The Road to Recertification: WIPP TRU Waste Inventory

B.A. Crawford, S.A. Lott, L.D. Sparks, G. Van Soest, B. McInroy
Los Alamos National Laboratory –Carlsbad Operations
115 N. Main St., Carlsbad, NM 88220
USA

ABSTRACT

The Waste Isolation Pilot Plant (WIPP), located near Carlsbad, New Mexico, is a deep geologic repository for the disposal of transuranic (TRU) wastes generated by atomic energy defense activities. The WIPP Land Withdrawal Act (LWA) [1] requires the U.S. Department of Energy (DOE) to submit documentation to the U.S. Environmental Protection Agency (EPA) that demonstrates WIPP’s continuing compliance with the disposal regulations in Title 40 of the Code of Federal Regulations (CFR) Part 191 Subparts B and C, not later than five years after initial receipt of waste for disposal at the repository, and every five years thereafter until the decommissioning of the facility is completed.

On May 18, 1998, after review of the Compliance Certification Application (CCA) (63 FR 27405), the EPA certified that the WIPP did comply with the final disposal regulations and criteria of 40 CFR parts 191 and 194. On March 26, 1999, the first receipt of contact-handled (CH) TRU waste was received at WIPP thus initiating the 5-year countdown to the first recertification.

Five years after the first receipt of waste at WIPP, on March 26, 2004, the DOE submitted a Compliance Recertification Application (CRA) [2]. The CRA includes TRU waste inventory as a key factor. The TRU waste inventory defines what is expected to be emplaced in the repository; and, therefore, how the performance of the repository will be affected. Performance of the WIPP is determined via the Performance Assessment (PA), a set of complex algorithms used to model the long-term performance of the repository. The TRU waste inventory data that are important to this assessment include: 1) volumes of stored, projected and emplaced waste; 2) radionuclide activity concentrations; 3) waste material parameter densities; 4) estimates of the masses of chelating agents; 5) estimates of the oxyanions; 6) estimates of expected cement masses; and 7) estimates of the types and amounts of materials that will be used to emplace the waste. The data that are collected and maintained as the TRU waste inventory provide the waste source term used in the PA to model long-term repository performance.

INTRODUCTION

The DOE is responsible for the disposition of TRU waste generated in whole or in part by atomic energy defense activities. The U.S. Congress established criteria for the management and operation of the WIPP in 1992 by its passage of the WIPP Land Withdrawal Act (LWA) [1]. The LWA required that, prior to opening the WIPP for the disposal of TRU waste, the EPA certify that the WIPP facility complies with the final disposal regulations. The DOE submitted the Compliance Certification Application (CCA) in October 1996 [3]. The CCA included documentation supporting the suitability of the geological, hydrological, physical, chemical, and environmental characteristics of the WIPP repository, located near Carlsbad, New Mexico. The application was used to demonstrate how these characteristics, along with engineered features of the facility, lead to a reasonable expectation that compliance will be maintained for the required 10,000-year regulatory period. The EPA reviewed the CCA, requested additional information and studies, and also performed independent analyses during its evaluation of the CCA. Public input was solicited during the evaluation as part of the process. Finally, on May 18, 1998 (63 FR 27405), the EPA certified that the WIPP did comply with the final disposal regulations and criteria of 40 CFR Parts 191 and 194, and on March 26, 1999, disposal operations began.

Section 8(f) of the LWA [1] requires that the DOE submit proof of compliance with the final disposal regulations that evolved from the approval of the CCA to the EPA and the State of New Mexico. The CRA documented the DOE's demonstration of the continuing compliance of the WIPP with the long-term disposal regulations in 40 CFR Part 191, Subparts B and C [4,5,6]. This documentation began five years after the initial receipt of waste for disposal at WIPP as the CRA and will continue every five years thereafter until the end of the decommissioning phase of the project. The documentation includes changes to the CCA and a PA using the most recent data on TRU waste inventory.

