CARD No. 53
Consideration of Underground Sources of Drinking Water

53.A.1 BACKGROUND

The Compliance Criteria include two general categories of quantitative requirements on the performance of the WIPP that are intended to ensure its safety. The first category consists of the containment requirements at Section 194.34, which implement the general containment requirements of the radioactive waste disposal regulations, Section 191.13. The containment requirements establish limits on the cumulative quantity of radioactive materials that may migrate beyond the specified, subsurface physical boundary that separates the WIPP repository area from the accessible environment. That is, they restrict to very low levels the amounts of radioactive materials that might escape from the WIPP.

The second category of quantitative requirements consists of the individual and ground water protection requirements, which implement Section 191.15. The individual and ground water protection requirements place limitations on both the potential radiation exposure of individuals and the possible levels of radioactive contamination of ground water due to disposal of waste in the WIPP. The individual protection requirement focuses on the annual radiation dose of a maximally exposed hypothetical person living on the surface just outside the boundary to the accessible environment.

The containment requirements and individual and ground water protection requirements are fundamentally different. The containment requirements apply to cumulative releases to the accessible environment over the 10,000-year regulatory period. To demonstrate compliance with the containment standards, DOE is required to consider human intrusion, such as deep drilling, shallow drilling, and mining. In contrast, the individual and ground water protection requirements apply to the doses received by an individual over a human lifespan. Moreover, compliance assessments utilized to demonstrate compliance with the individual and ground water protection requirements need not consider performance of the repository in the "disturbed" scenario. Thus, whereas releases resulting from human-initiated events such as drilling into the repository must be considered to demonstrate compliance with the containment requirements, such intrusion events are not considered in demonstrating compliance with the individual and ground water protection requirements.

Section 194.53 requires that the WIPP comply with the ground water protection requirements at 40 CFR Part 191, Subpart C, and specifies the factors that compliance assessments must consider when analyzing doses resulting from exposure to radioactive contaminants in underground sources of drinking water (USDWs). Compliance assessments pertain to scenarios in which the WIPP remains undisturbed throughout the regulatory period (i.e., there is no human intrusion such as drilling or mining). DOE must assume that doses can be received from any USDW in the accessible environment (i.e., outside the controlled area)[1],

[1] The "controlled area" is the 16 square mile territory identified by Section 3(c) of the 1992 Land Withdrawal Act, both above and below the surface.

provided that a connective pathway could be expected to be established via ground water transport. EPA, however, does not intend for DOE to expend resources analyzing USDWs located large distances from the repository (50 FR 5232).

53.A.2 Requirement

"In compliance assessments that analyze compliance with 40 CFR Part 191, Subpart C of this chapter, all underground sources of drinking water in the accessible environment that are expected to be affected by the disposal system over the regulatory time frame shall be considered. In determining whether underground sources of drinking water are expected to be affected by the disposal system, underground interconnections among bodies of surface water, ground water and underground sources of drinking water shall be considered."

53.A.3 Abstract

The CCA identified USDWs in the accessible environment that may be expected to be affected by the disposal system over the 10,000-year regulatory time frame. DOE then conducted a bounding analysis of the potential concentrations of contaminants to assess compliance with the ground water protection regulations. In this analysis, DOE assumed that the transport pathway for radioactive contaminants is direct from the boundary of the accessible environment to a receptor on the surface. In other words, DOE assumed for the sake of conservatism that concentrations in potential USDWs were equivalent to those in a hypothetical USDW at the land withdrawal boundary in the Salado Formation.

As a result of the bounding analysis, DOE concluded that radionuclide concentrations in the hypothetical USDW (approximately 10 picocuries per liter) would be less than EPA's maximum contaminant levels for drinking water (15 picocuries per liter), and the dose to a person drinking from the USDW (0.47 millirem) would be an order of magnitude less than the 4 millirem per year dose standard established under the Safe Drinking Water Act. DOE stated that the bounding analysis was sufficiently conservative to preclude the need for identification of underground interconnections.

