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Waste Isolation Pilot Plant

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Title: **Incorporation of Inventory Uncertainty in the CRA-2004 Performance Assessment Baseline Calculation**

Author	**Christi Leigh**	Christi Leigh	1/30/06	
	Print	Signature	Date	
Technical Review	**Ross Kirkes**	Ross Kirkes	1/30/06	
	Print	Signature	Date	
QA Review	**Doug Edmiston**	Douglas R. Edmiston	1/30/06	
	Print	Signature	Date	
Management Review	**Dave Kessel**	David Kessel	1/30/06	
	Print	Signature	Date	

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Eric Vugrin		1/30/06
PA PI Name	Initial	Date
Steve Wagner	SW	1/30/06
Regulatory Lead Name	Initial	Date

Additional Reviewers Assigned by Author (optional)

Tom Kirchner	TK/C	1/30/06
Lead/PI Name	Initial	Date
Lead/PI Name	Initial	Date
Lead/PI Name	Initial	Date

Incorporation of Inventory Uncertainty in the CRA-2004 Performance Assessment Baseline Calculation

CONTENTS

TABLES

FIGURES

1. INTRODUCTION

This document was prepared in response to an email that has been entered into the Environmental Protection Agency (EPA) docket (Chavez, 2005). In the email, the EPA asks:

1. In the CCA we accepted inventory information assuming it represented upper limits and this was adequate (see CCA CARD 24). Since there was no waste characterization history there was no firm handle on the uncertainty of radionuclides and the waste components that have limits.
We have several questions related to the reporting of the data now that there is a measurement and reporting history on this.
What is the measurement uncertainty for the tracked radionuclides and important waste components?
Where is this information captured?
How is the measurement uncertainty recorded and used? For example, the data we have seen in the WWIS appear to be point estimates.
There may be uncertainty associated with the measurements in the WWIS, but we have not seen it on an individual basis or compiled basis. Is this information in the WWIS or is it just tracked at the waste site generators?
How does the average or other central tendency measure compare to the values used in the PA when the uncertainty is included? How does the inventory estimate compare if extrapolated into the future? An understanding of this will be useful for future inventory estimates.
2. We believe that it is important to have a second analysis related to the PABC inventory report that compares the characterized inventory of the closed waste sites (Rocky Flats and a couple of small ones) to that predicted by the sites and which is used as the basis for PA. This information will help us understand how reliable the inventory predictions are and whether any changes need to be made in the future. I believe SNL is working on this type of analysis and I look forward to seeing it.
3. In the completeness comments we had asked for updated release info by pathway in the CRA-2004 PA calculations compared to the PAVT. We recently asked for the PAVT comparison against the PABC calculations.
SNL staff provided a SNL approved copy of the information, and we appreciate the speed of the response (ERMS 542046-PAVT_PABC_Comparison; and we appreciate the descriptive name added to the ERMS number).
However it had the caveat that it was not the official DOE response.
Has DOE now approved it officially so that we may docket it?

This document answers EPA Questions 1 and 2. Vugrin (2005) answers EPA Question 3. This document was prepared under *AP-112, Analysis Plan For CRA Response Activities* (Wagner and Kirkes, 2005).

1.1 BACKGROUND

The EPA questioned the U.S. Department of Energy (DOE) about the incorporation of the TRU waste inventory and its associated uncertainty in the original Compliance Certification Application (CCA) (U. S. DOE, 1996). EPA stated (U. S. EPA, 1997):

"Section 194.24(c)(1) requires DOE to demonstrate that for total inventory of waste proposed for disposal, WIPP complies with the numeric requirements of section 194.34 for the upper and lower waste limits, including their associated uncertainties.
It is not evident in the CCA how the Department is treating the associated uncertainties for the upper and lower limit for each waste component.
The Department needs to identify the method by which the uncertainties associated with the upper and lower limits for each waste component are being incorporated into the results of the performance assessment."

The DOE provided the requested information (EPA docket A93-02, Item II-I-28), and the EPA responded in CARD 24 stating (U. S. EPA, 1998):

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

1.2 WHAT HAS CHANGED?

At the time of the original certification, estimates of stored and to-be-generated TRU waste inventories from the TRU waste sites were used to develop the disposal inventory used in the performance assessment (PA) for the CCA. There was no emplaced waste at that time. At the time of the data call for CRA-2004 PABC (September 30, 2002), approximately five percent of the CH-TRU waste DOE plans to dispose in the Waste Isolation Pilot Plant (WIPP) had been emplaced in the repository. WIPP had received 1,255 shipments totaling 7,716 m^3 of CH-TRU waste, primarily from INEEL, LANL, and RFETS. SRS and Hanford-RL had also made shipments (U.S. DOE, 2004). As of August 1, 2005, approximately eighteen percent of the CH-TRU waste DOE plans to dispose in the WIPP had been emplaced in the repository (Leigh et al., 2005). WIPP had received 30,719 m^3 of CH-TRU waste which included all of the CH-TRU waste from RFETS.

1.3 PURPOSE

Now that there is a measurement and reporting history on approximately 18 percent of the CH-TRU waste DOE plans to dispose in the WIPP and knowing that the ratio of the volume of emplaced waste to stored and projected waste will increase as closure of the repository approaches, the EPA is revisiting the issue of inventory uncertainty and how it applies to PA. There is a non-quantifiable uncertainty in the inventory for PA while the repository is being filled because the inventory for PA is calculated from estimates provided by TRU waste sites for their stored and to-be-generated waste. Once the repository is closed, however, a quantifiable uncertainty based on measured values for emplaced waste should be available because measured values and their associated uncertainties are being tracked in the WIPP Waste Information System (WWIS, (U. S. DOE, 2001)). The question becomes then, once the program has reached its goal of a full repository, will the inventory estimates upon which PA is based adequately reflect the actual inventory emplaced in the repository and its associated uncertainty?

