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SOLUBILITY LIMITS ON RADIONUCLIDE DISSOLUTION AT A YUCCA MOUNTAIN REPOSITORY

by

Jerry F. Kerrisk

ABSTRACT

This report examines the effects of solubility in limiting dissolution rates of a number of important radionuclides from spent fuel and high-level waste. Two simple dissolution models were used for calculations that are characteristic of a Yucca Mountain repository. A saturation-limited dissolution model, in which the water flowing through the repository is assumed to be saturated with each waste element, is very conservative in that it overestimates dissolution rates. A diffusion-limited dissolution model, in which element-dissolution rates are limited by diffusion of waste elements into water flowing past the waste, is more realistic, but it is subject to some uncertainty at this time. Dissolution rates of some elements (uranium, plutonium, americium, and tin) are limited by solubility. Dissolution rates of other elements (cesium, technetium, neptunium, strontium, radium, and carbon) are not solubility limited; their release would be limited by dissolution of the bulk waste form. This report also presents calculated radionuclide dissolution rates and concentrations in water leaving the waste form.

I. INTRODUCTION

The most likely mechanism for release of radionuclides from a geologic repository is transport in water along flow paths to the accessible environment. This process involves the dissolution or breakup of the solid waste form as a result of contact with water at the repository and the transport of waste elements as dissolved species or in particulate form by the movement of water away from the repository. The Environmental Protection Agency (EPA) is setting standards to control the release of radionuclides to the accessible

environment. These standards, in their present form, place limits on the amounts of specific radionuclides that can be released in a given time period.[1] The Nuclear Regulatory Commission (NRC) will enforce these standards and define technical criteria for the disposal of radioactive wastes in geologic repositories.[2] To meet the regulations and requirements of the EPA and NRC, it will be necessary to mathematically model the transport of radionuclides in water that moves through the repository and the surrounding geologic environment. As input to the transport models, it is necessary to define the mechanisms that control the rate of release of radionuclides from the solid waste to the water or that control the concentrations of radionuclides in water near the waste. This report describes two simple solubility-limited dissolution models that can be used to calculate the release rates of radionuclides from a solid waste form into water as dissolved species. To calculate dissolution rates, both models use individual waste-element solubilities and other parameters describing the repository and waste form.

The range of solubilities of the various waste elements (activation products, fission products, and actinides) is quite large. Solubility depends on the chemistry of the element, water temperature, and water composition; water composition is important because speciation (the formation of various oxidation states and aqueous complexes with other dissolved species) significantly affects solubility. Cesium, an element with fission-product radionuclides, is very soluble in water; it is unlikely that cesium solubility will limit the concentration of cesium under any conditions. Technetium, another element with fission-product radionuclides, is very soluble under oxidizing conditions but relatively insoluble under reducing conditions. Other elements such as americium or plutonium should be relatively insoluble under most conditions. The primary purpose of this work is to estimate the effect of element solubilities on dissolution rates of elements from a solid waste form. If solubilities are important, a significant experimental effort to measure them can be justified. If solubilities are not important parameters in determining release rates, estimates may be sufficient.

A number of experimental investigations have indicated that solubility may be the process that controls the dissolution or leaching rate of waste elements from a solid waste form.[3-5] However, the actual rate-limiting mechanisms are still uncertain. Two simple dissolution models are employed in

this analysis. The first is a saturation-limited dissolution model, in which water flowing through the repository area is assumed to be saturated with each element. This is a very conservative model because it is highly unlikely that adequate contact between the water and waste (enough to saturate all the water) could be obtained. The second model is a diffusion-limited dissolution model in which element saturation is assumed at the waste/water interface and dissolution is limited by diffusion of the element into water flowing past the waste. This model requires assumptions about waste containers, water flow characteristics and velocity, and element diffusivities; thus, it is subject to more uncertainty. Neither model accounts for the effects of other parts of the engineered barrier system or of componants such as spent-fuel cladding in limiting waste-element dissolution. These constraints lead to conservative estimates of element-dissolution rates.

It is unrealistic to assume solubility-limited dissolution rates for certain elements; for example, cesium. The dissolution rates of these elements will be limited by the dissolution rate of the bulk waste form (congruent dissolution), whether it is spent fuel, borosilicate glass, or some other solid. In the models used here, each element's fractional dissolution rate (fraction of remaining element dissolved per unit of time) calculated from solubility considerations is compared with an assumed bulk waste-form fractional dissolution rate. If the element's solubility-limited fractional dissolution rate is larger than the bulk fractional dissolution rate, the bulk fractional dissolution rate is used for that element. This procedure assumes that elements that are not solubility limited will dissolve congruently; that is, at the same rate as the bulk waste form. Under certain circumstances this assumption may not be valid. During irradiation, some fission products such as iodine and cesium migrate to cooler parts of the fuel element; they collect in the gap between fuel and cladding and in the element plenum.[6] When spent fuel is the waste form, both iodine and cesium could be released at rates greater than the bulk waste-form fractional dissolution rate; however, that problem is not addressed in this analysis.

The two solubility-limited dissolution models have been applied to calculations of waste-element dissolution rates from solid waste forms at the Nevada Nuclear Waste Storage Investigations (NNWSI) proposed site for a geologic repository at Yucca Mountain, Nevada. The present target horizon for a repository at Yucca Mountain is above the static water level (in the

unsaturated zone), in a densely welded, devitrified tuff. Formation water from the target horizon is not available at this time. Water from Well J-13 on the Nevada Test Site, the nearest producing well, has been chosen as a reference water by the NNWSI program.[7] Water of this composition was used to estimate waste-element solubilities. The recharge rate of water at Yucca Mountain, which was used to calculate water flow rates and velocities, was obtained from a US Geological Survey estimate.[8] At this time, it is not clear what types of waste will be stored in a geologic repository. The two most likely are spent fuel (probably as zircaloy clad, UO_2 fuel elements) or high-level waste, which contains the waste from reprocessing spent fuel. High-level waste will probably be loaded into borosilicate glass, which will be the solid waste form. Calculations have been done for both spent fuel and high-level waste. Because the two types of waste contain different quantities of radioactive material, their solubility-limited dissolution rates can be different.

The following sections of this report describe (1) the assumed solubilities of elements in water at Yucca Mountain, (2) the saturation-limited dissolution model, (3) the diffusion-limited dissolution model, and (4) the calculated element dissolution rates and concentrations in water passing through the repository. A comparison of element solubility-limited dissolution rates with bulk waste-form dissolution rates indicates which elements may be controlled by solubility limits.

II. ELEMENT SOLUBILITIES

Solubilities were estimated for a number of important waste elements in water that is characteristic of Yucca Mountain. Analyses from Well J-13 were used to define water composition,[7] which is listed in Table I. The water pH was taken as 7. Oxidizing conditions (Eh of 700 mV) were assumed because present indications are that water in the unsaturated zone and upper portions of the saturated zone at Yucca Mountain may be oxidizing.[9] This assumption leads to higher solubilities for a number of elements than would occur under mildly or strongly reducing conditions.

The EQ3/6 chemical equilibrium computer programs are being used by the NNWSI program for solubility calculations.[10] At this time, however, thermodynamic data are available in the EQ3/6 data base for only a few of the important waste elements. Solubility calculations were done for americium,

TABLE I

WELL J-13 WATER COMPOSITION[a]

Species	Total Amount (mg/ℓ)
Na	45.2
K	5.47
Ca	11.5
Mg	1.73
Al	0.026
SiO_2	64.2
Sr	0.04
Ba	0.0023
Mn	0.0011
Fe	0.044
V	0.0425
Cl^-	6.4
SO_4^{2-}	18.1
F^-	2.1
NO_3^-	10.1
HPO_4^{2-}	0.10
HCO_3^-	143

[a]Average of six analyses from 6/18-51 to 6/18-56 (Ref. 7). The pH = 7; Eh = 700 mV.

plutonium, uranium, and strontium using EQ3/6. For cesium, technetium, and carbon, solubility limits were assumed to be so large that their dissolution rates would always be limited by bulk waste-form dissolution. Solubilities for radium, tin, and neptunium were estimated from reviews by Apps et al.[11] and Allard.[12] In both reviews, water compositions similar to those at Yucca Mountain were used for solubility calculations. Table II lists the solubilities employed in this study. The solubility of amorphous SiO_2 is included for estimates on bulk glass dissolution rates. The 10 waste elements account for ~99% of spent fuel activity at 1000 years after discharge from the reactor.

III. SATURATION-LIMITED DISSOLUTION MODEL

For the saturation-limited dissolution model, the flow rate of water through the repository area was estimated using an assumed maximum thermal loading for the repository and an assumed water recharge rate. At 10 years after discharge, the decay heat of pressurized water reactor (PWR) spent fuel is 1135 W/MTHM (watts per metric ton of heavy metal) (1 MTHM = 1000 kg of heavy metal); the decay heat of PWR high-level waste is 960 W/MTHM.[13] Assuming a maximum thermal loading of 10 W/m^2 and spent-fuel as the waste form, a repository would require 114 m^2 for each MTHM. The recharge rate of water through the unsaturated zone at Yucca Mountain was estimated as 8 mm/year.[8] At this rate, a water flow of 910 ℓ/year would pass through the horizontal area of 114 m^2 that is associated with each MTHM of waste. The saturation-limited dissolution model assumes that each element is at its solubility limit in this quantity of water or is limited by dissolution of the bulk waste form, whichever assumption gives the lower dissolution rate. From these assumptions, the fractional dissolution rate of an element is calculated as

$$F_S = QSM/W \quad , \tag{1a}$$

if $(QSM/W) \leq F_B$; otherwise

$$F_S = F_B \quad , \tag{1b}$$

where Q is the water flow rate (ℓ/year MTHM), S is the solubility (M), M is the molecular weight (g/mole), W is the element mass in the waste (g/MTHM),

TABLE II

SOLUBILITIES OF WASTE ELEMENTS

Element	Solubility (M)
Am	1.0×10^{-8}
Pu	1.8×10^{-6}
U	2.1×10^{-4}
Sr	9.4×10^{-4}
C	large
Cs	large
Tc	large
Np[a]	3.0×10^{-3}
Ra[b]	1.0×10^{-7}
Sn[b]	1.0×10^{-9}
SiO_2 (amor)[c]	1.0×10^{-3}

[a] Ref. 11.

[b] Ref. 12.

[c] SiO_2(amor) solubility is 2.0×10^{-3} M, but Well J-13 water contains 1.0×10^{-3} M. The capacity for additional dissolution is only 1.0×10^{-3} M.

F_B is the fractional dissolution rate assumed for the bulk waste form (1/year), and F_S is the fractional dissolution rate of the element as calculated by the model (1/year). After the value of F_S is established, other quantities of interest can be calculated as

$$D_S = F_S W \quad , \tag{2}$$

$$R_S = F_S W f_C \quad , \tag{3}$$

and

$$C_S = F_S W/QM \quad , \tag{4}$$

where D_S is the element dissolution rate (g/MTHM year), f_C is the radioactivity content of the element in the waste (Ci/g), R_S is the radioactivity release rate (Ci/MTHM year), and C_S is the concentration of the element in water leaving the repository (M). If $(QSM/W) \leq F_B$, then the concentration equals the solubility; that is, $C_S = S$. However, if $(QSM/W) > F_B$, the concentration is assumed to be controlled by bulk dissolution of the waste, and $C_S < S$. The concentrations of specific isotopes such as ^{243}Am or ^{90}Sr in the water are needed for transport calculations; they can be calculated as

$$C_S(j) = C_S W_j M/WM_j \quad , \tag{5}$$

where $C_S(j)$ is the concentration of isotope j (M), M_j is the molecular weight of isotope j (g/mole), and W_j is the mass of isotope j in the waste (g/MTHM). The radioactivity release rate of isotope j can be calculated as

$$R_S(j) = C_S(j) Q W_j f_C(j) \quad , \tag{6}$$

where $f_C(j)$ is the radioactivity content of isotope j in the waste (Ci/g). Values of f_C, $f_C(j)$, W, and W_j were obtained from the compilation of Croff and Alexander.[13] These data are a function of time after discharge from the reactor because of the different decay rates of the various isotopes of each element.

The saturation-limited dissolution model is very conservative in that it overestimates dissolution rates of elements. Although waste elements may be saturated in water flowing near the surface of the waste form, diffusion will

significantly limit concentrations in water that is midway between waste containers. Thus, the rate of removal of radionuclides from the repository and radionuclide concentrations in the water will be less than calculated by this model. A more realistic assessment of solubility controls on radionuclide dissolution is presented in the following section.

IV. DIFFUSION-LIMITED DISSOLUTION MODEL

In the diffusion-limited dissolution model, waste elements are assumed to be saturated at the interface between the waste and water flowing past. Dissolution is limited by diffusion of the waste elements into the water.[14] A simple, one-dimensional diffusion model was used to estimate the quantity of a diffusing species that enters the water. Figure 1 shows the geometry of the model; water in porous flow moves downward, past the surface of a solid waste form. If the concentration of an element is held at C_o on the waste surface, the concentration in the water at a distance x from the surface at a time t after contact starts is

$$C = C_o \left(\text{erfc}[x/2(Dt)^{1/2}]\right) \quad , \tag{7}$$

where D is the apparent diffusion coefficient of the element in water and erfc(y) represents the complementary error function of y.[15,16] A penetration depth (δ) can be defined such that the average concentration within δ of the surface is C_o,

$$\delta C_o = \int_o^\infty C dx \quad . \tag{8}$$

From this relation, δ can be approximated[16] as

$$\delta \simeq 1.1 (Dt)^{1/2} \quad . \tag{9}$$

If water is flowing past the waste at a velocity v, the contact time for a length L is $t = L/v$. Thus, δ evaluated at the bottom of the waste is

$$\delta \simeq 1.1 (DL/v)^{1/2} \quad . \tag{10}$$

Figure 1 shows how δ increases along the length of the waste.

