Recertification CARD No. 34
Results of Performance Assessments

BACKGROUND (194.34(a))

The radioactive waste disposal regulations at 40 CFR Part 191 include requirements for containment of radionuclides. The containment requirements at Section 191.13 specify that releases from a disposal system to the accessible environment must not exceed the release limits set forth in Appendix A, Table 1, of 40 CFR Part 191. Assessment of the likelihood that the the Waste Isolation Pilot Plant (WIPP) will meet the Appendix A release limits is conducted through the use of a process known as a "performance assessment" (PA). The WIPP PA essentially consists of a series of computer simulations that attempt to describe the physical attributes of the repository (site, geology, waste forms and quantities, engineered features) in a manner that captures the behaviors and interactions among its various components over the 10,000-year regulatory time frame.

The PA must consider all reasonable potential release mechanisms from the repository, and it must be structured and conducted in a way that demonstrates an adequate understanding of the physical conditions at the disposal system and its surroundings and shows that the future performance of the system can be predicted with reasonable assurance. Also, it must include both undisturbed conditions and human intrusion scenarios. The results of the PA are used to demonstrate compliance with the containment requirements at Section 191.13.

The containment requirements place limits on the likelihood of radionuclide releases from a disposal facility. A radionuclide release to the accessible environment is defined in terms of the location of the release and its magnitude. Any release of radioactivity to the ground surface, the atmosphere, or surface water is considered to be a release to the accessible environment. In addition, any subsurface transport of radioactivity beyond the boundary of the WIPP controlled area is also considered a release to the accessible environment.[9]

The results of the WIPP PA are to be expressed as complementary cumulative distribution functions (CCDFs). A CCDF indicates the probability of exceeding various levels of cumulative release. The CCDFs must be generated using random sampling techniques that draw upon the full range of values established for each uncertain parameter.

REQUIREMENT (194.34(a))

(a) "The results of performance assessments shall be assembled into "complementary, cumulative distribution functions" (CCDFs) that represent the probability of exceeding various levels of cumulative release caused by all significant processes and events."

[9] The "controlled area" withdrawn from public use pursuant to Section 3 of the WIPP Land Withdrawal Act extends to a depth of 6,000 feet. Therefore, the complete boundary of the WIPP controlled area is represented by the vertical plane extending from the surface boundary to a depth of 6,000 feet.

1998 CERTIFICATION DECISION (194.34(a))

To meet the requirements of 194.34(a), the U.S. Environmental Protection Agency (EPA or Agency) expected the Department of Energy (DOE or Department) to demonstrate that:

1) the results of the PA were assembled into CCDFs,

2) the CCDFs represent the probability of exceeding various levels of cumulative release caused by all significant processes and events, and

3) all significant processes and events that may affect the repository over the next 10,000 years have been incorporated into the CCDFs that are presented.

EPA reviewed the features, events and processes for WIPP and the construction of the CCDFs. EPA concluded that DOE appropriately captured in the CCDFs the significant processes and events that could occur during the regulatory period and thus complied with this section.

A complete description of EPA's 1998 Certification Decision for Section 194.34 can be obtained from Docket A-93-02, Items V-A-1 and V-B-2.

CHANGES IN THE CRA (194.34(a))

