Table 4-*8*~~7~~. Waste Characteristics and Components Expected to be Most Significant to Performance

Component	**Characteristic ~~and Component~~**	**Reason for Significance**
^{239}Pu, ^{240}Pu, ^{241}Am, ^{233}U, and ^{234}U	***Activity***	99 percent of EPA unit after 2,000 years
^{238}Pu	***Activity***	***Dominates*** ~~dominates~~ EPA unit at early times
~~plutonium~~ ***Pu*** and ~~americium~~ ***Am***	***Solubility*** ~~of Pu and Am~~	~~large~~ ***Large*** EPA unit; mobility depends on solubility
^{238}U	***Activity***	***Very*** ~~very~~ low activity; dilutes higher-activity uranium isotopes for brine-based releases
Iron	~~Iron~~***Redox Potential***	~~maintains~~ ***Sustains*** reducing environment so that lower, less soluble oxidation states of actinides predominate
Cellulosic material, plastic, rubber, nitrate, sulfate	***Nutrient for Microbes***	***Microbial*** ~~microbial~~ nutrients that are metabolized to methane and several other gases, increasing gas pressure; formation of colloids
~~humic~~ ***Humic*** materials, cellulose breakdown products	***Colloid Formation***	~~form~~ ***Formation of*** humic colloids that sorb and transport actinides
~~nonferrous~~ ***Nonferrous*** metals	***Organic Complexation***	~~prevent increase~~ ***Prevent increase*** in actinide solubility by binding with ligands
~~waste~~ ***Waste***	***S***~~s~~hear ***S***~~s~~trength	~~important~~ ***Important*** to spalling and cavings

Source: ~~Appendix WCA (Table WCA-12)~~ ***Appendix TRU Waste, Section 2***

The waste unit factor is the number of millions of ~~curies~~ ***Ci*** of alpha-emitting TRU radionuclides with half-lives longer than 20 years (~~40 CFR~~ Part 191 ***of the Code of Federal Regulations***, Appendix A). In the WIPP, ~~3.44~~***2.48***[3] million ~~curies~~ ***Ci*** of TRU waste will be in the repository at closure, so the waste unit factor is ~~3.44~~***2.48***. The radionuclides that contribute to the waste unit factor are based on an analysis (see Appendix ~~WCA.8.2~~ ***TRU WASTE, Section TRU WASTE-2.0***) of the radionuclide inventory in ~~Revision 3 of the TWBIR (Appendix BIR)~~ ***Appendix DATA, Attachment F*** and are ***presented in Table 4-9***~~8~~ (decayed to the end of 2033). ***The radionuclide contributions to the waste unit factor from the CCA are also presented in Table 4-9***~~8~~. Waste characteristics and components with an insignificant impact on performance are summarized in Table 4-***10***~~9~~. ***This table remains unchanged from CCA Table 4-9.***

[3] The value for the waste unit factor (WUF) in the CCA was inconsistently described; Chapter 4, Section 4.2.1 correctly listed the WUF that was used in the CCA PA as 3.44. CCA Appendix WCA Sections 1.4.2 and WCA Attachment WCA.8.1 incorrectly stated the 1995 decayed value of 4.07 was used in the CCA PA, however the preface to Attachment WCA.8.2 identified and corrected the error. During the EPA's review of the CCA, EPA required DOE to recalculate a new WUF of 3.59 that was ultimately included in the EPA's PAVT (EPA 1998). After the certification, the DOE incorporated the PAVT WUF value of 3.59 in the compliance baseline through an EPA approved change request (EPA 2002).

~~**Table 4-8. Radionuclides That Contribute to the Waste Unit Factor**~~

Nuclide	Half-Life (years)	Inventory at Closure (curies)	Percent of Waste Unit
^{241}Am	432.7	4.48×10^{5}	11
^{243}Am	7370	32.6	8.01×10^{-4}
^{249}Cf	351	.0685	1.69×10^{-6}
^{251}Cf	900	3.78×10^{-3}	9.28×10^{-6}
^{243}Cm	29.1	101.7	2.50×10^{-3}
^{245}Cm	8500	115	2.82×10^{-3}
^{246}Cm	4760	.102	2.51×10^{-6}
^{247}Cm	1.56×10^{7}	9.51×10^{-9}	7.88×10^{-14}
^{248}Cm*	3.48×10^{5}	3.21×10^{-2}	9.1×10^{-7}
^{237}Np	2.14×10^{6}	.0369	1.39×10^{-3}
^{238}Pu	87.7	56.4	64.1
^{239}Pu	2.41×10^{4}	2.61×10^{5}	19.5
^{240}Pu	6560	2.15×10^{5}	5.28
^{242}Pu	3.75×10^{5}	1170	2.87×10^{-2}
^{244}Pu	8.0×10^{7}	1.50×10^{-6}	3.68×10^{-11}
Total		4.07×10^{6}	

~~Source: Appendix WCA (Table WCA-5).~~
~~* This number differs slightly from that in Appendix WCA (Section WCA.8.2) as a result of more recent information.~~

4.2.2 Repository Limits

~~This~~ ***The*** following discussion ~~is responsive to~~ ***describes*** the criteria ~~at 40 CFR §~~ ***in Sections*** 194.24(c)(1) and ~~40 CFR §~~ 194.24(c)(2).

Waste c~~C~~omponents are the controlling factors for the ***waste*** characteristics**.** ~~; therefore any~~ ***Therefore,*** limits imposed on the waste components necessarily serve to limit the waste characteristics. In the case where a characteristic is benign with respect to repository performance, no control of the corresponding component is necessary and no limits need be imposed on that component. Conversely, should repository performance be sensitive to a particular waste characteristic, then control of the corresponding component is mandated and limits are established to restrict the maximum or minimum amounts of that component allowed for disposal.

Based on the ~~performance assessment~~ ***PA*** calculations and the rationale ~~developed~~ ***described*** in Appendix ~~WCL~~ ***TRU WASTE,*** Table 4-***11***~~10~~ identifies the characteristics of the components for which ~~assay~~ ***determination*** prior to emplacement is required. Table 4-***11***~~10~~ also lists any applicable repository-based emplacement limit***s*** for the components. Discussions of the rationale for the proposed assaying and emplacement limits for each component ***are presented*** in

Table 4-9. Radionuclides That Contribute to the Waste Unit Factor

Nuclide	*Half-Life (years)*	*Current Inventory Values*		*Values Reported in the CCA(1)*	
		Inventory at Closure (Ci)	*Percent of Waste Unit at Closure*	*Inventory at Closure (Ci)*	*Percent of Waste Unit at Closure*
^{241}Am	4.33×10^{2}	4.58×10^{5}	1.82×10^{1}	4.88×10^{5}	1.42×10^{1}
^{243}Am	7.37×10^{3}	2.17×10^{1}	8.63×10^{-4}	3.25×10^{1}	9.45×10^{-4}
^{249}Cf	3.51×10^{2}	7.24×10^{-2}	2.88×10^{-6}	6.38×10^{-2}	1.85×10^{-6}
^{251}Cf	9.00×10^{2}	5.10×10^{-4}	2.03×10^{-8}	3.67×10^{-3}	1.07×10^{-7}
^{243}Cm	2.91×10^{1}	4.07×10^{-1}	1.62×10^{-5}	2.07×10^{1}	6.02×10^{-4}
^{245}Cm	8.50×10^{3}	1.92×10^{-2}	7.62×10^{-7}	1.15×10^{-2}	3.34×10^{-7}
^{246}Cm	4.76×10^{3}	2.22×10^{0}	8.80×10^{-5}	1.02×10^{-1}	2.97×10^{-6}
^{247}Cm	1.56×10^{7}	9.45×10^{0}	3.75×10^{-4}	9.51×10^{-9}	2.76×10^{-13}
^{248}Cm	3.48×10^{5}	9.32×10^{-2}	3.70×10^{-6}	3.72×10^{-2}	1.08×10^{-6}
^{237}Np	2.14×10^{6}	1.01×10^{1}	4.00×10^{-4}	6.49×10^{1}	1.89×10^{-3}
^{238}Pu	8.77×10^{1}	1.25×10^{6}	4.98×10^{1}	1.94×10^{6}	5.64×10^{1}
^{239}Pu	2.41×10^{4}	6.65×10^{5}	2.64×10^{1}	7.95×10^{5}	2.31×10^{1}
^{240}Pu	6.56×10^{3}	1.08×10^{5}	4.30×10^{0}	2.14×10^{5}	6.22×10^{0}
^{242}Pu	3.75×10^{5}	2.71×10^{1}	1.08×10^{-3}	1.17×10^{3}	3.40×10^{-2}
^{244}Pu	8.00×10^{7}	1.10×10^{-3}	4.38×10^{-8}	1.51×10^{-6}	4.39×10^{-11}
Total	---	2.48×10^{6}	9.86×10^{1}	3.44×10^{6}	9.99×10^{1}

Source: Appendix TRU WASTE, Section TRU WASTE-2.0.
(1) Radionuclide activities and the WUF were reported with conflicting values in several places in the CCA. The values used in this table were the actual values used in the performance assessment for the CCA as recorded in the PAPDB.

Table 4-*10*~~9~~. Waste Characteristics and Components Expected to be *Ins*ignificant

Characteristics and Component	Reason for insignificant impact
~~radionuclides~~ ***Radionuclides*** other than those in Table 4-***8***~~7~~	EPA unit is negligible fraction of total, even with ingrowth
~~substances~~ ***Substances*** that may affect pH[1]	pH is buffered by MgO backfill
~~substances~~ ***Substances*** that produce CO_2 [1]	CO_2 is removed by reaction with MgO backfill
~~intrinsic~~ ***Intrinsic*** and mineral fragment colloids	~~fraction~~ ***Fraction*** of actinides mobilized by these colloids is insignificant
~~organic~~ ***Organic*** ligands	~~removed~~ ***Removed*** by binding with Mg and nonferrous metal
~~heat~~ ***Heat*** generated by exothermic reactions	~~heats~~ ***Heats*** of formation are small and thermal mass of repository is large so that temperature rise is negligible
~~fluid~~ ***Fluid*** in the waste	~~negligible~~ ***Negligible*** compared to brine volume

Source: Appendix ***TRU WASTE*** ~~WCA (Table WCA—13)~~
[1] These components are significant for gas generation, but not for actinide solubility.

