by sampling uncertainty so the assumption of random emplacement of containers is not important to the location of the CCDF and a load management plan is not necessary to support performance assessment assumptions" (Chapter 4.3.1, p. 4-35).

In response to comments made by EPA (Docket A-93-02, Item II-I-17) in its March 19, 1997 request for additional information on the WIPP CCA, DOE submitted additional analyses to address the possible impact of nonrandom loading on spallings or cuttings and cavings releases by considering releases conditional on: (1) the occurrence of a single intrusion 100 years after decommissioning into the highest-activity waste stream containing at least 810 drums, and (2) the association of a maximum-volume spalling or cuttings and cavings events under a borehole intrusion scenario (Docket A-93-02, Item II-I-28, Enclosure 1, pp. 8-18).

Of all the waste streams proposed for disposal at WIPP, DOE identified Rocky Flats residue as the highest activity waste stream to contain more than 810 drums. The Rocky Flats residue represents 20,100 drum equivalents of waste (2,800 cubic meters out of 1.6E+05 cubic meters total contact handled waste disposal volume) (Sanchez et al., 1997), with 0.0496 EPA units per drum equivalent at 100 years. This activity loading corresponds to 0.238 EPA units per cubic meter of waste, or 0.092 EPA units per cubic meter of the waste and backfill mixture filling the disposal-region volume. (As described in Appendix SA, p. SA-9, the ratio of waste volume to disposal-region volume is 0.386, calculated by dividing the total volume of waste containers by the total disposal volume.)

Based on an average activity of 0.092 EPA units per cubic meter, DOE concluded that the release of four cubic meters of Rocky Flats' residue from an intrusion at 100 years would result in the release of 0.368 EPA units, which is below the allowable releases specified in 40 CFR 191.13(a) of 10 EPA units at a probability of 0.001 (Docket A-93-02, Item II-I-24). DOE did not conduct a complete analysis of the probability of one or more such intrusions occurring into the Rocky Flats' residue within 10,000 years, conditioned on nonrandom loading. However, DOE stated that such multiple intrusions are highly unlikely. Specifically, based on the observation that the Rocky Flats' residues are approximately 2.5 percent of the WIPP waste by volume, DOE assumed that multiple intrusions into the residues will be far less likely than the multiple intrusions into the entire disposal region considered in the CCA. Thus, of the 14 intrusions that occurred into the entire disposal region in the CCA analysis with a probability of 0.001 in 10,000 years (Section 6, Table 6-28), less than one intrusion would be expected to occur into Rocky Flats' residues if they were emplaced in a single region.

As a result of the CCA analyses, DOE concluded that the CCDF is not affected by sampling uncertainty and that the assumption of random emplacements of containers in the WIPP is not important to the location of the CCDF (CCA, Section 4.3.1, p. 4-35). DOE also stated that the distribution of CCDFs is relatively tight (Appendix SA, p. 4). Specifically, since the volume of removed waste is the only quantity used in the determination of cuttings and cavings releases that is affected by a variable in the Latin hypercube sample (LHS), the uncertainty in the CCDFs is due entirely to the effective shear resistance for erosion. DOE therefore stated that a load management plan is unnecessary to support performance assessment assumptions (Chapter 4.3.1, p. 4-35). DOE concluded that cuttings, cavings, and spallings releases of the highest activity waste stream loaded non-randomly into a single disposal region could result in a shift in the compliance measure, but an analysis of the least favorable consequences showed that regulatory limits would not be exceeded.

24.J.6 EPA COMPLIANCE REVIEW

EPA reviewed the CCA to determine if DOE provided a final plan for waste loading that addressed the emplacement of waste and implement any assumptions about the distribution of such waste that were used in the performance assessment. DOE had the option of providing a waste loading plan or assuming random loading of waste. Because DOE chose to assume random loading, a waste loading plan was not required.

