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REEVALUATING TRANSURANIC WASTE CHARACTERIZATION FOR THE WASTE ISOLATION PILOT PLANT

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ABSTRACT

Waste destined for disposal at the Waste Isolation Pilot Plant (WIPP) must undergo thorough and costly characterization prior to transportation. The U.S. Environmental Protection Agency (EPA) evaluates waste characterization performed to meet requirements that were identified as important to the long-term repository performance. The EPA characterization requires identifying the amounts of Cellulosic, Plastic, and Rubber (CPR) materials, metals, and free water in the waste as well as the waste activity and surface dose rate. CPR materials were identified as impactful to the long-term performance of the WIPP repository.

This paper investigates the performance of the WIPP in situations where the amount of CPR is significantly increased. The results of this analysis show that the characterization requirement of determining the amount of CPR on each individual waste container could be reevaluated. If the current CPR characterization plan was modified based on analysis results, significant cost savings could be achieved. A cost-benefit analysis could be performed to determine if the amount of money saved from the reduced characterization required outweighs the cost of the additional MgO that would need to be emplaced to ensure sufficient quantities are present in the repository.

INTRODUCTION

The Waste Isolation Pilot Plant (WIPP) has safely operated for more than 10 years as America's first deep geologic repository licensed to dispose of long-lived radioactive waste. Both legislation and legally binding agreements between the Department of Energy (DOE) and the State of New Mexico limit the waste that may be emplaced in WIPP to defense-related transuranic materials. These same provisions bound transuranic (TRU) waste as material containing more than 3700 Becquerel per gram (Bq/g) of radioactive elements greater than the atomic number of Uranium (92) and with half lives greater than 20 years. To put this into perspective, TRU waste typically contains the most common transuranic element, Plutonium-239, which if present, at a mass concentration of about 1 part per million (ppm), would exceed the 3700 Bq/g lower bound and qualify as TRU waste.

Containment of the TRU waste at WIPP is regulated by the U.S. Environmental Protection Agency (EPA) according to the requirements set forth in Title 40 of the Code of Federal Regulations (CFR), Part 191 [1]. The DOE demonstrates compliance with the containment requirements according to the Certification Criteria in Title 40 CFR, Part 194 [2] by means of performance assessment (PA) calculations. After the original compliance certification in 1996, the application is updated with new information as part of a recertification process that occurs at five-year intervals following receipt in 1999 of the first shipment of waste at the site. The EPA requires a PA to demonstrate that potential cumulative releases of radionuclides to the accessible environment over a 10,000-year period after disposal are less than specified limits based on the nature of the materials disposed. The PA is to determine the effects of all significant features, events and processes (FEPs) that may affect the disposal system, consider the associated uncertainties of the FEPs, and estimate the probable cumulative releases of radionuclides.

WASTE CHARACTERIZATION

The waste characterization must undergo evaluations by two regulatory bodies. The New Mexico Environmental Department evaluates waste characterization performed to meet the Resource

Conservation and Recovery Act requirements concerning hazardous waste. The U.S. Environmental Protection Agency (EPA) evaluates waste characterization performed to meet requirements that were identified as important to the long-term repository performance. This paper will focus on the EPA characterization.

The EPA characterization requires identifying the amounts of Cellulosic, Plastic, and Rubber (CPR) materials, metals, and free water in the waste as well as the waste activity and surface dose rate. CPR materials are characterized because they were identified as impactful to the long-term performance of the WIPP repository. To reduce some of the effects of the CPR materials, magnesium oxide (MgO) is placed in the repository. The EPA requires that sufficient moles of MgO are emplaced to account for each mole of consumable carbon contained in the WIPP. Therefore, in order to determine the amount of MgO to be emplaced, characterization is performed to evaluate the amount of CPR in the waste. Consequently, either Visual Examination or Real Time Radiography is performed on every waste container that will be disposed at the WIPP. This requirement demands a lot of time and money with the evaluation of every container. Time and/or money could be saved by reducing the amount of waste characterization needed for the WIPP waste.

PERFORMANCE ASSESSMENT

The term PA signifies an analysis that (1) identifies the FEPs that might affect the disposal system; (2) examines the effects of these FEPs on the performance of the disposal system; and (3) estimates the cumulative releases of radionuclides, considering the associated uncertainties, caused by all significant FEPs. PA is designed to address three primary questions about the WIPP:

Q1: What FEPs could take place at the WIPP site over the next 10,000 years?
Q2: How likely are the various FEPs to take place at the WIPP site over the next 10,000 years?
Q3: What are the consequences of the various FEPs that could take place at the WIPP site over the next 10,000 years?