The following sections provide an answer to that question. Measurement techniques and associated uncertainties are discussed in Section 2. Section 3 discusses how measured values and uncertainties are tracked in the WWIS. Section 4 of this document discusses how data was taken from the WWIS for the CRA-2004 PABC inventory, using central tendency values from radionuclide measurements and point estimates for waste material quantities, and concludes that it is appropriate to use the central tendency values and point estimates to support PA now and in the future, as more waste is emplaced in the repository.

2. MEASUREMENT TECHNIQUES AND ASSOCIATED UNCERTAINTIES

In their request for information (Chavez, 2005), the EPA asks:

What is the measurement uncertainty for the tracked radionuclides and important waste components?

There are a variety of factors that contribute to the uncertainty of waste information and characterization values reported by TRU waste sites for waste shipped to WIPP. The inventory of radioactive material and other waste material in the WIPP repository is calculated from values reported to WIPP on waste packages prior to shipment. Audits are routinely performed by both the DOE and the EPA to insure errors associated with characterization processes are kept to a minimum; however, uncertainties still exist.

While other techniques exist and are approved for characterizing waste for WIPP, radioactive material measurements thus far have been performed using Non-Destructive Assay (NDA). Several different techniques of NDA are used depending on the type of radioactive material expected in the waste form.

The techniques used to report the weight of waste materials also contribute to the uncertainty of the inventory. In some cases, these weights can be measured using instrumentation, when such measurement is practical, such as when a waste item is made

completely of a particular material (an iron wrench or a plastic beaker for example). For items made of numerous materials, however, the weights of the various materials must be estimated. These estimates are made by trained operators viewing information on a video screen or through a glovebox window (see Section 2.2). The variety of techniques, programs employing the techniques, and number of people involved between all of the TRU waste sites, impacts the magnitude of the uncertainty. The magnitude of the uncertainty on the weights is not reported, because this uncertainty is unknown. Training, audits, and best management practices are used to keep this uncertainty at the lowest possible value.

2.1 RADIOACTIVITY MEASUREMENTS

Measurement techniques for determining radionuclide contents may be either invasive or non-invasive. Invasive methods may require that a container be physically opened to collect samples as either swipes or material pieces. In some cases, the samples, in this case swipes, may be taken of the external surfaces of the container or of the environment that the container is in, such as the storage area or hot cell wall. The samples are subsequently analyzed by either destructive radiochemical separation and counting or by application of non-destructive radiation counting techniques. The uncertainty in these analyses primarily relates to how representative the samples taken are and the statistical variations inherent in radioactive decay. Specific requirements for performing radiochemical analyses may be found in Appendix A of the WIPP CH-WAC (U. S. DOE, 2005).

Non-invasive techniques have been used for all of the waste in WIPP to date and are typically referred to as NDA. During NDA, radiation (either gamma, neutron, or both) emitted by the radioactive materials in the container are measured outside the container. The measured radiation is then correlated to the radioactive material contained in the container through detailed calibrations using surrogate materials, representative container geometries, known radioactive standards, and a detailed quality assurance program. The calibrations are prepared in accordance with the requirements found in Appendix A of the WIPP CH-WAC (U. S. DOE, 2005) and follow accepted ASTM consensus standards. In conjunction with the calibrations, a Total Measurement Uncertainty (TMU) document is prepared. The TMU document evaluates the individual sources of uncertainty in the measurement techniques and combines these to give an overall evaluation of the total uncertainty in the measurements of radioactive materials. Typical sources of uncertainty for NDA are calibration errors, the degree of inhomogeneity in the distribution of radioactive material in the container, counting statistics associated with detection method, reported standard values, and physical constants.

2.2 WASTE MATERIAL MEASUREMENTS

Certified TRU waste characterization programs typically employ the technique of Non-Destructive Examination (NDE) using Real Time Radiography (RTR) to view most packages of waste and estimate the types of material in the waste form. Each site that uses RTR for TRU waste characterization must also use Visual Examination (VE) as a quality check of RTR. A number of containers that represents a statistically significant

sample must be examined. VE is typically performed using gloveboxes in controlled environments with access controls, ventilation controls, etc. VE is sometimes used on every container in a waste stream instead of RTR, and is typically performed using gloveboxes. One other "visual" technique that is sometimes used is called the VE Technique. The VE Technique is used when newly generated waste is being packaged, and involves estimating material types and weights as the waste container is filled.

In all cases (RTR, VE as a control check, VE instead of RTR, and VE Technique), the weight of waste materials is estimated. Prior to NDE or VE, the gross weight of the package is measured using a scale and the packaging weight (drum, liner, etc.) estimated based on standard weights provided by manufacturers. Operators then calculate the difference in those weights, which provides the weight of the waste. Trained operators then estimate the proportions that the various materials contribute to the total weight of the waste using RTR images to determine volume percent of each material present and standard densities to convert volumes to weights. In some cases, during visual examination, components removed from the container will be weighed individually.

Data quality objectives have been set for this process. The data quality objectives indicate that a sum of the weights of individual components in a container can at most differ from the total weight of the container by 5 percent. Therefore, while it may be difficult to ascertain the subjective uncertainty associated with the weight of individual components in a container, there is a limit on the subjective uncertainty on the total weight of 5 percent. The WIPP CH-WAC (U. S. DOE, 2005) does not require uncertainty be reported for waste material weights.