EPA evaluated information contained in Chapter 8 and Appendix USDW of the Compliance Certification Application and concluded that the results of the bounding analysis were reliable. EPA identified some minor deficiencies in DOE's analysis, but determined that such deficiencies were adequately compensated for by DOE's conservative assumptions.

53.A.4 Compliance review criteria

The criteria for determining compliance with Section 194.53 are derived from the regulations for ground water protection specified in 40 CFR Part 191, Subpart C, and EPA's Compliance Application Guidance (CAG). To comply with the requirements of Section 194.53, EPA expected that the CCA would: (1) discuss the assumptions and approach used to consider USDWs as well as the uncertainty associated with the analysis; (2) indicate the estimated concentrations of radionuclides in affected USDWs in the accessible environment; (3) demonstrate that radionuclides in USDWs in the accessible environment will not exceed the maximum contaminant levels (MCLs) for radionuclides during the regulatory time period; (4) identify and characterize all USDWs in the accessible environment; (5) explain why any USDWs in the vicinity of the repository were not included in the analyses; and (6) document current and potential flow rates and direction to determine if aqueous interconnections could result in the migration of radionuclides from the repository to the accessible environment during the regulatory time frame.

EPA also noted in the CAG that "simplified models may be used to estimate radionuclide concentrations in ground water. . . if it can be shown that [they] are more conservative than more detailed and complex models. . ." (p. 68).

53.A.5 DOE METHODOLOGY AND CONCLUSIONS

DOE presented information related to compliance with Section 194.53 in Chapter 8 and Appendix USDW of the CCA. Chapter 8.1 discussed compliance with the individual protection requirements of Section 194.52, and Chapter 8.2 discussed the ground water protection requirements of Section 194.53 and whether the disposal system affects any USDWs. DOE assumed the transport pathways to be similar for both the individual and ground water protection requirements.

In Appendix USDW, DOE presented an assessment of the potential sources of ground water in the vicinity of the WIPP. Appendix USDW also included documents intended to support compliance with Section 194.53. Based on the guidance provided in 40 CFR 191.22, DOE developed three criteria to assess the presence of any USDW in the study area: (1) a minimum rate of five gallons per minute, (2) a capacity of the aquifer to maintain this rate for a 40-year duration, and (3) a maximum of 10,000 milligrams per liter of total dissolved solids (TDS); see Chapter 8 (pp. 8-12 to 8-14). DOE derived the five-gallon standard from the New Mexico State Engineer's report on water consumption for southwestern New Mexico communities (282 gallons per capita per day) and the US Census Bureau's estimate of 2.75 persons per household. Based on the three criteria DOE identified three geologic formations that could contain USDWs: the Culebra Member of the Rustler Formation, the Dewey Lake Formation, and the Santa Rosa Sandstone of the Dockum Group. The Capitan Formation and the Magenta Member of the Rustler Formation were disqualified on the basis of rate, capacity, and TDS; see Appendix USDW (pp. 17 and 23). In the case of the Capitan Formation, DOE acknowledged that the Capitan presently supplies water to the City of Carlsbad, but noted that wells closest to the WIPP site showed a concentrations of TDS far in excess of the upper limit of 10,000 milligrams per liter (Appendix USDW, p. 17).

DOE conducted a bounding assessment of contaminant concentrations that could potentially occur in a nearby USDW and doses that could be received by drinking from this contaminated source. DOE states that the results of the bounding analysis represent not realistic concentrations and doses, but maximum, conservative conditions in a hypothetical USDW; see Chapter 8 (pp. 8-4 to 8-7).