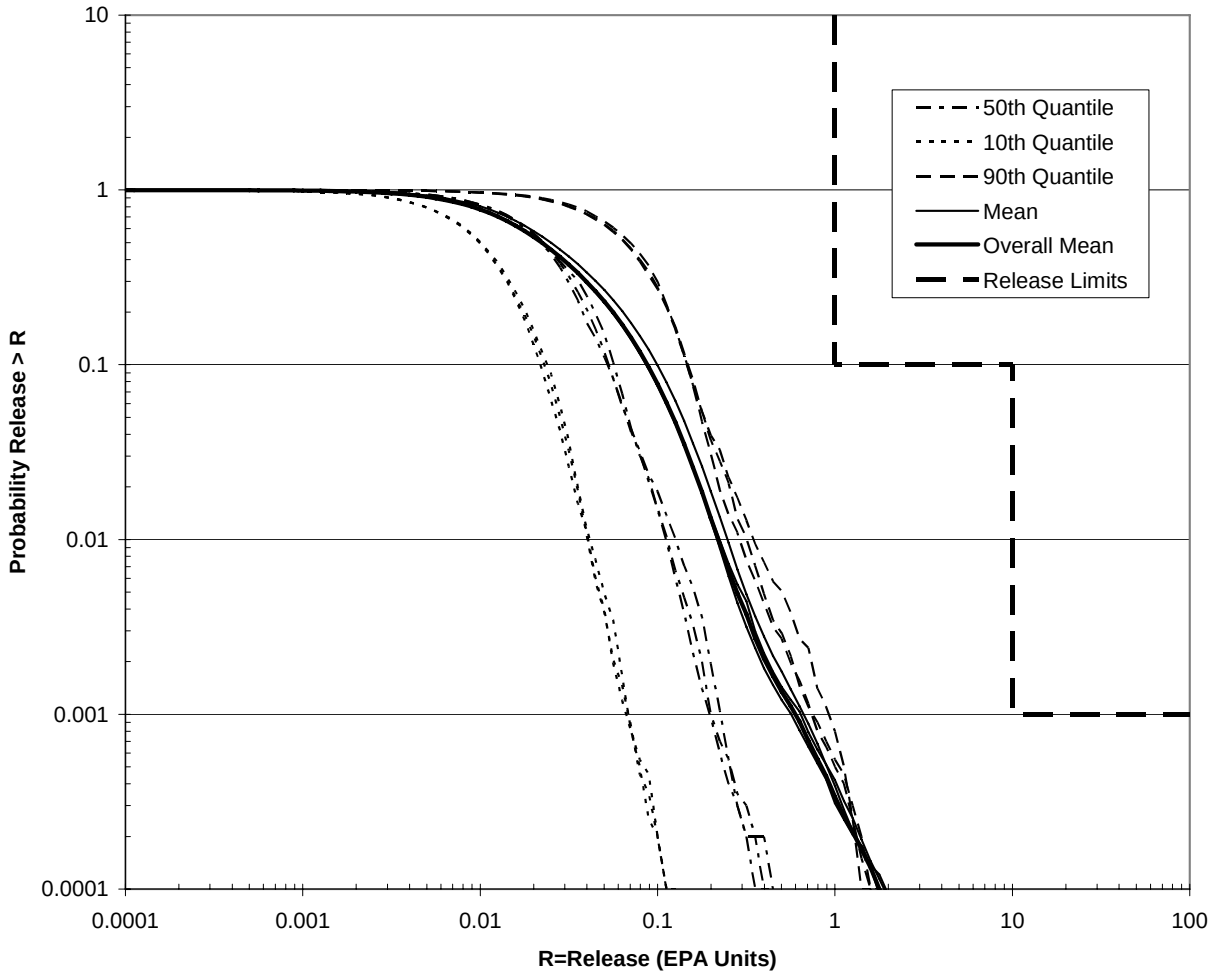
DOE developed CCDFs for the 2004 Compliance Recertification Application (2004 CRA) using a process similar to the process used in the Compliance Certification Application (CCA). Only the values represented by the CCDFs changed, reflecting changes in parameters and modeling assumptions.

EVALUATION OF COMPLIANCE FOR RECERTIFICATION (194.34(a))

DOE used selected computer codes and input parameters to generate estimates of radionuclides for a large number of release scenarios. In total, 300 CCDFs (100 for each of the three replicates) were constructed and presented in the Performance Assessment Baseline Calculation Report (Docket A-98-49, Item II-B2-60) for total normalized releases (Figure 34-1). Three hundred realizations were needed in order to satisfy the requirements of Section 194.34(d). Normalized release results for ten thousand future simulations were used to calculate each of the 300 CCDF curves. In addition, DOE provided CCDFs for individual pathways and by replicate. EPA's analysis (Docket A-98-49, Item II-B1-16) concluded that DOE adequately presented the PA results in CCDFs, which show the probability of exceeding various levels of cumulative releases.

EPA did not receive any public comments on DOE's continued compliance with the requirements of Section 194.34(a).