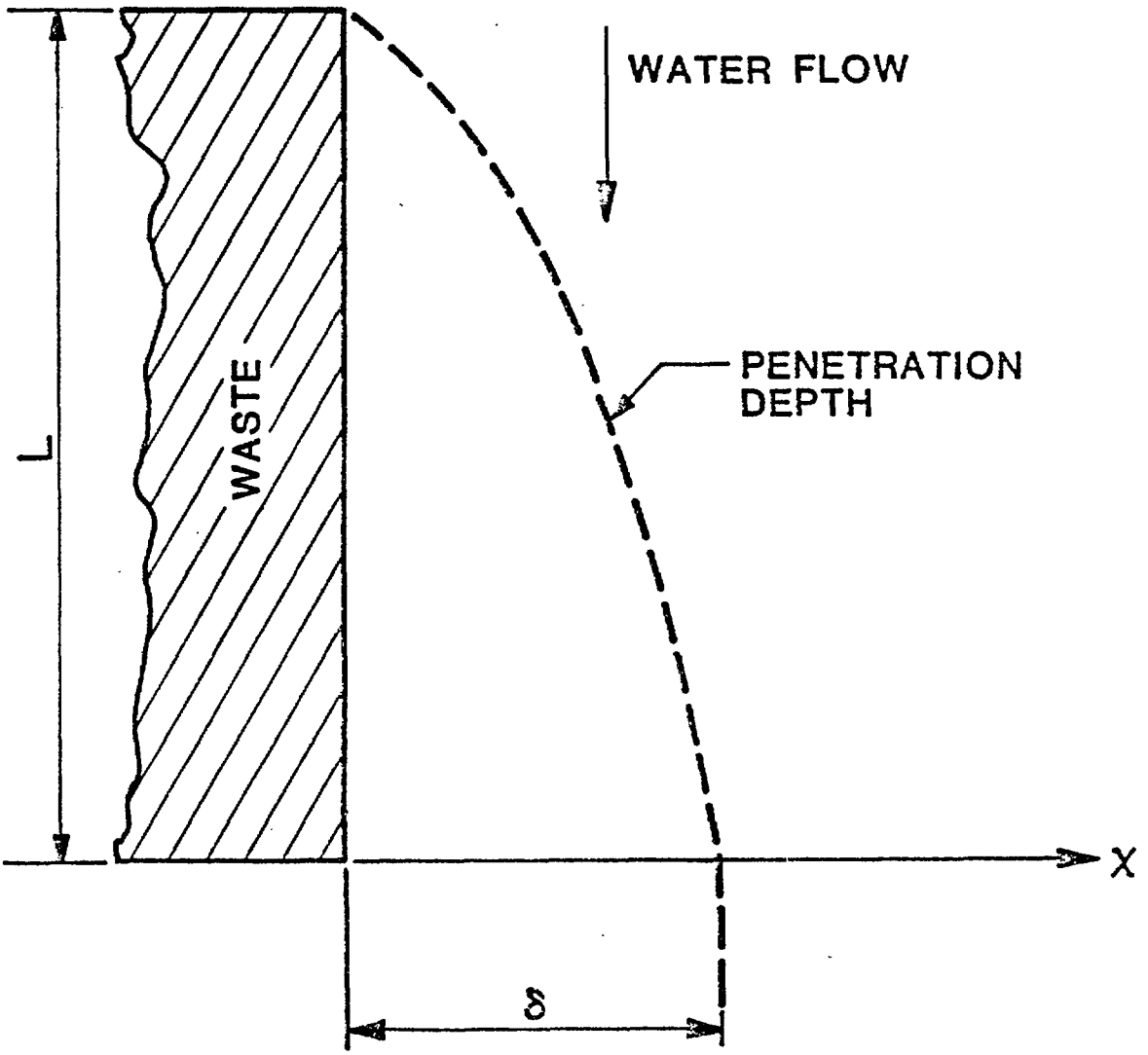

Fig. 1. Geometry of the diffusion-limited dissolution model.

The quantity of an element removed from the waste in a given time is the quantity passing through the plane at the bottom of the waste in that time (see Fig. 1). The diffusion-limited dissolution model assumes that this quantity can be calculated as the quantity of the element that has diffused into the water during its passage by the solid waste or as the quantity removed by dissolution of the bulk waste form, whichever assumption gives the lower dissolution rate. From these assumptions, the fractional dissolution rate of an element is calcuated as

$$F_D = SM\delta Z\varepsilon v/W \quad , \tag{11a}$$

if $(SM\delta Z\varepsilon v/W) \leq F_B$; otherwise,

$$F_D = F_B \quad . \tag{11b}$$

In these equations, Z is the waste-form dimension that is perpendicular to the water flow direction (LZ is the solid waste area), ε is the porosity of the rock, and F_D is the fractional dissolution rate of the element as calculated by the diffusion-limited dissolution model. Because the diffusion-limited dissolution model results in lower element-dissolution rates than the saturation-limited dissolution model does, it is generally true that

$$F_D \leq F_S \quad .$$

They are equal only when they both equal F_B, the bulk waste-form fractional dissolution rate. In that case, neither model limits element dissolution beyond what would be expected from bulk waste dissolution rates. After the value of F_D is established, the other quantities of interest can be calculated in the same manner as those for the saturation-limited dissolution model. Thus, the element-dissolution rate (D_D), the radioactivity release rate (R_D), the element concentration (C_D), the isotope concentration [$C_D(j)$], and the radioactivity release rate of isotope j [$R_D(j)$] can be calculated using Eqs. (2), (3), (4), (5), and (6), respectively, with F_D and C_D in place of F_S and C_S.

All dissolved species were assumed to have an apparent diffusion coefficient of 1×10^{-10} m^2/second (Ref. 7). This value results from assuming an ionic diffusion coefficient (D_i) of 1×10^{-9} m^2/second with connectivity α and tortuosity τ defined[16] so that

$$D = D_i(\alpha/\tau^2) = 0.1\ D_i \quad .$$

This model implicitly assumes that continuous water flow paths exist so that dissolved species can diffuse away from the solid waste surface. It is not clear whether water flow paths are continuous or discontinuous in the unsaturated zone where the repository is expected to be located. The assumption of continuous water flow paths is conservative in that it may overestimate the apparent diffusion coefficients. The porosity of the rock

surrounding the waste form was assumed to be 10% ($\varepsilon = 0.1$). Even though water movement in the repository horizon (Topopah Spring Member) may be mostly by fracture flow, it is not unreasonable to assume porous flow occurs around the waste canisters, where the backfill rather than the host rock will establish the flow conditions. The velocity of water flowing by the waste was taken as the recharge rate (8 mm/year) divided by the porosity of the rock; this gives $v = 8 \times 10^{-2}$ m/year. Using these nominal values of the parameters in Eq. (10) produces a penetration depth of 0.45 m.

In this model, dissolution rates depend on the size and shape of the solid waste form. The assumed solid waste size differed for spent fuel and high-level waste. For spent fuel, a solid waste that is 0.25-m radius by 4.5 m long (L = 4.5 m) containing 3 MTHM was assumed. For high-level waste, a solid waste that is 0.16-m radius by 3 m long (L = 3.0 m) containing 2 MTHM was used. The ratio of solid surface area per MTHM to water volume associated with one MTHM in a year (0.91 m^3) is approximately 2 $(m)^{-1}$. Flow was in the axial direction. For spent fuel, $Z = 2\pi(0.25) = 1.57$ m and for high-level waste, Z = 1.0 m. The use of a one-dimensional diffusion solution for a cylindrical waste form introduces some error into the results; however, the error is not large compared to uncertainties in solubilities, and the one-dimensional solution simplifies the analysis.

The model, as constituted so far, assumes that all flow is around the outside of the waste form. However, spent fuel will not be stored in large monolithic blocks, and borosilicate glass blocks may crack over long periods of time. To account for flow through the waste form, the volumetric flow rate of water through the waste was added to the volumetric flow rate inside the penetration depth [$\delta Z \varepsilon v$ in Eq. (11a)]. This modification increases fractional dissolution rates for this model by ~15% when the nominal values of the model parameters described in the preceding paragraph are used.

V. RESULTS

Calculations were done for both PWR spent fuel and PWR high-level waste, and at four times after discharge from the reactor: 100, 1000, 10 000, and 100 000 years. Most of the results are for the nominal model parameters that were described in the previous three sections. In addition, results are presented in which the bulk fractional dissolution rate F_B, solubilities, and water recharge rates are varied to assess the influence of these parameters on calculated dissolution rates and radioactivity release rates.

TABLE III

NOMINAL PARAMETER VALUES

Parameter	Value
Q	910 ℓ/MTHM year
F_B	1×10^{-4}/year
Spent-fuel waste	
Radius	0.25 m
L	4.5 m
Content	3.0 MTHM
High-level waste	
Radius	0.16 m
L	3.0 m
Content	2.0 MTHM
D	1.0×10^{-10} m^2/second
ε	0.1
v	8×10^{-2} m/year

A. Results from Nominal Parameters

The choices of nominal parameter values for these models were discussed in the sections describing element solubilities and the two dissolution models. The element solubilities are summarized in Table II; the other nominal parameters are listed in Table III. Detailed results that list fractional dissolution rates (F_S and F_D), element dissolution rates (D_S and D_D), radioactivity release rates (R_S and R_D), element concentrations (C_S and C_D), isotope radioactivity release rates [$R_S(j)$ and $R_D(j)$], and isotope concentrations [$C_S(j)$ and $C_D(j)$] are presented in the Appendix. Summariess of total radioactivity release rates are also included. As an example of the results in the Appendix, Table IV lists the element dissolution rates for four elements (americium, neptunium, plutonium, and technetiuim) for PWR spent fuel at 1000 years after discharge. For americium and plutonium, the dissolution rates are about a factor of 400 lower for the diffusion-limited dissolution

model than for the saturation-limited model. For technetium and neptunium, the dissolution rates are the same for both models. These results reflect the fact that americium and plutonium exhibit solubility-limited dissolution in both models, but neptunium and technetium are released at the bulk dissolution rate; that is, they dissolve congruently with the solid waste.

Table V lists the waste elements that show solubility-limited dissolution rates less than the bulk dissolution rate F_B. For spent fuel, uranium, plutonium, americium, and tin are solubility limited in the saturation-limited dissolution model; radium is added to the list in the diffusion-limited dissolution model. For high-level waste, only tin and americium are solubility limited in the saturation-limited dissolution model; whereas tin, americium, plutonium, and uranium are solubility limited in the diffusion-limited dissolution model. For some of these elements, solubility limits do not apply at all times after discharge. The primary difference between spent fuel and high-level waste is that 99.5% of the uranium and plutonium are removed during reprocessing of the spent fuel to produce high-level waste. The smaller quantities of uranium and plutonium (and in some cases other actinides) make it more difficult for these elements to exhibit solubility limits in high-level waste. More elements show solubility-limited dissolution with the diffusion-limited model because dissolution rates are lower in this model and more likely to be less than the bulk dissolution rate.

TABLE IV

SPENT-FUEL ELEMENT-DISSOLUTION RATES AT 1000 YEARS AFTER DISCHARGE

	Element-Dissolution Rate (g/MTHM year)	
	Saturation-Limited Dissolution Model	Diffusion-Limited Dissolution Model
Am	2.2×10^{-3}	5.3×10^{-6}
Np	1.4×10^{-1}	1.4×10^{-1}
Pu	3.9×10^{-1}	9.5×10^{-4}
Tc	7.7×10^{-2}	7.7×10^{-2}

TABLE V

ELEMENTS EXHIBITING SOLUBILITY-LIMITED

DISSOLUTION RATES LESS THAN THE BULK DISSOLUTION RATE[a]

Spent Fuel		High-Level Waste	
Saturation-Limited Model	Diffusion-Limited Model	Saturation-Limited Model	Diffusion-Limited Model
Pu[b]	Pu	Sn	Sn
Sn	Sn	Am[b]	Pu
U	U		U
Am[b]	Am[b]		Am[b]
	Ra[b]		

[a]Bulk fractional dissolution rate $F_B = 1 \times 10^{-4}$/year.

[b]Not solubility limited for all four times after discharge.

Of the other waste elements studied here, it was assumed that cesium, technetium, and carbon did not have solubility limits (see Table II). Thus, they are released at the bulk dissolution rate. The solubilities of strontium and neptunium were relatively high, which is the reason these elements do not exhibit solubility-limited dissolution rates. Radium has a relatively low solubility, but it is present in such small quantities (1 g/MTHM in spent fuel and 25 mg/MTHM in high-level waste at 100 000 year) that solubility limits apply under only one condition: spent fuel at 100 000 years for the diffusion-limited dissolution model. The high solubilities taken for uranium, neptunium, and technetium are mainly caused by the assumption of high Eh (oxidizing conditions) in the water. Solubilities of these elements may decrease along flow paths away from a repository at Yucca Mountain if water with lower Eh is encountered. The oxidizing conditions were assumed because this analysis deals only with conditions in the unsaturated zone at the repository.

The total radioactivity release from a solid waste form provides an overall measure of the difference between the two dissolution models employed here. Table VI lists the repository inventory and primary isotopes that

TABLE VI

REPOSITORY INVENTORY

	PWR Spent Fuel				PWR High-Level Waste			
	10^2 years[a]	10^3 years	10^4 years	10^5 years	10^2 years	10^3 years	10^4 years	10^5 years
Repository inventory (Ci/MTHM)								
Activation products	321	8.4	6.4	2.5	321	8.4	6.4	2.5
Actinides	6.79×10^3	1.72×10^3	443	38.7	321	82.7	20.5	2.5
Fission products	3.39×10^4	19.3	18.6	14.3	3.35×10^4	19.2	18.5	14.2
Total	4.10×10^4	1.75×10^3	468	55.5	3.41×10^4	110	45.4	19.2
Primary radioactive isotopes (% activity)								
	^{137}Cs (49)[b]	^{241}Am (51)	^{239}Pu (51)	^{239}Pu (32)	^{137}Cs (58)[b]	^{241}Am (38)	^{99}Tc (28)	^{99}Tc (49)
	^{90}Sr (34)[b]	^{240}Pu (27)	^{240}Pu (39)	^{99}Tc (17)	^{90}Sr (41)[b]	^{243}Am (14)	^{243}Am (15)	^{93}Zr (18)[b]
	^{241}Am (9)	^{239}Pu (17)	^{99}Tc (3)	^{93}Zr (6)[b]		^{239}Np (14)	^{239}Np (15)	^{59}Ni (11)
	^{238}Pu (3)		^{243}Pu (1)	^{59}Ni (4)		^{99}Tc (12)	^{59}Ni (10)	^{239}Pu (3)
			^{239}Np (1)			^{240}Pu (6)	^{239}Pu (9)	
						^{59}Ni (5)	^{240}Pu (5)	

[a] Time after discharge.

[b] Includes activity of short-lived daughter.

contribute to that inventory for PWR spent fuel and PWR high-level waste.[13] At 100 years, ^{137}Cs and ^{90}Sr are the major contributors. At 1000 years, actinides are the primary contributors. For longer times, a mix of actinides, fission products (especially ^{99}Tc), and activation products contribute to the total inventory. In Fig. 2, results from the saturation-limited dissolution model are shown in a plot of the ratio of the radioactivity release rate to the inventory as a function of time. Figure 3 shows a similar plot for results from the diffusion-limited model. Results from the saturation-limited dissolution model (Fig. 2) are not much below what would be obtained by assuming congruent dissolution; that is, all waste elements were released at the bulk dissolution rate. Based on this assumption, the release rate/inventory ratio in Fig. 2 would equal F_B (1×10^{-4}/year). The isotopes contributing to radioactivity release (see Appendix) are generally those present in the largest amounts (see Table VI). The relatively large water flux associated with the waste (910 ℓ/MTHM year) is the primary cause of the high dissolution rates obtained with this model.