Table 4-1***1***~~0~~. Repository-Based Emplacement Limits Related to ~~Performance Assessment~~ ***PA***

Waste Components	Associated Waste Characteristics	Components Requiring Quantification	Emplacement Limits
radionuclides	radioactivity at closure radioactivity after closure solubility colloid formation reduction-oxidation state	^{241}Am ^{238}Pu ^{239}Pu ^{240}Pu ^{242}Pu ^{233}U ^{234}U ^{238}U ^{90}Sr ^{137}Cs	none[*1*~~a~~]
ferrous metals (iron)	reduction-oxidation potential H_2 ~~has~~ ***gas*** generation complexing with organic ligands	none	minimum = 2 × 10^7 kilograms (amount from containers)[*2*~~b~~]
cellulose~~e~~***ic***, plastics, rubber ***materials***	gas generation humic colloids (see below) gas generation	sum of emplaced components	maximum = 2***.2*** × 10^7 kilograms[*3*~~c~~]
sulfates	gas generation	none	none[*4*~~d~~]
nitrates	gas generation	none	none[*4*~~d~~]
solid components	particle size effective shear resistance to erosion tensile strength	none	none
free ~~water~~***liquid*** emplaced with waste	gas generation	none	maximum = 1684 cubic meters for CH-TRU (limit of 1 percent total waste volume as set by the WAC) [e]
humic substances	radionuclide-bearing humic colloids	none	none
nonferrous metals (metals other than iron)	bind with organic ligands and prevent increased solubility	none	minimum = 2 × 10^3 kilograms[*5*~~f~~]
organic ligands	solubility	none	none[*4*~~d~~]

Source: Appendix ~~WCL~~ ***TRU WASTE, Section TRU WASTE-3.0***

1~~a~~ Inventory curie content will be tracked.

2~~b~~ Minimum set to ensure sufficient reactants for reducing radionuclides to lower and less soluble oxidation states. ~~Average density for CH-TRU container steel of 139 kilograms per cubic meter multiplied by the design basis value of 168,485 cubic meters.~~

3~~c~~ Maximum set to ensure sufficient MgO backfill is available to react with CO_2 produced.

4~~d~~ For the current waste generation processes that are documented in the TWBIR.

~~e 1 percent of the design basis values for CH-TRU of 168,485 cubic meters.~~

5~~f~~ Minimum quantity for complexing with organic ligands (see Appendix ~~SOTERM, Section SOTERM.5~~ ***PA, Attachment SOTERM***).

Appendix ***TRU WASTE*** ~~WCL~~. All of the components identified ***in CCA Appendix WCA and Appendix TRU WASTE, Section TRU WASTE.2-0*** were found to be insignificant to disposal system performance. Therefore, it is not necessary to establish ***additional*** container-based emplacement limits for these components. ~~other than those already imposed through the CH-TRU Waste Acceptance Criteria (WAC) (see next section).~~

Table 4-***12***~~11~~ is a supplement to Table 4-***11***~~10~~; that is, it lists the repository limits imposed by the LWA ~~(U.S. Congress 1992b)~~. Collectively, Tables 4-***11***~~10~~ and 4-***12***~~11~~ define the WIPP repository-based emplacement limits on the waste.

Since the first waste shipment arrival at the WIPP, DOE has tracked the quantities of materials identified in Tables 4-11 and 4-12 that have been emplaced in the repository. The quantities of these materials emplaced in WIPP since its opening through September 30, 2002, are listed in Tables 4-13 and 4-14.

4.2.3 Waste Container Limits

Waste limits have been established by ~~the~~ DOE as part of the WIPP's design development and by the WIPP LWA. ~~Table 4-12 identifies waste container limits.~~ ***Waste container limits relevant to the requirements of the WIPP LWA are identified in Table 4-15.*** The ***CH-TRU Waste Acceptance Criteria (***WAC***)*** ~~is a compilation of criteria that~~ restrict the physical, chemical, and radiological properties of the waste to mitigate conditions that will have adverse impacts on human health and the environment. ~~The current WIPP WAC (DOE 1996a) does not contain restrictions associated with or driven by performance assessment results.~~

~~The WAC is founded on transportation requirements, disposal operations safety criteria as documented in the Safety Analysis Report (SAR) (DOE 1995d), regulatory compliance requirements and several other drivers (depicted in Figure 4-4), including the WAP, the Safety Analysis Report, for Packaging (SARP), and this application. Only those wastes that meet established acceptance criteria and obtain waste stream profile approval from the CAO will be emplaced in the WIPP disposal system. Waste forms that do not meet these criteria will require treatment and/or repackaging prior to WIPP certification.~~

~~Application of the WAC extends to both CH-TRU and RH-TRU waste proposed for disposal in the WIPP. The current WAC limits shown in Table 4-12 are on a waste container basis. The~~ ***DOE*** ~~WAC~~ requires the ~~generator~~ ***TRU waste sites*** to prepare a waste-certification ~~program~~ ***plan*** that lists the methods and techniques used to determine compliance with the ***CH-TRU*** WAC and the ~~quality assurance~~ QA ***program (see Appendix QAPD-2004)***. ~~and~~ ***This includes QA and*** quality control criteria that are applied to the generator's waste certification program. Each participating ***TRU waste*** site is responsible for developing and implementing ~~site-~~specific TRU waste program documents (plans) that address all activities pertaining to TRU waste characterization, certification, packaging, and transportation of TRU waste to the WIPP. These plans include the TRU Waste Certification Plan and associated QA plan, the TRUPACT-II Authorized Methods for Payload Control and associated QA plans, and the TRU waste characterization QAPjP. Methods of compliance with each criterion and requirement are documented or specifically referenced and include procedural and administrative controls.

Table 4-12~~1~~. Repository-Based Emplacement Limits Imposed by the LWA

Waste Components	Emplacement Limits
Total Capacity (CH- and RH-TRU)	6.2 million ~~cubic feet~~ *ft*^{3} (175,564 ~~cubic meters~~ *m*^{3})
RH-***TRU*** waste total ~~curies~~ ***Ci***	5.1 million ~~curies~~ ***Ci*** (~18.9 × 10^{16} Becquerels)
RH-TRU waste total dose rate	***No more than five percent by volume of RH TRU waste may exceed 100 rems per hour***

Table 4-13. Quantities of Radionuclides Emplaced in the Repository as of September 30, 2002[1,2]

NR=Not reported or reported at values less than 10^{-13}

Radionuclide	Quantity (Ci)	Radionuclide	Quantity (Ci)
^{227}Ac	3.64×10^{-4}	^{147}Pm	NR
^{241}Am	1.17×10^{5}	^{238}Pu	5.64×10^{3}
^{243}Am	4.81×10^{-3}	^{239}Pu	1.38×10^{5}
^{14}C	NR	^{240}Pu	3.10×10^{4}
^{249}Cf	NR	^{241}Pu	4.37×10^{5}
^{251}Cf	NR	^{242}Pu	2.96×10^{0}
^{252}Cf	NR	^{244}Pu	NR
^{243}Cm	NR	^{226}Ra	7.88×10^{-6}
^{244}Cm	NR	^{228}Ra	NR
^{245}Cm	NR	^{79}Se	NR
^{246}Cm	NR	^{151}Sm	NR
^{247}Cm	NR	$^{121}Sn^{m}$	NR
^{248}Cm	NR	^{126}Sn	NR
^{60}Co	3.47×10^{-7}	^{90}Sr	NR
^{135}Cs	NR	^{99}Tc	NR
^{137}Cs	3.41×10^{-9}	^{229}Th	NR
^{129}I	NR	^{230}Th	2.41×10^{-5}
^{40}K	2.87×10^{-5}	^{232}Th	2.61×10^{-6}
^{22}Na	5.34×10^{-6}	^{232}U	NR
^{59}Ni	NR	^{233}U	2.73×10^{-1}
^{63}Ni	NR	^{234}U	1.26×10^{0}
^{237}Np	4.00×10^{-1}	^{235}U	1.22×10^{-1}
^{231}Pa	5.04×10^{-4}	^{236}U	NR
^{210}Pb	NR	^{238}U	6.53×10^{0}
^{107}Pd	NR	^{93}Zr	NR

Source: WWIS

[1] These data were taken from the WWIS and differ slightly from the data reported for WIPP in Appendix DATA Attachment F. This is because all data in Appendix DATA Attachment F have been decayed to a single base year 2001 (i.e., decayed through 2001) while the data provided in the WWIS are reported values based on assay and have not been decayed to a single base year.

[2] Isotopes other than the 10 listed in Table 4-11 are not required to be tracked unless required by DOT regulations.