In addition, accounting for uncertainty in the parameters of the PA models leads to a further question:

Q4: How much confidence should be placed in answers to the first three questions?

These questions give rise to a methodology for quantifying the probability distribution of possible radionuclide releases from the WIPP repository over the next 10,000 years and characterizing the uncertainty in that distribution due to imperfect knowledge about the parameters contained in the models used to predict releases.

The WIPP PA involves three basic entities: (1) a probabilistic characterization of different futures that could occur at the WIPP site over the next 10,000 years, (2) models for both the physical processes that take place at the WIPP site and the estimation of potential radionuclide releases that may be associated with these processes, and (3) a probabilistic characterization of the uncertainty in the models and parameters that underlies the WIPP PA.

When the EPA developed the containment requirements for the WIPP, they acknowledged many sources of uncertainty that could affect estimates of radionuclide releases. Hence, the containment requirements for the WIPP are defined in terms of both release limits and corresponding probabilities, so WIPP PA creates complementary cumulative distribution functions (CCDFs) for radionuclide releases. For a given release value, the CCDF indicates the probability that cumulative releases from the WIPP during the 10,000 year regulatory time period will exceed that release value. To capture the full range of uncertainty in releases, WIPP PA generally runs simulations with hundreds of different input parameter combinations, resulting in an equal number of CCDFs. An overall mean CCDF is created by averaging over the entire set of CCDFs and confidence limits on this mean are also determine. The overall mean CCDF and its confidence limits are compared with the prescribed release limits in Title 40 CFR, Part 191 [1], to determine compliance with containment regulations. The release limits are given in terms of EPA units. EPA units are a measure of a normalized radionuclide release to the accessible environment based on the type of waste being disposed, the initial waste inventory, and the size of release that may occur. They are defined in Title 40 CFR, Part 191 [1].

IMPACT ANALYSIS

PA calculations were completed for and documented in the 2009 Compliance Recertification Application (CRA-2009). The CRA-2009 PA included a number of technical changes and corrections, as well as updates to parameters and improvements to the WIPP PA computer codes [3]. An impact analysis, conducted to study the sensitivity to the amount of CPR materials in the repository, was performed using the CRA-2009 PA results as a baseline. For the impact analysis, the amount of CPR materials in the repository was modified to 1/10, 1/5, 1/2, 2, 5 and 10 times the amount of CPR materials included in the CRA-2009 PA calculations. It was also assumed that the required amount of MgO needed for each case would increase or decrease accordingly. The resulting overall mean CCDFs for total releases for each case are shown compared to the baseline in Figure 1.

