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SUPERSEDED
BY 532974 12/15/03 RH

date: November 6, 2003

to: Cliff Hansen (6821)

from: Steve W. Wagner (6821)

subject: Calculation of Combined ^{226}Ra and ^{228}Ra concentrations at boundary for Chapter 8 Compliance Assessment.

Technical review: Joshua Stein (6852) Mario Chavez for

QA review: Mario Chavez (6820) Mario Chavez

The following routine calculation provides an estimate of the combined ^{226}Ra and ^{228}Ra concentration at the Waste Isolation Pilot Plant (WIPP) Land Withdrawal Boundary (LWB) for the Compliance Recertification Application (CRA) Chapter 8, compliance assessment (40 CFR § 141.15(a)). This calculation follows the procedure outlined in the Compliance Certification Application (CCA) (DOE, 1996), and includes a correction identified during the Performance Assessment Verification Test (PAVT) (SNL, 1997). An analysis of ^{226}Ra and ^{228}Ra is required to evaluate compliance with the groundwater protection standards. Performance assessment (PA) calculations do not explicitly track Radium so an alternate method, described in the CCA was used to derive a conservative estimate of the potential Radium concentration in the groundwater outside the WIPP LWB for the undisturbed scenario. The following section describes the process used to calculate the combined ^{226}Ra and ^{228}Ra concentration for the CRA based on the procedure followed in the PAVT. The concentration calculated by this method is below the 5 picocuries per liter regulatory limit. This method is conservative, in part because the brine calculated to cross the LWB in 10,000 years is likely not to have originated in the repository, instead this brine was initially present in the marker beds. This method does not account for dilution, which would certainly occur due to significant dispersion during transport. However, in order to have a quantitative bounding estimate to compare to the protection standards, a method was derived for the CRA even though the estimated concentrations likely only represent numerical dispersion effects that greatly overestimate concentrations.

Chapter 8 of the CCA defines the procedure to determine the combined ^{226}Ra and ^{228}Ra concentration as follows:

> The total concentration (CH and RH) of either ^{226}Ra or ^{228}Ra at 10,000 years at the accessible environment boundary is calculated accordingly:

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1. Calculate the total mass load at 10,000 years by multiplying the total mass load at decommissioning by the ratio of activity loadings at 10,000 years and decommissioning, respectively.
2. Calculate the total mass concentration at the accessible environment boundary by dividing by the value of brine from the BRAGFLO simulation and multiplying by the scaling factor.
3. Convert to total concentration of activity at the accessible environment boundary by multiplying by the ratio of activity loading to mass loading at decommissioning.

The EPA mandated PAVT results included another assessment of Radium concentrations that recognized an error in the original CCA analysis. The PAVT analysis recalculated the Radium concentration using the brine volume originating in the repository instead of the brine volume that crossed the boundary over 10,000 years. Also, the PAVT analysis included a dilution factor (equal to 32.4 [SNL 1997]), which was necessary to account for the dilution required in order that the brine in the Culebra aquifer meets the 10,000 parts per million total dissolved solids drinking water standard . This dilution factor was used in all other groundwater dose calculations except the Radium calculation in the CCA. The PAVT analysis calculated a concentration of 0.14 picocuries per liter for the PAVT where the CCA calculated 2 picocuries per liter.

The following calculates the combined ^{226}Ra and ^{228}Ra concentration using the PAVT procedure and the updated inventory information used in the CRA Chapter 8 compliance assessment.

For the CRA, the Radium inventory is shown in Table 1 below.

Table 1
Total Inventory and Mass Loading of ^{226}Ra and ^{228}Ra [(a)]

Radionuclide	Waste Type	Total Inventory at Decommissioning (curies)	Total Inventory at 10,000 Years (curies)	Mass Loading at Decommissioning (kilograms)	Mass Loading at 10,000 years (kilograms)
^{226}Ra	CH	6.28×10^{0}	4.98×10^{1}	6.35×10^{-3}	5.04×10^{-2}
^{226}Ra	RH	4.99×10^{-5}	1.63×10^{0}	5.05×10^{-8}	1.65×10^{-3}
^{228}Ra	CH	7.63×10^{0}	7.70×10^{0}	2.81×10^{-5}	2.83×10^{-5}
^{228}Ra	RH	2.51×10^{-1}	2.54×10^{-1}	9.23×10^{-7}	9.34×10^{-7}
Total	CH+RH	1.42×10^{1}	5.94×10^{1}	6.38×10^{-3}	5.21×10^{-2}

(a) Source: Leigh (2003)

Step 1

[Total mass of Ra at 10,000 yrs (from Leigh 2003) ÷ Total brine volume in the repository at time = 0] × Scaling Factor = Concentration of Ra (kg/m^3) at LWB at 10,000 yrs.

The brine volume at time = 0 is 5,577 m^3. This volume is calculated as the product of three parameters: the initial volume of the waste-filled repository (Material: REFCON, Property:

VREPOS) (438,406 m^3), the initial brine saturation (Material: WAS_AREA, Property: SAT_IBRN) (0.015), and initial porosity (Material: WAS_AREA, Property: POROSITY) (0.848).

The NUTS screening tracer analysis scaling factor is 1.025×10^{-7} ($kg/m^{3)}$ / (kg/m^3) (Garner 2003).

$[5.21 \times 10^{-2}$ kg ÷ 5,577 $m^3] \times 1.025 \times 10^{-7} = 9.58 \times 10^{-13}$ kg/m^3

Step 2

Concentration of Ra at boundary at 10,000 yrs. × total curies of ^{226}Ra and ^{228}Ra at decommissioning ÷ total mass of ^{226}Ra and ^{228}Ra at decommissioning ÷ 1,000 liters per cubic meter = concentration at boundary (curies per liter)

9.58×10^{-13} $kg/m^3 \times [14.2$ curies ÷ 6.38×10^{-3} kg] ÷ 1,000 $l/m^3 = 2.13 \times 10^{-12}$ curies per liter

Step 3

The concentration derived in step 3 is divided by the dilution factor of 32.4.

2.13×10^{-12} curies per liter ÷ 32.4 = 6.58×10^{-14} curies per liter

Approximately = 0.07 picocuries per liter

These calculations were performed under AP-99 to NP-9-1.

References:

DOE 1996. "Title 40 CFR Part 191 Compliance Certification Application for the Waste Isolation Pilot Plant," DOE/CAO-1996-2184, U.S. Department of Energy, October 1996.

Garner, J. W. 2003. "CRA Marker Bed Concentrations," Memo to Record, ERMS# 532402. Albuquerque, NM: Sandia National Laboratories. October 16, 2003.

Leigh, C.L. 2003. "Calculation of Decayed Radionuclide Inventories for the Compliance Recertification Application," ERMS# 530992, Albuquerque, N M: Sandia National Laboratories.

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date: December 1, 2003

to: Cliff Hansen (6821)

from: Steve W. Wagner (6821)

subject: Revision 1 to November 6, 2003 Memo (ERMS# 532804) titled: Calculation of Combined ^{226}Ra and ^{228}Ra concentrations at boundary for Chapter 8 Compliance Assessment.

Technical review: Joshua Stein (6852)
Tom Pfeifle (6822)

QA review: Mario Chavez (6820)
Mary Mitchell (6820)
10 Dec 03

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