40 CFR Part 191
Subparts B and C
Compliance Recertification Application 2026
for the
Waste Isolation Pilot Plant

Results of Performance Assessments
(40 CFR 194.34)

United States Department of Energy
Waste Isolation Pilot Plant

Carlsbad Field Office
Carlsbad, New Mexico

Compliance Recertification Application 2026
Results of Performance Assessments
(40 CFR 194.34)

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ACRONYMS AND ABBREVIATIONS

CCDF	complementary cumulative distribution function
CFR	Code of Federal Regulations
CRA	Compliance Recertification Application
CRA26_IS	CRA-2026 Intermediate State Calculation
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
LHS	Latin hypercube sampling
PA	performance assessment
WIPP	Waste Isolation Pilot Plant

34.0 RESULTS OF PERFORMANCE ASSESSMENTS (40 CFR 194.34)

Title 40 CFR 194.34 (U.S. EPA 1996) mandates that the U.S. Department of Energy's (DOE) performance assessment (PA) results be generated, sampled, analyzed, and presented using statistically rigorous and transparent methods. This ensures, with a high degree of confidence (95%), that compliance with the radionuclide containment requirements specified in 40 CFR 191.13 (U.S. EPA 1993) is demonstrated. This document links the results presented in Appendix PA-2026 to the compliance requirements of 40 CFR 194.34 and provides clear conclusions regarding regulatory compliance.

34.1 Requirements

§ 194.34 Results of Performance Assessments

(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.

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

(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.

(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.

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

(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.

34.2 40 CFR 194.34(a)

34.2.1 Background

The radioactive waste disposal regulations in 40 CFR Part 191 Subparts B and C (U.S. EPA 1993) set containment requirements for radionuclides. Specifically, 40 CFR 191.13 establishes limits on releases from a disposal system to the accessible environment, as detailed in Part 191 Appendix A, Table 1. Performance assessments evaluate the likelihood that these release limits will be met, providing reasonable assurance of compliance with 40 CFR 191.13.

A release to the accessible environment is defined by its location and magnitude, including any radionuclide release to the ground surface, atmosphere, surface water, or subsurface transport beyond the Waste Isolation Pilot Plant (WIPP) controlled area.

To satisfy 40 CFR 194.34(a) (U.S. EPA 1996), WIPP PA results are expressed as complementary cumulative distribution functions (CCDFs), which show the probability of exceeding various cumulative release levels. These CCDFs are generated through random sampling of uncertain parameters and represent the probability of releases from all significant processes and events.

After reviewing the 2019 Compliance Recertification Application (CRA-2019), the U.S. Environmental Protection Agency (EPA) concluded that the DOE continues to comply with 40 CFR 194.34(a) criteria (U.S. EPA 2022, pp. 56-57).

34.2.2 Changes or New Information Since the CRA-2019

The CRA-2026 PA reflects updated repository design information, revised parameter values, and refinements to PA implementation since the CRA-2019 data cutoff, as detailed in Appendix PA-2026, Section PA-1.3. However, the CCDFs developed for the CRA-2026 PA (also referred to as the CRA26 Intermediate State or CRA26_IS calculation) are based on the same sampling processes and computational techniques as previous applications (U.S. DOE 2019). In total, 300 CCDFs (100 for each of 3 replicates) for total normalized releases are constructed and presented in Figure 34-1, Figure 34-2, and Figure 34-3 (Appendix PA-2026, Figure PA-88, Figure PA-89, and Figure PA-90). Thus, the DOE continues to demonstrate compliance with the provisions of section 194.34(a).