EPA agrees with DOE’s premise that the spatial distribution of the TRU waste within the disposal system is important when evaluating the significance of human intrusion on long-term repository performance, since the release of radioactive waste to the accessible environment becomes possible if a drill bit penetrates containers of waste within the disposal system.

EPA agrees with DOE’s assumptions that the location of each borehole intrusion within the waste disposal region should be sampled randomly (requirement from 40 CFR part 194.33(b)2) and that each penetration could encounter either CH-TRU or RH-TRU waste. EPA evaluated DOE’s approach and assumptions, including (1) that containers of waste would be emplaced randomly according to the distribution of the 569 waste streams tracked in TWBIR, Revision 3, and (2) that sampling of 10,000 futures was large enough that the relatively low probability combination of three of the waste streams with higher activity loading occurring in a single drilling event was captured in the CCDFs. EPA agreed that intrusion events are random events; however, EPA determined that DOE’s assumption that containers would be randomly placed in the WIPP does not account for the likely, “real world” scenario where a specific generator, such as Rocky Flats, sends a large shipment of a waste stream (Rocky Flats residues are estimated to represent 15 percent of the total curies emplaced in the WIPP at closure) all at once. EPA also determined that the placement of these residue drums (stacked three high) in a nonrandom manner was inadequately described by DOE's modeling; therefore, the probability of subsequent penetration may be too low.

As a result of these observations, EPA requested that DOE submit additional analyses to address the possible impact of nonrandom loading on spallings or cuttings and cavings releases (Docket A-93-02, Item II-I-17). DOE conducted a supplemental analysis that considered releases conditional on: (1) the occurrence of a single intrusion 100 years after decommissioning into the highest-activity waste stream containing at least 810 drums, and (2) the association of a maximum-volume spalling or cuttings and cavings event under a borehole intrusion scenario (Docket A-93-02, Item II-I-24). EPA reviewed DOE’s supplemental analysis and found that DOE correctly addressed the potential consequences from the nonrandom loading of the highest activity waste stream (of at least 810 drums) into a single disposal region, because DOE no longer based its analysis on the weighted average of activity in a drum.

EPA also reviewed DOE's decision that a final plan for waste loading to control the emplacement of waste was not necessary. EPA determined that, because DOE had (1) assumed random waste loading and (2) evaluated the potential consequences resulting from the non-random loading of the highest-activity waste stream containing at least 810 drums, a final waste loading plan was in fact unnecessary. EPA determined that DOE was therefore not required to describe how the planned distribution of radioactive waste (as assumed in the PAs) would be achieved because the random distribution of waste containers in the WIPP resulted in compliance (i.e., it did not matter to compliance how the drums were placed in the WIPP).

EPA then determined if DOE cross-referenced the assumption of random emplacement in the waste loading plan with the waste distribution assumption used in the PA. DOE's discussion of the conceptual and computational models and methodologies used to perform the system-level consequence analysis (PA) of waste distribution within the waste disposal system is contained in Chapter 6.4.12.3 and 6.4.12.4 (pp. 6-137 to 6-140). EPA found that DOE’s sensitivity and uncertainty analyses (Appendix SA, pp. SA-1 to SA-15) were based on the random distribution of waste containers following the distribution of waste streams and radionuclide concentrations found in the TWBIR. Although DOE's initial analyses were based on the random distribution of waste containers following the distribution of waste streams and radionuclide concentrations found in the TWBIR, DOE's supplemental analyses concerning the possible affects of non-random loading (Docket A-93-02, Item II-I-24) were based on analyses conducted on the highest activity waste stream to contain more than 810 drums (Sanchez et al., 1997). EPA therefore concluded that DOE adequately cross-referenced the resultant waste distribution assumptions from the waste loading plan with the waste distribution assumptions used in the PA.

24.K.1 REQUIREMENT

(g) "The Department shall demonstrate in any compliance application that the total inventory of waste emplaced in the disposal system complies with the limitations on transuranic waste disposal described in the WIPP LWA."