REGULATORY COMPLIANCE

The WIPP LWA [1] made the EPA the Administrator of WIPP. In addition, the LWA required that the disposal regulations issued by EPA on September 19, 1985 40 CFR Part 191 subpart B [4] be in effect. The Administrator was required to issue final disposal regulations and issue final criteria for the EPA's certification of compliance with the final disposal regulations. These disposal regulations were delineated as 40 CFR Part 191 Subpart B – Environmental Disposal Standards and Subpart C [5] – Environmental Standards for Ground-Water Protections. Under these standards radioactive material releases of TRU wastes were identified and modeled in the PA and the groundwater monitoring was put into place at WIPP.

TRU waste inventory data are used to define the waste that will fill the WIPP repository in terms of volume, radionuclides, waste material parameters, and other chemical components, and to model these data over a 10,000-year evolution. The information provided for the CRA was developed in accordance with the criteria established by the EPA, 40 CFR Part 194 [6]. The data pertain to TRU waste that is defined in the LWA, as "…waste containing more than 100 nanocuries of alpha-emitting transuranic isotopes per gram of waste, with half-lives greater than 20 years…" [1]. Defining TRU waste further, the wastes are classified as either contact-handled (CH) or remote-handled (RH-) TRU waste, depending on the dose rate at the surface of the waste container. CH-TRU wastes are packaged TRU wastes with an external surface dose rate less than 200 millirem (mrem) per hour, while RH-TRU wastes are packaged TRU wastes with an external surface dose rate of 200 mrem or greater per hour [1].

Applications, submitted as part of this requirement, must include a definition of the TRU waste that is expected to fill the repository. The TRU waste inventory that was provided for the CRA and subsequently for the Performance Assessment Baseline Calculation (PABC) contained the components of the waste that are important as identified in 40 CFR Part 194.24 that states:

> (a) Any compliance application shall describe the chemical, radiological and physical composition of all existing waste proposed in the disposal system. To the extent practicable, …shall also describe the chemical, radiological and physical composition of the to-be-generated waste proposed for disposal in the disposal system. These descriptions shall include a list of waste components and their approximate quantities in the waste. (b)…(1) That all waste characteristics influencing containment of waste in the disposal have been identified and assessed for their impact on disposal system performance. …(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 component to be analyzed shall include but shall not be limited to: metals, cellulosics, chelating agents, water and other liquids and activity of radionuclides present…

Upon submittal of the CRA, EPA performed a completeness review prior to starting the process to determine if the CRA demonstrates continued compliance with the disposal regulations. During their review, EPA requested additional information from DOE that required supplementary analyses and lead to the PABC to be performed. EPA requested an updated PA calculation in a letter dated March 4, 2005 [7]. At the time of this request, two changes were identified in the TRU waste inventory that had significant impact. Since these changes were significant, the EPA requested that this “updated” inventory be included in the new PABC. These changes are incorporated into included in the TRU waste inventory that is discussed in the sections that follow. This updated inventory used in the PABC is referred to as the “PABC Inventory.” It differs from the inventory used in the original PA for the CRA in that it contains Idaho National Laboratory (INL) buried waste and a significant reduction in the waste reported by Hanford Richland Operations (Hanford RL).

TRU WASTE INVENTORY FOR RECERTIFICATION

The TRU waste inventory that is required by 40 CFR Part 194.24 for use in the WIPP PA includes the most up-to-date information that is available from the DOE TRU waste sites. Data were collected from the 27 TRU waste sites shown in Fig. 1. for the CRA. This information was subsequently updated for the PABC inventory.