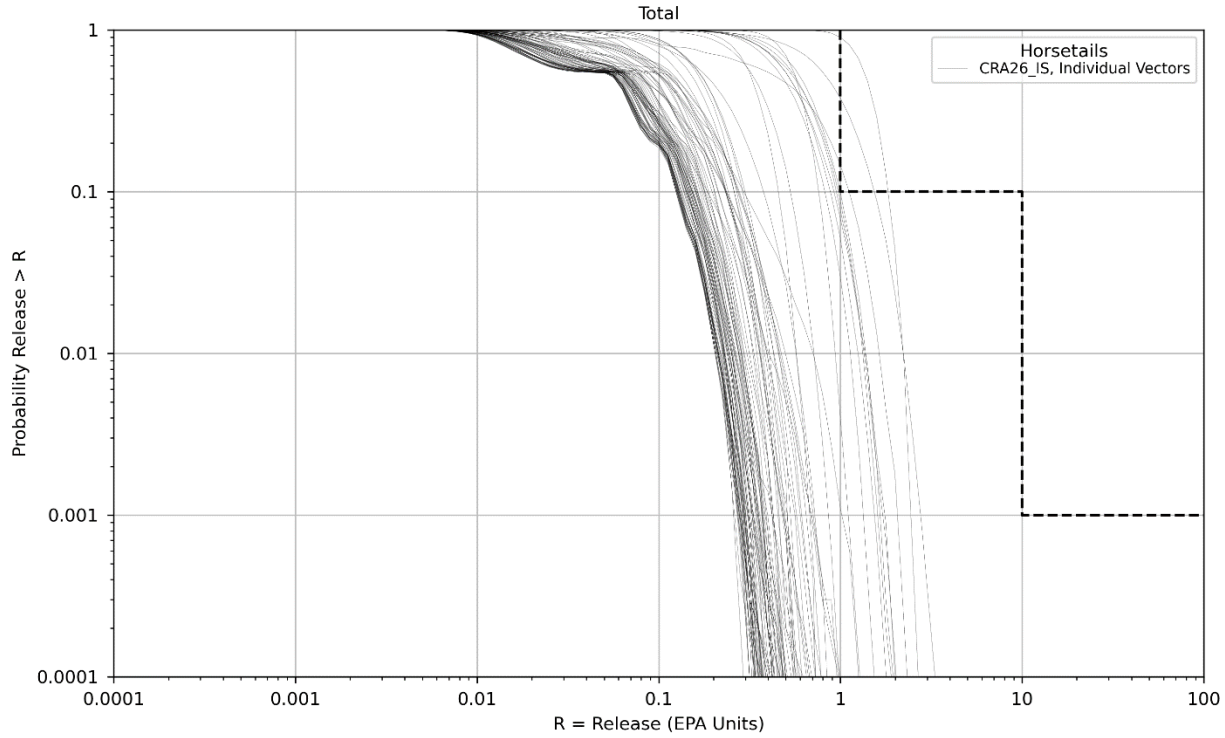


Figure 34-1. Total Normalized Releases, 100 CCDFs of Replicate R1, CRA26_IS

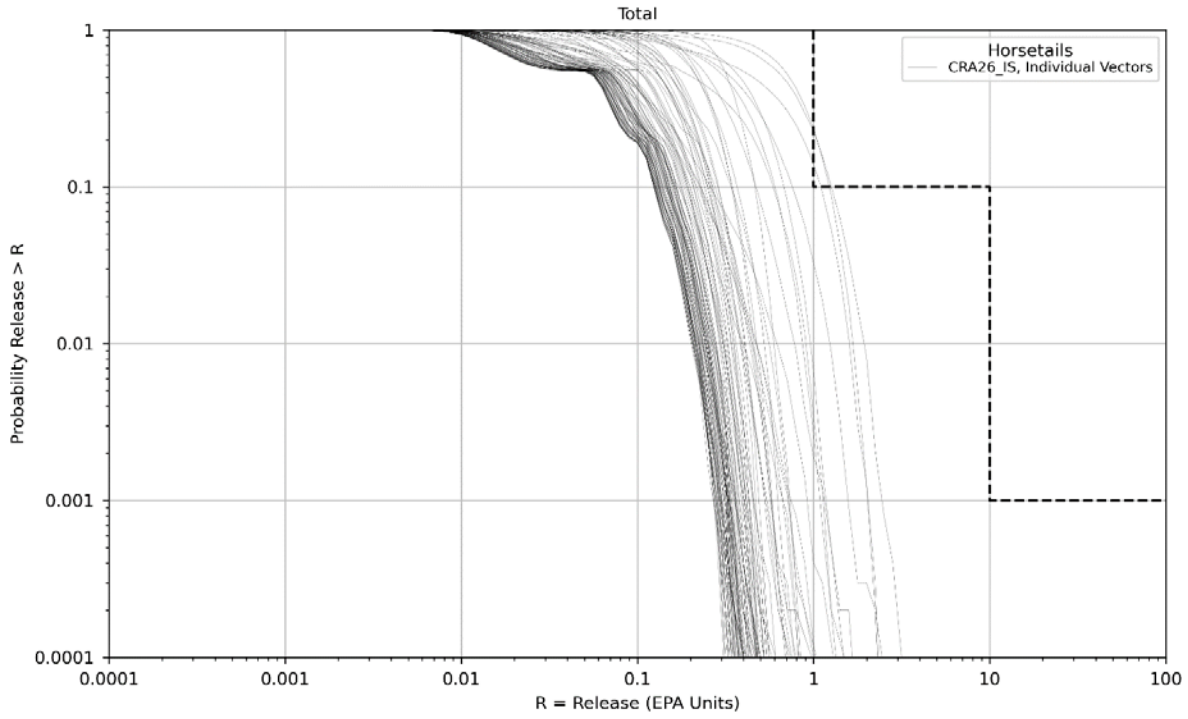


Figure 34-2. Total Normalized Releases, 100 CCDFs of Replicate R2, CRA26_IS

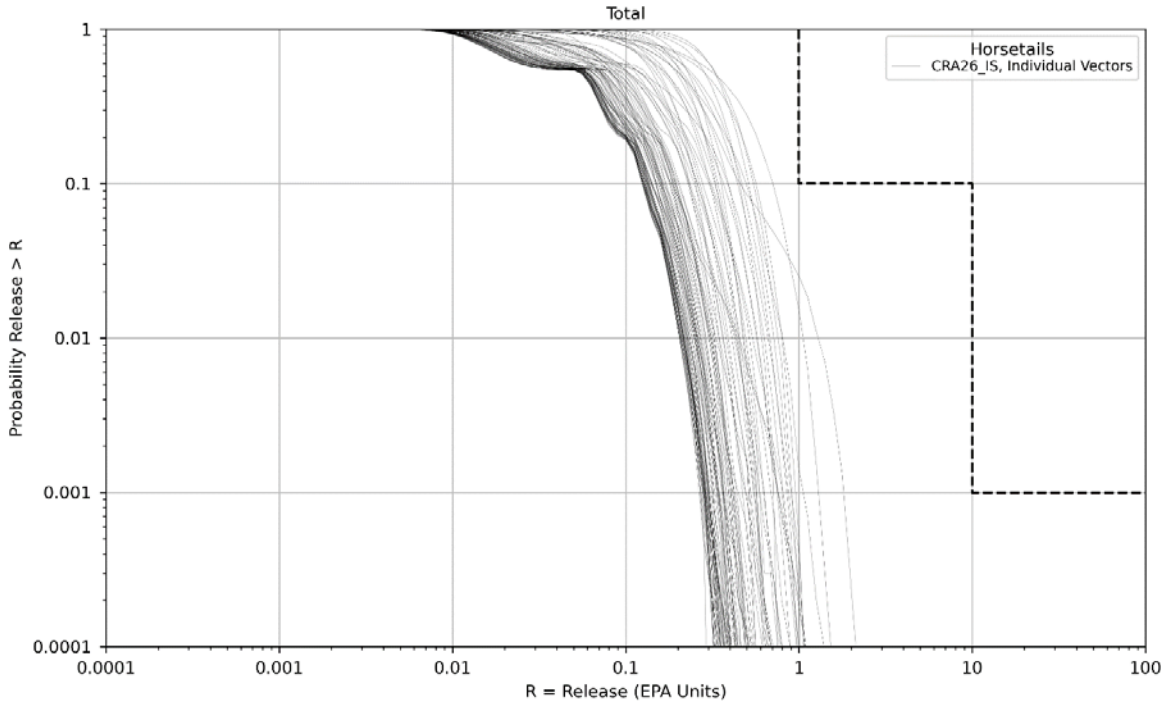


Figure 34-3. Total Normalized Releases, 100 CCDFs of Replicate R3, CRA26_IS

34.3 40 CFR 194.34(b)

34.3.1 Background

There is inherent uncertainty in many of the parameters used in the WIPP PA. Title 40 CFR 194.34(b) requires that probability distributions for uncertain disposal system parameter values used in PAs be developed and documented in any compliance application. This ensures that uncertainty is appropriately characterized and accounted for in the PA.

To comply with 40 CFR 194.34(b), the data and methods used to construct the parameter probability distributions are documented, the distribution forms and their statistical characteristics are identified, and supporting data are qualified and controlled consistent with 40 CFR 194.22.

The data and methods used to create probability distributions for each of the 57 sampled variables are discussed in previous applications, the most recent of which is the CRA-2019. The discussion includes general information on probability distributions, data sources, distribution forms, bounds, and the relative importance of parameters to release outcomes.

In its review of the PA for CRA-2019, the EPA evaluated the selection of parameters and probability distributions. The EPA found that the probability distributions were adequately documented, including a discussion of the data and methods used to generate them. Based on

its review of the CRA-2019, the EPA determined that the DOE continued to comply with the requirements of Section 194.34(b) (U.S. EPA 2022, p. 57).