Table 4-14. Quantities of Non-Radionuclide Waste Components Emplaced in the Repository as of September 30, 2002, and Associated Emplacement Limits

Waste Components	*Quantity*	*Emplacement Limit*
Ferrous metal (iron)	*2,487,261 kilograms*	*Minimum = 2 × 10^7 kilograms*
Cellulosic, plastic, and rubber materials	*700,981 kilograms*	*Maximum = 2.2 × 10^7 kilograms*
Nonferrous metals (metals other than iron)	*31,059 kilograms*	*Minimum = 2 × 10^3 kilograms*

Source: WWIS

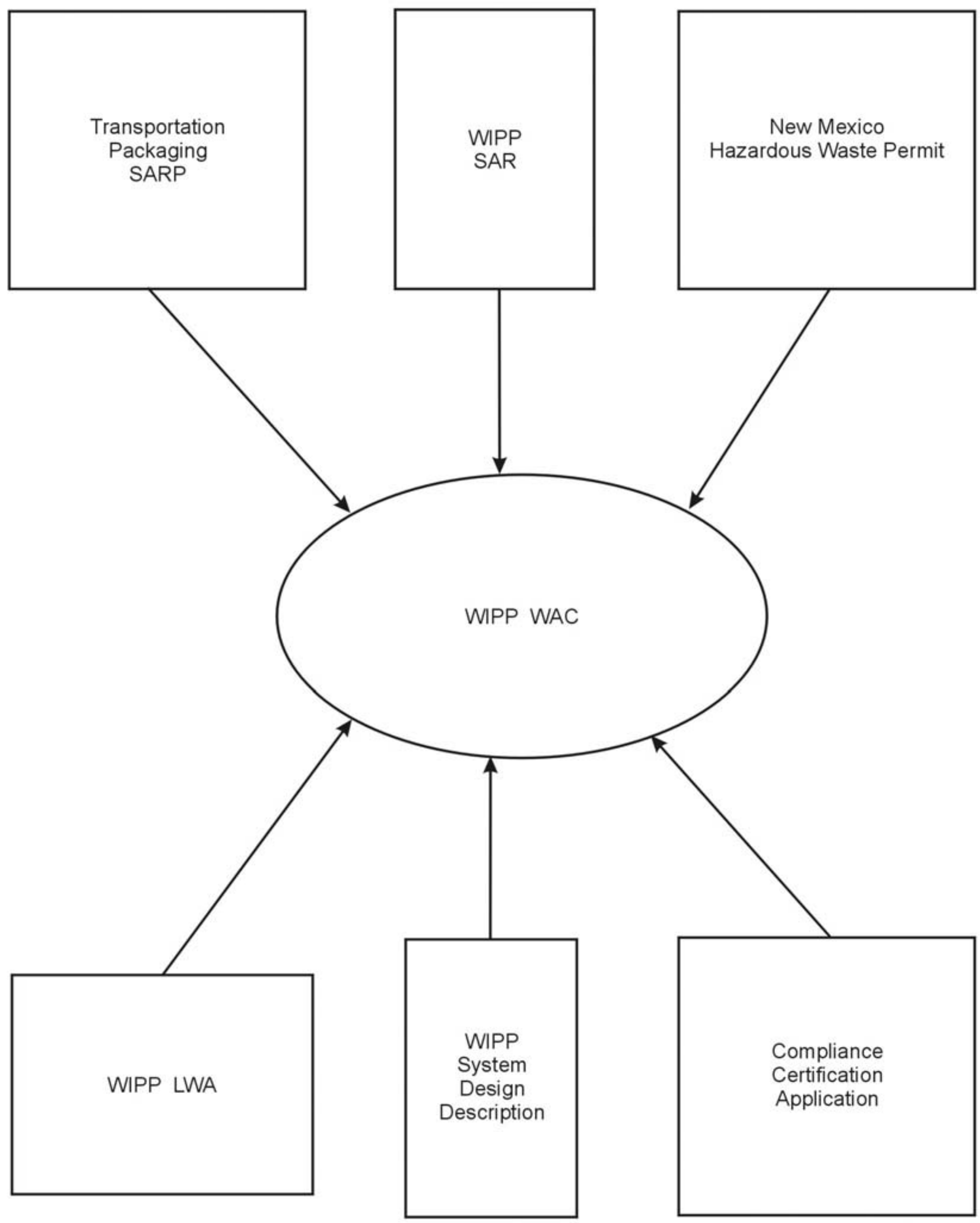
~~Table 4-12. Container-Based Limits Imposed by the WAC~~

~~Waste Component or Characteristic~~	~~Limit~~
~~CH and RH waste criticality~~	~~<200 fissile gram equivalents (FGE) per 55-gallon drum~~ ~~<325 FGE per standard waste box (SWB)~~
~~CH and RH waste ^{239}Pu equivalent activity~~	~~Untreated Waste~~ ~~80 plutonium equivalent curies (PE-Ci) per drum~~ ~~<130 PE-Ci per SWB~~ ~~<1800 PE-Ci per drum~~[1] ~~Solidified/Vitrified Waste~~ ~~£1800 PE-Ci/55 gallon drum~~
~~CH and RH waste surface dose rate~~	~~<200 mrem/hr (CH)~~ ~~<1000 rem/hr (RH)~~
~~RH waste thermal power~~	~~Report if 70.1 watts/cubic feet~~
~~RH waste curies per liter~~	~~23 curies/liter~~
~~Liquids or aqueous waste~~	~~No liquid wastes~~ ~~<2 liters total residual liquid per 55 gallon drum~~ ~~<8 liters total residual liquid per SWB~~ ~~<inch in the bottom of any container~~
~~Explosives~~	~~None~~
~~Compressed gases~~	~~None~~
~~Pyrophoric materials~~	~~<1% radionuclide pyrophorics~~ ~~No nonradionuclide pyrophorics~~
~~Polychlorinated Biphenyls~~	~~<50 ppm~~

~~Overpacked in a SWB or a ten-drum overpack~~

Table 4-15. Container-Based Limits

Waste Component or Characteristic	*Limit*
CH-TRU and RH-TRU waste activity	*> 100 nCi/gram of waste*
CH-TRU waste surface dose rate	*≤ 200 mrem/hour (CH)*
RH-TRU waste surface dose rate	*≤ 1000 rem/hour (RH)*
RH-TRU waste Ci per liter	*23 Ci/liter averaged over the container*



Note: Adapted from Figure 2-1, WAC Revision 5.

CCA-082-2

~~Figure 4-4. Origins of the WAC~~

Based on the acceptance of the site-specific waste characterization and QA program, the ~~The DOE~~ ~~CAO~~ ***CBFO*** Manager is responsible for granting and revoking the ***program certification that allows the TRU waste site to characterize and to ship waste to WIPP***. ~~authority to a site to certify TRU waste to the WAC.~~ The ~~CAO~~ ***CBFO*** performs certification audits of the ***TRU waste*** sites to assess the implementation of and compliance with the approved plans. On the basis of acceptable results of the certification audits, the DOE grants TRU waste certification authority and transportation authority to the ***TRU waste*** site. ***DOE provides*** ~~C~~***c***ontinuing oversight of ~~participating~~ ***TRU waste*** sites ~~is provided by the DOE~~ through periodic audits of TRU waste characterization, certification, and transportation activities.

Consistent with the provisions of section 194.8, the EPA also has a role in the approval process. The EPA determines compliance with requirements for site-specific QA programs.

~~A waste-stream profile form (contained in the WAP) is used by generator site personnel to notify the WIPP that a waste stream has been identified and characterized. The data described on this form are used by the WIPP as the basis for acceptance of the waste characterization process identified for each container belonging to this waste stream. The~~ ***CH-TRU*** WAC ~~establishes~~***provides the*** limits for the physical, radiological, and chemical characteristics of the waste in addition to specifications for the waste packaging. ***Waste that is characterized according to and approved program and meets the requirements of the CH-TRU WAC can be shipped to the WIPP. Additional information regarding the TRU waste site waste characterization and QA program requirements is provided in Appendix TRU WASTE.***

~~Once the DOE has obtained necessary operating permits and certifications, a~~ ***A***ppropriate changes to the ***CH-TRU*** WAC will be published to reflect new restrictions and conditions imposed by permits and certifications. These changes will be communicated to the ~~generator and storage~~ ***TRU waste*** sites as a change to the ***CH-TRU*** WAC. Those retrievably stored or newly generated waste streams that do not meet the ~~current disposal~~ ***CH-TRU*** WAC, however, may require processing (including repackaging and/or treatment) until ***compliance***~~certification~~ can be attained. Any such processing is the responsibility of the site proposing to ship the waste to the WIPP. TRU waste that has been characterized in accordance with prior revisions of the ***CH-TRU*** WAC ~~and the QAPP~~ may be reconciled with current requirements. This reconciliation is documented and filed at the ***TRU waste*** site.

Changes related to waste characterization documents have occurred since the initial certification. Waste characterization elements of the QAPP (TRU Waste Characterization Quality Assurance Program Plan, CAO [CBFO] 94-1010) have been incorporated into recent revisions of the CH-TRU WAC, the WAP, and the QAPD. The QAPP and the TRU Waste Characterization Sampling and Analysis Methods manual (DOE 1995b) have been cancelled.

4.3 Waste Controls

This section describes those processes that ensure compliance with the limits for CH-TRU ***waste*** and RH-TRU waste to be emplaced in the WIPP disposal system.

4.3.1 Load Management

The following ~~discussion~~ ***discusses*** ~~is responsive to the criteria at 40 CFR §~~ ***compliance with Section*** 194.24(d) ***and*** (f).

Load management is the process of controlling the shipment and emplacement of TRU waste in order to achieve a predetermined (that is, nonrandom) distribution of waste within the disposal system. ~~An important reason for considering the impact of~~ ***DOE must assess whether the*** spatial distribution of waste in the repository ~~is because of the~~ ***could have*** significance ~~of~~ ***for*** human intrusion on long-term repository performance. As described in Section 6.4.12, drilling events are assumed to be random in time and space. The location of each intrusion borehole within the waste disposal region is sampled randomly. Each intrusion borehole that penetrates waste may encounter CH-TRU waste or RH-TRU waste. For calculating direct releases to the accessible environment, containers are assumed to be placed in the WIPP from the various ~~569~~ waste streams which comprise CH-TRU waste in a random manner. In calculating direct releases resulting from a drill bit penetrating containers, each of the three stacked containers can come from different waste streams and have different activity loading. As described in Section 6.5, direct release from cuttings and cavings are the most important releases in assessing compliance with the quantitative containment requirements in ~~40 CFR §~~ ***Section*** 191.13(a) ***for both the CCA and CRA-2004.***

The CCDFs presented in Section 6.5 are constructed by estimating cumulative radionuclide releases to the accessible environment for 10,000 different possible futures. The estimated release for each future includes the randomly sampled waste streams for each of the various intruding boreholes that comprise that sampled future. A sampling of 10,000 futures is large enough that the relatively low probability combination of three of the waste streams with higher activity loading occurring in a single drilling event is captured in the CCDFs presented in Section 6.5. As described in Section 6.5, the CCDF is not impacted 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~~ ***PA*** assumptions.

In support of CRA-2004, DOE investigated the impact of non-homogeneous patterns of waste emplacement in the repository. The investigation verified that non-homogeneous emplacement will not have a significant impact on PA. The results of the investigation are reported in Chapter 6.0.