Figure 34.1. Mean and Quantile CCDFs for Total Normalized Releases: All Replicates of the CRA-2004 PABC (from Figure 6-4, 2004 Compliance Recertification Application Performance Assessment Baseline Calculation, Docket A-98-49, Item B2-51)



RECERTIFICATION DECISION (194.34(a))

Based on a review and evaluation of the 2004 CRA and supplemental information provided by DOE (FDMS Docket ID No. EPA-HQ-OAR-2004-0025, Air Docket A-98-49), EPA determines that DOE continues to comply with the requirements for Section 194.34.

BACKGROUND (194.34(b))

The 2004 CRA WIPP performance assessment used approximately 1700 parameters. Many of these parameters are constants, but some are uncertain. Section 194.34 (b) addresses the need for the uncertain parameters to be sampled from a probability distribution (e.g., uniform, normal, etc.) that has been appropriately documented.

REQUIREMENT (194.34(b))

(b) "Probability distributions for uncertain disposal system parameter values used in performance assessments shall be developed and documented in any compliance application."

1998 CERTIFICATION DECISION (194.34(b))

To meet the requirements of Section 194.34(b), EPA expected DOE to:

1) discuss the sources used and the methods by which each of the probability distributions was developed (e.g., experimental data, field data, etc.),

2) identify the functional form of the probability distribution (e.g., uniform, lognormal) used for the sampled parameters,

3) describe the statistics of each probability distribution, including the values for lower and upper ranges, mean (geometric mean when appropriate) and median,

4) Identify the importance of the sampled parameters to the final releases, and

5) Demonstrate that the data used to develop the input parameter probability distribution were qualified and controlled in accordance with Section 194.22.

EPA reviewed DOE's parameters and found that DOE adequately documented the probability distributions in CCA Appendix PAR, and discussed the data from which, and the method by which, the probability distribution of each of the 57 sampled variables was created. DOE provided general information on probability distributions, data sources for parameter distribution, forms of distributions, bounds, and importance of parameters to releases. EPA identified with some of the parameter values and probability distributions, but these were resolved for the Performance Assessment Verification Test EPA required DOE to conduct.

A complete description of EPA's 1998 Certification Decision for Section 194.34 can be obtained from Docket A-93-02, Items V-A-1 and V-B-2.

CHANGES IN THE CRA (194.34(b))

There were some changes in parameter values and probability distributions in the 2004 CRA. Many of these changes are related to inventory changes, but some are related to modeling assumption changes (See 2004 CRA, CARD 23). However, the basic process that DOE used to develop the parameter information and the sampling of the parameters did not change from the CCA methodology.

EVALUATION OF COMPLIANCE FOR RECERTIFICATION (194.34(b))

DOE documented its selection of parameters and probability distributions for the key parameters in Chapter 6 of the 2004 CRA, Appendix PA Attachment PAR, the PABC report (Docket A-98-49, Item II-B2-51) and associated references. For the 2004 CRA PA, DOE selected 75 uncertain subjective parameters whose values were obtained through random sampling in the PA. In comparison, the CCA PA sampled 57 uncertain parameters. The 2004 CRA PABC sampled 56 parameters, and there were changes to several of the parameters for the PABC (the PABC report and Kirchner, 2005 [ERMS 540279] in Docket A-98-49, Item II-B2-60). The ultimate goal of parameter sampling was to capture uncertainties in the parameters and show their effects on the CCDFs, which DOE discussed in 2004 CRA, Chapter 6, Sections 6.4 and 6.5 and in the PABC report section 2.9 (Docket A-98-49, Item II-B2-51).

EPA reviewed DOE's parameter selection and probability distributions in several Technical Support Documents related to computer codes (Docket A-98-49, Items II-B1-7, II-B1-8), parameters (Docket A-98-49, Items II-B1-3, II-B1-6, II-B1-9), and chemistry (Docket A-98-49, Items II-B1-3, II-B1-9, II-b1-16). The Agency found that DOE adequately documented the probability distributions and discussed the data from which, and the method by which, the probability distribution of each of the sampled variables was created.

EPA did not receive any public comments on DOE's continued compliance with the requirements of Section 194.34(b).