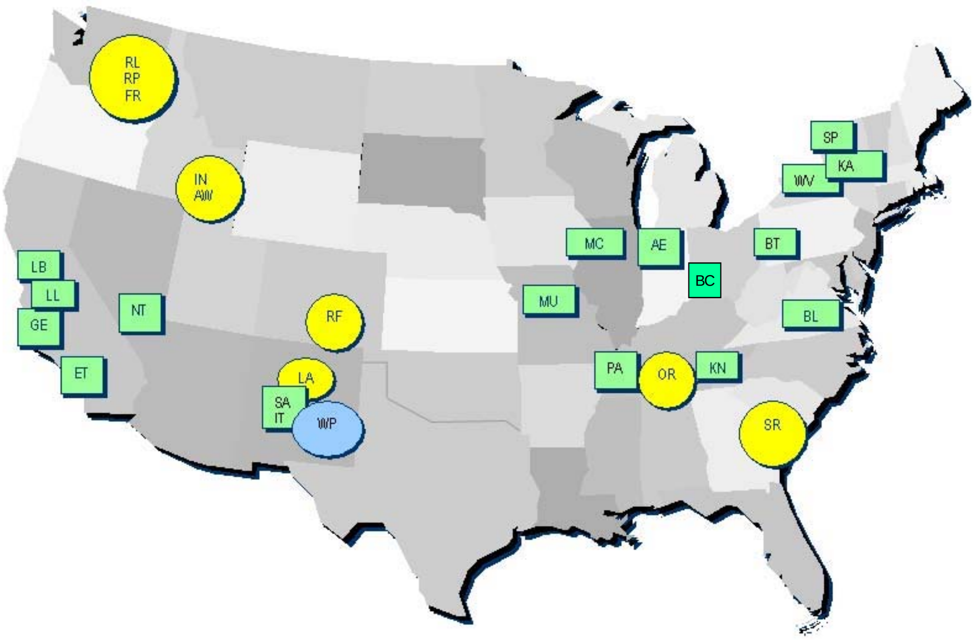

Fig. 1. Sites that provided updated inventory data for the CRA

TRU Waste Inventory Changes at the TRU Waste Sites

The volume, physical and radiological characteristics of TRU waste that a TRU waste site may report at a given time depends on several factors including: regulations on the federal and state level, waste program management decisions at the site, at the WIPP and on the national level, funding for waste management on site, availability and confidence in supplemental characterization information or process knowledge, and the forecast for upcoming programs on site, to name a few.

The TRU waste inventory obtained for the CRA was based on the best estimate that the TRU waste sites could provide as of September 30, 2002. At that time, some of the sites had developed plans for managing waste cost effectively through waste compression. Some sites had obtained additional characterization information that helped better define their TRU waste. Other sites had discovered TRU waste that was not reported for the CCA and some sites are only now developing methods for retrieval and packaging for shipment to WIPP. Finally, some sites embarking on decontamination and decommissioning work found it necessary to increase waste volumes as a result of these activities. Based on these changes an inventory cut off date was determined so that the best estimate of TRU waste could be provided for the PA model at the time.

TRU Waste Site Data Management and Response

In response to the CRA data calls, most TRU waste sites used a site-specific waste tracking system, usually a database, to develop the data reported to the Inventory Team. The information contained in each of these tracking systems, provided historic information about the radiological content and container materials in each of the waste streams reported in the waste profiles for the CRA. In most cases, the radiological content of the waste had been historically tracked on mass balance sheets or engineering flow sheets that originated at the TRU waste site's generating facilities. Information about the physical form of the TRU waste is also tracked for most sites and is maintained in hard-copy record or in databases.

Data Collection and Processing

The focus used in collecting data for the CRA from the TRU waste sites was to capture the changes that each site had undergone since the CCA [3] was submitted, keeping the original information from the CCA, wherever possible. In order to appropriately capture these changes, each TRU waste site was sent a copy of the data they submitted for the CCA in the form of waste profiles from the TWBIR Revision 2 [8]. The sites were then instructed in the associated data call to mark all changes on the profiles provided and return the marked up profiles to the Inventory Team.

The TRU waste sites complied with the data call and provided the data to the Inventory Team (Step 1 of Fig. 2.). Then the TRU Waste Inventory Team reviewed the information. If there were questions regarding the data, discussions continued with the site until all questions were resolved or the information was clarified (Step 2, Fig. 2.). Once the data were obtained, the data were reviewed to ensure they could be used in PA calculations and the data were verified (see steps 3 and 4, Fig. 2.). Once review of the record submitted by the site was complete, the data were entered into the electronic database, the *Transuranic Waste Baseline Inventory Database* (TWBID) Revision 2.1 [9].

Upon completion of data entry and verification, the data were provided to the respective TRU waste sites with a signature sheet that the DOE Site TRU Waste Manager signed (step 4 of Fig. 2.). These signed sheets were used to verify that the data the site provided were entered into the database correctly. All site information and associated correspondence used to clarify questions and provide objective evidence that the site reviewed and approved the data in the database were entered into record in the WIPP Record Center.