4.3.2 WIPP Waste Information System

The following ***discusses compliance with*** ~~discussion is responsive to~~ the criteria at ~~40 CFR §~~ ***Sections*** 194.24(c)(4), ~~and 40 CFR § 194.24~~(c)(5), and ~~those at 40 CFR § 194.24~~(e).

The WWIS is ~~a computerized~~ ***an electronic*** data management system used by ~~the~~ ***DOE*** ~~WIPP~~ to gather, store, and process information pertaining to TRU waste destined for or disposed at the WIPP. The system supports those organizations ~~who~~ ***that*** have responsibility for managing TRU waste by collecting information into one source and providing data in a uniform format that has been verified or certified as being accurate. The WWIS is used to store ~~all~~ information pertaining to characterization, certification, and emplacement of waste at the WIPP. Information ~~for~~ ***in*** this system is supplied by the ~~generator~~ ***TRU waste*** sites ~~of TRU waste~~ and the WIPP facility. Figure 4-***2***~~5~~ depicts the process and flow of data from the ***TRU waste*** sites to the WWIS.

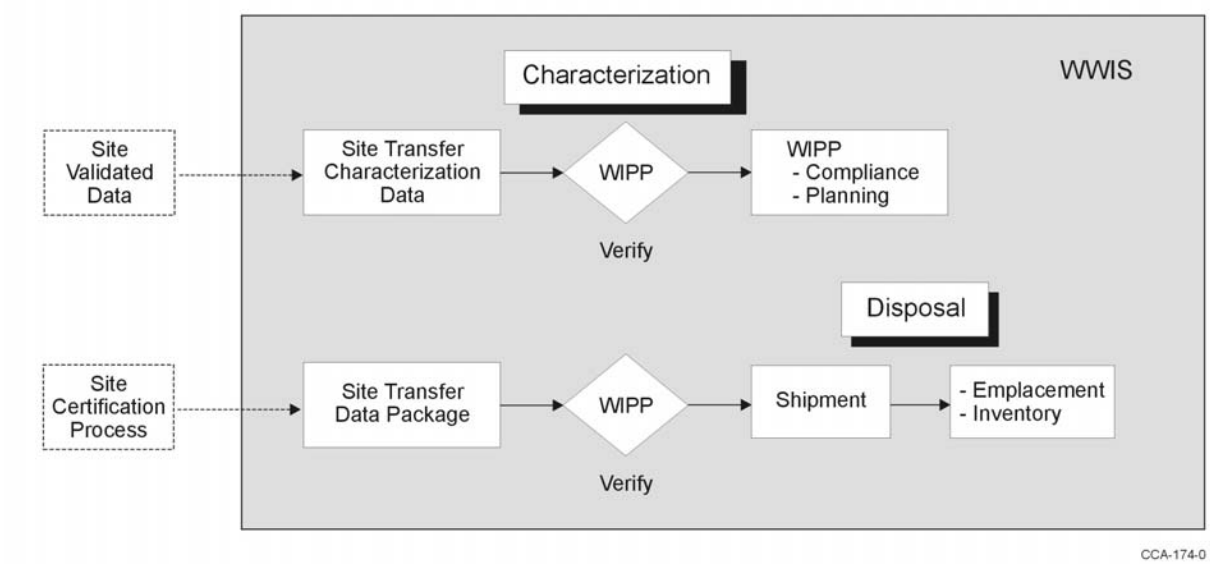


Figure 4-*2*~~5~~. WIPP Waste Information System Process and Data Flow

At the time of the CCA, the ~~The~~ WWIS use***d***~~s~~ the Oracle (Version 7) database management system that follow~~s~~***ed*** American National Standards Institute (ANSI) standard query language. The database management system ~~resides~~ ***was resident*** on a Digital Equipment Corporation hardware platform***,*** ~~and is~~ compliant with the majority of existing computer hardware throughout the DOE complex. UNIX ~~is~~ ***was*** the operating system and support***ed***~~s~~ multiuser and multitasking environments. ***The current computing system remains unchanged except that the software employed now is Oracle Version 9. Additional computing system upgrades may be implemented in the future.***

Minor upgrades and improvements have been made to the WWIS since the EPA certification. Minor changes to several documents related to the design and operation of the system have also been made. All changes improved the system or updated information. The WWIS ~~shall be~~ ***is*** available seven days a week, 24 hours a day except for periodic maintenance and ~~shall~~ support***s*** the maximum number of simultaneous users determined by the database management system license agreement and the operating system license agreement. The network communication protocol of the WWIS is Transmission Control Protocol/Internet Protocol (TCP/IP). Other features ~~that distinguish the WWIS from its predecessor~~ include automatic limit, range, and QA checks; automatic report generation; and compliance with QA requirements for computer software for nuclear facility applications (American Society of Mechanical Engineers [ASME], Nuclear Quality Assurance [NQA]-1, NQA-2, Part 2.7, and NQA-3 [ASME 1989a, 1989b, and 1989c~~ in the Bibliography~~]).

The following WWIS documentation has been identified as necessary and sufficient to document the software lifecycle:

- WWIS Evaluation & Recommendation – provides an evaluation of hardware and software configurations for the WWIS and recommends an approach for implementation.

- WWIS Software Quality Assurance Plan – identifies and defines the standards and methodologies required to ensure conformance to accepted quality standards during the development, maintenance, and operation of the WWIS. This plan ensures that products conform to established technical requirements.

- WWIS Software Verification and Validation Plan – describes the criteria for verification and validation activities for the requirements, design, testing, and all necessary documentation.

- WWIS Software Requirements Specification – defines the requirements essential to the WWIS based on the WWIS Functional and Operational Requirements Document. All requirements shall be internally consistent and verifiable through demonstration, analysis, or testing.

- WWIS Software Design Description – defines the major features of the WWIS including the operating environment, databases, tables, external and internal interfaces, overall structure, sizing, modeling, and system throughput.

- WWIS Software Configuration Management Plan – describes the methods used for identifying software configuration items, controlling and implementing changes, and recording and reporting change implementation status.

- WWIS Security Plan – details the information for handling the security needs of the system (data, software, and hardware). This plan also describes password and access control procedures.

At the time of the CCA, ~~The~~***the*** DOE ~~has~~ identified more than 130 data fields for inclusion in the WWIS. An alphabetical listing and description of these data fields is found in ~~Appendix C13 of Appendix~~ ***the*** WAP ***(NMED 2002).*** The majority of these data fields are considered pertinent to demonstrate compliance with TRU waste transportation and disposal requirements***. These listings are now updated and maintained in the WWIS User's Manual (DOE 2001).***~~, those data fields identified as relevant to this application include the following:~~

- ***Radionuclides present in container***

- ***Activity of individual radionuclides***

- ***Uncertainty associated with the activity of individual radionuclides***

- ***Mass of the individual radionuclides***

- ***Uncertainty associated with the mass of individual radionuclides***

- ***Estimated weight of waste material parameters***

- ***Date of assay***

- ~~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~~
- ~~WMPs~~
- ~~WMC~~

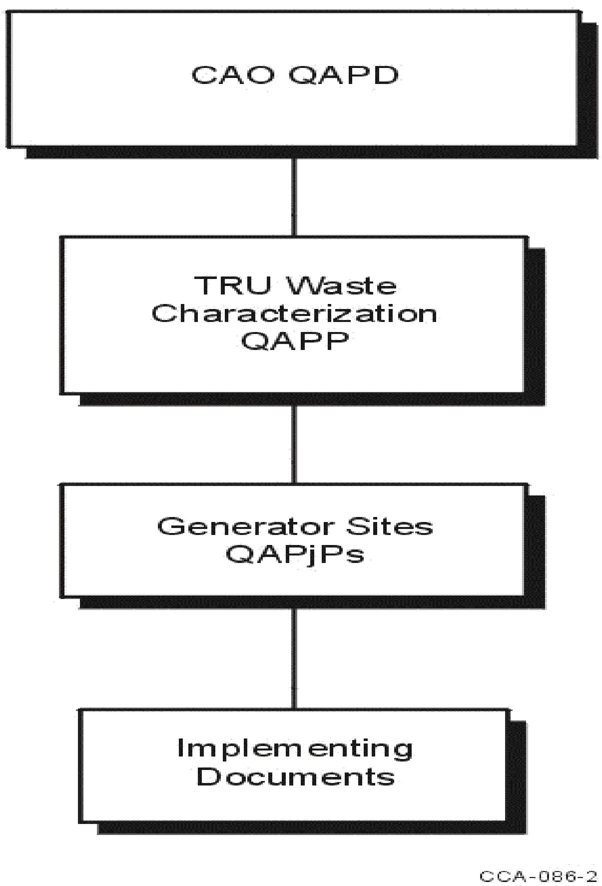
To ensure compliance with the data requirements, personnel at the WIPP review the ***WWIS information on each*** data package for completeness and adequacy before notifying the shipping site of acceptance. Thus, the WWIS becomes an integral part of the waste information screening process described in the WAP.

4.3.3 Quality Assurance

The implementation of a formal ~~quality assurance~~ ***QA*** program demonstrates the commitment of DOE to perform all work activities and operations to the highest standards of quality. DOE has established an effective QA program that complies with applicable sections of NQA-1, NQA-2 (Part 2.7), and NQA-3. The management controls defined by the various ~~quality assurance~~ ***QA*** plans and procedures ensure that all work is planned, documented, performed under controlled conditions, and periodically assessed to establish work item quality and process effectiveness and to promote improvement. The complexity, inherent risk, and significance of the work to the overall project and to public safety are key factors in determining applicable quality management requirements. Internal and external organizational interfaces and responsibilities are described in detail in Chapter 5.0.