RECERTIFICATION DECISION (194.34(b))

Based on a review and evaluation of the 2004 CRA and supplemental information provided by DOE (FDMS Docket ID No. EPA-HQ-OAR-2004-0025, Air Docket A-98-49), EPA determines that DOE continues to comply with the requirements for Section 194.34(b).

BACKGROUND (194.34(c))

In section 194.34(c), EPA's intent was to ensure that the sampled parameters were appropriately selected for use in performance assessment. DOE chose to use the Latin Hypercube Sampling (LHS) methodology to sample the probabilistic parameters.

REQUIREMENT (194.34(c))

(c) "Computational techniques, which draw random samples from across the entire range of the probability distributions developed pursuant to paragraph (b) of this section, shall be used in generating CCDFs and shall be documented in any compliance application."

1998 CERTIFICATION COMPLIANCE DECISION (194.34(c))

To demonstrate compliance with Section 194.34(c), EPA expected DOE to:

1) discuss the computational techniques used for random sampling, and

2) demonstrate that sampling occurred across the entire range of each parameter.

EPA agreed that it was appropriate to use the LHS method for the 57 sampled parameters described in CCA Appendix PAR. The CCDFGF code also sampled stochastic variables with Monto Carlo sampling for each realization. EPA concluded that DOE adequately discussed the computational techniques and the sampling ranges.

A complete description of EPA's 1998 Certification Decision for Section 194.34(c) can be obtained from Docket A-93-02, Items V-A-1 and V-B-2.

CHANGES IN THE CRA (194.34(c))

Like in the CCA, DOE used the LHS methodology for sampling uncertain parameters. There is no change in the methodology for the 2004 CRA.

EVALUATION OF COMPLIANCE FOR RECERTIFICATION (194.34(c))

EPA determined in the CCA that this method ensures that parameter values will be selected from the entire range of the probability distributions because LHS stratifies the probability distributions into a number (100, in this case) of equal-probability regions and then samples one value from each region. EPA noted that the LHS sampling is appropriate for generating random samples.

EPA did not receive any public comments on DOE's continued compliance with the requirements of Section 194.34(c).

RECERTIFICATION DECISION (194.34(c))

Based on a review and evaluation of the 2004 CRA and supplemental information provided by DOE (FDMS Docket ID No. EPA-HQ-OAR-2004-0025, Air Docket A-98-49), EPA determines that DOE continues to comply with the requirements for Section 194.34(c).

BACKGROUND (194.34(d))

In Section 194.34(d), EPA's intent was to ensure that PA modeling appropriately sampled uncertain parameters and future scenarios were appropriately used in performance assessment. In the CCA and the recertification analyses, DOE generated 300 CCDFs in order to meet this requirement.

REQUIREMENT (194.34(d))

(d) "The number of CCDFs generated shall be large enough such that, at cumulative releases of 1 and 10, the maximum CCDF generated exceeds the 99th percentile of the population of CCDFs with at least a 0.95 probability. Values of cumulative release shall be calculated according to Note 6 of Table 1, Appendix A of Part 191 of this chapter."

1998 CERTIFICATION COMPLIANCE DECISION (194.34(d))

To demonstrate compliance with Section 194.34(d), EPA expected DOE to:

1) identify the number of CCDFs generated,

2) discuss how DOE determined the number of CCDFs to be generated, and

3) List the probabilities of exceeding cumulative releases of 1 and 10 for each CCDF generated.

Demonstrate that the maximum CCDF generated, at cumulative normalized releases of 1 and 10, exceeds the 99th percentile with at least a 0.95 probability with a discussion that includes examples of calculations.

EPA found the analysis presented in CCA Chapter 8 sufficient to show that 298 CCDF curves would satisfy the statistical criterion. EPA's independent analysis also verified that the 300 CCDF curves computed and presented in the CCA were sufficient (CCA, CARD 34). DOE correctly interpreted the definition of the 99th percentile value, and applied standard mathematical expressions for deriving the probability of an outcome of multiple events (i.e., the generation of multiple CCDF curves). The probabilistic analysis was found to be appropriate for sampling with the LHS method, which achieves better coverage than non-stratified random sampling of parameter ranges

A complete description of EPA's 1998 Certification Decision for Section 194.34(d) can be obtained from Docket A-93-02, Items V-A-1 and V-B-2.