24.K.2 ABSTRACT

EPA expected the compliance application to describe the WIPP waste inventory in terms of the units specified in the limitations of the LWA and to describe how these limitations will be assured through implementation of the required system of controls. DOE identified the following limits:

- Curie limits for RH-TRU waste: 5.1 million curies (app. 19.8 x 10^{16} Becquerels).
- Total capacity of RH and CH TRU waste that may be disposed: 6.2 million cubic feet (175,564 cubic meters).
- Waste will not exceed 1,000 rem per hour, no more than 5 percent by volume of RH will exceed 100 rem per hour, and RH will not exceed 23 curies per liter.

DOE provided numerous tables that presented the WIPP waste inventory in terms of curies and total volumes. In addition, DOE presented information pertaining to the WIPP WWIS, which will track and control waste. EPA examined the CCA to determine whether it identified the curie content of RH waste, the total anticipated and scaled capacity of the WIPP, and the quantities of important waste material components. EPA also examined the CCA to determine whether DOE described a system of controls to ensure that LWA limitations are met.

24.K.3 COMPLIANCE REVIEW CRITERIA

DOE is required to demonstrate in the compliance certification application, compliance with the limitations on transuranic (TRU) waste disposal as described in the Waste Isolation Pilot Plant Land Withdrawal Act (LWA). The limits established by the LWA are as follows:

- Curie limits for RH-TRU waste.

- ♦ Total capacity of RH and CH TRU waste that may be disposed.

- ♦ Rem (roentgen equivalent in man) limitations for RH waste.

As stated in the CAG (p. 36), EPA expected the compliance application to: (1) describe the inventory of waste proposed for disposal at the WIPP in terms of the units specified in the limitations of the LWA, in addition to limits of important waste components; and (2) describe how these limitations will be met through implementation of the required system of controls.

24.K.4 DOE METHODOLOGY AND CONCLUSIONS

DOE identified the LWA- related Emplacement Limits in Chapter 4, Table 4-11 and pp. 4-5 to 4-6. These limits are:

- ♦ Curie limits for RH-TRU waste: 5.1 million curies (app. 19.8 x 10^{16} Becquerels).

- ♦ Total capacity of RH and CH TRU waste that may be emplaced: 6.2 million cubic feet (175,564 cubic meters).

- ♦ Waste will not exceed 1,000 rem per hour, no more than 5 percent by volume of RH will exceed 100 rem per hour, and RH will not exceed 23 curies per liter.

DOE presented the disposal inventory in Appendix BIR of the CCA (TWBIR, Revision 3), which includes estimates for the disposal inventory in curies per cubic meter and total curies for each radionuclide on a waste stream through total inventory basis. These inventories are also described in terms of final forms and include stored, projected, anticipated, and total disposal volumes for CH-TRU and RH-TRU waste. See Section 194.24(a) of this CARD for further discussion of the BIR. Table 3-1 of Appendix BIR shows the total estimated RH-TRU waste inventory for each radionuclide. DOE anticipates approximately 1.2 million total curies of RH waste to be emplaced in the WIPP. Tables ES-3 and ES-4 of Appendix BIR (pp. ES-6 and ES-7) show the estimated total volume of CH and RH waste expected for WIPP, approximately 140,000 cubic meters. Also, Chapter 4.1.3.2, Table 4-3, shows the total TRU waste disposal inventory for the WIPP in cubic meters, which includes DOE's scaling of waste volume from 140,000 cubic meters to the full allowable WIPP capacity of approximately 170,000 cubic meters. See Section 194.24(a) above for further discussion of inventory scaling. Tables ES-1 and ES-2 of Appendix BIR (pp. ES-4 and ES-5) present the total volume of each waste material parameter expected for emplacement, including important waste components identified in Appendix WCL, Table WCL-1, and Chapter 4.2.2, Table 4-10. The development of repository-based emplacement limits established for important waste components is described in Appendix WCL and is discussed in Section 194.24(c)(1) of this CARD.