~~The QA requirements for TRU waste characterization are contained in the DOE TRU Waste Characterization QAPP. The QAPP is applicable to all DOE TRU waste generator sites that anticipate characterizing TRU waste. Participating sites must follow acceptable analytical methods as specified in the Transuranic Waste Characterization Sampling and Analysis Methods manual (DOE 1995c). Included in the QAPP for each method is a description of the specific performance requirements. These are referred to as quality assurance objectives (QAOs). Should modifications to the approved test methods be necessary, whether for personnel protection from radiation or to implement an improved methodology, these modifications are to be fully documented and approved in accordance with the QAPP and the Sampling and Analysis Methods Manual.~~

~~The QAPjPs developed at each generator and storage site describe the characterization activities that are performed in conformance with the QA requirements specified in the QAPP. The DOE conducts annual certification audits, supplemented by surveillances to ensure that the sites comply with their approved site-specific QAPjPs. Figure 4-6 shows the quality assurance document hierarchy for waste characterization.~~



~~**Figure 4-6. QA Document Hierarchy for Waste Characterization.**~~

~~The QAOs for the nondestructive assay (NDA) of CH-TRU waste are listed in the QAPP and are intended to establish minimum performance requirements for the approved types of measurement systems. The QAOs include criteria for precision, accuracy, minimum detectable concentration, completeness, and total uncertainty. All measurements of activity for CH-TRU waste must have a precision bounded by the range of values in the QAOs established in the QAPP. Only those containers that can be assayed with a precision falling within these bounding values can be accepted for disposal at the WIPP.~~

The DOE TRU Waste Characterization QAPP (DOE 1995a) and the TRU Waste Characterization Sampling and Analysis Methods Manual (DOE 1995b) were replaced as of November 26, 1999. Figure 4-3 shows the revised QA document hierarchy for waste characterization.

Additional information regarding the quality assurance and quality controls used in ascertaining the waste description is given in Chapter 5.0.

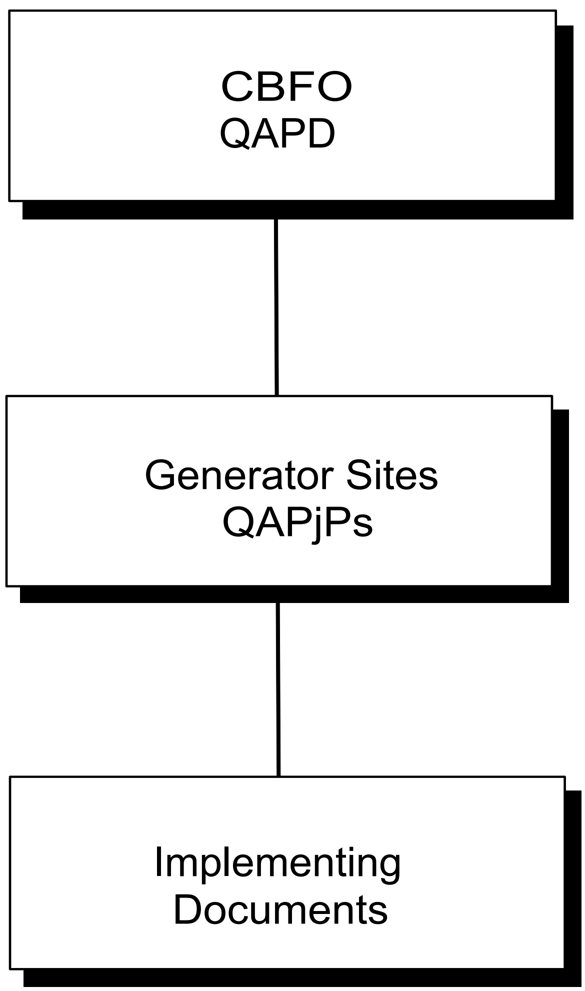


Figure 4-3. QA Documents Hierarchy

4.3.3.1 Performance Demonstration Programs

Another aspect of the waste-characterization QA process that has changed is related to the Performance Demonstration Program (PDP). The program evaluates the capability of sites to perform waste characterization within acceptable limits. Initially, participating laboratories were required to participate in the PDP twice per year. The CBFO has reduced the required frequency from twice per year to once per year. The CBFO described this change to the EPA in correspondence dated November 10, 1998, and April 22, 1999. Based on this information, the EPA determined that the changes reported did not require a modification, suspension, or revocation of the initial certification (EPA June 3, 1999).

The CBFO is the revising and approving authority for the NDA PDP and plans. The CBFO uses the PDP as part of the assessment and approval process for measurement facilities supplying characterization services for the NDA of TRU wastes intended for disposal at WIPP. The NDA PDP is similar to a blind sample program. The NDA PDP plans use 55-gallon drums or SWB's with simulated waste matrix and source standards. The NDA plans identify the elements that comprise the program, the criteria used to evaluate NDA system performance and the responsibilities of the program participants. The PDP NDA plans are revised as required. NDA analysis of drums or boxes is performed by measurement systems that have demonstrated acceptable PDP performance.

~~The Performance Demonstration Program (PDP) plan for NDA for the TRU Waste Characterization Program (DOE 1995a) is designed to help ensure compliance with the QAOs identified in the TRU Waste Characterization QAPP for the WIPP. This plan, as well as the radioassay portion of the current revision of the QAPP, defines QAOs and measurement requirements for the characterization of alpha-emitting TRU isotopes associated with weapons-grade (WG) plutonium. WG plutonium is selected because of its predominance in an isotopic mixture within the TRU waste generated and retrievably stored across the DOE complex.The CAO is the reviewing and approving authority for the PDP. All DOE facilities intending to dispose of their TRU waste at the WIPP must participate in the PDP and pass all individual tests within each PDP cycle. The CAO uses the PDP plan to assess, evaluate, and approve DOE facilities for waste measurement and characterization before the waste is shipped to the WIPP facility. This approval process also includes the evaluation of method performance data submitted by the measurement facility and the performance of QA audits.~~

~~The PDP plan describes the detailed elements that comprise the program, including the test materials and the analysis required. The PDP plan also identifies the criteria used for the evaluation of laboratory performance and the responsibilities of the program coordinator, the standard preparation team, and the participating laboratories. The radioactive source standards encompass the range of activities (masses) anticipated in actual waste characterization. The PDP sample standards address activity ranges relative to WIPP WAC limits, QAPP QAOs, and/or NDA method detection limits (DOE 1995a). The isotopes analyzed under this program plan include but are not limited to ^{238}Pu, ^{239}Pu, ^{240}Pu, and ^{241}Am.~~

~~In conjunction with the source standards, the 55-gallon drums used in the PDP also contain manufactured matrix inserts. These matrix inserts simulate waste matrix conditions and provide acceptable consistency in the sample preparation process at each measurement facility. For the~~

~~first PDP cycle, the sample 55-gallon drums contain either no matrix material or a benign material.~~

~~Laboratory performance must be demonstrated by the successful analysis of blind samples by all participating measurement facilities on a semiannual basis. The blind samples (called PDP samples) are prepared twice during a calendar year at approximately six-month intervals. The PDP samples are analyzed using the methods the measurement facility anticipates using for the analysis of WIPP wastes. These methods must have been developed and approved within the specifications of the QAPP. Only the methods actually used in the PDP are considered acceptable to support the analysis of WIPP wastes. The data generated as a result of the performance demonstration indicate the appropriateness of the method used as well as the performance of the measurement facility. The program coordinator uses a set of standards that encompasses the range of WG material anticipated in actual WIPP waste.~~

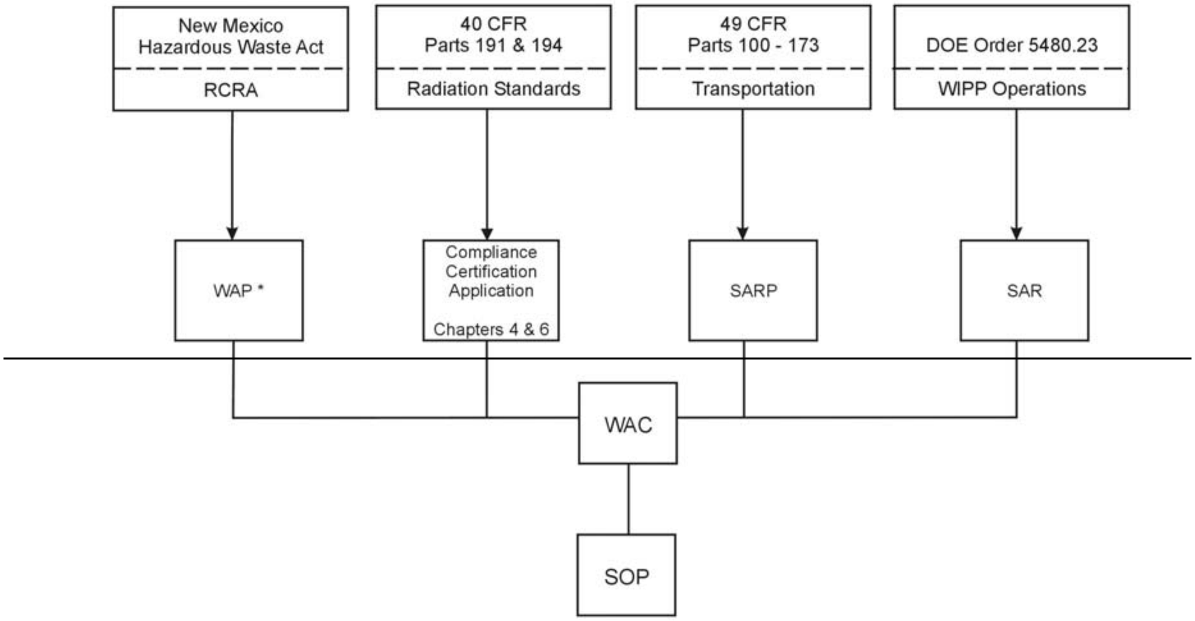
~~The measurement facility analyzes the contents of each PDP sample using the procedures in the WIPP waste characterization program. The scoring system for the PDP is a pass-fail system. To pass a specific test, the measurement must fall within the specified QAOs of the QAPP. To pass the PDP cycle, the measurement must pass all individual tests. The scoring system of the PDP ensures that the QAOs are satisfied at the 95-percent confidence level.~~

~~Waste analyses may be performed only by measurement facilities that have demonstrated acceptable performance in the PDP. Measurement facility performance is used to assess general problems that may affect the facility's ability to analyze total alpha activity within a 55-gallon waste drum. Identified problems are resolved in accordance with the established QA program.~~

4.4 Waste Characterization

The process of waste characterization identifies the ***significant*** physical, chemical, and radiological properties of the waste using a variety of methodologies. ~~(DOE 1995c), including acceptable knowledge, headspace gas sampling and analysis, solid waste sampling and analysis, visual examination, NDA, and nondestructive examination (NDE).~~ The measured waste properties obtained by the ***TRU waste*** ~~generator and storage~~ sites are either on a ~~waste~~ container or waste stream basis and serve to demonstrate compliance with the limits imposed by transportation requirements (DOT), ***the Type B package certificate of compliance, the Hazardous Waste Facility Permit (HWFP),*** and operational safety requirements (DOE). In contrast, the waste component limits described in Appendix WCL are on a repository basis and serve as an upper bound for the accumulative waste inventory. As described in Section 4.3.2, the linkage between the collective waste inventory and the repository limits is provided by the WWIS.