3. TRACKING MEASURED VALUES AND UNCERTAINTIES FOR EMPLACED WASTE

In their request for information (Chavez, 2005), the EPA asks:

Where is this information captured?
How is the measurement uncertainty recorded and used? For example, the data we have seen in the WWIS appear to be point estimates.
There may be uncertainty associated with the measurements in the WWIS, but we have not seen it on an individual basis or compiled basis. Is this information in the WWIS or is it just tracked at the waste site generators?

Waste data, which include radionuclide and waste material inventory measurements, is entered into the WWIS by the shipping site prior to being shipped to WIPP. After emplacement, the location of each assembly and the date of emplacement are entered into the WWIS by WIPP Waste Handling. In this manner, the location, in terms of panel, room, row column and height is tracked. The WWIS application has the ability to find a chosen emplacement package assembly and show the emplacement data.

3.1 TRACKING RADIOACTIVITY MEASUREMENTS

Radioisotope data associated with the waste is reported to the WWIS in curies. The uncertainties on the activities are reported in the WWIS as 1σ, or 1 standard deviation. As discussed above, this data is entered into the WWIS by the shipping site. The TRU waste site sends data which describes the radioisotope content in curies of the waste being sent to the repository. Isotopic data to identify at least 95% of the radioactivity in the container (to meet DOT requirements) is sent.

Attachment 1 is an example "Waste Container Data Report." This is a data report for a single container from the WWIS. On Page 2 of the report, the total TRU alpha activity is reported as 2.82 Ci. The total TRU alpha activity uncertainty for this container is reported as 1.01 Ci. On Page 3 of the report, the curies of individual isotopes are given. For example, the Ci of ^{239}Pu is given as 9.06×10^{-2} Ci. The activity uncertainty for this value is 3.85×10^{-2} Ci. The assay date is given on Page 4 of the waste container report as February 22, 2004. The assay method is listed as Z-211-103: Canberra Drum Assay.

3.2 TRACKING WASTE MATERIAL MEASURMENTS

The constituent components of the waste materials and packaging materials (cellulose, plastic, rubber [CPR], etc) are tracked in the WWIS. The WWIS currently has eighteen different fields as identified in Attachment 2 (a table from "Waste Material Parameter Reference Data"). As previously discussed, waste generators do not report error associated with waste material measurements. Therefore, waste material measurement error is not reported to the WWIS.

The waste material masses are given on Page 3 of the waste container data report as shown in Attachment 1. The mass of OTHER INORGANIC MATERIALS is .76 kg. The mass of SOLIDIFIED INORGANIC MATERIAL is 179.99 kg. The mass of STEEL CONTAINER MATERIALS is 26.76 kg, and the mass of PLASTIC/LINERS CONTAINER MATERIALS is 9.53 kg. The characterization method is given on Page 4 along with the characterization date.

4. INCORPORATION OF MEASUREMENT UNCERTAINTY IN PERFORMANCE ASSESSMENT

In their request for information (Chavez, 2005), the EPA asks:

How does the average or other central tendency measure compare to the values used in the PA when the uncertainty is included? How does the inventory estimate compare if extrapolated into the future? An understanding of this will be useful for future inventory estimates.

4.1 FROM WWIS TO CRA-2004 PABC

Data for waste emplaced in the WIPP as of September 30, 2002 was obtained from the WWIS in order to prepare the inventory for the CRA-2004 PABC. The WWIS stores

data for each container emplaced in WIPP as shown in Attachment 1. For the data that supports the CRA-2004 PABC, the WWIS data from waste containers in an emplaced waste stream were summed to obtain the volume, radionuclide activities, and waste material masses.

The radionuclide data used were the data reported in the column labeled "Activity (Ci)" for each radionuclide on Page 3 of the Waste Container Data Report (as shown in Attachment 1). There is also an activity uncertainty listed on Page 3 of the Waste Container Data Report, but no uncertainty was taken into account in preparation of the WWIS data for the CRA-2004 PABC. Thus, central tendency values were used for radionuclide activities.

The waste material masses used were the values reported in the column labeled "Weight (kg)" on Page 3 of the Waste Container Data Report. No uncertainty in waste material masses was taken into account in preparation of the WWIS data for the CRA-2004 PABC. Thus, point estimates were used for waste material masses.

4.2 CENTRAL TENDENCY VALUES AND POINT ESTIMATES

The CRA-2004 PABC inventory used central tendency values from radionuclide measurements and point estimates for waste material masses from the WWIS for emplaced waste streams. This approach provides the best inventory basis for PA for several reasons.

First, it is important to note that all measurement uncertainty is due to either random errors or systematic errors. **Random errors** are statistical fluctuations (in either direction) in the measured data. In measuring radionuclide activities by counting decay events, the stochastic nature of decay gives rise to uncertainty in the measured counts. Theory says that the standard deviation of the counts is equal to the square root of the number of counts (Turner, 1986). Random errors can also result from the measurer's inability to take the same measurement in exactly the same way to get exactly the same number. Subjective estimates can be subject to random error as well, such as those described in Section 2 for the way that waste material masses are measured. **Systematic errors**, by contrast, are reproducible inaccuracies that are consistently in the same direction. Systematic errors are often due to a problem which persists throughout the entire experiment, such as a poorly calibrated instrument. An individual making subjective estimates of a quantity, as is used in waste material quantification, could introduce systematic errors if he or she consistently underestimates or overestimates the quantity. Systematic errors can also be introduced into reported values when assumptions are made about the value assigned to "censored" data. Censored data are encountered when the true value lies beyond the range of an instrument, such as values below the lower limit of detection (LLD).