Results from the diffusion-limited dissolution model (Fig. 3) show lower release rate-to-inventory ratios, particularly for spent fuel. An examination of the radioactivity release rates (see Appendix) shows that they are similar for spent fuel and high-level waste in the diffusion-limited model; however, for times of 1000 years or longer, the spent-fuel inventory is much greater than the high-level waste inventory (see Table VI). Thus, the release rate-to-inventory ratio is much lower for spent fuel than for high-level waste. Most of the radioactivity release with the diffusion-limited dissolution model comes from elements that do not exhibit solubility-limited dissolution rates: strontium and cesium at 100 years, and neptunium and technetium at longer times (see Appendix). Thus, the diffusion-limited model indicates that elements with low solubilities (americium, plutonium, and uranium) make only minor contributions to the total radioactivity release rate.

Element concentrations and radionuclide concentrations for the various calculations are shown in the Appendix. These concentrations can serve as initial conditions for radionuclide transport calculations. Radionuclides will be subject to dilution, sorption, physical flow processes, and possibly, other solubility constraints along flow paths toward the environment. Thus, these concentrations are much greater than the radionuclide concentrations in water that would actually reach the accessible environment.

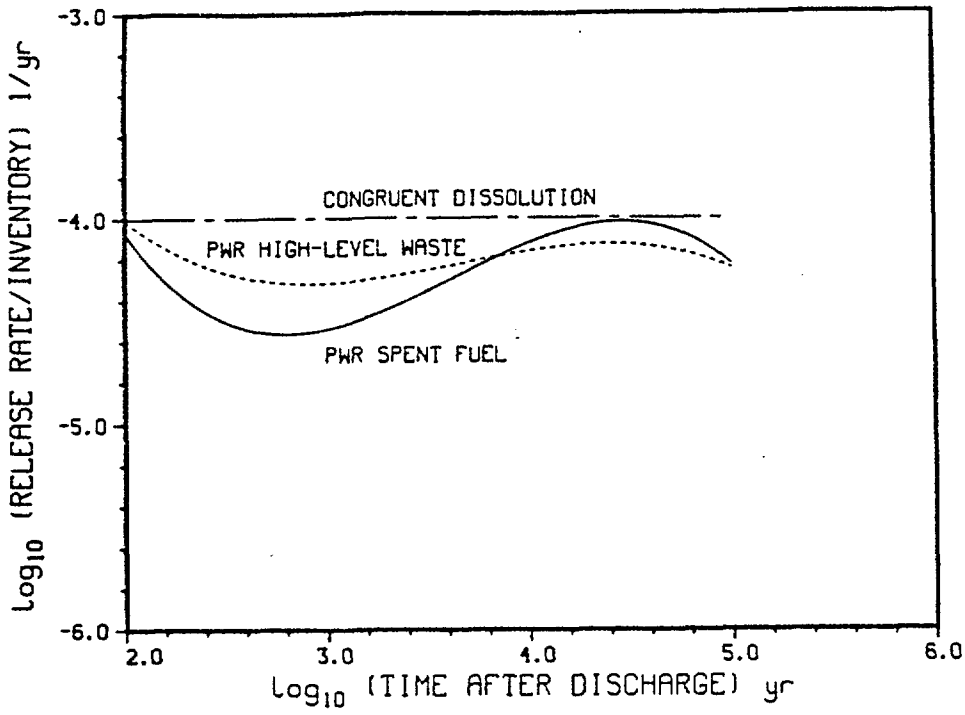

Fig. 2. Release rate-to-inventory ratio for saturation-limited dissolution model.

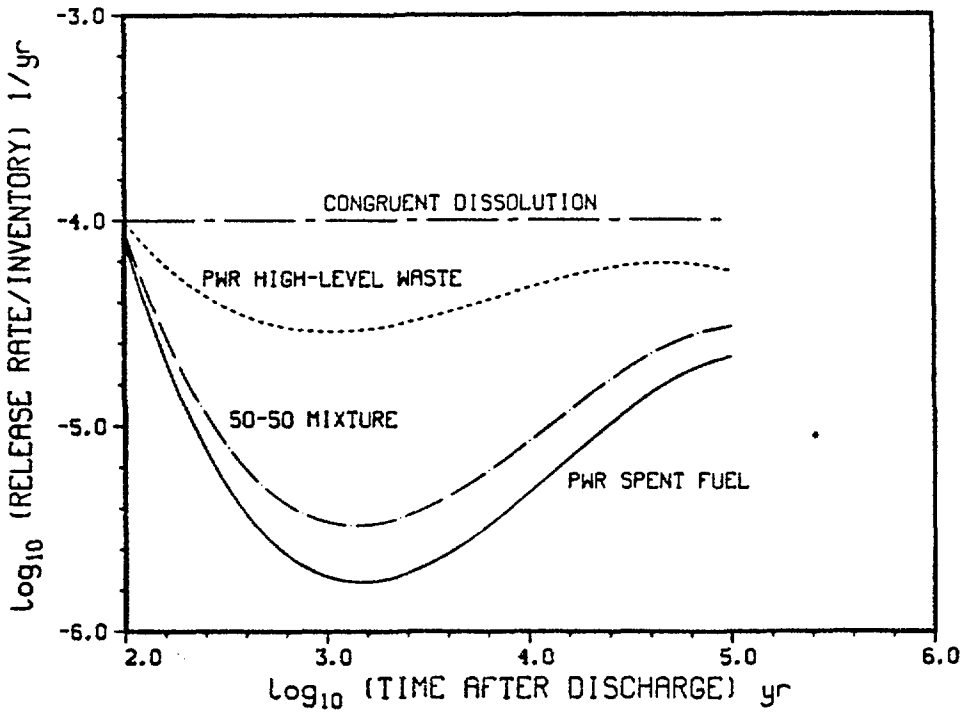

Fig. 3. Release rate-to-inventory ratio for diffusion-limited dissolution model.

B. Effects of Varying Model Parameters

The nominal value of the bulk waste fractional dissolution rate, which is an upper limit for individual element fractional dissolution rates, was assumed to be 1×10^{-4}/year. Spent fuel is primarily uranium oxide. The calculated fractional dissolution rates for uranium from spent fuel are ~5×10^{-5}/year by the saturation-limited dissolution model and ~5×10^{-7}/year by the diffusion-limited dissolution model (see Appendix). These results indicate that if solubility limits bulk dissolution, the choice of 1×10^{-4}/year is conservative because uranium solubility-limited dissolution rates are less than 1×10^{-4}/year.

High-level waste will probably be contained in a borosilicate glass. If amorphous silica solubility limits high-level-waste dissolution, an estimate of bulk high-level-waste fractional dissolution rates can be made from silica dissolution rates.[17] For the high-level solid waste form (0.16-m radius by 3 m long and containing 2 MTHM), which is assumed to have a density of 3 g/cm^3 with 40 wt.% SiO_2, there are 1.5×10^5 g silica/MTHM. Amorphous silica solubility is 2×10^{-3} M; however, Well J-13 water already contains 1×10^{-3} M dissolved silica so the capacity for additional silica dissolution is only 1×10^{-3} M (see Table II). For these conditions, the calculated fractional dissolution rates for silica from high-level waste are ~4×10^{-4}/year by the saturation-limited dissolution model and ~7×10^{-7}/year by the diffusion-limited dissolution model (see Appendix). The result from the saturation-limited model is somewhat higher than the value of F_B assumed for these calculations, but the diffusion-limited result is much less than 1×10^{-4}/year. Measured silica leach rates from borosilicate glass are equivalent to bulk fractional dissolution rates of ~1×10^{-5}/year (Ref. 18). Thus, the choice of $F_B = 1 \times 10^{-4}$/year also appears conservative for high-level waste.

To assess the effects of F_B on the results, calculations were also done with $F_B = 1 \times 10^{-3}$ and 1×10^{-5}/year. Figure 4 shows a plot of the ratio of the total radioactivity release rate to the inventory at 1000 years for spent fuel and high-level-waste results from both models. It is evident that the release rate-to-inventory ratio is a strong function of F_B. Although the choice of $F_B = 1 \times 10^{-4}$/year for the nominal calculations appears conservative (it is larger than expected), careful consideration must be given to mechanisms that control the release of those waste elements that are not solubility limited.

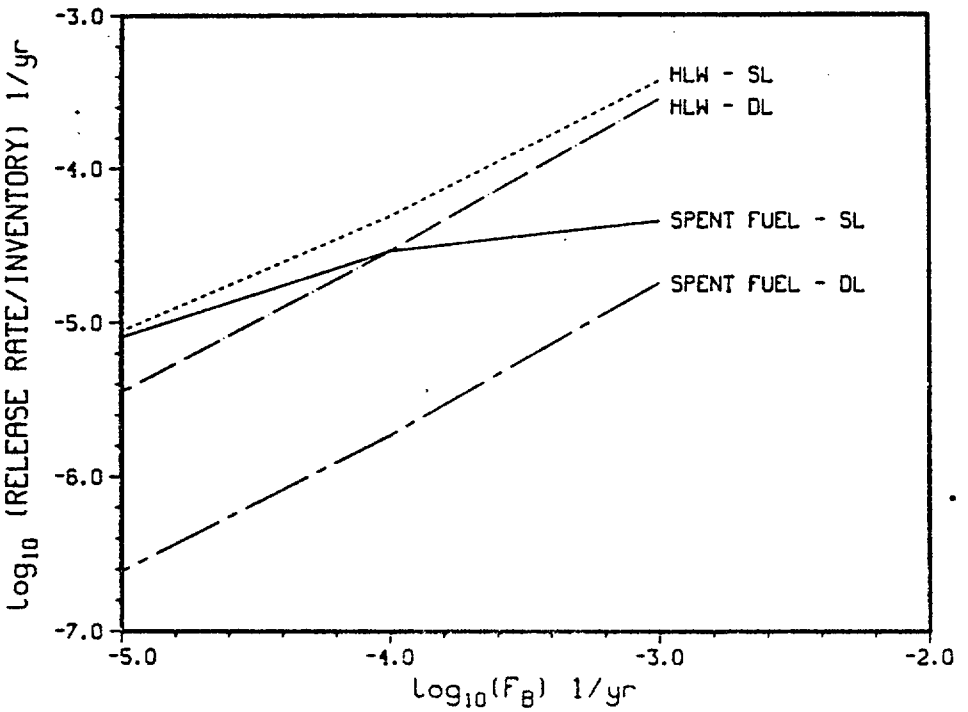

Fig. 4. Effect of bulk dissolution rate on release rate-to-inventory ratio at 1000 years. HLW = high-level waste; SL = saturation-limited dissolution model; and DL = diffusion-limited dissolution model.

Two other nominal model parameters were varied to assess their effects on the calculated dissolution rates and radioactivity release rates. Calculations were done in which the water recharge rate (nominal value, 8 mm/year) was reduced to 0.8 mm/year. This change affected the two dissolution models differently. For the saturation-limited dissolution model, Q, the water flow associated with each MTHM of waste, was reduced to 91 ℓ/MTHM. Table VII lists the ratio of the total radioactivity release rate to the inventory at 1000 years for the nominal parameter values and for the reduced water recharge rate. For spent fuel, the saturation-limited model shows a significant drop in release rate as the recharge rate is reduced; for high-level waste, there is only a small drop. The difference is that more of the radioactivity release with spent fuel is from elements that show solubility-limited dissolution and, thus, are directly affected by the water flux. More of the

TABLE VII

EFFECT OF VARYING WATER RECHARGE RATE AND SOLUBILITIES ON RATIO OF RADIOACTIVITY RELEASE-TO-INVENTORY AT 1000 YEARS

	Nominal	Reduced Water Recharge Rate	Reduced Solubility
Saturation-limited model			
Spent fuel	2.9×10^{-5}	4.5×10^{-6}	2.1×10^{-6}
High-level waste	4.8×10^{-5}	3.7×10^{-5}	3.3×10^{-5}
Diffusion-limited model			
Spent fuel	1.9×10^{-6}	1.8×10^{-6}	9.5×10^{-7}
High-level waste	2.9×10^{-5}	2.8×10^{-5}	1.7×10^{-5}

radioactivity release with high-level waste is from elements that are not solubility limited and, therefore, are unaffected by changes in the water flux. For the diffusion-limited model, reducing the recharge rate reduces the velocity to 8×10^{-3} m/year. This change, however, increases the contact time between the water and solid waste. The net result is that the radioactivity release rate is essentially the same (see Table VII).

Calculations were also performed in which the solubilities listed in Table II were reduced by a factor of 100. Solubilities of carbon, technetium, and cesium were still considered large enough to not limit dissolution. The change in radioactivity release rate was large only for spent fuel with the saturation-limited model (see Table VII). In the other cases, a large fraction of the radioactivity release is from elements that are not solubility limited. Neptunium and strontium show solubility-limited dissolution in certain cases when their solubilities are reduced.

VI. DISCUSSION

A first-order approximation to the dissolution rate of waste elements from a solid waste form would be an assumption that all elements dissolve at the same fractional dissolution rate; that is, that congruent dissolution occurs. The two models proposed here attempt to improve on that approximation by accounting for limits imposed by the solubilities of the different

elements. The saturation-limited dissolution model assumes that the total quantity of water passing through the repository area is saturated with each waste element; it is very conservative in that it overestimates dissolution rates of elements that are limited by solubility. This occurs because the model fails to recognize that there is only limited contact between the waste and the total quantity of water that would pass through the repository. Saturation of this quantity of water would require physical conditions that are highly unlikely, if not impossible. The conservatism of this model is reflected in the relatively small improvement in total radioactivity release over the congruent-dissolution assumption (see Fig. 2). The saturation-limited model is useful because the upper limits for waste-element dissolution rates that it provides are independent of the actual dissolution mechanism.

The diffusion-limited dissolution model assumes that waste-element dissolution is limited by diffusion into water flowing past the solid waste; it also assumes that waste elements are saturated at the solid/water interface. This model is a significant improvement over the saturation-limited model; it accounts, in a physically realistic way, for a mechanism to transport waste elements from the solid into the adjacent water. However, in accounting for this process, the model requires information about the solid waste, water flow in the surrounding medium, and element diffusivities. Using estimates of these parameters discussed here, the diffusion-limited model provides a small improvement in total radioactivity release over the congruent-dissolution assumption for high-level waste but a significant improvement for spent fuel as the solid waste form (see Fig. 3). Because the diffusion-limited model depends on details of the dissolution process, the results from this model are more uncertain at this time.