Recognizing that the ***CH-TRU*** WAP ***and the CH-TRU WAC provide*** ~~establishes~~ the ~~TRU mixed~~ waste characterization requirements for ~~DOE~~ waste destined for the WIPP, it is necessary to understand the complementary role played by the radiological characterization of ~~TRU~~ waste. Figure 4-***4***~~7~~ shows the requirements hierarchy governing the characterization of ~~TRU~~ waste for purposes of transportation, disposal, and long-term regulatory compliance. The implementation of waste characterization occurs on a waste-stream basis at the lowest tier of the diagram through the Standard Operating Procedures (SOPs). The next higher tier of Figure 4-***4***~~7~~ includes the ***CH-TRU*** WAC, followed by progressively higher-tier requirements~~, including this application~~. The



* Chapter C of Part B of the WIPP RCRA Permit Application

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~~Figure 4-7. Requirements Hierarchy of TRU Waste Characterization for Transportation and Disposal~~

waste characterization requirements for compliance with the EPA's regulations ~~pertaining to the identification of the disposed waste's hazardous and radiological components~~ are implemented by the SOPs.

The WAP includes requirements ***necessary for compliance with the New Mexico Hazardous Waste Act*** ~~for the determination of the physical and chemical properties of CH-TRU and RH-TRU mixed waste streams —~~ specifically the identification and quantification of their hazardous components (see ~~Appendix~~ ***Attachment B of the*** WAP ***[NMED 2002]***). A combination of five waste characterization methodologies is employed by the WAP and includes acceptable knowledge, radiography, visual examination, headspace gas sampling and analysis, and solidified waste sampling and analysis. The capabilities and applicabilities of these five methodologies to TRU mixed waste are discussed in considerable detail in the WAP. ~~and the QAPP.~~ Except for a brief overview of acceptable knowledge, radiography, and visual examination, a description of the five waste characterization methodologies ***presented in the WAP*** will not be repeated in this document. Radiological characterization of TRU waste is needed for compliance demonstrations to 40 CFR Parts 191 and 194. A quantitative determination of the radionuclides listed in ~~Table 4-10~~ ***Table 4-11*** ~~is driven by~~ ***results from*** the need to demonstrate compliance with the release limits as specified in Appendix A to ~~40 CFR~~ Part 191~~, Subpart B~~ and the RH-TRU waste curie limit established by the LWA (see Table 4-1***2***~~1~~).

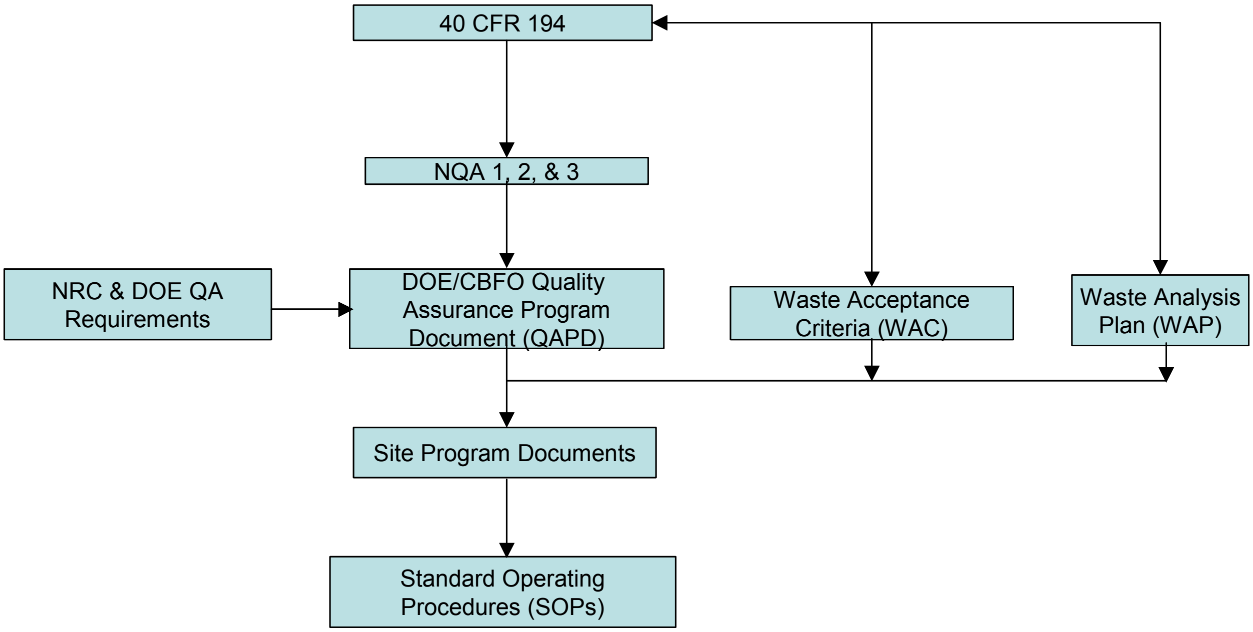

Figure 4-4. Program QA Document Hierarchy

Collectively, those elements of the waste characterization program that support long-term regulatory compliance include the determination of the radionuclide inventory (for purposes of normalizing radionuclide releases as required for comparison with ~~40 CFR §~~ ***Section*** 191.13(a)), the identification of the physical and chemical waste form inventories (if applicable), and the verification that no wastes are emplaced in the WIPP that exceed the disposal system's safety and/or performance limitations.

In a manner analogous to the WAP, the WIPP waste radioassay characterization program is conducted by ~~generator and storage~~ ***TRU waste*** site personnel and is implemented in accordance with the requirements of the ~~QAPP and the~~ ***CH-TRU*** WAC. ~~A description of the approved waste characterization methodologies and QAOs is provided in the QAPP. Generator and storage~~ ***TRU waste*** sites may propose alternative characterization ~~methodologies~~ ***methods***, either because of the availability of newer technologies offering enhanced performance or the modification of older technologies to facilitate meeting the ~~QAOs~~ ***requirements of Appendix A of the CH-TRU WAC***. In these instances, method performance must be demonstrated and approved ***in accordance with Section 194.8*** prior to its use in characterization ***of*** TRU waste for disposal at the WIPP.

Implementation of the TRU waste characterization program at DOE ***TRU waste*** 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. Conformance with applicable regulatory, programmatic, and operational requirements is monitored by ~~CAO~~ ***CBFO*** audits and surveillances. Refer to ***Chapter 5 and CCA*** Appendix QAPD ~~and Sections 3.2.3 and 3.2.4~~ for a more detailed discussion of the ~~CAO~~ ***CBFO*** audit and surveillance program. The documentation requirements important to the implementation of the TRU Waste Characterization Program at each ***TRU waste*** site are briefly discussed below.

- QA requirements. Implementation of individual site-specific waste certification and characterization programs must meet the QA requirements contained in the ~~CAO~~ ***CBFO*** QAPD, which are traceable to the applicable sections of ASME NQA-1 through NQA-3 (ASME 1989a, ***1989***b, and ***1989***c in the ~~Bibliography~~***References***). The ***WAP and the CH-TRU WAC*** ~~QAPP~~ describe~~s~~ the specific ***QA objectives (***QAOs***)*** for the TRU Waste Characterization Program. The ***WAP and the CH-TRU WAC*** ~~QAPP and its associated document, the TRU Waste Characterization Sampling and Analysis Methods Manual~~, delineate approved analytical methods for meeting regulatory requirements.

- QAPjPs. ~~Generator~~ ***TRU waste*** sites prepare site-specific QAPjPs that describe waste characterization activities in support of the TRU waste characterization program. These documents, developed in accordance with the applicable requirements in the ~~CAO~~ ***CBFO*** QAPD ***and the WAP,*** ~~and the QAPP,~~ define QA management and program elements that provide for planning, implementation, and assessment of the TRU waste characterization data-collection activities.

- SOPs. The ~~QAPP~~ ***QAPD*** requires that each DOE ***TRU waste*** site develop, implement, and control written SOPs that provide detailed descriptions of routine, standardized, or critical waste characterization activities. The SOPs serve as the basis for quality assessments of waste characterization activities at the site level because they provide detailed descriptions of required activities.

- PDPs. Analytical facilities characterizing waste for disposal at the WIPP must successfully participate in the applicable portions of the PDP. The PDP supports the determination of a facility's ability to meet the QA ~~objectives~~***requirements*** identified in the ***CBFO QAPD*** ~~QAPP~~. A more detailed description of the PDP can be found in Section 4.3.3.1.

As the ~~generator~~ ***TRU waste*** sites complete the necessary program documentation, they commence waste characterization activities. Information derived from these activities is on a waste-stream basis and is used in preparing the site's waste-stream profile forms required for waste acceptance at the WIPP. The waste characterization data are electronically backed-up in databases at the ~~generator~~ sites and downloaded into the WWIS database (DOE 1996b). The WWIS is described in Section 4.3.2.