CHANGES IN THE CRA (194.34(d))

Like in the CCA, DOE generated 300 CCDFs in three sets (replicates) of 100. There is no change in the methodology for the 2004 CRA.

EVALUATION OF COMPLIANCE FOR RECERTIFICATION (194.34(d))

DOE generated three sets of 100 CCDFs each and discussed the statistical confidence levels for the set of CCDFs. Based on the analysis in the CCA and the fact that DOE used the same approach in the 2004 CRA, EPA concurs with DOE's CRA analyses.

EPA did not receive any public comments on DOE's continued compliance with the requirements of Section 194.34(d).

RECERTIFICATION DECISION (194.34(d))

Based on a review and evaluation of the 2004 CRA and supplemental information provided by DOE (FDMS Docket ID No. EPA-HQ-OAR-2004-0025, Air Docket A-98-49), EPA

determines that DOE continues to comply with the requirements for Section 194.34(d).

BACKGROUND (194.34(e))

In section 194.34(e), DOE was required to show the full range of CCDFs in order to provide an indication of the nature of the releases.

REQUIREMENT (194.34(e))

(e) "Any compliance application shall display the full range of CCDFs generated."

1998 CERTIFICATION DECISION (194.34(e))

To demonstrate compliance with Section 194.34(e), EPA expected DOE to:

1) display the full range of CCDFs generated,

2) present the appropriate information so that EPA may confirm DOE's PA analysis, including steps used to arrive at the result and data values that are represented by the CCDFs, and

3) Include descriptive statistics such as the range, mean, median, etc., for the estimated CCDFs at cumulative releases of 1 and 10.

DOE employed LHS to create three independent replicates of 100 realizations each, yielding 300 CCDF curves. The range of normalized release values indicated on the horizontal axis extends from below one in a million (10^{-6}) to values above 1 (10^{0}) and 10 (10^{1}). The CCDF probability values on the vertical axis range from 10^{-4} up to the highest possible probability value of 1 (See Figure 34-1). DOE concluded that the requirement of Section 194.34(e) was met. EPA concurred with this conclusion.

A complete description of EPA's 1998 Certification Decision for Section 194.34(e) can be obtained from Docket A-93-02, Items V-A-1 and V-B-2.

CHANGES IN THE CRA (194.34(e))

There were no changes to the approached used by DOE in the 2004 CRA PA and PABC.

EVALUATION OF COMPLIANCE FOR RECERTIFICATION (194.34(e))