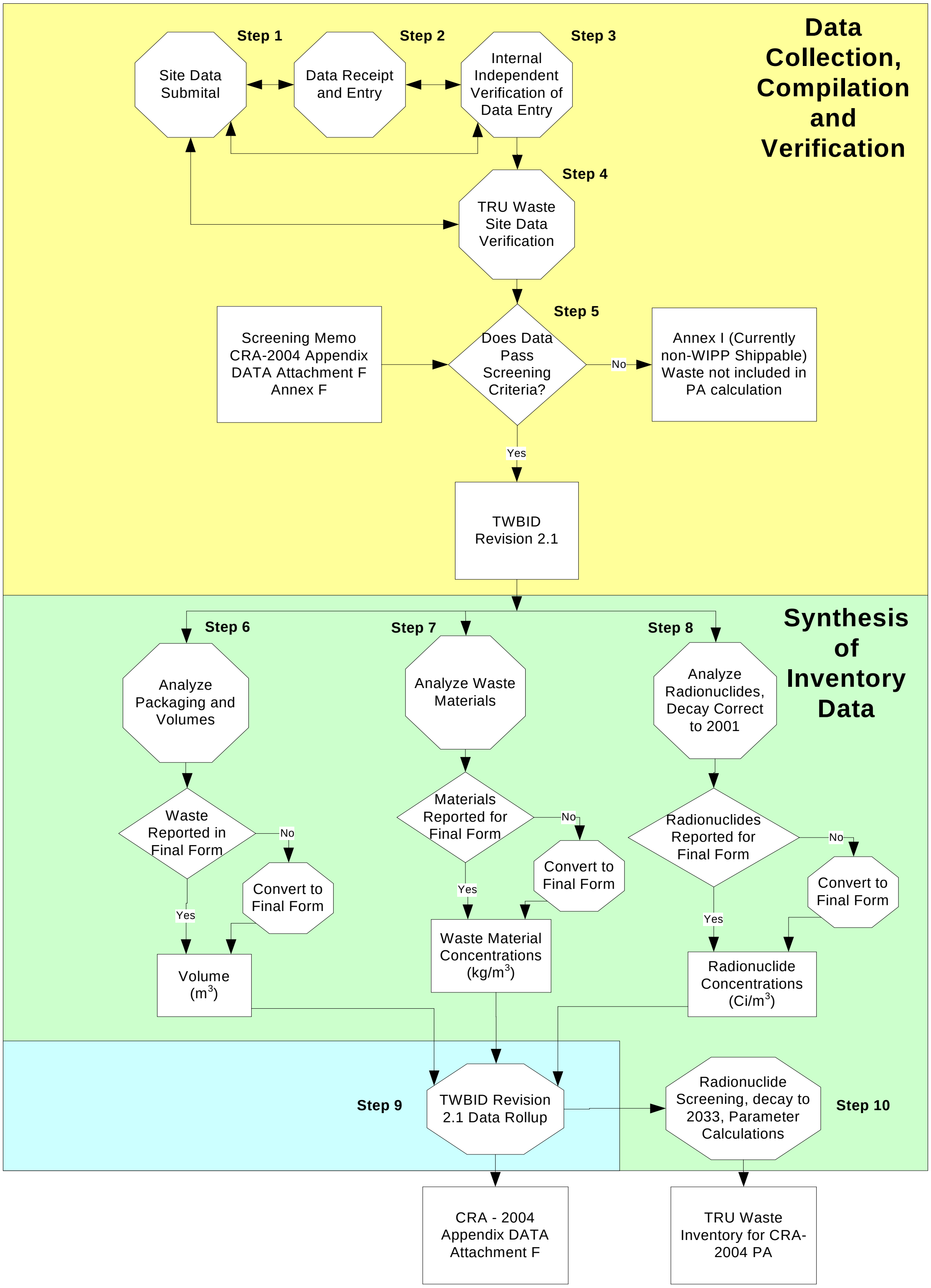

Fig. 2. TRU waste inventory data flowchart for CRA-2004

PERFORMANCE ASSESSMENT BASELINE CALCULATION DATA

The TRU waste inventory data that are important to the PA include: 1) volumes of stored, projected and emplaced waste; 2) radionuclide activity concentrations; 3) waste material parameter densities; 4) estimates of the masses of chelating agents; 5) estimates of the oxyanions; 6) estimates of expected cement; and 7) estimates of the types and amounts of materials that will be used to emplace the waste.