Measurement of radionuclide activities is likely to involve to some extent both random and systematic errors. However, when the magnitude of systematic errors can be determined, corrections can be made to account for these errors in the measurements. When computing sums or averages of values having systematic errors, the systematic

errors can be reasonably treated as random errors 1) if there is no reason to believe that the bias is consistently positive or negative (as might occur with a simplistic approach to handling censored data) and 2) if the values come from many instruments or many different people making subjective estimates. Therefore, the measurement uncertainty reported on the radionuclide activities in containers in the WWIS is treated as random error. Based on the descriptions given in Section 2 for the methods used to estimate waste material masses, it can only be assumed that the errors associated with the point estimate values for waste material masses, if they were known, would be random.

When using measurements that have uncertainty, it is generally preferable to use an estimate of the central tendency of the value as the "best estimate" of the measurement. The best estimate is, on average, the most probable estimate of the "true" value. There are several parameters of a distribution that can be used to measure its central tendency, such as the mean, median or mode. For symmetrical distributions of uncertainty, which are expected for both the individual measurements of the emplaced waste and the sum of those measurements, the mean (i.e. the measured value or the sum of the measure values) is generally considered the best estimate. This applies both for radionuclide activities and for waste material weights. Assuming that the errors associated with the point estimate values for waste material masses are random, the central tendency (point estimate value) is the most appropriate value for PA.

4.3 MEASUREMENT UNCERTAINTY FOR A CLOSED SITE

Using central tendency values and point estimates is also a sound approach for creating an inventory basis for PA because variations in the inventory seen when uncertainty is included are generally not noticeable, at least for radionuclide activities.

An analysis was performed by Los Alamos National Laboratories (LANL) on data in the WWIS as of August 1, 2005 for three sites including the Rocky Flats Environmental Technology Site (RFETS) (Crawford, 2006). In that analysis, the radionuclide activities for ^{241}Am, ^{123}Cs, ^{238}Pu, ^{239}Pu, ^{240}Pu, ^{242}Pu, ^{90}Sr, ^{233}U, ^{234}U, ^{238}U and the total activity were reported. The total activity for RFETS from the WWIS was compared to the CRA-2004 PABC RFETS inventory in Crawford (2006). In addition, Speed (2006) calculated the standard deviations (1σ) on the sums reported in Crawford (2006). Those results are summarized in Table 1.

Figure 1 shows a comparison between the CRA-2004 PABC radionuclide activity (for the ten isotopes shown in Table 1) and the WWIS data for RFETS as of August 1, 2005. The figure shows how the CRA-2004 PABC inventory compares to the average or central tendency measure when uncertainty is included. Both the uncertainty at one standard deviation (68.3% of a normal distribution) and at two standard deviations (95% of a normal distribution) are shown in Figure 1.

Table 1. Radionuclide Activity for Ten Radionuclides from RFETS[a]

Isotope	CRA-2004 PABC Activity (Ci) [b]	WWIS Activity (Ci) [b]	σ (Ci) [c]	Activity + 1σ (Ci) [d]	Activity + 2σ (Ci) [e]
^{241}Am	1.15E+05	1.03E+05	1.27E+02	1.03E+05	1.03E+05
^{137}Cs	1.92E-02	9.81E-03	2.25E-03	1.21E-02	1.43E-02
^{238}Pu	7.62E+03	7.77E+03	5.85E+01	7.83E+03	7.89E+03
^{239}Pu	2.09E+05	2.04E+05	1.45E+02	2.04E+05	2.04E+05
^{240}Pu	4.72E+04	4.63E+04	8.49E+01	4.64E+04	4.65E+04
^{242}Pu	4.47E+00	4.15E+00	2.38E-02	4.17E+00	4.20E+00
^{90}Sr	0.00E+00	3.11E-02	4.83E-03	3.59E-02	4.08E-02
^{233}U	6.63E-02	6.63E-02	1.05E-02	7.68E-02	8.74E-02
^{234}U	1.30E+00	1.72E+00	1.19E-02	1.73E+00	1.74E+00
^{238}U	1.88E-01	1.12E+00	1.92E-02	1.14E+00	1.16E+00
Total Ci	3.79E+05	3.61E+05	2.18E+02	3.61E+05	3.61E+05

[a]All RFETS waste was emplaced in WIPP as of August 1, 2005; [b]from Crawford 2006; [c]from Speed 2006 [d]Calculated as the sum of the activity (column 2) and 1(σ) (column 3), [e]Calculated as the sum of the activity (column 2) and 2(σ) (column 3).