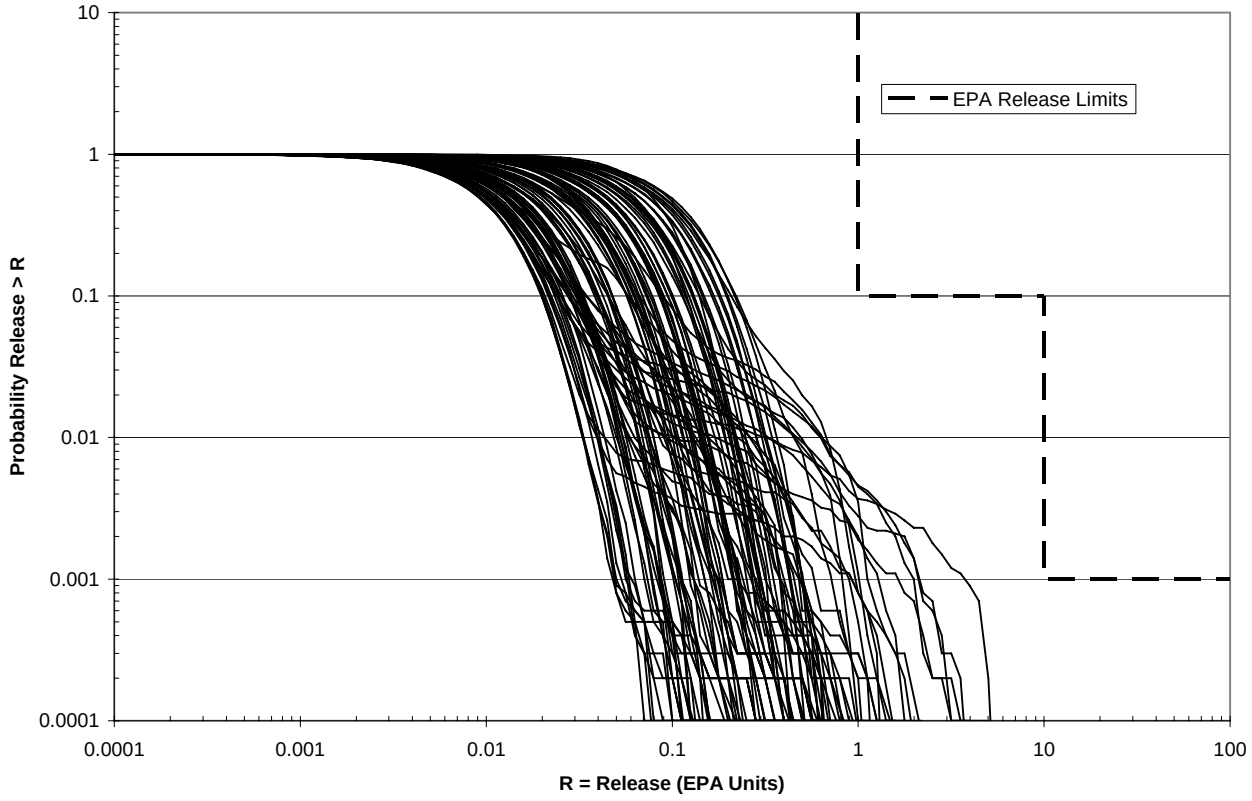
DOE presented and discussed the results of the performance assessment analysis in the 2004 CRA, Chapter 6 and the PABC report, Chapter 6 (Docket A-98-49, Item II-B2-60). Figure 34-2 shows the releases from replicate R1 of the CRA-2004 PABC.

EPA did not receive any public comments on DOE's continued compliance with the requirements of Section 194.34(e).

RECERTIFICATION DECISION (194.34(e))

Based on a review and evaluation of the 2004 CRA and supplemental information provided by DOE (FDMS Docket ID No. EPA-HQ-OAR-2004-0025, Air Docket A-98-49) and the fact that DOE included the full range of CCDFs as required by this section, EPA determines that DOE continues to comply with the requirements for Section 194.34(e).

Figure 34-2. Total Normalized Releases for 100 CCDFs of Replicate R1 of the CRA-2004 PABC (Figure 6-1, PABC Report, Docket A-98-49, Item II-B2-60).



BACKGROUND (194.34(f))

Because of the unique nature of the WIPP, EPA wanted to ensure that the data could be used to adequately support a certification decision. To this end, EPA required DOE to demonstrate compliance with a high statistical confidence. DOE must show, in effect, that the mean of its 300 CCDF curves, and the 95th percentile upper confidence limit of the mean of the

population for the cumulative releases at 1 and 10 EPA units.

REQUIREMENT (194.34(f))

(f) "Any compliance application shall provide information which demonstrates that there is at least a 95 percent level of statistical confidence that the mean of the population of CCDFs meets the containment requirements of 40 CFR 191.13."

1998 CERTIFICATION DECISION (194.34(f))

To demonstrate compliance with Section 194.34(f), EPA expected DOE to:

1) present the appropriate information, including steps used to arrive at the result and the data used in the analysis, so that EPA can confirm that the mean of the population of CCDFs meets the containment requirements of Section 191.13 with a 95 percent level of statistical confidence,

2) identify the mean of the sample of CCDFs generated for the cumulative releases at 1 and 10 as specified in Section 191.13, and

3) identify the values of the CCDFs associated with a 95 percent level of statistical confidence of the mean of the population for the cumulative releases at 1 and 10 as specified in Section 191.13 (CAG, p. 52).