34.3.2 Changes or New Information Since the CRA-2019

The distributions for seven uncertain parameters have been updated since CRA-2019 (Appendix PA-2026, Table PA-16). Despite these changes, the DOE has applied the same EPA-approved methodology for developing and documenting probability distributions for uncertain disposal system parameters, as detailed in Appendix PA-2026 Section PA-5.2. All changes and updates were performed in accordance with quality assurance procedures compliant with 40 CFR 194.22. Therefore, the DOE continues to demonstrate compliance with the provisions of section 194.34(b).

34.4 40 CFR 194.34(c)

34.4.1 Background

Title 40 CFR 194.34(c) requires that random samples used to generate CCDFs must be drawn from across the entire range of the probability distributions. Sampling techniques must be documented in any compliance application to demonstrate adequate coverage of parameter uncertainty.

To satisfy this requirement, the Latin Hypercube Sampling (LHS) method has been employed consistently in all previous applications. LHS ensures comprehensive coverage by dividing each parameter's probability distribution into 100 equal-probability intervals and selecting one sample value from each interval, providing a stratified sampling approach that improves coverage over simple random sampling.

The EPA reviewed the information provided for CRA-2019 (U.S. EPA 2022, p. 57) and determined that the DOE continued to comply with the criteria outlined in 40 CFR 194.34(c).

34.4.2 Changes or New Information Since the CRA-2019

In the CRA-2026, the LHS methodology, described in Appendix PA-2026, Section PA-6.1.1, is used for sampling uncertain parameters. Thus, the DOE maintains compliance with the provisions of section 194.34(c).

34.5 40 CFR 194.34(d)

34.5.1 Background

Title 40 CFR 194.34(d) requires that the number of CCDFs meets the statistical requirement that, at cumulative releases of 1 and 10, the maximum CCDF exceeds the 99th percentile of the set of CCDFs with a probability of at least 0.95. To meet this requirement, PA uses a total sample size of 300, divided among 3 replicates of size 100 each.

The EPA reviewed the CRA-2019 analysis (U.S. EPA 2022, p. 57) and found it sufficient to demonstrate that 298 CCDF curves satisfy the statistical criterion. The probabilistic analysis employs LHS, which provides better coverage of parameter space than non-stratified random sampling. Based on this, the EPA concluded that the DOE continued to comply with the criteria of 40 CFR 194.34(d).

34.5.2 Changes or New Information Since the CRA-2019

In CRA-2026, the same methodology that was employed in CRA-2019 is used to generate 300 CCDFs in 3 replicates of 100 each, as shown in Figure 34-1, Figure 34-2, and Figure 34-3 (Appendix PA-2026, Section PA-6.1 and Figure PA-88, Figure PA-89, and Figure PA-90). Thus, the DOE continues to demonstrate compliance with the provisions of section 194.34(d).

34.6 40 CFR 194.34(e)

34.6.1 Background

Title 40 CFR 194.34(e) requires that the full range of CCDFs to be presented. For the CRA-2019, a total of 300 CCDFs were generated and documented. The EPA reviewed the information provided and determined that the criteria of 40 CFR 194.34(e) continued to be met (U.S. EPA 2022, p. 57).

34.6.2 Changes or New Information Since the CRA-2019

The CRA-2026 uses the same approach as in the CRA-2019. The full range of CCDFs generated for the CRA-2026 PA is presented in Figures 34-1, 34-2, and 34-3 (Appendix PA-2026, Figure PA-88, Figure PA-89, and Figure PA-90). Thus, the DOE continues to demonstrate compliance with the provisions of section 194.34(e).

34.7 40 CFR 194.34(f)

34.7.1 Background

Title 40 CFR 194.34(f) requires that the mean CCDF complies with the containment limits specified in 40 CFR 191.13, with a 95 percent level of statistical confidence.

For the CRA-2019, a confidence interval about the mean CCDF was calculated from the full set of 300 CCDFs. The EPA reviewed the information provided for CRA-2019 and determined that the criteria of 40 CFR 194.34(f) continued to be met (U.S. EPA 2022, page 58).

34.7.2 Changes or New Information Since the CRA-2019

The mean of the 300 CCDFs, along with the 95 percent confidence interval around the overall mean for the total normalized releases of the CRA-2026 PA, is illustrated in Figure 34-4. Table 34-1 lists the overall mean total normalized release CCDF values of the CRA-2026 PA at compliance probabilities of 0.1 and 0.001, along with the values at the upper and lower bounds

of the 95 percent confidence interval at the same probabilities. More details on the normalized release results of the CRA-2026 PA are discussed in Appendix PA-2026, Section PA-9.5.