The PABC consists of a complex set of computer codes and parameters that, when executed, model repository behavior under various conditions and predicts the probability of actinide release from the repository over long-term storage periods. There are three primary characteristics of TRU waste that are important to model TRU waste in the WIPP repository. These characteristics are the waste volume, the radionuclides present in the waste, and the mass of components of the waste that decompose over time (waste material parameters). The PABC Inventory is tabulated and discussed below.

Volumes of TRU Waste in the PABC Inventory

The WIPP LWA [1] identifies the total amount of TRU waste allowed in the WIPP as approximately 175,540 m^3 (6,200,000 cubic feet (ft^3). The *Agreement for Consultation and Cooperation* [10] limits the amount of RH waste allowed in the WIPP to 7,080 m^3 (250,000 ft^3). Therefore, the remaining volume 168,460 m^3 (5,950,000 ft^3) is expected to be filled with Contact-Handled (CH) waste. Tables I and II list the volume data for the PABC Inventory that were used for the CRA.

Table I. WIPP CH TRU Waste Anticipated Inventory By Site

Site Name	Total Stored (m^3)	Total Projected (m^3)
Argonne National Laboratory – East	1.1E+02	7.9E+01
Argonne National Laboratory – West	6.0E+00	3.8E+01
Battelle Columbus Laboratories	5.2E+00	0.0E+00
Bettis Atomic Power Laboratory	1.9E+01	0.0E+00
Energy Technology Engineering Center	2.3E+00	0.0E+00
Hanford (Richland) Site	1.3E+04	5.5E+03
Hanford (River Protection) Site	3.9E+03	0.0E+00
Idaho National Engineering & Environmental Laboratory	6.1E+04	1.7E+04
Knolls Atomic Power Laboratory - Nuclear Fuel Services	5.5E+01	1.7E+02
Lawrence Livermore National Laboratory	3.5E+02	2.1E+03
Los Alamos National Laboratory	1.2E+04	3.3E+03
Nevada Test Site	6.2E+02	4.6E+02
Oak Ridge National Laboratory	0.0E+00	4.5E+02
Paducah Gaseous Diffusion Plant	5.7E+00	5.7E+00
Rocky Flats Environmental Technology Site	5.4E+03	2.7E+03
Sandia National Laboratory - Albuquerque	2.4E+01	0.0E+00

Site Name	Total Stored (m^3)	Total Projected (m^3)
Savannah River Site	1.3E+04	2.4E+03
U.S. Army Material Command	2.5E+00	0.0E+00
University of Missouri Research Reactor	1.5E+00	0.0E+00
Totals	**1.1E+05**	**3.5E+04**
Emplaced Waste		
Waste Isolation Pilot Plant	7.7E+03	0.0E+00
Grand Totals	**1.2E+05**	**3.5E+04**

Table II. WIPP RH-TRU Waste Anticipated Inventory By Site

Site Name	Total Stored (m^3)	Total Projected (m^3)
Argonne National Laboratory - East	1.5E+01	1.0E+02
Argonne National Laboratory - West	2.4E+01	6.9E+01
Battelle Columbus Laboratories	4.4E+01	1.8E+00
Bettis Atomic Power Laboratory	2.0E+00	0.0E+00
Energy Technology Engineering Center	5.0E+00	0.0E+00
Hanford (Richland) Site	3.8E+02	1.1E+03
Hanford (River Protection) Site	4.5E+03	0.0E+00
Idaho National Engineering & Environmental Laboratory	2.2E+02	0.0E+00
Knolls Atomic Power Laboratory - Schenectady	0.0E+00	1.4E+02
Los Alamos National Laboratory	1.2E+02	0.0E+00
Oak Ridge National Laboratory	0.0E+00	6.6E+02
Sandia National Laboratory - Albuquerque	4.6E+00	0.0E+00
Savannah River Site	0.0E+00	2.3E+01
Totals	**5.3E+03**	**2.1E+03**