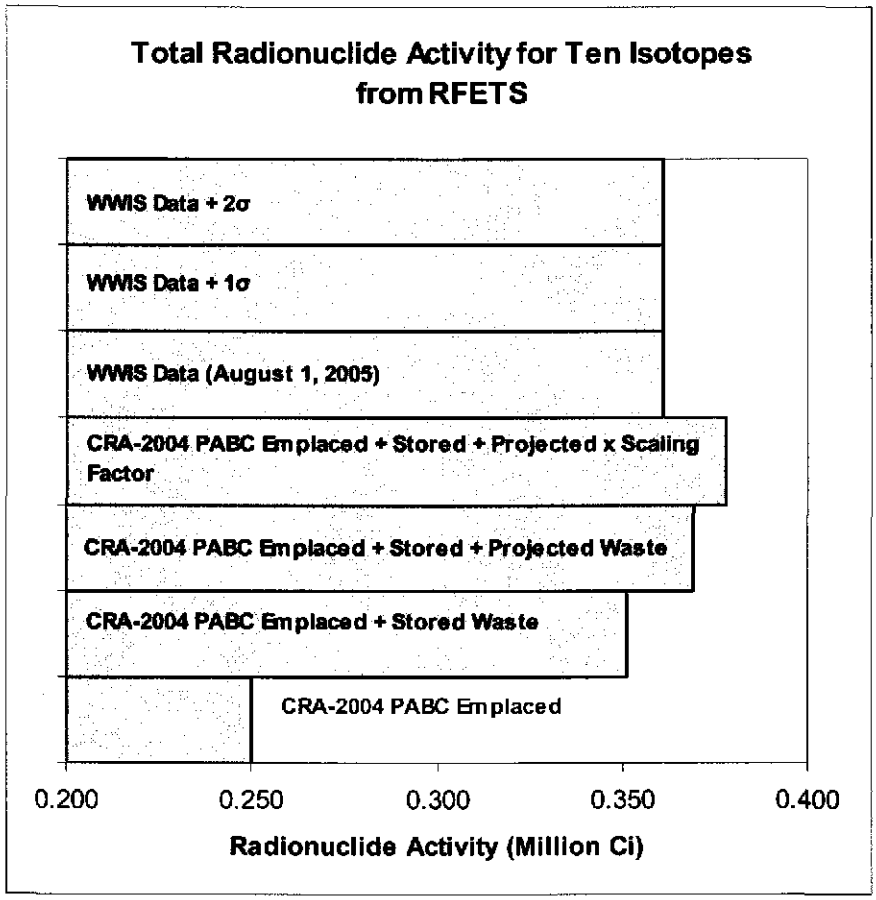

Figure 1. Total Radionuclide Activity from CRA-2004 PABC (decay corrected to 2001) and WWIS for Ten Radionuclides from RFETS

Since as of August 1, 2005 RFETS was a closed site, Figure 1 offers perspective on how PA inventory estimates will compare to WWIS data as more sites close and ultimately, the WIPP repository is filled. Once the repository is closed, all of the uncertainty on the emplaced radionuclides will be quantified much as the uncertainty on emplaced radionuclides from RFETS is quantified here. Thus, Figure 1 indicates that the impact of uncertainty on the radionuclide activity inventory basis for PA will be small.

An analysis was performed by Los Alamos National Laboratories (LANL) on data in the WWIS as of August 1, 2005 for RFETS (Crawford, 2006). In that analysis, the CPR masses were reported. The CPR masses for RFETS from the WWIS were compared to the CRA-2004 PABC RFETS inventory in Crawford (2006). Those results are summarized in Table 2.

Table 2. Cellulose, Plastic and Rubber from RFETS[a]

	CELLULOSE	PLASTICS	RUBBER
WWIS data in kg[b]			
RFETS	9.22E+05	5.21E+05	2.66E+04
CRA 2004 PABC Inventory in kg[b]			
RFETS	7.46E+05	5.60E+05	1.07E+05

[a]All RFETS waste was emplaced in WIPP as of August 1, 2005; [b]from Crawford (2006)

Measurement uncertainty for waste material weights is not tracked in the WWIS. Therefore, it is not possible to speculate on how waste material estimates with uncertainties included would compare to the point estimates used in PA either now or in the future.

4.4 IMPACT OF UNCERTAINY ON RELATIVE RELEASES

Finally, using central tendency values for radionuclide activities is the best approach for creating an inventory basis for PA because the alternative of using upper limits for radionuclide inventories in PA does not necessarily lead to conservatively large releases.

A common misconception concerning the inventory used for PA is that larger amounts of radionuclides in the inventory will always lead to larger releases. However, since releases are reported in normalized units, this is not always the case. This section presents a simplistic example that contradicts this misconception.

40 CFR 191 requires that WIPP PA results be reported in terms of a normalized release. Specifically, a normalized release R (in EPA units) is defined by:

$$R = \sum_i \frac{Q_i}{L_i}\left(\frac{1\times10^6\, curies}{C}\right) \quad (1)$$

where

Q_i = 10,000 year cumulative release (in curies) of the radionuclide i

L_i = Release limit (as specified by 40 CFR 191) for radionuclide i

C = Total transuranic inventory (in curies) of α emitters w/half-lives greater than 20 years.

For a hypothetical case where only three radionuclides, N_1, N_2, and N_3, comprise the inventory, Table 3 lists inventory estimates of the radionuclides that makeup the inventory and a possible set of 10,000 year cumulative releases from a future simulated in PA. Additionally, Table 3 lists the release limits for each radionuclide. For simplicity, the release limit is 100 for each radionuclide.

Table 3. Hypothetical Inventory, Cumulative Releases, and Release Limits for N_1, N_2, and N_3

Radionuclide	Inventory Quantity (Ci)	10,000 Year Cumulative Release (Ci)	Release Limit
N_1	80,000	2	100
N_2	110,000	4	100
N_3	60,000	5	100

These numbers would result in a normalized release of R = 0.44 EPA units as shown in Equation 2.

$$R = \left(\frac{2+4+5}{(8+11+6)\times10000}\right)\left(\frac{1,000,000}{100}\right) = \frac{11}{25} \quad (2)$$

Table 4 lists a possible set of uncertainties associated with the activity of each radionuclide. The values in Table 4 indicate that the amount of N_1 is expected to fall in the range [80,000-40,000; 80,000+40,000] curies.

Table 4. Uncertainties Associated with Inventory Estimates

Radionuclide	Inventory Quantity (Ci)	Standard Deviation - 1 σ (Ci)	Inventory Upper Bound (Ci)	Relative Uncertainty
N_1	80,000	40,000	120,000	50 %
N_2	110,000	27,500	137,500	25 %
N_3	60,000	12,000	72,000	20 %

It is reasonable to assume that if the same PA simulation that led to the releases in Table 3 was run but the inventory numbers in that simulation were replaced with the inventory upper limits in Table 4, the cumulative releases would increase by the same percentage that the inventory values were increased. Thus, expected cumulative releases are listed in Table 5.