Chapter 8 states that in the simulation of the undisturbed repository, transport of ^{226}Ra and ^{228}Ra was not included because these radionuclides are not prevalent components of the projected inventory of the repository (Chapter 8.2.3.2, p. 8-15). However, an assessment of radon concentrations is required by the ground water protection regulations. To meet this requirement, DOE used the results of a tracer test to calculate a "generic" radionuclide concentration at the boundary of the accessible environment, which was then used to estimate, or scale, the ^{226}Ra and ^{228}Ra concentrations. Specifically, DOE applied the results of a tracer run of the NUTS code to determine the concentration of a generic radionuclide at the accessible environment, assuming 1 kilogram per cubic meter radionuclide concentration in the repository. Concentrations at the boundary of the accessible environment were estimated by transporting the passive tracer in the flow field generated using the BRAGFLO code for realization 1, shown in Table 8-2 of the CCA. The calculated concentration of radionuclides in brine at the accessible environment boundary by this run is 2.5×10^{-7} kilogram per cubic meter. (For explanations of NUTS, BRAGFLO, and other codes, see the discussion of Section 194.23(c) in **CARD 23—Models and Computer Codes**).

DOE then applied this scaling factor to the mass and activity loads of ^{226}Ra and ^{228}Ra projected to be in the repository at decommissioning and at 10,000 years. The mass and activity loads for ^{226}Ra and ^{228}Ra in the radionuclide inventory at decommissioning and at 10,000 years that were used in the model are shown in Table 8-4. The ORIGEN 2 code was used to calculate activity loads at 10,000 years, resulting in 94.98 curies of ^{226}Ra in CH (contact handled) and RH (remote handled) waste and 1.01 curies of ^{228}Ra in CH and RH waste. (For a description of the ORIGEN 2 code, see **CARD 23—Models and Computer Codes**.) The result of this calculation was that the quantity of maximum concentration of ^{226}Ra and ^{228}Ra in the accessible environment was 2 picocuries per liter, which is below the EPA standard of 5 picocuries per liter (40 CFR 141.15(a)). These concentrations are based on the cumulative volume of brine (441,375 cubic feet) projected by BRAGFLO to flow across the boundary of the accessible environment for up to 10,000 years.

Gross alpha particle activity, including ^{226}Ra but excluding radon and uranium, also was assessed by summing the maximum concentration values provided in Table 8-1 (p. 8-7) for ^{241}Am, ^{239}Pu, ^{230}Th, and ^{234}U. The result is a total value of 7.81 picocuries per liter (about 9 picocuries per liter if radon were included), which is below the maximum contaminant level of 15 picocuries per liter of alpha emitters in drinking water sources.

The CCA notes that the maximum concentrations of radioactive contaminants are estimated to occur at the subsurface boundary of the accessible environment, in the anhydrite interbeds of the Salado Formation. The Salado is not a realistic source of drinking water because its average concentration of TDS (324,000 mg per liter) is much higher than EPA's definition of USDWs as containing fewer than 10,000 mg TDS per liter (Chapter 8, p. 8-8).

To assess annual dose equivalent from the average annual concentration of beta particle and photon radioactivity, DOE considered the transport of ^{239}Pu, ^{238}Pu, ^{230}Th, and ^{234}U. The maximum annual dose for these radionuclides resulting from DOE's modeling was 0.47 millirems (see Table 8-2, p. 8-9). This value, which includes beta, photon, and alpha radiation, is an order of magnitude below the dose standard of 4 millirem established by the Safe Drinking Water Act, which considers only beta and photon radiation.

DOE stated that the bounding analysis resulted in an overestimation of potential doses and contaminant concentrations (p. 8-7). DOE concluded that (1) the assumption of a USDW in the accessible environment is conservative, (2) the maximum concentration of contaminants in the hypothetical USDW would be less than half the EPA ground water protection limits, and (3) the maximum potential dose to a receptor who drinks from the USDW would be an order of magnitude less than the standard (p. 8-17). Moreover, because the bounding analysis assumes that all contaminants reaching the accessible environment are directly available to the receptor, the interconnections of surface, ground, and underground drinking water are treated as one USDW source. This conservative assumption obviates the need to consider underground aqueous connections (p. 8-18).