DOE stated that "[The] limits are repository-scale limits that should be met at the time of repository decommissioning. The process for demonstrating compliance with these limits is to track the waste-component quantity and the uncertainty associated with that quantity as waste is emplaced in the repository" (Chapter 4, p. 4-1). DOE indicated that it will use the WIPP Waste Information System (WWIS) to track the specific data related to each of the emplacement limits imposed by the LWA (Chapter 4.3.2, pp. 4-35 to 4-39). By generating routine reports, DOE will be able to determine whether emplacement of a shipment of waste will exceed any LWA limits. DOE also established procedures regarding data traceability and consistency to ensure that waste emplacement limits are not exceeded (Chapter 4.3.2, pp. 4-35 to 4-39). See Section 194.24(c)(4) of this CARD for additional information regarding the WWIS.

24.K.5 EPA Compliance Review

EPA reviewed the CCA to determine if DOE adequately described the inventory of waste proposed for disposal at the WIPP in terms of the units specified in the limitations of the LWA, in addition to limits of important waste components. Specifically, EPA reviewed the Transuranic Waste Baseline Inventory Report in its entirety, including (TWBIR) Revision 3, Tables ES-1, ES-2, ES-3, ES-4, 2-1, and 3-1. EPA also reviewed Chapter 4, Section 4.1.3.2, Table 4-3 and Section 4.2.2, Table 4-10, and Appendix WCL, Table WCL-1. EPA concluded that the CCA adequately described the inventory of waste proposed for disposal at the WIPP in terms of the units specified in the limitations of the LWA as they pertain to total RH activity and total volume, in addition to limits for important waste components. See EPA Technical Support Document for Section 194.24: WIPP Facility and Waste Characterization (EPA 1998c) for further discussion of the BIR.

EPA noted that the CCA does not specify the rem limitations found in the LWA on Table 4-10, although the text of the CCA (p. 4-5 and 4-6) discussed these limits. This information will be gathered as part of the waste characterization process, since each container will undergo nondestructive assay and surface dose rate analysis in accordance with the WIPP WAC (Table 4-12, p. 4-33) (DOE 1996c). This information will be tracked by the WWIS, therefore EPA concluded that it did not need to be specified in the CCA.

EPA reviewed information pertaining to the WWIS, including Chapter 4.3.2 (pp. 4-35 to 4-39), to determine its ability to track emplacement limits imposed by the LWA. EPA also reviewed the CCA to determine if DOE described how these limitations will be ensured through implementation of the required system of controls. EPA found that Appendix WAP, Section C-5, provided a detailed description of DOE's Phase I and II waste stream/shipment screening and verification procedures. In general, Phase I describes waste stream screening and verification that will occur before waste is shipped to the WIPP. These data will be entered into the WIPP Waste Information System (WWIS), which will provide DOE the ability to generate: (1) container emplacement reports; (2) shipment summary reports; (3) characterization data reports; and (4) a change log report. Verification of these data will be carried out through the Waste Operations section and Environmental Compliance and Support staff. Phase II of the waste shipment screening and verification procedures occurs after waste is received at the WIPP. In this phase, DOE will make determinations about the wastes concerning completeness and accuracy of EPA hazardous waste manifest, waste shipment completeness, and land disposal restriction notice completeness for hazardous waste components. EPA concluded that DOE adequately described how these limitations will be assured through implementation of the required system of controls. For further discussion of these controls, see Section 194.24(c)(4) above.

EPA noted that DOE identified a number of data fields contained in the WWIS that can store and track information relevant to demonstrating compliance with 40 CFR 194.24(g). The WWIS data fields include the following:

- ^{239}Pu fissile gram equivalent
- Radionuclide activity
- Radionuclide activity uncertainty
- Radionuclide mass
- TRU alpha activity
- TRU alpha activity uncertainty
- WAC certification data
- Waste Material Parameters (WMPs) and
- Waste Matrix Codes (WMCs).

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