Certain waste elements do not exhibit solubility-limited dissolution because of the relation between the element solubility, the quantity of the waste element present, and the water flux past the waste. It was assumed that these elements dissolved congruently with the solid waste. Significantly, in the calculations for the diffusion-limited model, most of the radioactivity released from the solid waste comes from elements that do not exhibit solubility-limited dissolution. At 100 years, cesium and strontium account for essentially all the radioactivity release; both of these elements have relatively large solubilities. However, the waste package should remain intact long enough for these elements to decay to insignificant levels (300 to

500 years). Also, at 100 years, temperatures may be high enough so that liquid water will not exist near the waste. Thus, the release of these elements at 100 years is very unlikely. At 1000 years and longer, technetium and neptunium account for most of the radioactivity release from the solid with the diffusion-limited model and with the saturation-limited model for high-level waste. The solubility of both elements was taken as relatively large because oxidizing conditions were assumed at the repository. Transport of neptunium away from the repository area should be very limited because the tuff at Yucca Mountain shows good sorption capacity for neptunium.[7] Technetium, however, is not strongly sorbed, probably because it exists as an anion in solution. Thus, technetium presents a unique problem because neither solubility nor sorption may significantly limit its transport. This assessment could change if reducing conditions were encountered along water flow paths from the repository.

Tin and americium show solubility limits on their dissolution rates for all the cases examined. Uranium and plutonium show solubility limits under most conditions. Radium, although it has a low solubility, shows solubility-limited dissolution in only one situation because it is present in such small quantities. Accurate estimates of the solubilities of these elements in Yucca Mountain water are needed because they can be used in solubility-limited dissolution models to assess the source term for radionuclide transport calculations. Without accurate solubility data, larger dissolution rates than necessary might be assumed for these elemnts. A more accurate estimate of the solubility of neptunium is also needed; if it is lower than assumed for these calculations, neptunium may also show a solubility-limited dissolution rate.

A relation between the assumed value of the bulk fractional dissolution rate and solubility-limited dissolution is also evident from these calculations. When $F_B = 1 \times 10^{-4}$/year is assumed, as was done for most of the calculations, certain elements show solubility-limited dissolution. However, if F_B were 1 to 2 orders of magnitude lower, low congruent dissolution rates of the bulk waste form would limit most waste-element dissolution rates.

The analysis presented here represents an attempt to predict waste-element dissolution rates and to assess the importance of solubility in limiting dissolution. The results and conclusions are strong functions of the many assumptions made about solubilities and model parameters. These assumptions should be reviewed as better data concerning waste-element solubilities

and Yucca Mountain itself become available. Solubility-limited dissolution models may ultimately provide a powerful tool for estimating source terms for performance assessments of a repository. This work is merely a first step in that direction.