~~Generator and storage~~ ***TRU waste*** sites prepare documented and approved programs controlling their TRU waste characterization, certification (which includes characterization), and transportation processes. Site-specific TRU waste certification plans document how compliance with the ***CH-***WAC ~~and QAPP are~~***is*** accomplished. Site certification ~~shall be~~ ***is*** granted by the ~~CAO~~ ***CBFO*** manager ~~contingent~~ upon ~~final~~ approval of the following documentation:

1. TRU waste certification plan (including QA),

2. QAPjP(s),

3. ***NRC Type B packaging methods for payload compliance*** TRU package transporter, Model 2 (TRUPACT II) Authorized Methods for Payload Compliance,

4. ~~p~~***P***ackaging QA plan, and

5. ~~p~~***P***erformance in applicable PDPs.

In addition to approval of this site-specific documentation, ~~generator and storage~~ ***TRU waste*** sites must pass an initial ***TRU waste*** site certification audit where adequate and effective implementation of these programs is assessed (see Sections 5.1.~~1~~ and 5.3.19). ***Also, as described in Section 4.1.2, EPA approval of QA program documentation and implementation is also required.***

Each ~~TRU~~ ~~waste~~ ~~generator and storage~~ site that is characterizing TRU waste ~~to the requirements of the QAPP and the WAC~~ is recertified by the ~~CAO~~ ***CBFO*** annually. A recertification consists of reviewing (if applicable)***:***

1. ~~s~~***S***ite-specific program documents that are written and approved to the latest ***CH-TRU*** WAC~~,~~***;***

2. ~~p~~***P***rogram implementation as determined by a ***TRU waste*** site certification audit~~,~~***;***

3. ~~r~~***R***eports from surveillances conducted during the past year~~,~~***;***

4. ~~p~~***P***erformance in shipping TRU waste to the WIPP~~,~~***;*** and

5. ~~p~~***P***erformance in the PDPs.

To ensure that ~~the~~ DOE ~~generator and storage~~ ***TRU waste*** sites comply with the WIPP TRU waste certification program, audits are conducted by the ~~CAO~~ ***CBFO***. An initial audit is conducted at each ~~generator~~ ***TRU waste*** site performing waste characterization activities prior to the formal acceptance of the waste-stream profile forms and/or any waste characterization data supplied by ***TRU waste*** site personnel. This formal acceptance is referred to as ***TRU waste*** site certification. Audits are performed at least annually thereafter, including the possibility of unannounced (not regularly scheduled) audits. These audits verify that the ~~generator~~ site has implemented a QA program for all certification activities. The accuracy of the physical waste description and the subsequent waste stream assignment are verified by a review of acceptable knowledge documentation, radiography data, and visual examination results (if applicable). Table 4-1***6***~~3~~ summarizes the characterization requirements and methods detailed in the ***CH-TRU*** WAC ***and the WAP*** that support this application. ***The EPA often observes the DOE audits in fulfilling its obligations defined in Section 194.8 (see Section 4.1.2).***

Additional information regarding RH-TRU waste characterization has been developed by DOE and has been submitted to the EPA (letter from DOE to EPA December 16, 2002). No RH-TRU waste has been shipped to the WIPP at the time of CRA-2004. EPA approval of DOE's proposed RH-TRU waste characterization procedure is pending.

Table 4-*16*~~3~~. Applicable CH- and RH-TRU Waste Component Characterization Methods

Waste Properties	Waste Components	Waste Characterization Methods
Nuclear	Radionuclides	NDA OR previous isotopic distribution from destructive radiochemistry OR previous radioassay data reconciled with ***CH-TRU*** WAC requirements
Physical	ferrous metals nonferrous metals cellulos***ic,*** plastic***,*** rubber ***materials*** solid components free water humic substances	radiography with statistical selection for visual examination OR visual examination and documentation of container content at time of waste packaging for newly generated waste OR documentation and verification (random sampling) for newly generated waste
Chemical	sulfates nitrates organic ligands	No upper or lower limits apply to these chemicals; therefore no waste characterization methods are applied.

4.4.1 Qualitative Methodologies

The criteria at ~~40 CFR §~~ ***Section*** 194.24(a) ~~state that~~ ***require*** a description of the physical, chemical, and radiological composition of the TRU waste to be emplaced in the WIPP disposal system ~~be provided~~. With regard to the waste's nonhazardous physical and chemical components (such as cellulosic ***materials***), there are three qualitative methodologies, used either singularly or in combination, for verifying adherence to the compliance limits. ~~contained in Appendix WCL.~~ These methodologies include acceptable knowledge, nonintrusive examination using penetrating radiation such as X-ray (referred to as either RTR, radiographic examination, radiometric examination, or ***nondestructive examination (***NDE***)***), and intrusive visual examination consisting of opening the container and recording the contents. ***The use of Acceptable Knowledge information is presented in the WAP and the CH-TRU WAC.***

4.4.1.1 Acceptable Knowledge

The following ~~discussion is responsive to the~~ ***discusses compliance with*** criteria at ~~40 CFR §~~ ***Section*** 194.24(c)(3).

Acceptable knowledge is defined in the EPA Guidance Manual (EPA 1994) ~~in the Bibliography~~. Acceptable knowledge includes information regarding the physical form of the waste, the base materials composing the waste, and the process that generate~~s~~***d*** the waste. Waste characterization will be used to confirm acceptable knowledge information. ***The WAP and the CH-WAC provide details regarding the application of acceptable knowledge.***

Consistency among DOE ***TRU waste*** sites in using acceptable knowledge information to characterize TRU waste involves a three-phase process: (1) compiling the minimum acceptable knowledge documentation in an auditable record, (2) confirming acceptable knowledge information, and (3) auditing acceptable knowledge records.

~~Appendix WAP, Figure C9-1 illustrates provides an overview of the process for assembling acceptable knowledge documentation into an auditable record. The first step is to assemble all of the mandatory acceptable knowledge information and any supplemental information regarding the materials and processes that generate a specific waste stream. DOE sites must ensure the following criteria are met in establishing acceptable knowledge records:~~

- ~~Acceptable knowledge information must be compiled in an auditable record, including a road map for all applicable information.~~

- ~~The overview of the facility and TRU waste management operations in the context of the facility's mission must be correlated to specific waste stream information.~~

- ~~Correlations between waste streams, with regard to time of generation, waste generating processes, and site-specific facilities must be clearly described.~~

Acceptable knowledge documentation provides qualitative information that cannot be assessed according to specific data quality objectives that are used for analytical techniques. QAOs ~~objectives~~ for analytical results are described in terms of precision, accuracy, completeness, comparability, and representativeness. Analytical results will be used to confirm the characterization of wastes based on acceptable knowledge.

~~To ensure that the acceptable knowledge process is consistently applied, sites must comply with the following data quality indicators for acceptable knowledge documentation.~~

- ~~Precision – Precision is the agreement among a set of replicate measurements without assumption of the knowledge of a true value. The qualitative determinations, such as compiling and assessing acceptable knowledge documentation, do not lend themselves to statistical evaluations of precision.~~

- ~~Accuracy – Accuracy is the degree of agreement between an observed sample result and the true value. The percentage of waste containers that require reassignment to a new WMC will be reported as a measure of acceptable knowledge accuracy.~~

- ~~Completeness – Completeness is an assessment of the number of waste streams or number of samples collected to the number of samples determined to be useable through the data validation process. The acceptable knowledge record must contain 100 percent of the required information (see Section C9-3 in Appendix WAP). The useability of the acceptable knowledge information will be assessed for completeness during audits.~~

- ~~Comparability – Data are considered comparable when one set of data can be compared to another set of data. Comparability is ensured through sites meeting the training requirements and complying with the minimum standards outlined for procedures that are used to implement the acceptable knowledge process.~~

- ~~Representativeness – Representativeness expresses the degree to which sample data accurately and precisely represent characteristics of a population. Representativeness is a qualitative parameter that will be satisfied by ensuring that the process of obtaining, evaluating, and documenting acceptable knowledge information is performed in accordance with the minimum standards listed in Section C9-4 contained in Appendix WAP. Sites also must assess and document the limitations of the acceptable knowledge information.~~

The acceptable knowledge process and waste stream documentation must be evaluated through internal assessments by ~~quality assurance~~ ***QA*** organizations and assessments by auditors external to the organization (that is, the ~~CAO~~ ***CBFO***).

The ~~CAO~~ ***CBFO*** ~~will~~ ***has conducted and will continue to*** conduct an initial audit of each ~~generator and storage~~ ***TRU waste*** site prior to certifying the ***TRU waste*** site for shipment of TRU waste to the WIPP facility (see ~~Figure C9-2~~ ~~in Appendix WAP~~ ***the Hazardous Waste Facility Permit [NMED 2002] Attachment B through B6, including Figure B4-3***). This initial audit will establish an approved baseline that will be reassessed annually.

~~Audit plans will identify the scope of the audit, requirements to be assessed, participating personnel, activities to be audited, organizations to be notified, applicable documents, and schedule. Audits will be performed in accordance with written procedures and checklists. The audit checklists will include specific items associated with the compilation and evaluation of the required acceptable knowledge information.~~

~~Audit checklists must include all of the following elements for review during the audit:~~

- ~~Documentation of the process used to compile, evaluate, and record acceptable knowledge is available and implemented;~~
- ~~Personnel qualifications and training are documented;~~
- ~~Required acceptable knowledge documentation has been compiled in an auditable record;~~
- ~~A procedure exists for resolving inconsistencies in acceptable knowledge documentation;~~
- ~~A procedure exists for confirming acceptable knowledge information; and~~
- ~~Results of other audits of the TRU waste characterization programs at the site are available in site records.~~

~~Members of the audit team will be knowledgeable regarding the required acceptable knowledge information regarding the use of acceptable knowledge for waste characterization. Audit team members will be independent of all TRU waste management operations at the site being audited.~~

~~Auditors will evaluate documents associated with the evaluation of the acceptable knowledge documentation for at least one debris waste stream and one solidified waste stream during the audit. For these waste streams, auditors will review procedures and associated processes developed by the site for documenting the process of compiling acceptable knowledge~~

~~documentation; correlating information to specific waste inventories; and identifying, resolving, and documenting discrepancies in acceptable knowledge records. The adequacy of acceptable knowledge procedures and processes will be assessed and any deficiencies in procedures documented in the audit report.~~