As shown in Figure 34-4 and Table 34-1 (Appendix PA-2026, Figure PA-92 and Table PA-30), the results of the PA demonstrate a level of statistical confidence greater than 95 percent that the overall mean of the population of CCDFs complies with the containment requirements of section 191.13. Thus, the DOE continues to comply with provisions of section 194.34(f).

34.8 Summary

This document has addressed the requirements of 40 CFR 194.34, demonstrating that all applicable provisions, (a) through (f), have been satisfied in the CRA-2026 performance assessment. Accordingly, the CRA-2026 performance assessment fully complies with the provisions of 40 CFR 194.34, thereby supporting the continued certification of the WIPP disposal system.

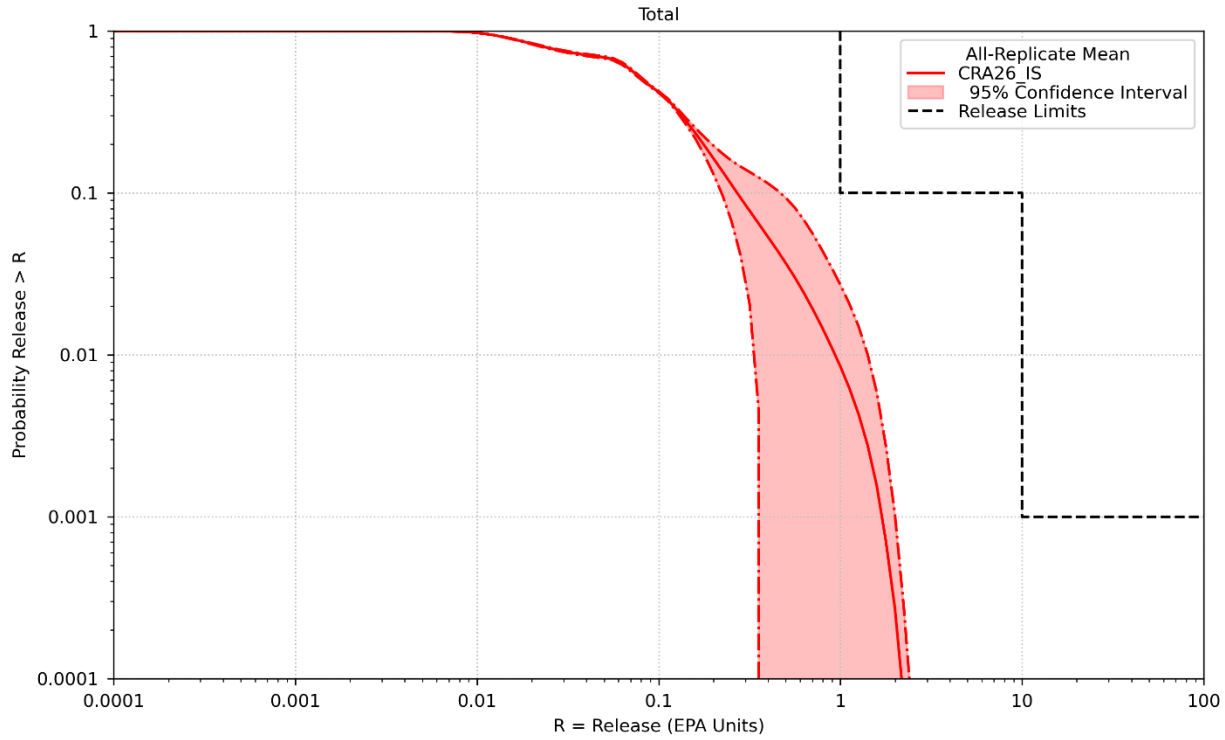


Figure 34-4. Mean CCDF with Confidence Interval for Total Normalized Releases: CRA-2026 IS PA

Table 34-1. CRA-2026 IS PA Statistics on the Overall Mean for Total Normalized Releases at Probabilities of 0.1 and 0.001, All Replicates Pooled and Compared with Release Limits.

Probability	Lower 95% Confidence Interval	Mean Total Release	Upper 95% Confidence Interval	Regulatory Limit
0.1	0.2219	0.2713	0.4679	1
0.001	0.3678	1.7121	2.0062	10

34.9 References

(*Indicates a reference that has not been previously submitted.)

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