Radionuclides in TRU Waste

There are twenty radionuclides that are significant to assessments of release parameters for the PABC. These radionuclides are the ten WIPP-tracked radioisotopes: Am-241, Cs-137, Pu-238, Pu-239, Pu-240, Pu-242, Sr-90, U-233, U-234 and U-238. In addition, the activity concentrations of ten additional radionuclides are considered in the PABC. These radionuclides are: Am-243, Cm-244, Np-237, Pu-241, Pu-244, Th-229, Th-230, Th-232, U235 and U-236. These radionuclides are decay corrected to extend 10,000 years beyond WIPP closure and are based on the site-reported stored and projected radionuclides. The radionuclide data are fed into the performance model to develop the waste unit factor (WUF) that is normalized for the repository with respect to total Ci content and serves as a prediction for possible risk of release. Table III presents the 20 radionuclides decay corrected through 2001 that are important to PA.

Table III. WIPP Disposal Radionuclide Inventory For the 20 Radionuclides Significant to Performance Assessment [1]

Nuclide	CH-TRU Waste (Ci/m^3)	RH-TRU Waste (Ci/m^3)	CH-TRU Waste (Total Curies)[2]	RH-TRU Waste (Total Curies)[2]
Am-241	2.82E+00	1.95E+00	4.75E+05	1.38E+04
Am-243	4.62E-04	1.40E-04	7.78E+01	9.92E-01
Cm-244	3.66E-02	1.54E-01	6.17E+03	1.09E+03
Cs-137	4.38E-02	6.02E+01	7.38E+03	4.26E+05
Np-237	3.69E-05	9.47E-05	6.22E+00	6.70E-01
Pu-238	8.60E+00	5.38E-01	1.45E+06	3.81E+03
Pu-239	3.43E+00	7.41E-01	5.78E+05	5.24E+03
Pu-240	5.59E-01	2.24E-01	9.41E+04	1.58E+03
Pu-241	1.16E+01	1.84E+01	1.96E+06	1.31E+05
Pu-242	7.23E-05	6.77E-05	1.22E+01	4.79E-01
Pu-244	7.36E-12	7.81E-07	1.24E-06	5.53E-03
Sr-90	3.33E-01	4.55E+01	5.61E+04	3.22E+05
Th-229	8.06E-06	2.61E-05	1.36E+00	1.85E-01
Th-230	5.66E-07	2.65E-07	9.53E-02	1.88E-03
Th-232	1.48E-05	1.30E-04	2.50E+00	9.20E-01
U-233	6.53E-03	1.79E-02	1.10E+03	1.27E+02
U-234	1.17E-03	4.30E-03	1.97E+02	3.04E+01
U-235	2.31E-05	1.54E-04	3.90E+00	1.09E+00
U-236	8.73E-06	1.86E-04	1.47E+00	1.31E+00
U-238	4.70E-04	1.95E-02	7.91E+01	1.38E+02

[1] Decayed through 2001.
[2] Total curies estimated by assuming a volume of 168,400 cubic meters for CH-TRU waste and 7,080 cubic meters for RH-TRU waste.

Waste Material Parameters in TRU Waste

The waste material parameters reported by the TRU waste sites are: iron-base metal/alloys, aluminum-base metal/alloys, other metal/alloys, other inorganic materials, cellulosics, rubber, plastics, solidified, inorganic matrix, solidified, organic matrix and soils. The most important physical components of the waste with regard to repository performance are ferrous metals, cellulose, plastic, and rubber materials.

Steel, cellulose, plastic and rubber from packaging and waste emplacement materials are also tracked and considered in the PABC.

Ferrous metals are important in maintaining actinides at lower oxidation states that are less soluble and therefore less likely to be released from the repository. The steel making up the drums of currently emplaced CH TRU waste meets the lower limit of ferrous metals to maintain the oxidation of actinides for lower solubility. Cellulose, plastic and rubber are biodegradable. These components create gas during biodegradation and create the possibility of gas releases, as well as, interaction with brines that effect brine pH. The change in brine pH then changes actinide solubility conditions. In order to ensure pH does not change in the repository, magnesium oxide (MgO), a buffering compound, is added to the repository in excess based on worst-case scenario cellulose, plastic and rubber degradation.

Table IV shows the mass of CH-TRU and RH TRU waste material parameters per unit volume in cubic meters(m^3) expected to fill the WIPP repository.