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APPENDIX

This Appendix contains the detailed results of element dissolution rates, radioactivity release rates, and concentrations for the saturation-limited and diffusion-limited dissolution model calculations. These results are for the nominal parameter values listed in Table III. The results are given in the following order: (1) spent fuel, saturation-limited model, (2) spent fuel, diffusion-limited model, (3) high-level waste, saturation-limited model, and (4) high-level waste, diffusion-limited model.

```
PWR SPENT FUEL
SATURATION-LIMITED DISSOLUTION MODEL

WATER FLOW =  9.100E+02 L/MTHM YR
BULK FRACTIONAL DISSOLUTION RATE =  1.000E-04 1/YR


DATA FOR AMERICIUM

SOLUBILITY =  1.000E-08 MOLES/L      MOLECULAR WEIGHT =  242.00 G/MOLE

AT    100. YR       3.770E+03 CURIES/MTHM       1.180E+03 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  1.866E-06 1/YR
     ELEMENT DISSOLUTION RATE =  2.202E-03 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  7.036E-03 CURIES/MTHM YR
          AM241   RELEASE RATE =  6.977E-03 CURIES/MTHM YR
          AM243   RELEASE RATE =  3.158E-05 CURIES/MTHM YR
     ELEMENT CONCENTRATION =  1.000E-08 MOLES/L
     AM241   CONCENTRATION =  9.276E-09 MOLES/L
     AM243   CONCENTRATION =  7.140E-10 MOLES/L

AT   1000. YR       9.100E+02 CURIES/MTHM       3.390E+02 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  6.496E-06 1/YR
     ELEMENT DISSOLUTION RATE =  2.202E-03 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  5.912E-03 CURIES/MTHM YR
          AM241   RELEASE RATE =  5.816E-03 CURIES/MTHM YR
          AM243   RELEASE RATE =  1.010E-04 CURIES/MTHM YR
     ELEMENT CONCENTRATION =  1.000E-08 MOLES/L
     AM241   CONCENTRATION =  7.731E-09 MOLES/L
     AM243   CONCENTRATION =  2.283E-09 MOLES/L

AT  10000. YR       6.680E+00 CURIES/MTHM       3.350E+01 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  6.574E-05 1/YR
     ELEMENT DISSOLUTION RATE =  2.202E-03 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  4.391E-04 CURIES/MTHM YR
          AM241   RELEASE RATE =  6.359E-07 CURIES/MTHM YR
          AM243   RELEASE RATE =  4.391E-04 CURIES/MTHM YR
     ELEMENT CONCENTRATION =  1.000E-08 MOLES/L
     AM241   CONCENTRATION =  8.453E-13 MOLES/L
     AM243   CONCENTRATION =  9.929E-09 MOLES/L

AT 100000. YR       1.470E-03 CURIES/MTHM       7.330E-03 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  1.000E-04 1/YR  (BULK RATE)
     ELEMENT DISSOLUTION RATE =  7.330E-07 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  1.470E-07 CURIES/MTHM YR
          AM241   RELEASE RATE =  5.968E-10 CURIES/MTHM YR
          AM243   RELEASE RATE =  1.464E-07 CURIES/MTHM YR
     ELEMENT CONCENTRATION =  3.328E-12 MOLES/L
     AM241   CONCENTRATION =  7.934E-16 MOLES/L
     AM243   CONCENTRATION =  3.310E-12 MOLES/L


DATA FOR CARBON

SOLUBILITY =  1.000E+10 MOLES/L      MOLECULAR WEIGHT =   12.00 G/MOLE

AT    100. YR       1.530E+00 CURIES/MTHM       1.670E+02 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  1.000E-04 1/YR  (BULK RATE)
     ELEMENT DISSOLUTION RATE =  1.670E-02 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  1.530E-04 CURIES/MTHM YR
          C14     RELEASE RATE =  1.529E-04 CURIES/MTHM YR
     ELEMENT CONCENTRATION =  1.529E-06 MOLES/L
     C14     CONCENTRATION =  3.141E-09 MOLES/L

AT   1000. YR       1.370E+00 CURIES/MTHM       1.670E+02 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  1.000E-04 1/YR  (BULK RATE)
     ELEMENT DISSOLUTION RATE =  1.670E-02 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  1.370E-04 CURIES/MTHM YR
          C14     RELEASE RATE =  1.373E-04 CURIES/MTHM YR
     ELEMENT CONCENTRATION =  1.529E-06 MOLES/L
     C14     CONCENTRATION =  2.821E-09 MOLES/L

AT  10000. YR       4.620E-01 CURIES/MTHM       1.670E+02 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  1.000E-04 1/YR  (BULK RATE)
     ELEMENT DISSOLUTION RATE =  1.670E-02 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  4.620E-05 CURIES/MTHM YR
          C14     RELEASE RATE =  4.635E-05 CURIES/MTHM YR
     ELEMENT CONCENTRATION =  1.529E-06 MOLES/L
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     C14      CONCENTRATION =  9.524E-10 MOLES/L

AT 100000. YR       8.620E-06 CURIES/MTHM       1.670E+02 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  1.000E-04 1/YR  (BULK RATE)
     ELEMENT DISSOLUTION RATE =  1.670E-02 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  8.620E-10 CURIES/MTHM YR
          C14      RELEASE RATE =  8.602E-10 CURIES/MTHM YR
     ELEMENT CONCENTRATION =  1.529E-06 MOLES/L
     C14      CONCENTRATION =  1.767E-14 MOLES/L


DATA FOR CESIUM

SOLUBILITY =  1.000E+10 MOLES/L      MOLECULAR WEIGHT =  137.00 G/MOLE

AT    100. YR       2.010E+04 CURIES/MTHM       1.550E+03 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  1.000E-04 1/YR  (BULK RATE)
     ELEMENT DISSOLUTION RATE =  1.550E-01 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  2.010E+00 CURIES/MTHM YR
          CS135    RELEASE RATE =  3.456E-05 CURIES/MTHM YR
          CS137    RELEASE RATE =  2.009E+00 CURIES/MTHM YR
     ELEMENT CONCENTRATION =  1.243E-06 MOLES/L
     CS135    CONCENTRATION =  2.442E-07 MOLES/L
     CS137    CONCENTRATION =  9.537E-08 MOLES/L

AT   1000. YR       3.450E-01 CURIES/MTHM       1.430E+03 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  1.000E-04 1/YR  (BULK RATE)
     ELEMENT DISSOLUTION RATE =  1.430E-01 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  3.450E-05 CURIES/MTHM YR
          CS135    RELEASE RATE =  3.456E-05 CURIES/MTHM YR
          CS137    RELEASE RATE =  1.876E-09 CURIES/MTHM YR
     ELEMENT CONCENTRATION =  1.147E-06 MOLES/L
     CS135    CONCENTRATION =  2.442E-07 MOLES/L
     CS137    CONCENTRATION =  8.904E-17 MOLES/L

AT  10000. YR       3.440E-01 CURIES/MTHM       1.430E+03 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  1.000E-04 1/YR  (BULK RATE)
     ELEMENT DISSOLUTION RATE =  1.430E-01 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  3.440E-05 CURIES/MTHM YR
          CS135    RELEASE RATE =  3.444E-05 CURIES/MTHM YR
          CS137    RELEASE RATE =  0.        CURIES/MTHM YR
     ELEMENT CONCENTRATION =  1.147E-06 MOLES/L
     CS135    CONCENTRATION =  2.434E-07 MOLES/L
     CS137    CONCENTRATION =  0.        MOLES/L

AT 100000. YR       3.350E-01 CURIES/MTHM       1.420E+03 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  1.000E-04 1/YR  (BULK RATE)
     ELEMENT DISSOLUTION RATE =  1.420E-01 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  3.350E-05 CURIES/MTHM YR
          CS135    RELEASE RATE =  3.352E-05 CURIES/MTHM YR
          CS137    RELEASE RATE =  0.        CURIES/MTHM YR
     ELEMENT CONCENTRATION =  1.139E-06 MOLES/L
     CS135    CONCENTRATION =  2.369E-07 MOLES/L
     CS137    CONCENTRATION =  0.        MOLES/L


DATA FOR NEPTUNIUM

SOLUBILITY =  3.000E-03 MOLES/L      MOLECULAR WEIGHT =  237.00 G/MOLE

AT    100. YR       1.730E+01 CURIES/MTHM       5.900E+02 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  1.000E-04 1/YR  (BULK RATE)
     ELEMENT DISSOLUTION RATE =  5.900E-02 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  1.730E-03 CURIES/MTHM YR
          NP237    RELEASE RATE =  4.161E-05 CURIES/MTHM YR
          NP239    RELEASE RATE =  1.692E-03 CURIES/MTHM YR
     ELEMENT CONCENTRATION =  2.736E-07 MOLES/L
     NP237    CONCENTRATION =  2.736E-07 MOLES/L
     NP239    CONCENTRATION =  3.343E-14 MOLES/L

AT   1000. YR       1.650E+01 CURIES/MTHM       1.420E+03 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  1.000E-04 1/YR  (BULK RATE)
     ELEMENT DISSOLUTION RATE =  1.420E-01 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  1.650E-03 CURIES/MTHM YR
          NP237    RELEASE RATE =  1.002E-04 CURIES/MTHM YR
          NP239    RELEASE RATE =  1.554E-03 CURIES/MTHM YR
     ELEMENT CONCENTRATION =  6.584E-07 MOLES/L
     NP237    CONCENTRATION =  6.584E-07 MOLES/L
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     NP239    CONCENTRATION =  3.071E-14 MOLES/L

AT  10000. YR        7.850E+00 CURIES/MTHM        1.670E+03 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  1.000E-04 1/YR  (BULK RATE)
     ELEMENT DISSOLUTION RATE =  1.670E-01 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  7.850E-04 CURIES/MTHM YR
           NP237   RELEASE RATE =  1.178E-04 CURIES/MTHM YR
           NP239   RELEASE RATE =  6.678E-04 CURIES/MTHM YR
     ELEMENT CONCENTRATION =  7.743E-07 MOLES/L
     NP237    CONCENTRATION =  7.743E-07 MOLES/L
     NP239    CONCENTRATION =  1.320E-14 MOLES/L

AT 100000. YR        1.150E+00 CURIES/MTHM        1.620E+03 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  1.000E-04 1/YR  (BULK RATE)
     ELEMENT DISSOLUTION RATE =  1.620E-01 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  1.150E-04 CURIES/MTHM YR
           NP237   RELEASE RATE =  1.143E-04 CURIES/MTHM YR
           NP239   RELEASE RATE =  1.459E-07 CURIES/MTHM YR
     ELEMENT CONCENTRATION =  7.511E-07 MOLES/L
     NP237    CONCENTRATION =  7.511E-07 MOLES/L
     NP239    CONCENTRATION =  2.883E-18 MOLES/L


DATA FOR PLUTONIUM

SOLUBILITY =  1.800E-06 MOLES/L    MOLECULAR WEIGHT =  239.00 G/MOLE

AT    100. YR        2.960E+03 CURIES/MTHM        7.860E+03 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  4.981E-05 1/YR
     ELEMENT DISSOLUTION RATE =  3.915E-01 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  1.474E-01 CURIES/MTHM YR
           PU238   RELEASE RATE =  5.454E-02 CURIES/MTHM YR
           PU239   RELEASE RATE =  1.553E-02 CURIES/MTHM YR
           PU240   RELEASE RATE =  2.611E-02 CURIES/MTHM YR
           PU241   RELEASE RATE =  5.100E-02 CURIES/MTHM YR
           PU242   RELEASE RATE =  8.750E-05 CURIES/MTHM YR
     ELEMENT CONCENTRATION =  1.800E-06 MOLES/L
     PU238    CONCENTRATION =  1.472E-08 MOLES/L
     PU239    CONCENTRATION =  1.150E-06 MOLES/L
     PU240    CONCENTRATION =  5.245E-07 MOLES/L
     PU241    CONCENTRATION =  2.255E-09 MOLES/L
     PU242    CONCENTRATION =  1.011E-07 MOLES/L

AT   1000. YR        7.840E+02 CURIES/MTHM        7.450E+03 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  5.255E-05 1/YR
     ELEMENT DISSOLUTION RATE =  3.915E-01 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  4.120E-02 CURIES/MTHM YR
           PU238   RELEASE RATE =  5.080E-05 CURIES/MTHM YR
           PU239   RELEASE RATE =  1.599E-02 CURIES/MTHM YR
           PU240   RELEASE RATE =  2.503E-02 CURIES/MTHM YR
           PU241   RELEASE RATE =  1.008E-06 CURIES/MTHM YR
           PU242   RELEASE RATE =  9.231E-05 CURIES/MTHM YR
     ELEMENT CONCENTRATION =  1.800E-06 MOLES/L
     PU238    CONCENTRATION =  1.371E-11 MOLES/L
     PU239    CONCENTRATION =  1.184E-06 MOLES/L
     PU240    CONCENTRATION =  5.029E-07 MOLES/L
     PU241    CONCENTRATION =  4.457E-14 MOLES/L
     PU242    CONCENTRATION =  1.067E-07 MOLES/L

AT  10000. YR        4.230E+02 CURIES/MTHM        5.080E+03 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  7.706E-05 1/YR
     ELEMENT DISSOLUTION RATE =  3.915E-01 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  3.260E-02 CURIES/MTHM YR
           PU238   RELEASE RATE =  0.          CURIES/MTHM YR
           PU239   RELEASE RATE =  1.828E-02 CURIES/MTHM YR
           PU240   RELEASE RATE =  1.416E-02 CURIES/MTHM YR
           PU241   RELEASE RATE =  7.096E-07 CURIES/MTHM YR
           PU242   RELEASE RATE =  1.330E-04 CURIES/MTHM YR
     ELEMENT CONCENTRATION =  1.800E-06 MOLES/L
     PU238    CONCENTRATION =  0.          MOLES/L
     PU239    CONCENTRATION =  1.354E-06 MOLES/L
     PU240    CONCENTRATION =  2.844E-07 MOLES/L
     PU241    CONCENTRATION =  3.138E-14 MOLES/L
     PU242    CONCENTRATION =  1.536E-07 MOLES/L

AT 100000. YR        1.950E+01 CURIES/MTHM        6.740E+02 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  1.000E-04 1/YR  (BULK RATE)
     ELEMENT DISSOLUTION RATE =  6.740E-02 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  1.950E-03 CURIES/MTHM YR
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          PU238    RELEASE RATE =  0.          CURIES/MTHM YR
          PU239    RELEASE RATE =  1.795E-03 CURIES/MTHM YR
          PU240    RELEASE RATE =  1.317E-06 CURIES/MTHM YR
          PU241    RELEASE RATE =  5.980E-10 CURIES/MTHM YR
          PU242    RELEASE RATE =  1.470E-04 CURIES/MTHM YR
     ELEMENT CONCENTRATION =  3.099E-07 MOLES/L
     PU238   CONCENTRATION =  0.        MOLES/L
     PU239   CONCENTRATION =  1.329E-07 MOLES/L
     PU240   CONCENTRATION =  2.647E-11 MOLES/L
     PU241   CONCENTRATION =  2.645E-17 MOLES/L
     PU242   CONCENTRATION =  1.698E-07 MOLES/L


DATA FOR RADIUM

SOLUBILITY =  1.000E-07 MOLES/L     MOLECULAR WEIGHT =  226.00 G/MOLE

AT    100. YR       2.700E-03 CURIES/MTHM       2.650E-05 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  1.000E-04 1/YR  (BULK RATE)
     ELEMENT DISSOLUTION RATE =  2.650E-09 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  2.700E-07 CURIES/MTHM YR
          RA226   RELEASE RATE =  2.620E-09 CURIES/MTHM YR
     ELEMENT CONCENTRATION =  1.289E-14 MOLES/L
     RA226   CONCENTRATION =  1.289E-14 MOLES/L

AT   1000. YR       3.560E-03 CURIES/MTHM       3.090E-03 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  1.000E-04 1/YR  (BULK RATE)
     ELEMENT DISSOLUTION RATE =  3.090E-07 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  3.560E-07 CURIES/MTHM YR
          RA226   RELEASE RATE =  3.055E-07 CURIES/MTHM YR
     ELEMENT CONCENTRATION =  1.502E-12 MOLES/L
     RA226   CONCENTRATION =  1.502E-12 MOLES/L

AT  10000. YR       1.510E-01 CURIES/MTHM       1.320E-01 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  1.000E-04 1/YR  (BULK RATE)
     ELEMENT DISSOLUTION RATE =  1.320E-05 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  1.510E-05 CURIES/MTHM YR
          RA226   RELEASE RATE =  1.305E-05 CURIES/MTHM YR
     ELEMENT CONCENTRATION =  6.418E-11 MOLES/L
     RA226   CONCENTRATION =  6.418E-11 MOLES/L

AT 100000. YR       1.440E+00 CURIES/MTHM       1.050E+00 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  1.000E-04 1/YR  (BULK RATE)
     ELEMENT DISSOLUTION RATE =  1.050E-04 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  1.440E-04 CURIES/MTHM YR
          RA226   RELEASE RATE =  1.038E-04 CURIES/MTHM YR