53.A.6 EPA COMPLIANCE REVIEW

In assessing whether the CCA demonstrates compliance with Section 194.53, EPA: (1) examined whether the approaches and assumptions associated with DOE's USDW identifications, including the uncertainty associated with these analyses, were accurate and sufficiently supported; (2) evaluated all possible aquifers to determine whether USDWs were properly identified and described within the CCA; (3) examined the CCA to determine whether accurate and appropriate flow rates and directions were provided in supporting materials; (4) investigated in detail the modeling assumptions and specifications for the bounding analysis to assess the reliability and safety assurance aspects of the outcome; and (5) reviewed the estimated concentrations of radionuclides to determine that they were conservative and that the margin of error was adequate to ensure that the ground water protection standard was met.

EPA determined that the outcome of the bounding analysis, which employed the tracer exercise and the flow field generated by BRAGFLO, was reliable and the assumptions were conservative. The gross alpha activity—even when the highest realization values for each radionuclide were summed—was less than 10 picocuries per liter, which is below the standard of 15 picocuries per liter. The maximum annual dose for all alpha, beta, and gamma radiation (0.47 millirem) was about an order of magnitude less than the 4 millirem per year dose standard for beta and gamma radiation alone.

EPA noted that the bounding concentration of alpha radionuclides (about 9 picocuries per liter) does not allow for a large margin of error, being less than a factor of two under the MCL of 15 picocuries per liter for alpha emitters. Similarly, the calculated maximum annual exposure for all radiation (0.47 millirem) is only one order of magnitude less than the standard, and this relatively small margin of error could be significantly reduced if changes have to be made to the performance assessment containment requirements or results. However, DOE's calculated concentrations took into account numerous conservative assumptions (e.g., direct accessibility to a USDW of brine at the subsurface boundary of the accessible environment). As such, EPA concluded that the margins of error between DOE's estimates and the standards are acceptable.

DOE identified three potential rock units in the WIPP area that could contain USDWs: the Culebra Member of the Rustler Formation, the Dewey Lake Formation, and the Santa Rosa Sandstone of the Dockum Group. The methodologies used by DOE to identify these aquifers were somewhat inconsistent, and the specific locations of the aquifers, as well as the possibility for aquifer interaction and interconnection, could be questioned. EPA found, however, that DOE sufficiently mitigated these concerns by assuming that water within the Salado interbeds was available for immediate consumption at the boundary of the accessible environment (following dilution of Salado waters to the standard of 10,000 mg TDS per liter of drinking water, which is unlikely), and by assuming that an interconnection between the Salado interbeds and the potential drinking water receptor is available. In other words, DOE's assumptions that USDWs are present in the area of the WIPP and that brine is immediately available for consumption following dilution compensate in the analysis for a non-definitive characterization of the extent of USDWs in the area of the WIPP. In addition, no transport of radionuclides from the WIPP to the potential USDWs identified by DOE is expected even under disturbed conditions (i.e., in the event of human intrusion). This finding eliminates the Culebra, Dewey Lake, and Santa Rosa Formations as potential pathways (DOE 1997, p. 1-3).

The CAG stated EPA's expectation that the CCA would contain maps showing the location of USDWs. EPA's initial review of the CCA revealed that DOE had not included these maps. In a letter to DOE dated December 19, 1996, EPA specified that "the CCA needs to include appropriate maps of USDWs using plan views with information such as township, range, and estimated latitude and longitude of the center of the USDW" (Docket A-93-02, Item II-I-01, Enclosure 1, p. 19). DOE responded to EPA's letter with supplementary information dated February 26, 1997 (Air Docket A-93-02, Item II-I-10, Enclosure 1j). The supplementary information contained a map showing the boundaries nearest the WIPP of potential USDWs in the Culebra, Santa Rosa, and Dewey Lake Formations. DOE argued that available data are not sufficient to indicate the center of these potential USDWs. EPA found the map to be sufficient for purposes of compliance assessment because it identified potential USDWs near the WIPP. As noted above, no radionuclides from the WIPP are expected to reach any of the potential USDWs identified by DOE.

53.B References

DOE 1997. U.S. Department of Energy. Summary of the EPA-Mandated Performance Assessment Verification Test Results for the Individual and Groundwater Protection Requirements. WPO#47258. September 12, 1997. (Docket A-93-02, Item II-G-39)