Table IV. WIPP CH-TRU and RH-TRU Waste Material Parameter Disposal Inventories

Waste Material Parameters	**CH TRU Waste Average Density (Kg/m3)**	**RH TRU Waste Average Density (Kg/m3)**
Iron-Base Metal/Alloys	1.1E+02	5.9E+01
Aluminum-Base Metal/Alloys	1.4E+01	5.0E+00
Other Metal/Alloys	3.2E+01	5.7E+01
Other Inorganic Materials	4.0E+01	1.6E+01
Cellulosics	6.0E+01	9.3E+00
Rubber	1.3E+01	6.7E+00
Plastics	4.3E+01	8.0E+00
Solidified, Inorganic Matrix	1.1E+02	6.2E+01
Cement (Solidified)	3.9E+01	1.9E+00
Vitrified	5.8E+00	1.2E-01
Solidified, Organic Matrix	3.3E+01	8.3E-01
Soils	1.1E+02	5.0E+01
Container Materials		
Steel	1.7E+02	5.4E+02
Plastic	1.7E+01	3.1E+00
Lead	1.3E-02	4.2E+02

Chemical Components in TRU Waste

As part of the data call to support the CRA [2], the sites were asked to provide information about the chemical components of the waste. Specifically, the sites were asked about complexing agents (acetate, citrate, oxalate, ethylenediaminetetraacetic acid [EDTA]), oxyanions (nitrate, sulfate, and phosphate), and cement.

The TRU waste sites had not reported cement densities consistently over time. Therefore, an analysis was performed to identify waste streams that contained cement using newly reported cement densities where they were available and assigning cement densities to waste streams where cement was listed in waste descriptions but were not reported as waste material parameters. The total estimated mass of cement in the scaled solidified waste streams for the PABC Inventory was 8.80×10^6 kg. Interestingly, this estimate was nearly identical to the estimate made for the CCA (8.54×10^6 kg).

Several process changes at the TRU waste sites have taken place since TRU baseline inventory reports were prepared to support the CCA. These changes were considered in the development of the PABC inventory data. The DOE’s strategy for processing waste streams at the INL had changed, and new waste streams containing complexing agents have been identified at Rocky Flats Environmental Technology Site (RFETS) and Hanford Office of River Protection (RP). Incineration operations for INL TRU waste did not occur as planned. Therefore, the data reported in Appendix B-4 of the TWBIR Revision 3 [11] without the thermal treatment assumption was used in the current calculation of mass of complexing agents. RFETS reported that EDTA might be present at trace levels (< 1 wt%) in their waste and Hanford RP identified sodium acetate and sodium oxalate in their waste streams. The total mass of acetic acid, sodium acetate, citric acid, sodium citrate, oxalic acid, sodium oxalate, and sodium EDTA estimated for the WIPP repository are reported in Table V.

Table V. Mass of Potential Complexing Agents in the WIPP Repository

Compound	RFETS (kg)	LANL (kg)	Hanford RP (kg)	Total (kg)
Acetic Acid	132	10	---	142
Sodium Acetate	1,110	---	7,400	8,510
Citric Acid	90	1,100.5	---	1,190.5
Sodium Citrate	400	---	---	400
Oxalic Acid	90	13,706	---	13,796
Sodium Oxalate	---	---	33,940	33,940
EDTA	25.6	---	---	25.6

Only a slight increase in EDTA was reported with this updated information over that reported in TWBIR Revision 3 [11]. The increase comes from one waste stream at RFETS that reported trace amounts of EDTA present in the waste and is reported as the upper limit of expected concentration. Waste from Hanford RP waste tanks is included in Table V as well, and represents a significant increase in sodium acetate and sodium oxalate that had not been reported for the TRU inventory in TWBIR Revision 3 [11].

The CRA PA required an estimate of the mass of nitrate, sulfate, and phosphate in waste expected for disposal in the repository. The TRU waste sites did not report any new information about oxyanions for the PABC Inventory with the exception of new waste streams reported by Hanford RP and LANL, and revised values for a waste stream at RFETS. The mass of nitrate, sulfate, and phosphate in the repository was calculated for the PABC as the sum of the mass of nitrate, sulfate, and phosphate in the TWBIR Revision 3 adjusting for the new waste stream volumes from this update plus the mass of nitrate, sulfate, and phosphate reported by the sites for their new waste streams. Table VI presents the mass of nitrate, sulfate, phosphate and cement for disposal in the WIPP repository for the PABC.