     ELEMENT CONCENTRATION =  5.106E-10 MOLES/L
     RA226   CONCENTRATION =  5.106E-10 MOLES/L


DATA FOR STRONTIUM

SOLUBILITY =  9.400E-04 MOLES/L     MOLECULAR WEIGHT =  90.00 G/MOLE

AT    100. YR       1.350E+04 CURIES/MTHM       4.000E+02 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  1.000E-04 1/YR  (BULK RATE)
     ELEMENT DISSOLUTION RATE =  4.000E-02 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  1.350E+00 CURIES/MTHM YR
          SR90    RELEASE RATE =  1.354E+00 CURIES/MTHM YR
     ELEMENT CONCENTRATION =  4.884E-07 MOLES/L
     SR90    CONCENTRATION =  6.056E-08 MOLES/L

AT   1000. YR       6.720E-06 CURIES/MTHM       3.500E+02 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  1.000E-04 1/YR  (BULK RATE)
     ELEMENT DISSOLUTION RATE =  3.500E-02 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  6.720E-10 CURIES/MTHM YR
          SR90    RELEASE RATE =  6.743E-10 CURIES/MTHM YR
     ELEMENT CONCENTRATION =  4.274E-07 MOLES/L
     SR90    CONCENTRATION =  3.016E-17 MOLES/L

AT  10000. YR       0.          CURIES/MTHM       3.500E+02 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  1.000E-04 1/YR  (BULK RATE)
     ELEMENT DISSOLUTION RATE =  3.500E-02 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  0.          CURIES/MTHM YR
          SR90    RELEASE RATE =  0.          CURIES/MTHM YR
     ELEMENT CONCENTRATION =  4.274E-07 MOLES/L
     SR90    CONCENTRATION =  0.          MOLES/L
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AT 100000. YR       0.          CURIES/MTHM       3.500E+02 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  1.000E-04 1/YR  (BULK RATE)
     ELEMENT DISSOLUTION RATE =  3.500E-02 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  0.          CURIES/MTHM YR
          SR90    RELEASE RATE =  0.          CURIES/MTHM YR
     ELEMENT CONCENTRATION =  4.274E-07 MOLES/L
     SR90    CONCENTRATION =  0.          MOLES/L


DATA FOR TECHNETIUM

SOLUBILITY =  1.000E+10 MOLES/L     MOLECULAR WEIGHT =   99.00 G/MOLE

AT    100. YR       1.310E+01 CURIES/MTHM       7.710E+02 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  1.000E-04 1/YR  (BULK RATE)
     ELEMENT DISSOLUTION RATE =  7.710E-02 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  1.310E-03 CURIES/MTHM YR
          TC99    RELEASE RATE =  1.308E-03 CURIES/MTHM YR
     ELEMENT CONCENTRATION =  8.558E-07 MOLES/L
     TC99    CONCENTRATION =  8.558E-07 MOLES/L

AT   1000. YR       1.300E+01 CURIES/MTHM       7.690E+02 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  1.000E-04 1/YR  (BULK RATE)
     ELEMENT DISSOLUTION RATE =  7.690E-02 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  1.300E-03 CURIES/MTHM YR
          TC99    RELEASE RATE =  1.304E-03 CURIES/MTHM YR
     ELEMENT CONCENTRATION =  8.536E-07 MOLES/L
     TC99    CONCENTRATION =  8.536E-07 MOLES/L

AT  10000. YR       1.270E+01 CURIES/MTHM       7.460E+02 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  1.000E-04 1/YR  (BULK RATE)
     ELEMENT DISSOLUTION RATE =  7.460E-02 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  1.270E-03 CURIES/MTHM YR
          TC99    RELEASE RATE =  1.265E-03 CURIES/MTHM YR
     ELEMENT CONCENTRATION =  8.281E-07 MOLES/L
     TC99    CONCENTRATION =  8.281E-07 MOLES/L

AT 100000. YR       9.440E+00 CURIES/MTHM       5.570E+02 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  1.000E-04 1/YR  (BULK RATE)
     ELEMENT DISSOLUTION RATE =  5.570E-02 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  9.440E-04 CURIES/MTHM YR
          TC99    RELEASE RATE =  9.447E-04 CURIES/MTHM YR
     ELEMENT CONCENTRATION =  6.183E-07 MOLES/L
     TC99    CONCENTRATION =  6.183E-07 MOLES/L


DATA FOR TIN

SOLUBILITY =  1.000E-09 MOLES/L     MOLECULAR WEIGHT =  119.00 G/MOLE

AT    100. YR       8.290E-01 CURIES/MTHM       9.000E+01 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  1.203E-06 1/YR
     ELEMENT DISSOLUTION RATE =  1.083E-04 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  9.975E-07 CURIES/MTHM YR
          SN126   RELEASE RATE =  9.355E-07 CURIES/MTHM YR
     ELEMENT CONCENTRATION =  1.000E-09 MOLES/L
     SN126   CONCENTRATION =  2.991E-10 MOLES/L

AT   1000. YR       7.720E-01 CURIES/MTHM       8.980E+01 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  1.206E-06 1/YR
     ELEMENT DISSOLUTION RATE =  1.083E-04 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  9.310E-07 CURIES/MTHM YR
          SN126   RELEASE RATE =  9.310E-07 CURIES/MTHM YR
     ELEMENT CONCENTRATION =  1.000E-09 MOLES/L
     SN126   CONCENTRATION =  2.976E-10 MOLES/L

AT  10000. YR       7.250E-01 CURIES/MTHM       8.810E+01 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  1.229E-06 1/YR
     ELEMENT DISSOLUTION RATE =  1.083E-04 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  8.911E-07 CURIES/MTHM YR
          SN126   RELEASE RATE =  8.919E-07 CURIES/MTHM YR
     ELEMENT CONCENTRATION =  1.000E-09 MOLES/L
     SN126   CONCENTRATION =  2.852E-10 MOLES/L

AT 100000. YR       3.890E-01 CURIES/MTHM       7.630E+01 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  1.419E-06 1/YR
     ELEMENT DISSOLUTION RATE =  1.083E-04 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  5.521E-07 CURIES/MTHM YR
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      SN126    RELEASE RATE =  5.537E-07 CURIES/MTHM YR
ELEMENT CONCENTRATION =  1.000E-09 MOLES/L
SN126    CONCENTRATION =  1.770E-10 MOLES/L


DATA FOR URANIUM

SOLUBILITY =  2.100E-04 MOLES/L      MOLECULAR WEIGHT =  238.00 G/MOLE

AT    100. YR       2.190E+00 CURIES/MTHM       9.560E+05 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  4.758E-05 1/YR
     ELEMENT DISSOLUTION RATE =  4.548E+01 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  1.042E-04 CURIES/MTHM YR
          U233    RELEASE RATE =  8.080E-09 CURIES/MTHM YR
          U234    RELEASE RATE =  7.570E-05 CURIES/MTHM YR
          U235    RELEASE RATE =  8.190E-07 CURIES/MTHM YR
          U236    RELEASE RATE =  1.226E-05 CURIES/MTHM YR
          U238    RELEASE RATE =  1.509E-05 CURIES/MTHM YR
     ELEMENT CONCENTRATION =  2.100E-04 MOLES/L
     U233    CONCENTRATION =  3.949E-12 MOLES/L
     U234    CONCENTRATION =  5.697E-08 MOLES/L
     U235    CONCENTRATION =  1.773E-06 MOLES/L
     U236    CONCENTRATION =  8.817E-07 MOLES/L
     U238    CONCENTRATION =  2.074E-04 MOLES/L

AT    1000. YR       2.590E+00 CURIES/MTHM       9.570E+05 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  4.753E-05 1/YR
     ELEMENT DISSOLUTION RATE =  4.548E+01 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  1.231E-04 CURIES/MTHM YR
          U233    RELEASE RATE =  1.532E-07 CURIES/MTHM YR
          U234    RELEASE RATE =  9.431E-05 CURIES/MTHM YR
          U235    RELEASE RATE =  8.315E-07 CURIES/MTHM YR
          U236    RELEASE RATE =  1.289E-05 CURIES/MTHM YR
          U238    RELEASE RATE =  1.507E-05 CURIES/MTHM YR
     ELEMENT CONCENTRATION =  2.100E-04 MOLES/L
     U233    CONCENTRATION =  7.486E-11 MOLES/L
     U234    CONCENTRATION =  7.097E-08 MOLES/L
     U235    CONCENTRATION =  1.800E-06 MOLES/L
     U236    CONCENTRATION =  9.272E-07 MOLES/L
     U238    CONCENTRATION =  2.071E-04 MOLES/L

AT   10000. YR       2.680E+00 CURIES/MTHM       9.590E+05 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  4.743E-05 1/YR
     ELEMENT DISSOLUTION RATE =  4.548E+01 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  1.271E-04 CURIES/MTHM YR
          U233    RELEASE RATE =  2.284E-06 CURIES/MTHM YR
          U234    RELEASE RATE =  9.204E-05 CURIES/MTHM YR
          U235    RELEASE RATE =  9.435E-07 CURIES/MTHM YR
          U236    RELEASE RATE =  1.673E-05 CURIES/MTHM YR
          U238    RELEASE RATE =  1.504E-05 CURIES/MTHM YR
     ELEMENT CONCENTRATION =  2.100E-04 MOLES/L
     U233    CONCENTRATION =  1.116E-09 MOLES/L
     U234    CONCENTRATION =  6.927E-08 MOLES/L
     U235    CONCENTRATION =  2.043E-06 MOLES/L
     U236    CONCENTRATION =  1.204E-06 MOLES/L
     U238    CONCENTRATION =  2.067E-04 MOLES/L

AT 100000. YR       2.730E+00 CURIES/MTHM       9.630E+05 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  4.723E-05 1/YR
     ELEMENT DISSOLUTION RATE =  4.548E+01 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  1.289E-04 CURIES/MTHM YR
          U233    RELEASE RATE =  1.937E-05 CURIES/MTHM YR
          U234    RELEASE RATE =  7.456E-05 CURIES/MTHM YR
          U235    RELEASE RATE =  1.296E-06 CURIES/MTHM YR
          U236    RELEASE RATE =  1.905E-05 CURIES/MTHM YR
          U238    RELEASE RATE =  1.498E-05 CURIES/MTHM YR
     ELEMENT CONCENTRATION =  2.100E-04 MOLES/L
     U233    CONCENTRATION =  9.467E-09 MOLES/L
     U234    CONCENTRATION =  5.611E-08 MOLES/L
     U235    CONCENTRATION =  2.805E-06 MOLES/L
     U236    CONCENTRATION =  1.370E-06 MOLES/L
     U238    CONCENTRATION =  2.059E-04 MOLES/L


TOTAL RADIOACTIVITY RELEASE RATES

AT    100. YR       3.518E+00 CURIES/MTHM YR
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      CS137     ( 57.1 PER CENT)
      SR90      ( 38.5 PER CENT)
      PU238     (  1.6 PER CENT)
      PU241     (  1.4 PER CENT)
      PU240     (   .7 PER CENT)

AT    1000. YR        5.035E-02 CURIES/MTHM YR
      PU240     ( 49.7 PER CENT)
      PU239     ( 31.8 PER CENT)
      AM241     ( 11.5 PER CENT)
      NP239     (  3.1 PER CENT)
      TC99      (  2.6 PER CENT)
      C14       (   .3 PER CENT)

AT   10000. YR        3.532E-02 CURIES/MTHM YR
      PU239     ( 51.8 PER CENT)
      PU240     ( 40.1 PER CENT)
      TC99      (  3.6 PER CENT)
      NP239     (  1.9 PER CENT)
      AM243     (  1.2 PER CENT)
      PU242     (   .4 PER CENT)

AT  100000. YR        3.316E-03 CURIES/MTHM YR
      PU239     ( 54.1 PER CENT)
      TC99      ( 28.5 PER CENT)
      PU242     (  4.4 PER CENT)
      NP237     (  3.4 PER CENT)
      RA226     (  3.1 PER CENT)
      U234      (  2.2 PER CENT)
      CS135     (  1.0 PER CENT)
      U233      (   .6 PER CENT)
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PWR SPENT FUEL
DIFFUSION-LIMITED DISSOLUTION MODEL

WASTE CONTAINER IS    .250 M RADIUS AND  4.500 M LONG
WITH   3.000 MTHM OF WASTE

APPARENT DIFFUSION COEFFICIENT =  1.000E-10 M**2/S
ROCK POROSITY =    .1000
WATER VELOCITY =  8.000E-02 M/YR
PENETRATION DEPTH =  4.633E-01 M
DISSOLUTION INCREASED BY   14.00 PER CENT FOR FLOW THROUGH WASTE


DATA FOR AMERICIUM

SOLUBILITY =  1.000E-08 MOLES/L      MOLECULAR WEIGHT =  242.00 G/MOLE

AT     100. YR        3.770E+03 CURIES/MTHM        1.180E+03 G/MTHM
      FRACTIONAL DISSOLUTION RATE =  4.538E-09 1/YR
      ELEMENT DISSOLUTION RATE =  5.354E-06 G/MTHM YR
      RADIOACTIVITY RELEASE RATE =  1.711E-05 CURIES/MTHM YR
            AM241    RELEASE RATE =  1.696E-05 CURIES/MTHM YR
            AM243    RELEASE RATE =  7.678E-08 CURIES/MTHM YR
      ELEMENT CONCENTRATION =  2.431E-11 MOLES/L
      AM241    CONCENTRATION =  2.255E-11 MOLES/L
      AM243    CONCENTRATION =  1.736E-12 MOLES/L

AT    1000. YR        9.100E+02 CURIES/MTHM        3.390E+02 G/MTHM
      FRACTIONAL DISSOLUTION RATE =  1.579E-08 1/YR
      ELEMENT DISSOLUTION RATE =  5.354E-06 G/MTHM YR
      RADIOACTIVITY RELEASE RATE =  1.437E-05 CURIES/MTHM YR
            AM241    RELEASE RATE =  1.414E-05 CURIES/MTHM YR
            AM243    RELEASE RATE =  2.454E-07 CURIES/MTHM YR
      ELEMENT CONCENTRATION =  2.431E-11 MOLES/L
      AM241    CONCENTRATION =  1.880E-11 MOLES/L
      AM243    CONCENTRATION =  5.550E-12 MOLES/L

AT   10000. YR        6.680E+00 CURIES/MTHM        3.350E+01 G/MTHM
      FRACTIONAL DISSOLUTION RATE =  1.598E-07 1/YR
      ELEMENT DISSOLUTION RATE =  5.354E-06 G/MTHM YR
      RADIOACTIVITY RELEASE RATE =  1.068E-06 CURIES/MTHM YR
            AM241    RELEASE RATE =  1.546E-09 CURIES/MTHM YR
            AM243    RELEASE RATE =  1.068E-06 CURIES/MTHM YR
      ELEMENT CONCENTRATION =  2.431E-11 MOLES/L
      AM241    CONCENTRATION =  2.055E-15 MOLES/L
      AM243    CONCENTRATION =  2.414E-11 MOLES/L

AT 100000. YR        1.470E-03 CURIES/MTHM        7.330E-03 G/MTHM
      FRACTIONAL DISSOLUTION RATE =  1.000E-04 1/YR  (BULK RATE)
      ELEMENT DISSOLUTION RATE =  7.330E-07 G/MTHM YR
      RADIOACTIVITY RELEASE RATE =  1.470E-07 CURIES/MTHM YR
            AM241    RELEASE RATE =  5.968E-10 CURIES/MTHM YR
            AM243    RELEASE RATE =  1.464E-07 CURIES/MTHM YR
      ELEMENT CONCENTRATION =  3.328E-12 MOLES/L
      AM241    CONCENTRATION =  7.934E-16 MOLES/L
      AM243    CONCENTRATION =  3.310E-12 MOLES/L


DATA FOR CARBON

SOLUBILITY =  1.000E+10 MOLES/L      MOLECULAR WEIGHT =   12.00 G/MOLE

AT     100. YR        1.530E+00 CURIES/MTHM        1.670E+02 G/MTHM
      FRACTIONAL DISSOLUTION RATE =  1.000E-04 1/YR  (BULK RATE)
      ELEMENT DISSOLUTION RATE =  1.670E-02 G/MTHM YR
      RADIOACTIVITY RELEASE RATE =  1.530E-04 CURIES/MTHM YR
            C14      RELEASE RATE =  1.529E-04 CURIES/MTHM YR
      ELEMENT CONCENTRATION =  1.529E-06 MOLES/L
      C14      CONCENTRATION =  3.141E-09 MOLES/L

AT    1000. YR        1.370E+00 CURIES/MTHM        1.670E+02 G/MTHM
      FRACTIONAL DISSOLUTION RATE =  1.000E-04 1/YR  (BULK RATE)
      ELEMENT DISSOLUTION RATE =  1.670E-02 G/MTHM YR
      RADIOACTIVITY RELEASE RATE =  1.370E-04 CURIES/MTHM YR
            C14      RELEASE RATE =  1.373E-04 CURIES/MTHM YR
      ELEMENT CONCENTRATION =  1.529E-06 MOLES/L
      C14      CONCENTRATION =  2.821E-09 MOLES/L
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AT  10000. YR       4.620E-01 CURIES/MTHM       1.670E+02 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  1.000E-04 1/YR  (BULK RATE)
     ELEMENT DISSOLUTION RATE =  1.670E-02 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  4.620E-05 CURIES/MTHM YR
           C14      RELEASE RATE =  4.635E-05 CURIES/MTHM YR
     ELEMENT CONCENTRATION =  1.529E-06 MOLES/L
     C14      CONCENTRATION =  9.524E-10 MOLES/L

AT 100000. YR       8.620E-06 CURIES/MTHM       1.670E+02 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  1.000E-04 1/YR  (BULK RATE)
     ELEMENT DISSOLUTION RATE =  1.670E-02 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  8.620E-10 CURIES/MTHM YR
           C14      RELEASE RATE =  8.602E-10 CURIES/MTHM YR
     ELEMENT CONCENTRATION =  1.529E-06 MOLES/L
     C14      CONCENTRATION =  1.767E-14 MOLES/L


DATA FOR CESIUM

SOLUBILITY =  1.000E+10 MOLES/L      MOLECULAR WEIGHT =  137.00 G/MOLE