Table 5. Releases for Inventory comprised of Upper Limits

Radionuclide	Inventory Quantity (Ci)	10,000 Year Cumulative Release (Ci)	Release Limit
N_1	120,000	3	100
N_2	137,500	5	100
N_3	72,000	6	100

These releases correspond to a normalized release of R = 0.42 EPA units as shown in Equation 3.

$$R = \left(\frac{3+5+6}{(12+13.75+7.2)\times 10000}\right)\left(\frac{1,000,000}{100}\right) = \frac{14}{32.95} \qquad (3)$$

Hence, using larger inventory values does not necessarily lead to larger normalized releases. This simple example illustrates that using upper limits for radionuclide inventories in PA does not necessarily lead to conservatively large releases. Rather than using upper limits, it is appropriate that PA uses the fixed values that best estimate the inventory.

5. CONCLUSION

Radionuclide activities and waste material masses are measured or estimated at the TRU waste sites as waste is being prepared for shipment to WIPP. Measured values for radionuclide activities have uncertainties associated with them that are reported when waste characterization information is being entered by the site into the WWIS. Estimated values for waste material masses do not have uncertainties reported in the WWIS. The inventory for the CRA-2004 PABC used the central tendency values for radionuclide activities and point estimates for waste material masses for waste emplaced in the WIPP as of September 30, 2002. The remainder of the inventory for the CRA-2004 PABC was estimated from data provided by TRU waste sites for their stored and to-be-generated waste.

The CRA-2004 PABC inventory was the first PA inventory to include emplaced waste. As a result, the CRA-2004 PABC sets a precedent for future PAs. This analysis indicates that using central tendency values for radionuclide activities provides the best inventory basis for PA because: 1) it is the most probable estimate of the "true" value, 2) variations in the inventory seen when uncertainty is included are generally not noticeable, and 3) the alternative of using upper limits for radionuclide inventories in PA does not necessarily lead to conservatively large releases.

In addition, using point estimates for waste material masses provides the best inventory basis for PA because while the uncertainties associated with the point estimates are not reported in the WWIS, it can only be assumed that the associated errors are random. Given that, the point estimate is the best estimate to use.

Moreover, the EPA (1998) has indicated that when the uncertainty is unknown (like it was before DOE started certifying waste for shipment to WIPP), their preferred method for dealing with uncertainty in the inventory is by setting bounding values to insure that the repository performance predicted by PA is valid. An example of a bounding value is limiting the mass of plastic that can be accepted in the repository. The bounding values for the CCA were given in Appendix WCL and WCA of U.S DOE (1996). The bounding values at the time of re-certification of the repository will be the values used in the CRA-2004 PABC. If the WWIS were to indicate that the mass of a material emplaced in the repository was close to exceeding the bounding value set at the last re-certification, another PA would be needed to demonstrate compliance with an increased waste material value.

6. REFERENCES

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ATTACHMENT 1

WIPP Waste Information System
Waste Container Data Report

Report	***RP0360***
Version	***2.3***
Instance	***PRD01***
Run by	***SPEEDD***
Report Date	***01/12/2006 15:03***
Total Pages	***6***

Selection Criteria -

Container Number	***10010133***
Site Id	***%***
Waste Stream	***%***
Data Status Code	***%***

Waste Container Data Report

WIPP Waste Information System

Waste Isolation Pilot Plant

Container Number :	**10010133**
Site ID :	**BN - AMWTP @ INEEL**
Site Address :	**765 LINDSAY BLVD IDAHO FALLS, ID 83402**
Site EPA ID :	**ID4890008952**
Technical Contact :	**ERIC SCHWEINSBERG**
Data Status Code :	**Certification Data Approved by WIPP**
Waste Stream Profile :	**BNINW216**
Container Type :	**19 - 55 GAL DRUM TO BE OVERPACKED - SOLID/VITRIFIED - DAMAGED**

Waste Container Information

WAC Ex. # :			Handling Code :	**CH**	
WAC Rev # :	**3**		Waste Type:	**MTRU**	
Cert Date :	**10/01/2005**		Waste Stream BIR ID :	**INW216**	
Cert Site :	**BN – AMWTP @ INEEL**		Waste Stream MWIR ID	**INW216**	
Generator Site :	**RF – ROCKY FLATS**		TRU Alpha Act (Ci) :		**2.820E+00**
IDC Code :	**001**		TRU Alpha Act Uncert (Ci) :		**1.010E+00**
Matrix Code :	**S3121**		TRU Alpha Act Conc (Ci/g) :		**1.560E-05**
TRUCON Code :	**ID211A**		TRU Alpha Act Conc Uncert (Ci/g)		**5.590E-06**
Shipping Category :	**1001300154**		Pu239 Eq Act (PE Ci) :		**2.830E+00**
			Pu239 Fiss Gm Eq (FGE) :		**2.060E+00**
PCB Conc (ppm) :	**0**		Pu239 Fiss Gm Eq Uncert (FGE) :		**6.600E-01**
			Layers of Packaging :		**2**
Decay Heat (watts) :	**9.520E-02**		Fill Factor (%) :		**85**
Decay Heat Uncert (watts) :	**3.420E-02**		Liner Exists :		**Y**
Closure Date :	**01/28/1973**		Liner Hole Size (mm) :		**7.62**
Vent Date :	**04/02/2004**		Gross Weight (kg) :		**217.04**
Aspiration Method ID :	**3**		Gross Weight Uncert (kg) :		**.6**
Gas Gen Rate :			Alpha Surf Cont (dpm/100cm2)		**19**
Gas Hyd Meth Gen Rate :			BG Surf Cont (dpm/100cm2) :		**199**
Gas Gen Comp Date :			BG Dose Rate (mrem/hr) :		**14**
Shipment Num :			Neut Dose Rate (mrem/hr) :		**.05**
Packaging Num :			Total Dose Rate (mrem/hr) :		**14.05**
Assembly ID :			PCB Waste :		**N**
Container Disposal Date:			PCB Mass (kg) :		
Container Status Code :	**PRE**		PCB Out of Service Date :		
It can be established through process knowledge that the concentration of flammable VOCs present in the headspace of this container is <= 500ppm:		**N**	Aqueous Material :		**Y**
Beryllium present and <=100 kg :		**N**	Machine Compacted :		**N**
Beryllium <= 18.14 kg :		**N**	1/2" Separation Criteria Met for Compacted Waste :		**N**
Beryllium <= 5 kg :		**N**			
Beryllium <= 1% by Weight :		**N**	Overpack Cntr Number	**BN10061595**	
Beryllium in form of shavings or fines:		**N**	Overpack Cntr Type :	**3 - TEN DRUM OVERPACK (TDOP)**	