~~Auditors will review the acceptable knowledge documentation for selected waste streams for logic, completeness, and defensibility. The criteria that will be used by auditors to evaluate the logic and defensibility of the acceptable knowledge documentation include completeness and traceability of the information, consistency of application of information, clarity of presentation, degree of compliance with Appendix C9 of the WAP with regard to acceptable knowledge confirmation data, nonconformance procedures, and oversight procedures. Auditors will evaluate compliance with written site procedures for developing the acceptable knowledge record. A completeness review will evaluate the availability of the minimum required TRU waste management and TRU waste stream information. Records will be reviewed for correlation to specific waste streams. Auditors will verify that sites include all required information. All deficiencies in the acceptable knowledge documentation will be included in the audit report.~~

~~Auditors will verify and document that sites use administrative controls and follow written procedures to make waste determinations for newly generated and retrievably stored wastes. Auditors will review procedures used by the sites to confirm acceptable knowledge information.~~

~~After the audit is complete, the CAO will provide the site with preliminary results at a close-out meeting. The CAO will prepare a final audit report that includes all observations and findings identified during the audit. Sites must respond to all audit findings and identify corrective actions. Audit results will be available at CAO for review by regulatory agencies, and copies will be provided upon request. If acceptable knowledge procedures do not exist, the minimum required information is not available, or significant findings of noncompliance are identified, the CAO will not grant the site waste characterization and certification authority for the subject waste. Waste stream characterization and certification authority may be revoked or suspended if there are significant findings during subsequent annual audits.~~

~~Prior to notifying a site that a waste stream can be shipped and accepted at the WIPP facility, the CAO will review the Waste Stream Profile Forms and associated data packages. Sites must provide all of the required data associated with waste steam characterization. The data packages will be evaluated as illustrated in Figure C9-2 in Appendix WAP. The CAO will review information provided by the sites to ensure that changes to waste codes are identified and justified. If data consistently indicates discrepancies with acceptable knowledge information, the CAO will require sites to increase sampling, reassess the materials and processes that generate the waste, and resubmit waste stream profile information. Until discrepancies are resolved, shipment of the waste stream to the WIPP will be prohibited.~~

4.4.1.2 Nondestructive Examination

NDE is a ~~nondestructive~~ qualitative technique that involves ***the use of*** X-ray***s*** ~~interrogation~~ ***examination*** of waste containers to identify and verify the contents. NDE is used to verify the absence of prohibited items and to determine the appropriate methodologies to be used for waste characterization. NDE is not required for newly generated waste because controls exist to verify compatibility of the matrix material(s) and the absence of prohibited items prior to and during waste packaging.

~~A typical NDE system consists of an X-ray producing device, a container handling system, and an imaging detector. X-ray generators typically used in NDE produce X-rays ranging in energy from under 100 kiloelectron volts up to approximately 450 kiloelectron volts. If higher energies are needed, either because of a high-density waste matrix or the need to penetrate shielded payload containers, then the use of a linear accelerator becomes a viable approach for producing a pulsed X-ray beam with energies to 25 megaelectron volts and beyond.~~

~~The X-ray detector has the function of converting the radiation input signal into a corresponding optical or electronic output signal that ultimately is used to reconstruct an image of the payload container contents. An example of a system presently in use at many of the generator and storage sites is RTR, which gives the operator the opportunity to view events in progress (that is, in real time). In an RTR system, the imaging system typically utilizes a fluorescent screen and a low light television camera (since the light output of most screens is quite low). The resulting image is transferred to a remotely located television screen, and the operator conducts the examination by viewing the remote television screen.~~

~~Data acquired by NDE are documented as required by the QAPP. The QAOs for radiography, as listed in Section 10 of the QAPP, include precision, accuracy, completeness, and comparability. Since radiography, the primary methodology for performing NDE, is basically a qualitative determination, there is no specification for a method detection limit. The QAOs for NDE using radiography are summarized below.~~

~~Precision and Accuracy – The qualitative determinations made during radiography do not readily lend themselves to statistical evaluation of precision or accuracy. An estimate of precision and accuracy can be made, however, by comparing the results of NDE with the results of visual examination of a randomly selected statistical portion of waste containers.~~

~~Completeness – An audiotape or videotape of the radiography examination (or equivalent for other NDE methodologies) and a radiography data form, validated according to the requirements in Section 3.0 in the QAPP, must be obtained for 100 percent of the retrievably stored waste containers.~~

~~Comparability – The comparability of radiography data from different sites shall be enhanced by using standardized radiography procedures and operator qualifications. in accordance with the requirements of the QAPP.~~

All activities required to achieve the radiography objectives must be described in ***TRU waste*** site QAPjPs and SOPs. Retrievably stored containers will have this type of permanent record on file throughout the life of the WIPP project. As a quality control check on NDE, a statistically determined number of retrievably stored containers within the population subjected to NDE will be randomly selected and visually examined.

4.4.1.3 Visual Examination

~~The v~~***V***isual examination ~~technique~~ is used by ~~the~~ DOE to provide an acceptable level of confidence in NDE. There is no equivalent method in the EPA sampling and analysis guidance documents. ~~A detailed procedure that meets the requirements of this method can be found in the WIPP Waste Characterization Program Sampling and Analysis Methods Manual (DOE 1995c).~~ ~~Generator~~ ***TRU waste*** site personnel develop training programs that are based on waste form and waste management operations. These training programs are used to assess operator performance. The QAPjPs and supporting SOPs specify the training requirements and other activities required to achieve the visual examination objectives. The visual examination expert must be familiar with the waste generating processes that have taken place at that ***TRU waste*** site and also with the types of waste being characterized at the site. For an explanation of the hypergeometric approach used in determining the number of containers to be statistically sampled by visual examination, see the ***WAP***. ~~Appendix A of the QAPP (DOE 1995b).~~

4.4.2 Quantitative Methodologies

To minimize exposure, the quantitative methodology used to determine the radionuclide inventory of the waste is NDA. The nonintrusive methodology of NDA employs radiation detection techniques for determining the waste's isotopic content and activity. This is the preferred approach because of the safety hazards involved in opening waste containers having radioactive contaminants. Although the data generated by radioassay serve many functions including the calculation of the ^{239}Pu equivalent activity, the ^{239}Pu fissile gram equivalent, and the decay heat of waste containers, the purpose of these data relative to long-term regulatory compliance with 40 CFR Part 191 is to provide corroborative data relating to the radionuclide inventory reported in the ~~TWBIR~~ ***CRA-2004*** and furnish radionuclide information on a container basis to maintain a running inventory of TRU waste emplaced in the WIPP disposal system.

TRU nuclides emit both ionizing radiation (including alpha particles, beta particles, and gamma rays) and nonionizing radiation (neutrons). Based on detection of these emissions, several technologies have been developed to measure one or more of these radiations as they emerge from the waste container. Although most of the ionizing radiation (alpha and beta particles) are not able to penetrate the walls of the waste container, both gamma rays and neutrons can penetrate the waste matrix as well as the waste container to varying degrees. Combining gamma ray measurements, other advanced particle detection techniques specific to neutrons, and acceptable knowledge provides the precision and accuracy required by the QAOs contained in the ***CH-TRU WAC Appendix A*** ~~QAPP~~. Mass spectroscopy and radiochemistry also provide the precision and accuracy to meet the QAO requirements in the ***CH-TRU WAC Appendix A*** ~~QAPP~~.

Special techniques, instrumentation, and detectors have been developed to measure the gamma ray energies. Because there are many different gamma rays originating from any one radionuclide with each gamma ray having a unique energy and rate of occurrence characteristic of the radionuclide from which it originated, the resulting distribution or spectrum of gamma ray energies provides a fingerprint or signature of that particular radionuclide. In practice, with the application of appropriate correction factors and the utilization of acceptable knowledge, gamma ray and neutron NDA systems provide radioisotope inventory information about the waste without the need for opening the container.

All radioassay systems must be calibrated using a variety of matrix and source standards to simulate the various waste compositions, source distributions, and interferences common to the waste streams originating from a particular ~~generator~~ ***TRU waste*** site. By applying the resulting correction factors to the measurements, an accurate assessment of the radionuclide inventory within the waste container is feasible. NDA methods appropriate to a particular waste stream profile are used in the radionuclide analysis.

4.4.2.1 Nondestructive Assay

A variety of NDA methodologies are effective in meeting the requirements of the ***CH-TRU WAC Appendix A*** ~~QAPP~~. ~~Table 9-2 of the QAPP identifies a number of such systems that are in use at various DOE and/or contractor testing facilities.~~ ~~These~~ ***NDA*** instruments can be classified as belonging to one or more of the four categories listed below:

- gamma ray measurements
  - low- and high-resolution spectroscopy using a sodium iodide and intrinsic germanium detector, ~~respectfully,~~
  - 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~~***Am***-~~L~~***l***ithium 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.

The list is neither complete nor limiting and is meant to illustrate the breadth of choice available. QAOs may be met with the listed systems or by modifications, functionally equivalent alternatives, multiple combinations, or hybrids of the systems.

For each of the radionuclide components identified in Table 4-***11***~~10~~ as being significant to ~~performance assessment~~ ***PA*** and requiring assay, any of the above NDA methodologies, either singularly or in combination, may be used in determining the activity and corresponding uncertainty. In the case of 100-percent sampling, these measurements are performed on a ~~waste~~ container basis. For the case of less than 100-percent sampling, the reported values are on a waste stream basis. Upon receipt of the waste at the WIPP, the measured activity of these significant radionuclide components, plus their associated uncertainty, are accumulated by the WWIS in order to ensure that the volume and activity limits of the repository are not exceeded.

4.4.3 Additional Change to the Waste Characterization Program

Since the certification of the WIPP, an additional change related to the waste characterization program has occurred. In the past, DOE planned to declassify any classified materials in waste before shipment to WIPP. In 2002, the RFETS proposed sending waste containing classified shapes to WIPP, where the associated radiography and VE records would be classified and require a DOE security clearance for review and audit. In 2003, the EPA determined that classified waste may be shipped to WIPP provided DOE meets certain specified requirements (EPA letter of February 11, 2003, to DOE CBFO).

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