AT    100. YR       2.010E+04 CURIES/MTHM       1.550E+03 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  1.000E-04 1/YR  (BULK RATE)
     ELEMENT DISSOLUTION RATE =  1.550E-01 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  2.010E+00 CURIES/MTHM YR
           CS135    RELEASE RATE =  3.456E-05 CURIES/MTHM YR
           CS137    RELEASE RATE =  2.009E+00 CURIES/MTHM YR
     ELEMENT CONCENTRATION =  1.243E-06 MOLES/L
     CS135    CONCENTRATION =  2.442E-07 MOLES/L
     CS137    CONCENTRATION =  9.537E-08 MOLES/L

AT    1000. YR       3.450E-01 CURIES/MTHM       1.430E+03 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  1.000E-04 1/YR  (BULK RATE)
     ELEMENT DISSOLUTION RATE =  1.430E-01 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  3.450E-05 CURIES/MTHM YR
           CS135    RELEASE RATE =  3.456E-05 CURIES/MTHM YR
           CS137    RELEASE RATE =  1.876E-09 CURIES/MTHM YR
     ELEMENT CONCENTRATION =  1.147E-06 MOLES/L
     CS135    CONCENTRATION =  2.442E-07 MOLES/L
     CS137    CONCENTRATION =  8.904E-17 MOLES/L

AT  10000. YR       3.440E-01 CURIES/MTHM       1.430E+03 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  1.000E-04 1/YR  (BULK RATE)
     ELEMENT DISSOLUTION RATE =  1.430E-01 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  3.440E-05 CURIES/MTHM YR
           CS135    RELEASE RATE =  3.444E-05 CURIES/MTHM YR
           CS137    RELEASE RATE =  0.        CURIES/MTHM YR
     ELEMENT CONCENTRATION =  1.147E-06 MOLES/L
     CS135    CONCENTRATION =  2.434E-07 MOLES/L
     CS137    CONCENTRATION =  0.        MOLES/L

AT 100000. YR       3.350E-01 CURIES/MTHM       1.420E+03 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  1.000E-04 1/YR  (BULK RATE)
     ELEMENT DISSOLUTION RATE =  1.420E-01 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  3.350E-05 CURIES/MTHM YR
           CS135    RELEASE RATE =  3.352E-05 CURIES/MTHM YR
           CS137    RELEASE RATE =  0.        CURIES/MTHM YR
     ELEMENT CONCENTRATION =  1.139E-06 MOLES/L
     CS135    CONCENTRATION =  2.369E-07 MOLES/L
     CS137    CONCENTRATION =  0.        MOLES/L


DATA FOR NEPTUNIUM

SOLUBILITY =  3.000E-03 MOLES/L      MOLECULAR WEIGHT =  237.00 G/MOLE

AT    100. YR       1.730E+01 CURIES/MTHM       5.900E+02 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  1.000E-04 1/YR  (BULK RATE)
     ELEMENT DISSOLUTION RATE =  5.900E-02 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  1.730E-03 CURIES/MTHM YR
           NP237    RELEASE RATE =  4.161E-05 CURIES/MTHM YR
           NP239    RELEASE RATE =  1.692E-03 CURIES/MTHM YR
     ELEMENT CONCENTRATION =  2.736E-07 MOLES/L
     NP237    CONCENTRATION =  2.736E-07 MOLES/L
     NP239    CONCENTRATION =  3.343E-14 MOLES/L

AT    1000. YR       1.650E+01 CURIES/MTHM       1.420E+03 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  1.000E-04 1/YR  (BULK RATE)
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     ELEMENT DISSOLUTION RATE =  1.420E-01 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  1.650E-03 CURIES/MTHM YR
           NP237   RELEASE RATE =  1.002E-04 CURIES/MTHM YR
           NP239   RELEASE RATE =  1.554E-03 CURIES/MTHM YR
     ELEMENT CONCENTRATION =  6.584E-07 MOLES/L
     NP237   CONCENTRATION =  6.584E-07 MOLES/L
     NP239   CONCENTRATION =  3.071E-14 MOLES/L

AT   10000. YR       7.850E+00 CURIES/MTHM       1.670E+03 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  1.000E-04 1/YR  (BULK RATE)
     ELEMENT DISSOLUTION RATE =  1.670E-01 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  7.850E-04 CURIES/MTHM YR
           NP237   RELEASE RATE =  1.178E-04 CURIES/MTHM YR
           NP239   RELEASE RATE =  6.678E-04 CURIES/MTHM YR
     ELEMENT CONCENTRATION =  7.743E-07 MOLES/L
     NP237   CONCENTRATION =  7.743E-07 MOLES/L
     NP239   CONCENTRATION =  1.320E-14 MOLES/L

AT 100000. YR       1.150E+00 CURIES/MTHM       1.620E+03 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  1.000E-04 1/YR  (BULK RATE)
     ELEMENT DISSOLUTION RATE =  1.620E-01 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  1.150E-04 CURIES/MTHM YR
           NP237   RELEASE RATE =  1.143E-04 CURIES/MTHM YR
           NP239   RELEASE RATE =  1.459E-07 CURIES/MTHM YR
     ELEMENT CONCENTRATION =  7.511E-07 MOLES/L
     NP237   CONCENTRATION =  7.511E-07 MOLES/L
     NP239   CONCENTRATION =  2.883E-18 MOLES/L


DATA FOR PLUTONIUM

SOLUBILITY =  1.800E-06 MOLES/L      MOLECULAR WEIGHT =  239.00 G/MOLE

AT    100. YR       2.960E+03 CURIES/MTHM       7.860E+03 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  1.211E-07 1/YR
     ELEMENT DISSOLUTION RATE =  9.518E-04 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  3.585E-04 CURIES/MTHM YR
           PU238   RELEASE RATE =  1.326E-04 CURIES/MTHM YR
           PU239   RELEASE RATE =  3.775E-05 CURIES/MTHM YR
           PU240   RELEASE RATE =  6.348E-05 CURIES/MTHM YR
           PU241   RELEASE RATE =  1.240E-04 CURIES/MTHM YR
           PU242   RELEASE RATE =  2.127E-07 CURIES/MTHM YR
     ELEMENT CONCENTRATION =  4.376E-09 MOLES/L
     PU238   CONCENTRATION =  3.578E-11 MOLES/L
     PU239   CONCENTRATION =  2.795E-09 MOLES/L
     PU240   CONCENTRATION =  1.275E-09 MOLES/L
     PU241   CONCENTRATION =  5.483E-12 MOLES/L
     PU242   CONCENTRATION =  2.458E-10 MOLES/L

AT    1000. YR       7.840E+02 CURIES/MTHM       7.450E+03 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  1.278E-07 1/YR
     ELEMENT DISSOLUTION RATE =  9.518E-04 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  1.002E-04 CURIES/MTHM YR
           PU238   RELEASE RATE =  1.235E-07 CURIES/MTHM YR
           PU239   RELEASE RATE =  3.888E-05 CURIES/MTHM YR
           PU240   RELEASE RATE =  6.085E-05 CURIES/MTHM YR
           PU241   RELEASE RATE =  2.450E-09 CURIES/MTHM YR
           PU242   RELEASE RATE =  2.244E-07 CURIES/MTHM YR
     ELEMENT CONCENTRATION =  4.376E-09 MOLES/L
     PU238   CONCENTRATION =  3.333E-14 MOLES/L
     PU239   CONCENTRATION =  2.878E-09 MOLES/L
     PU240   CONCENTRATION =  1.223E-09 MOLES/L
     PU241   CONCENTRATION =  1.084E-16 MOLES/L
     PU242   CONCENTRATION =  2.593E-10 MOLES/L

AT   10000. YR       4.230E+02 CURIES/MTHM       5.080E+03 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  1.874E-07 1/YR
     ELEMENT DISSOLUTION RATE =  9.518E-04 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  7.926E-05 CURIES/MTHM YR
           PU238   RELEASE RATE =  0.         CURIES/MTHM YR
           PU239   RELEASE RATE =  4.445E-05 CURIES/MTHM YR
           PU240   RELEASE RATE =  3.442E-05 CURIES/MTHM YR
           PU241   RELEASE RATE =  1.725E-09 CURIES/MTHM YR
           PU242   RELEASE RATE =  3.233E-07 CURIES/MTHM YR
     ELEMENT CONCENTRATION =  4.375E-09 MOLES/L
     PU238   CONCENTRATION =  0.         MOLES/L
     PU239   CONCENTRATION =  3.291E-09 MOLES/L
     PU240   CONCENTRATION =  6.915E-10 MOLES/L
     PU241   CONCENTRATION =  7.629E-17 MOLES/L
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     PU242   CONCENTRATION =  3.735E-10 MOLES/L

AT 100000. YR       1.950E+01 CURIES/MTHM       6.740E+02 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  1.412E-06 1/YR
     ELEMENT DISSOLUTION RATE =  9.518E-04 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  2.754E-05 CURIES/MTHM YR
           PU238   RELEASE RATE =  0.         CURIES/MTHM YR
           PU239   RELEASE RATE =  2.534E-05 CURIES/MTHM YR
           PU240   RELEASE RATE =  1.860E-08 CURIES/MTHM YR
           PU241   RELEASE RATE =  8.446E-12 CURIES/MTHM YR
           PU242   RELEASE RATE =  2.076E-06 CURIES/MTHM YR
     ELEMENT CONCENTRATION =  4.376E-09 MOLES/L
     PU238   CONCENTRATION =  0.        MOLES/L
     PU239   CONCENTRATION =  1.877E-09 MOLES/L
     PU240   CONCENTRATION =  3.737E-13 MOLES/L
     PU241   CONCENTRATION =  3.735E-19 MOLES/L
     PU242   CONCENTRATION =  2.398E-09 MOLES/L


DATA FOR RADIUM

SOLUBILITY =  1.000E-07 MOLES/L     MOLECULAR WEIGHT =  226.00 G/MOLE

AT    100. YR       2.700E-03 CURIES/MTHM       2.650E-05 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  1.000E-04 1/YR  (BULK RATE)
     ELEMENT DISSOLUTION RATE =  2.650E-09 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  2.700E-07 CURIES/MTHM YR
           RA226   RELEASE RATE =  2.620E-09 CURIES/MTHM YR
     ELEMENT CONCENTRATION =  1.289E-14 MOLES/L
     RA226   CONCENTRATION =  1.289E-14 MOLES/L

AT    1000. YR       3.560E-03 CURIES/MTHM       3.090E-03 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  1.000E-04 1/YR  (BULK RATE)
     ELEMENT DISSOLUTION RATE =  3.090E-07 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  3.560E-07 CURIES/MTHM YR
           RA226   RELEASE RATE =  3.055E-07 CURIES/MTHM YR
     ELEMENT CONCENTRATION =  1.502E-12 MOLES/L
     RA226   CONCENTRATION =  1.502E-12 MOLES/L

AT   10000. YR       1.510E-01 CURIES/MTHM       1.320E-01 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  1.000E-04 1/YR  (BULK RATE)
     ELEMENT DISSOLUTION RATE =  1.320E-05 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  1.510E-05 CURIES/MTHM YR
           RA226   RELEASE RATE =  1.305E-05 CURIES/MTHM YR
     ELEMENT CONCENTRATION =  6.418E-11 MOLES/L
     RA226   CONCENTRATION =  6.418E-11 MOLES/L

AT 100000. YR       1.440E+00 CURIES/MTHM       1.050E+00 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  4.762E-05 1/YR
     ELEMENT DISSOLUTION RATE =  5.000E-05 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  6.858E-05 CURIES/MTHM YR
           RA226   RELEASE RATE =  4.944E-05 CURIES/MTHM YR
     ELEMENT CONCENTRATION =  2.431E-10 MOLES/L
     RA226   CONCENTRATION =  2.431E-10 MOLES/L


DATA FOR STRONTIUM

SOLUBILITY =  9.400E-04 MOLES/L     MOLECULAR WEIGHT =   90.00 G/MOLE

AT    100. YR       1.350E+04 CURIES/MTHM       4.000E+02 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  1.000E-04 1/YR  (BULK RATE)
     ELEMENT DISSOLUTION RATE =  4.000E-02 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  1.350E+00 CURIES/MTHM YR
           SR90    RELEASE RATE =  1.354E+00 CURIES/MTHM YR
     ELEMENT CONCENTRATION =  4.884E-07 MOLES/L
     SR90    CONCENTRATION =  6.056E-08 MOLES/L

AT    1000. YR       6.720E-06 CURIES/MTHM       3.500E+02 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  1.000E-04 1/YR  (BULK RATE)
     ELEMENT DISSOLUTION RATE =  3.500E-02 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  6.720E-10 CURIES/MTHM YR
           SR90    RELEASE RATE =  6.743E-10 CURIES/MTHM YR
     ELEMENT CONCENTRATION =  4.274E-07 MOLES/L
     SR90    CONCENTRATION =  3.016E-17 MOLES/L

AT   10000. YR       0.         CURIES/MTHM       3.500E+02 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  1.000E-04 1/YR  (BULK RATE)
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     ELEMENT DISSOLUTION RATE =  3.500E-02 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  0.        CURIES/MTHM YR
           SR90    RELEASE RATE =  0.        CURIES/MTHM YR
     ELEMENT CONCENTRATION =  4.274E-07 MOLES/L
     SR90    CONCENTRATION =  0.        MOLES/L

AT 100000. YR       0.        CURIES/MTHM       3.500E+02 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  1.000E-04 1/YR  (BULK RATE)
     ELEMENT DISSOLUTION RATE =  3.500E-02 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  0.        CURIES/MTHM YR
           SR90    RELEASE RATE =  0.        CURIES/MTHM YR
     ELEMENT CONCENTRATION =  4.274E-07 MOLES/L
     SR90    CONCENTRATION =  0.        MOLES/L


DATA FOR TECHNETIUM

SOLUBILITY =  1.000E+10 MOLES/L     MOLECULAR WEIGHT =   99.00 G/MOLE

AT    100. YR       1.310E+01 CURIES/MTHM       7.710E+02 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  1.000E-04 1/YR  (BULK RATE)
     ELEMENT DISSOLUTION RATE =  7.710E-02 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  1.310E-03 CURIES/MTHM YR
           TC99    RELEASE RATE =  1.308E-03 CURIES/MTHM YR
     ELEMENT CONCENTRATION =  8.558E-07 MOLES/L
     TC99    CONCENTRATION =  8.558E-07 MOLES/L

AT   1000. YR       1.300E+01 CURIES/MTHM       7.690E+02 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  1.000E-04 1/YR  (BULK RATE)
     ELEMENT DISSOLUTION RATE =  7.690E-02 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  1.300E-03 CURIES/MTHM YR
           TC99    RELEASE RATE =  1.304E-03 CURIES/MTHM YR
     ELEMENT CONCENTRATION =  8.536E-07 MOLES/L
     TC99    CONCENTRATION =  8.536E-07 MOLES/L

AT  10000. YR       1.270E+01 CURIES/MTHM       7.460E+02 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  1.000E-04 1/YR  (BULK RATE)
     ELEMENT DISSOLUTION RATE =  7.460E-02 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  1.270E-03 CURIES/MTHM YR
           TC99    RELEASE RATE =  1.265E-03 CURIES/MTHM YR
     ELEMENT CONCENTRATION =  8.281E-07 MOLES/L
     TC99    CONCENTRATION =  8.281E-07 MOLES/L

AT 100000. YR       9.440E+00 CURIES/MTHM       5.570E+02 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  1.000E-04 1/YR  (BULK RATE)
     ELEMENT DISSOLUTION RATE =  5.570E-02 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  9.440E-04 CURIES/MTHM YR
           TC99    RELEASE RATE =  9.447E-04 CURIES/MTHM YR
     ELEMENT CONCENTRATION =  6.183E-07 MOLES/L
     TC99    CONCENTRATION =  6.183E-07 MOLES/L


DATA FOR TIN

SOLUBILITY =  1.000E-09 MOLES/L     MOLECULAR WEIGHT =  119.00 G/MOLE

AT    100. YR       8.290E-01 CURIES/MTHM       9.000E+01 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  2.925E-09 1/YR
     ELEMENT DISSOLUTION RATE =  2.633E-07 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  2.425E-09 CURIES/MTHM YR
           SN126   RELEASE RATE =  2.274E-09 CURIES/MTHM YR
     ELEMENT CONCENTRATION =  2.431E-12 MOLES/L
     SN126   CONCENTRATION =  7.272E-13 MOLES/L

AT   1000. YR       7.720E-01 CURIES/MTHM       8.980E+01 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  2.932E-09 1/YR
     ELEMENT DISSOLUTION RATE =  2.633E-07 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  2.263E-09 CURIES/MTHM YR
           SN126   RELEASE RATE =  2.264E-09 CURIES/MTHM YR
     ELEMENT CONCENTRATION =  2.431E-12 MOLES/L
     SN126   CONCENTRATION =  7.237E-13 MOLES/L

AT  10000. YR       7.250E-01 CURIES/MTHM       8.810E+01 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  2.989E-09 1/YR
     ELEMENT DISSOLUTION RATE =  2.633E-07 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  2.167E-09 CURIES/MTHM YR