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Technical Contact :	**ERIC SCHWEINSBERG**
Data Status Code :	**Certification Data Approved by WIPP**
Waste Stream Profile :	**BNINW216**
Container Type :	**19 - 55 GAL DRUM TO BE OVERPACKED - SOLID/VITRIFIED - DAMAGED**

Nuclide Information

Radionuclide	Description	Activity (Ci)	Activity Uncert (Ci)	Mass (g)	Mass Uncert (g)	List
AM-241	AMERICIUM 241	2.710E+00	1.010E+00	7.900E-01	2.950E-01	
CS-137	CESIUM 137	<LLD	<LLD	<LLD	<LLD	
NP-237	NEPTUNIUM 237	2.830E-05	1.050E-05	4.020E-02	1.500E-02	
PU-238	PLUTONIUM 238	2.690E-03	1.550E-03	1.570E-04	9.080E-05	
PU-239	PLUTONIUM 239	9.060E-02	3.850E-02	1.460E+00	6.210E-01	
PU-240	PLUTONIUM 240	2.020E-02	8.730E-03	8.880E-02	3.850E-02	
PU-241	PLUTONIUM 241	2.240E-01	1.040E-01	2.160E-03	9.990E-04	
PU-242	PLUTONIUM 242	2.640E-06	1.760E-06	6.680E-04	4.440E-04	
SR-90	STRONTIUM 90	<LLD	<LLD	<LLD	<LLD	
U-233	URANIUM 233	<LLD	<LLD	<LLD	<LLD	
U-234	URANIUM 234	<LLD	<LLD	<LLD	<LLD	
U-235	URANIUM 235	1.950E-06	8.280E-07	9.040E-01	3.830E-01	
U-238	URANIUM 238	<LLD	<LLD	<LLD	<LLD	

Material Parameters Information

Waste Matl Parm	Description	Weight (kg)
4	OTHER INORGANIC MATERIALS	.76
9	SOLIDIFIED INORGANIC MATERIAL	179.99
13	STEEL CONTAINER MATERIALS	26.76
14	PLASTIC/LINERS CONTAINER MATERIALS	9.53

Filter Model Information

Filter Model	Description	Quantity	Install Date
BNFLSS		1	04/02/2004

Waste Container Data Report

WIPP Waste
Information System

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Container Type :	**19 - 55 GAL DRUM TO BE OVERPACKED - SOLID/VITRIFIED - DAMAGED**

Assay Methods Information

Radio Assay Method	Description	Assay Date
9DA2	Z-211-103: CANBERRA DRUM ASSAY	02/24/2004

Characterization Methods Information

Method ID	Description	Charz Method Date
9RR2	RTR SYSTEM (Z-213-106)	02/22/2004

Hazardous Code Information

Haz Code	Description
D004	ARSENIC
D005	BARIUM
D006	CADMIUM
D007	CHROMIUM
D008	LEAD
D009	MERCURY
D010	SELENIUM
D011	SILVER
D022	CHLOROFORM
F001	SPENT HALOGENATED SOLVENTS
F002	SPENT HALOGENATED SOLVENTS
F003	SPENT NON-HALOGENATED SOLVENTS
F005	SPENT NON-HALOGENATED SOLVENTS
F006	WASTEWATER TREATMENT SLUDGE
F007	SPENT CYANIDE PLATING BATH
F009	SPENT STRIPPING SOLUTION

Sample Information

Sample ID: **10010133**
Layer No Sampled : 0

Sample Type : HS
Date Sampled : 09/23/2005

CAS Number - Analyte Name	Method ID	Concentration	Date Analyzed	Detection Flags
100-41-4 - ETHYL BENZENE	9HG4	1.500 Ppm	09/24/2005	U
107-06-2 - 1,2-DICHLOROETHANE	9HG4	1.700 Ppm	09/24/2005	U

Waste Container Data Report

WIPP Waste
Information System

Waste Isolation Pilot Plant

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Site EPA ID :	**ID4890008952**
Technical Contact :	**ERIC SCHWEINSBERG**
Data Status Code :	**Certification Data Approved by WIPP**
Waste Stream Profile :	**BNINW216**
Container Type :	**19 - 55 GAL DRUM TO BE OVERPACKED - SOLID/VITRIFIED - DAMAGED**

Sample Information (continued)