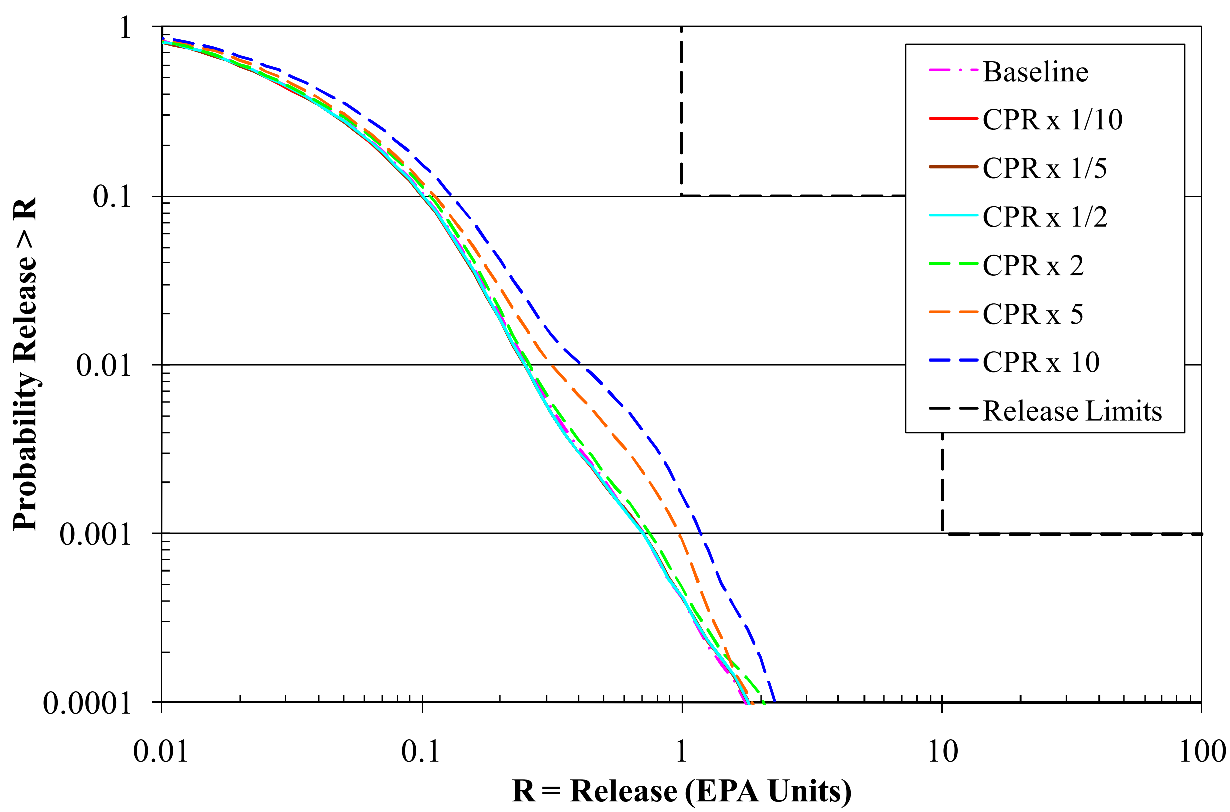

Figure 1. Overall mean CCDFs for total normalized releases in EPA units for the CRA-2009 PA and each CPR sensitivity case compared with the release limits in Title 40 CFR, Part 191.

The overall mean CCDFs for the cases with the decreased amount of CPR materials are essentially the same as the baseline overall mean CCDF. This indicates that a reduction in the amount of CPR materials in the repository would not reduce the potential releases from the repository. The overall mean CCDF for the case with twice the amount of CPR materials shifts slightly to the right, while for the five and ten times cases, the shift in the overall mean CCDF is more pronounced. This shows that the overall mean

CCDF may only be significantly impacted if the amount of CPR material increase is greater than 100%. Interestingly enough, all the cases are still below (to the left of) the releases limits (dashed black line) in Title 40 CFR, Part 191. This indicates that even with an order of magnitude increase in the amount of CPR materials in the repository, the long-term performance of the repository would still be in compliance with the containment requirements.

The response of the overall mean CCDFs to the changes in CPR material amounts are due to the interaction of the CPR material degradation and iron corrosion. As CPR materials degrade, gas is generated. The anoxic corrosion of the iron in repository also generates gas. Gas generation increases the pressure in the repository, which in turn can affect the amount of radionuclides released. Reducing the amount of CPR materials did not lower the overall mean CCDF, because the amount of gas generated from iron corrosion is large enough to mask any potential reduction in pressure that could arise from the decrease in CPR materials. Once the increase of CPR materials reaches five times the baseline amount, the increase in the pressure and its impact on the overall mean CCDF of total releases is appreciable. This occurs because the amount of gas from CPR material degradation is appreciable compared with the gas generated from iron corrosion once the amount of CPR material is increased by a factor of five or ten.

IMPLICATIONS

This impact analysis identifies that the PA is relatively insensitive to a change in the amount of CPR materials up to a factor of twice the amount of CPR materials used in the CRA-2009 PA, as long as there is adequate MgO present. Even an order of magnitude increase in the amount of CPR materials in the repository would not jeopardize compliance. This information could be used to reduce the burden currently required during the waste characterization. Potentially, CPR in the waste could be estimated based on samples taken from the waste streams and/or historical data. While this would increase the uncertainty in the total amount of CPR materials in the repository, the potential impact on the PA would be minimal.

Based on the estimates of CPR materials, the amount of MgO that would be required to be emplaced in the repository could be estimated. The amount of MgO emplaced may need to be increased to confirm that the safety factor was met. A cost-benefit analysis could be performed to determine if the amount of money saved from the reduced characterization required outweighs the cost of the additional MgO that would need to be emplaced to account for the increased uncertainty in the amount of MgO needed to ensure that the safety factor is met.

CONCLUSIONS

Waste destined for disposal at the WIPP must undergo thorough and costly characterization prior to transportation. One of the aspects of characterization is determining the amount of CPR materials in the waste. An impact analysis showed that PA results are relatively insensitive to a change in the amount of CPR materials in the repository as long as there is adequate MgO present. No appreciable change was observed in the overall mean CCDF for reductions in the amount of CPR material in the repository. Only minor changes in the overall mean CCDF are seen when the amount of CPR material in the repository is doubled. Furthermore, an order of magnitude increase in the amount of CPR materials in the repository was shown to not jeopardize compliance. This determination could potentially lead to a reduced requirement of waste characterization for CPR materials which could lead to a saving of time and/or money. A cost-benefit analysis could be performed to determine if the amount of money saved from the reduced characterization required outweighs the cost of the additional MgO that would need to be emplaced.

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