The CCA PAVT results yielded CCDFs with 100 percent of the curves lying below the limit of resolution at R=10, and over 90 percent of the CCDFs below the limit of resolution at R=1. The estimated mean CCDF for the PAVT was also below the limit of resolution at R=1 and R=10. The PAVT results also demonstrated that the level of statistical confidence is significantly greater than 95 percent and that the mean of the CCDFs meets the Section 191.13 containment requirements. Therefore, EPA concluded that the final result of the PAVT was in compliance with the containment requirements of Section 191.13 and that the results were presented in accordance with Section 194.34(f).

A complete description of EPA's 1998 Certification Decision for Section 194.34(f) can be obtained from Docket A-93-02, Items V-A-1 and V-B-2.

CHANGES IN THE CRA (194.34(f))

In the 2004 CRA, DOE used the same general approach to calculating the statistical confidence for release limits. However, there were some modeling implementation errors that EPA identified would cause the performance assessment results to possibly be out of compliance with this requirement section. Thus, EPA required DOE to conduct an additional performance assessment.

EVALUATION OF COMPLIANCE FOR RECERTIFICATION (194.34(f))

DOE provided the CCDFs and uncertainty information in the 2004 CRA documentation. EPA's and DOE's review of the 2004 CRA identified that there were several errors that possibly affected the 2004 CRA PA's compliance with section 194.34 (f) (March 4, 2005, letter from EPA to DOE, Docket A-98-49, Item II-B3-80 and DOE's responses in Docket A-98-49, Items II-B2-39 and II-B2-40). Incorrect LHS transfer files were used as input to PRECCDFGF for replicates 2 and 3, thus some of the same parameter inputs were used multiple times instead of being appropriately sampled for each replicate; however, they were minor. EPA believed that this was essentially equivalent to using the same parameter values instead of being adequately sampled as required. A spallings release calculation for the volume fraction of contact-handled waste was omitted from CCDFGF. Also, there was an error in the input control file for the computer code SUMMARIZE that affected spallings results. Finally, only 50 vectors for DRSPALL calculations were run for the 2004 CRA performance assessment instead of a full set of 100 vectors, thus potentially reducing the range of spallings releases.

Because of these problems, EPA required DOE to run a full set of DRSPALL vectors and correct the problem with LHS transfer files. DOE conducted another performance assessment, called the Performance Assessment Baseline Calculations (PABC). The results of the PABC are provided in DOE's PABC report (Docket A-98-49, Item II-B2-60). Table 6-1 of that report, reproduced here in Table 34-1, lists the mean total normalized releases at the compliance probabilities of 0.1 and 0.001, along with the upper and lower 95% confidence limits. EPA's review of the PABC identified that the errors were corrected.

Table 34-1. CCA PAVT, CRA-2004, and CRA-2004 PABC Statistics on the Overall Mean for Total Normalized Releases (in EPA Units) at Probabilities of 0.1 and 0.001, All Replicates Pooled. From Table 6-1 of DOE's PABC report (Docket A-98-49, Item II-B2-60).

Probability	Analysis	Mean Total Release	90th Quantile Total Release	Lower 95% CL	Upper 95% CL
0.1	CCA PAVT	1.237E-1	1.916E-1	1.231E-1	1.373E-1
	CRA-2004	9.565E-2	1.571E-1	8.070E-2	1.104E-1
	CRA-2004	8.770E-2	1.480E-1	8.471E-2	9.072E-2

	PABC				
0.001	CCA PAVT	3.819E-1	3.907E-1	2.809E-1	4.357E-1
	CRA-2004	5.070E-1	8.582E-1	2.778E-1	5.518E-1
	CRA-2004 PABC	6.006E-1	8.092E-1	5.175E-1	6.807E-1

CL = Confidence Limit

EPA did not receive any public comments on DOE's continued compliance with the requirements of Section 194.34(f).

RECERTIFICATION DECISION (194.34(f))

Table 34-1 shows that the PABC demonstrates at least a 95% level of statistical confidence that the mean of the population of CCDFs meets the containment regulations of 40 CFR 191.13.

Based on a review and evaluation of the 2004 CRA and supplemental information provided by DOE (FDMS Docket ID No. EPA-HQ-OAR-2004-0025, Air Docket A-98-49), EPA determines that DOE continues to comply with the requirements for Section 194.34(f).