Sample ID: 10010133 (continued)
Layer No Sampled : 0

Sample Type : HS
Date Sampled : 09/23/2005

CAS Number - Analyte Name	Method ID	Concentration	Date Analyzed	Detection Flags
108-10-1 - METHYL ISOBUTYL KETONE	9HG4	30.000 Ppm	09/24/2005	U
108-67-8 - 1,3,5-TRIMETHYLBENZENE	9HG4	1.300 Ppm	09/24/2005	U
108-88-3 - TOLUENE	9HG4	1.400 Ppm	09/24/2005	U
108-90-7 - CHLOROBENZENE	9HG4	1.400 Ppm	09/24/2005	U
108383/106423 - M,P-XYLENE	9HG4	1.300 Ppm	09/24/2005	U
110-82-7 - CYCLOHEXANE	9HG4	1.200 Ppm	09/24/2005	U
127-18-4 - TETRACHLOROETHYLENE	9HG4	1.500 Ppm	09/24/2005	J
1333-74-0 - HYDROGEN	9HG4	.0260 Volume	09/24/2005	U
156-59-2 - CIS-1,2-DICHLOROETHYLENE	9HG4	1.500 Ppm	09/24/2005	U
156-60-5 - TRANS-1,2- DICHLOROETHYLENE	9HG4	1.400 Ppm	09/24/2005	U
56-23-5 - CARBON TETRACHLORIDE	9HG4	1.900 Ppm	09/24/2005	U
60-29-7 - ETHYL ETHER	9HG4	2.500 Ppm	09/24/2005	U
67-56-1 - METHANOL	9HG4	73.000 Ppm	09/24/2005	U
67-64-1 - ACETONE	9HG4	13.000 Ppm	09/24/2005	U
67-66-3 - CHLOROFORM	9HG4	1.300 Ppm	09/24/2005	U
71-36-3 - BUTANOL	9HG4	46.000 Ppm	09/24/2005	U
71-43-2 - BENZENE	9HG4	1.200 Ppm	09/24/2005	U
71-55-6 - 1,1,1-TRICHLOROETHANE	9HG4	10.000 Ppm	09/24/2005	NA
74-82-8 - METHANE	9HG4	.0170 Volume	09/24/2005	U
74-87-3 - METHYL CHLORIDE	9HG4	2.500 Ppm	09/24/2005	U
75-09-2 - METHYLENE CHLORIDE	9HG4	1.600 Ppm	09/24/2005	U
75-25-2 - BROMOFORM	9HG4	1.300 Ppm	09/24/2005	U
75-34-3 - 1,1-DICHLOROETHANE	9HG4	1.500 Ppm	09/24/2005	U
75-35-4 - 1,1-DICHLOROETHYLENE	9HG4	2.700 Ppm	09/24/2005	U
76-13-1 - 1,1,2-TRICHLORO-1,2,2-TRIFLUOROETHANE	9HG4	2.800 Ppm	09/24/2005	U

Waste Container Data Report

WIPP Waste
Information System

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Waste Stream Profile :	**BNINW216**
Container Type :	**19 - 55 GAL DRUM TO BE OVERPACKED - SOLID/VITRIFIED - DAMAGED**

Sample Information (continued)

Sample ID: 10010133 (continued)
Layer No Sampled : 0

Sample Type : HS
Date Sampled : 09/23/2005

CAS Number - Analyte Name	Method ID	Concentration	Date Analyzed	Detection Flags
78-93-3 - METHYL ETHYL KETONE	9HG4	16.000 Ppm	09/24/2005	U
79-01-6 - TRICHLOROETHYLENE	9HG4	17.000 Ppm	09/24/2005	NA
79-34-5 - 1,1,2,2-TETRACHLOROETHANE	9HG4	1.200 Ppm	09/24/2005	U
95-47-6 - O-XYLENE	9HG4	1.500 Ppm	09/24/2005	U
95-63-6 - 1,2,4-TRIMETHYLBENZENE	9HG4	1.200 Ppm	09/24/2005	U

ATTACHMENT 2

WIPP Waste Information System

Waste Material Parameter Reference Data

Report	***RP0230***
Version	***1.2***
Instance	***PRD01***
Run by	***SPEEDD***
Report Date	***01/12/2006 15:32***
Total Pages	***2***

Selection Criteria –

Report Status **VALID**

Waste Material Parameter Reference Data

WIPP Waste
Information System
Waste Isolation Pilot Plant
Page 2 of 2

Valid Waste Material Parameters

Waste Matl	Description	Matl Typ	Category
1	IRON BASE METAL ALLOYS	WASTE	
2	ALUMINUM BASE METAL/ALLOYS	WASTE	
3	OTHER METAL/ALLOYS	WASTE	
4	OTHER INORGANIC MATERIALS	WASTE	
6	CELLULOSICS	WASTE	
7	RUBBER	WASTE	
8	PLASTICS	WASTE	
9	SOLIDIFIED INORGANIC MATERIAL	WASTE	
10	SOLIDIFIED ORGANIC MATERIAL	WASTE	
12	SOILS	WASTE	
13	STEEL CONTAINER MATERIALS	STEEL PKG	
14	PLASTIC/LINERS CONTAINER MATERIALS	PLAST PKG	
15	CELLULOSICS PACKAGING MATERIALS	CELLU PKG	
16	MAGNESIUM OXIDE	UNKNOWN	
17	STEEL EMPLACEMENT MATERIAL	UNKNOWN	
18	CELLULOSIC EMPLACEMENT MATERIAL	UNKNOWN	
19	RUBBER EMPLACEMENT MATERIAL	UNKNOWN	
20	PLASTIC EMPLACEMENT MATERIAL	UNKNOWN	