Table VI. Mass of Oxyanions and Cement in the WIPP Disposal Inventory

Chemical Component	**Mass (kg)**
Nitrate	2.67×10^6
Sulfate	4.43×10^5
Phosphate	1.05×10^5
Cement	8.80×10^6

SUMMARY

The data that are collected and maintained as the TRU waste inventory form the TRU waste source term that supports the PA, used to demonstrate WIPP compliance for recertification.

The TRU waste inventory continues to improve as more characterization data become available and the TRU waste sites begin to process their waste for shipment to WIPP. As more information is gathered, waste streams are re-defined and their characteristics are reported based on investigation of process and facility records. As the waste is characterized, this information is used to update TRU inventory information. Additional assessments are made based on processing and packaging assumptions such as how large boxes will go through size reduction and containers will be over-packed. As work continues across the DOE complex, new sites and projects may be started that generate new waste. In addition, as decontamination and decommissioning work continues, progress assumptions change based on new TRU waste discoveries.

During the CRA process, inventory changes at the TRU waste sites were captured in the PABC inventory. The TRU Waste Inventory Team will continue to monitor these sites as well as others across the DOE TRU waste complex for annual inventory updates.

REFERENCES

1. U.S. Congress. 1992. Public Law 102-579. 1992. Waste Isolation Pilot Plant Land Withdrawal Act, as amended by Public Law 104-201, 1996.
2. U.S. Department of Energy (DOE) 2004. Title 40 CFR Part 191, Subparts B and C, Compliance Recertification Application 2004, DOE/WIPP-2004-3231, March 2004, Carlsbad, NM.
3. U.S. Department of Energy (DOE) 1996. Title 40 CFR Part 191, Compliance Certification Application for the Waste Isolation Pilot Plant, DOE/CAO-1996-2184, 1996, Carlsbad, NM.
4. U.S. Environmental Protection Agency (EPA). 1985. 40 CFR Part 191 Environmental Standards for the Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Radioactive Wastes: Final Rule. Federal Register, Vol. 50, No. 182, pp. 38066.38089, September 19, 1985. Office of Radiation Programs, Washington, D.C. WPO 39132.
5. U.S. Environmental Protection Agency (EPA). 1993. 40 CFR Part 191 Environmental Radiation Protection Standards for the Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Radioactive Wastes: Final Rule. Federal Register, Vol. 58, no. 242, pp. 66398. 66416, December 20, 1993. Office of Radiation and Indoor Air, Washington D.C. WPO 39133.
6. U.S. Environmental Protection Agency (EPA). 1996a. 40 CFR Part 194: Criteria for the Certification and Re-Certification of the Waste Isolation Pilot Plant's Compliance with the 40 CFR Part 191 Disposal Regulations: Final Rule. Federal Register, Vol. 61, No. 28, pp. 5224. 5245, February 9, 1996. Office of Radiation and Indoor Air, Washington, D.C.

7. U.S. Environmental Protection Agency (EPA). 2005. Conducting the Performance Assessment Baseline Change (PABC) Verification Test. Letter from Cotsworth dated March 4, 2005. Office of Radiation and Indoor Air, Washington, D.C.
8. U.S. Department of Energy (DOE) 1995. “Transuranic Waste Baseline Inventory Report”, Revision 2, DOE/CAO-95-1121, December 1995.
9. LANL 2004. Transuranic Waste Baseline Inventory Database, Revision 2.1 Version 3.13, Data Version 04.15, Carlsbad, NM: Los Alamos National Laboratory.
10. U. S. Department of Energy (DOE) and State of New Mexico, 1981. “Agreement for Consultation and Cooperation Between the Department of Energy and the State of New Mexico on the Waste Isolation Pilot Plant,” July 1, 1981 (dated April 18, 1988).
11. U.S. Department of Energy (DOE), 1996a “Transuranic Waste Baseline Inventory Report”, Revision 3, DOE/CAO-95-1121, June 1996.