           SN126   RELEASE RATE =  2.169E-09 CURIES/MTHM YR
     ELEMENT CONCENTRATION =  2.431E-12 MOLES/L
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     SN126    CONCENTRATION =  6.933E-13 MOLES/L

AT 100000. YR        3.890E-01 CURIES/MTHM        7.630E+01 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  3.451E-09 1/YR
     ELEMENT DISSOLUTION RATE =  2.633E-07 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  1.342E-09 CURIES/MTHM YR
           SN126    RELEASE RATE =  1.346E-09 CURIES/MTHM YR
     ELEMENT CONCENTRATION =  2.431E-12 MOLES/L
     SN126    CONCENTRATION =  4.304E-13 MOLES/L


DATA FOR URANIUM

SOLUBILITY =  2.100E-04 MOLES/L      MOLECULAR WEIGHT =  238.00 G/MOLE

AT    100. YR        2.190E+00 CURIES/MTHM        9.560E+05 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  1.157E-07 1/YR
     ELEMENT DISSOLUTION RATE =  1.106E-01 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  2.533E-07 CURIES/MTHM YR
           U233     RELEASE RATE =  1.965E-11 CURIES/MTHM YR
           U234     RELEASE RATE =  1.841E-07 CURIES/MTHM YR
           U235     RELEASE RATE =  1.991E-09 CURIES/MTHM YR
           U236     RELEASE RATE =  2.980E-08 CURIES/MTHM YR
           U238     RELEASE RATE =  3.669E-08 CURIES/MTHM YR
     ELEMENT CONCENTRATION =  5.106E-07 MOLES/L
     U233     CONCENTRATION =  9.602E-15 MOLES/L
     U234     CONCENTRATION =  1.385E-10 MOLES/L
     U235     CONCENTRATION =  4.311E-09 MOLES/L
     U236     CONCENTRATION =  2.144E-09 MOLES/L
     U238     CONCENTRATION =  5.042E-07 MOLES/L

AT    1000. YR        2.590E+00 CURIES/MTHM        9.570E+05 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  1.156E-07 1/YR
     ELEMENT DISSOLUTION RATE =  1.106E-01 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  2.993E-07 CURIES/MTHM YR
           U233     RELEASE RATE =  3.724E-10 CURIES/MTHM YR
           U234     RELEASE RATE =  2.293E-07 CURIES/MTHM YR
           U235     RELEASE RATE =  2.022E-09 CURIES/MTHM YR
           U236     RELEASE RATE =  3.134E-08 CURIES/MTHM YR
           U238     RELEASE RATE =  3.665E-08 CURIES/MTHM YR
     ELEMENT CONCENTRATION =  5.106E-07 MOLES/L
     U233     CONCENTRATION =  1.820E-13 MOLES/L
     U234     CONCENTRATION =  1.726E-10 MOLES/L
     U235     CONCENTRATION =  4.377E-09 MOLES/L
     U236     CONCENTRATION =  2.254E-09 MOLES/L
     U238     CONCENTRATION =  5.036E-07 MOLES/L

AT   10000. YR        2.680E+00 CURIES/MTHM        9.590E+05 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  1.153E-07 1/YR
     ELEMENT DISSOLUTION RATE =  1.106E-01 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  3.090E-07 CURIES/MTHM YR
           U233     RELEASE RATE =  5.553E-09 CURIES/MTHM YR
           U234     RELEASE RATE =  2.238E-07 CURIES/MTHM YR
           U235     RELEASE RATE =  2.294E-09 CURIES/MTHM YR
           U236     RELEASE RATE =  4.069E-08 CURIES/MTHM YR
           U238     RELEASE RATE =  3.657E-08 CURIES/MTHM YR
     ELEMENT CONCENTRATION =  5.106E-07 MOLES/L
     U233     CONCENTRATION =  2.714E-12 MOLES/L
     U234     CONCENTRATION =  1.684E-10 MOLES/L
     U235     CONCENTRATION =  4.966E-09 MOLES/L
     U236     CONCENTRATION =  2.926E-09 MOLES/L
     U238     CONCENTRATION =  5.026E-07 MOLES/L

AT 100000. YR        2.730E+00 CURIES/MTHM        9.630E+05 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  1.148E-07 1/YR
     ELEMENT DISSOLUTION RATE =  1.106E-01 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  3.135E-07 CURIES/MTHM YR
           U233     RELEASE RATE =  4.710E-08 CURIES/MTHM YR
           U234     RELEASE RATE =  1.813E-07 CURIES/MTHM YR
           U235     RELEASE RATE =  3.150E-09 CURIES/MTHM YR
           U236     RELEASE RATE =  4.631E-08 CURIES/MTHM YR
           U238     RELEASE RATE =  3.642E-08 CURIES/MTHM YR
     ELEMENT CONCENTRATION =  5.106E-07 MOLES/L
     U233     CONCENTRATION =  2.302E-11 MOLES/L
     U234     CONCENTRATION =  1.364E-10 MOLES/L
     U235     CONCENTRATION =  6.820E-09 MOLES/L
     U236     CONCENTRATION =  3.331E-09 MOLES/L
     U238     CONCENTRATION =  5.005E-07 MOLES/L
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TOTAL RADIOACTIVITY RELEASE RATES

AT	100. YR	3.364E+00	CURIES/MTHM YR
	CS137	(59.7	PER CENT)
	SR90	(40.3	PER CENT)
	NP239	(.1	PER CENT)
AT	1000. YR	3.237E-03	CURIES/MTHM YR
	NP239	(48.0	PER CENT)
	TC99	(40.3	PER CENT)
	C14	(4.2	PER CENT)
	NP237	(3.1	PER CENT)
	PU240	(1.9	PER CENT)
	PU239	(1.2	PER CENT)
	CS135	(1.1	PER CENT)
	AM241	(.4	PER CENT)
AT	10000. YR	2.231E-03	CURIES/MTHM YR
	TC99	(56.7	PER CENT)
	NP239	(29.9	PER CENT)
	NP237	(5.3	PER CENT)
	C14	(2.1	PER CENT)
	PU239	(2.0	PER CENT)
	CS135	(1.5	PER CENT)
	PU240	(1.5	PER CENT)
	RA226	(.6	PER CENT)
AT	100000. YR	1.189E-03	CURIES/MTHM YR
	TC99	(79.4	PER CENT)
	NP237	(9.6	PER CENT)
	RA226	(4.2	PER CENT)
	CS135	(2.8	PER CENT)
	PU239	(2.1	PER CENT)
	PU242	(.2	PER CENT)

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PWR HIGH-LEVEL WASTE
SATURATION-LIMITED DISSOLUTION MODEL

WATER FLOW =  9.100E+02 L/MTHM YR
BULK FRACTIONAL DISSOLUTION RATE =  1.000E-04 1/YR


DATA FOR AMERICIUM

SOLUBILITY =  1.000E-08 MOLES/L      MOLECULAR WEIGHT =  242.00 G/MOLE

AT    100. YR       2.010E+02 CURIES/MTHM       1.370E+02 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  1.607E-05 1/YR
     ELEMENT DISSOLUTION RATE =  2.202E-03 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  3.231E-03 CURIES/MTHM YR
           AM241   RELEASE RATE =  2.884E-03 CURIES/MTHM YR
           AM243   RELEASE RATE =  2.726E-04 CURIES/MTHM YR
     ELEMENT CONCENTRATION =  1.000E-08 MOLES/L
     AM241   CONCENTRATION =  3.818E-09 MOLES/L
     AM243   CONCENTRATION =  6.164E-09 MOLES/L

AT   1000. YR       5.810E+01 CURIES/MTHM       9.030E+01 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  2.439E-05 1/YR
     ELEMENT DISSOLUTION RATE =  2.202E-03 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  1.417E-03 CURIES/MTHM YR
           AM241   RELEASE RATE =  1.037E-03 CURIES/MTHM YR
           AM243   RELEASE RATE =  3.800E-04 CURIES/MTHM YR
     ELEMENT CONCENTRATION =  1.000E-08 MOLES/L
     AM241   CONCENTRATION =  1.373E-09 MOLES/L
     AM243   CONCENTRATION =  8.591E-09 MOLES/L.

AT  10000. YR       6.680E+00 CURIES/MTHM       3.350E+01 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  6.574E-05 1/YR
     ELEMENT DISSOLUTION RATE =  2.202E-03 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  4.391E-04 CURIES/MTHM YR
           AM241   RELEASE RATE =  6.065E-07 CURIES/MTHM YR
           AM243   RELEASE RATE =  4.404E-04 CURIES/MTHM YR
     ELEMENT CONCENTRATION =  1.000E-08 MOLES/L
     AM241   CONCENTRATION =  8.030E-13 MOLES/L
     AM243   CONCENTRATION =  9.959E-09 MOLES/L

AT 100000. YR       1.420E-03 CURIES/MTHM       7.120E-03 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  1.000E-04 1/YR  (BULK RATE)
     ELEMENT DISSOLUTION RATE =  7.120E-07 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  1.420E-07 CURIES/MTHM YR
           AM241   RELEASE RATE =  5.968E-10 CURIES/MTHM YR
           AM243   RELEASE RATE =  1.422E-07 CURIES/MTHM YR
     ELEMENT CONCENTRATION =  3.233E-12 MOLES/L
     AM241   CONCENTRATION =  7.901E-16 MOLES/L
     AM243   CONCENTRATION =  3.215E-12 MOLES/L


DATA FOR CARBON

SOLUBILITY =  1.000E+10 MOLES/L      MOLECULAR WEIGHT =   12.00 G/MOLE

AT    100. YR       1.530E+00 CURIES/MTHM       1.670E+02 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  1.000E-04 1/YR  (BULK RATE)
     ELEMENT DISSOLUTION RATE =  1.670E-02 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  1.530E-04 CURIES/MTHM YR
           C14     RELEASE RATE =  1.529E-04 CURIES/MTHM YR
     ELEMENT CONCENTRATION =  1.529E-06 MOLES/L
     C14     CONCENTRATION =  3.141E-09 MOLES/L

AT   1000. YR       1.370E+00 CURIES/MTHM       1.670E+02 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  1.000E-04 1/YR  (BULK RATE)
     ELEMENT DISSOLUTION RATE =  1.670E-02 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  1.370E-04 CURIES/MTHM YR
           C14     RELEASE RATE =  1.373E-04 CURIES/MTHM YR
     ELEMENT CONCENTRATION =  1.529E-06 MOLES/L
     C14     CONCENTRATION =  2.821E-09 MOLES/L

AT  10000. YR       4.620E-01 CURIES/MTHM       1.670E+02 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  1.000E-04 1/YR  (BULK RATE)
     ELEMENT DISSOLUTION RATE =  1.670E-02 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  4.620E-05 CURIES/MTHM YR
           C14     RELEASE RATE =  4.635E-05 CURIES/MTHM YR
     ELEMENT CONCENTRATION =  1.529E-06 MOLES/L
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     C14      CONCENTRATION =  9.524E-10 MOLES/L

AT 100000. YR        8.620E-06 CURIES/MTHM        1.670E+02 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  1.000E-04 1/YR  (BULK RATE)
     ELEMENT DISSOLUTION RATE =  1.670E-02 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  8.620E-10 CURIES/MTHM YR
           C14      RELEASE RATE =  8.602E-10 CURIES/MTHM YR
     ELEMENT CONCENTRATION =  1.529E-06 MOLES/L
     C14      CONCENTRATION =  1.767E-14 MOLES/L


DATA FOR CESIUM

SOLUBILITY =  1.000E+10 MOLES/L      MOLECULAR WEIGHT =  137.00 G/MOLE

AT    100. YR        2.010E+04 CURIES/MTHM        1.550E+03 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  1.000E-04 1/YR  (BULK RATE)
     ELEMENT DISSOLUTION RATE =  1.550E-01 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  2.010E+00 CURIES/MTHM YR
           CS135    RELEASE RATE =  3.456E-05 CURIES/MTHM YR
           CS137    RELEASE RATE =  2.011E+00 CURIES/MTHM YR
     ELEMENT CONCENTRATION =  1.243E-06 MOLES/L
     CS135    CONCENTRATION =  2.442E-07 MOLES/L
     CS137    CONCENTRATION =  9.545E-08 MOLES/L

AT    1000. YR        3.450E-01 CURIES/MTHM        1.430E+03 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  1.000E-04 1/YR  (BULK RATE)
     ELEMENT DISSOLUTION RATE =  1.430E-01 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  3.450E-05 CURIES/MTHM YR
           CS135    RELEASE RATE =  3.456E-05 CURIES/MTHM YR
           CS137    RELEASE RATE =  1.876E-09 CURIES/MTHM YR
     ELEMENT CONCENTRATION =  1.147E-06 MOLES/L
     CS135    CONCENTRATION =  2.442E-07 MOLES/L
     CS137    CONCENTRATION =  8.904E-17 MOLES/L

AT   10000. YR        3.440E-01 CURIES/MTHM        1.430E+03 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  1.000E-04 1/YR  (BULK RATE)
     ELEMENT DISSOLUTION RATE =  1.430E-01 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  3.440E-05 CURIES/MTHM YR
           CS135    RELEASE RATE =  3.444E-05 CURIES/MTHM YR
           CS137    RELEASE RATE =  0.        CURIES/MTHM YR
     ELEMENT CONCENTRATION =  1.147E-06 MOLES/L
     CS135    CONCENTRATION =  2.434E-07 MOLES/L
     CS137    CONCENTRATION =  0.        MOLES/L

AT 100000. YR        3.350E-01 CURIES/MTHM        1.420E+03 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  1.000E-04 1/YR  (BULK RATE)
     ELEMENT DISSOLUTION RATE =  1.420E-01 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  3.350E-05 CURIES/MTHM YR
           CS135    RELEASE RATE =  3.352E-05 CURIES/MTHM YR
           CS137    RELEASE RATE =  0.        CURIES/MTHM YR
     ELEMENT CONCENTRATION =  1.139E-06 MOLES/L
     CS135    CONCENTRATION =  2.369E-07 MOLES/L
     CS137    CONCENTRATION =  0.        MOLES/L


DATA FOR NEPTUNIUM

SOLUBILITY =  3.000E-03 MOLES/L      MOLECULAR WEIGHT =  237.00 G/MOLE

AT    100. YR        1.720E+01 CURIES/MTHM        4.510E+02 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  1.000E-04 1/YR  (BULK RATE)
     ELEMENT DISSOLUTION RATE =  4.510E-02 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  1.720E-03 CURIES/MTHM YR
           NP237    RELEASE RATE =  3.181E-05 CURIES/MTHM YR
           NP239    RELEASE RATE =  1.689E-03 CURIES/MTHM YR
     ELEMENT CONCENTRATION =  2.091E-07 MOLES/L
     NP237    CONCENTRATION =  2.091E-07 MOLES/L
     NP239    CONCENTRATION =  3.338E-14 MOLES/L

AT    1000. YR        1.590E+01 CURIES/MTHM        4.900E+02 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  1.000E-04 1/YR  (BULK RATE)
     ELEMENT DISSOLUTION RATE =  4.900E-02 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  1.590E-03 CURIES/MTHM YR
           NP237    RELEASE RATE =  3.463E-05 CURIES/MTHM YR
           NP239    RELEASE RATE =  1.552E-03 CURIES/MTHM YR
     ELEMENT CONCENTRATION =  2.272E-07 MOLES/L
     NP237    CONCENTRATION =  2.277E-07 MOLES/L
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     NP239    CONCENTRATION =  3.067E-14 MOLES/L

AT   10000. YR        7.020E+00 CURIES/MTHM        5.010E+02 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  1.000E-04 1/YR  (BULK RATE)
     ELEMENT DISSOLUTION RATE =  5.010E-02 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  7.020E-04 CURIES/MTHM YR
           NP237    RELEASE RATE =  3.534E-05 CURIES/MTHM YR
           NP239    RELEASE RATE =  6.678E-04 CURIES/MTHM YR
     ELEMENT CONCENTRATION =  2.323E-07 MOLES/L
     NP237    CONCENTRATION =  2.323E-07 MOLES/L
     NP239    CONCENTRATION =  1.320E-14 MOLES/L

AT  100000. YR        3.450E-01 CURIES/MTHM        4.870E+02 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  1.000E-04 1/YR  (BULK RATE)
     ELEMENT DISSOLUTION RATE =  4.870E-02 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  3.450E-05 CURIES/MTHM YR
           NP237    RELEASE RATE =  3.435E-05 CURIES/MTHM YR
           NP239    RELEASE RATE =  1.422E-07 CURIES/MTHM YR
     ELEMENT CONCENTRATION =  2.258E-07 MOLES/L
     NP237    CONCENTRATION =  2.258E-07 MOLES/L
     NP239    CONCENTRATION =  2.809E-18 MOLES/L


DATA FOR PLUTONIUM

SOLUBILITY =  1.800E-06 MOLES/L     MOLECULAR WEIGHT =  239.00 G/MOLE

AT     100. YR        6.570E+01 CURIES/MTHM        6.070E+01 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  1.000E-04 1/YR  (BULK RATE)
     ELEMENT DISSOLUTION RATE =  6.070E-03 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  6.570E-03 CURIES/MTHM YR
           PU238    RELEASE RATE =  5.236E-03 CURIES/MTHM YR
           PU239    RELEASE RATE =  1.621E-04 CURIES/MTHM YR
           PU240    RELEASE RATE =  6.632E-04 CURIES/MTHM YR
           PU241    RELEASE RATE =  5.032E-04 CURIES/MTHM YR
           PU242    RELEASE RATE =  8.882E-07 CURIES/MTHM YR
     ELEMENT CONCENTRATION =  2.791E-08 MOLES/L
     PU238    CONCENTRATION =  1.413E-09 MOLES/L
     PU239    CONCENTRATION =  1.200E-08 MOLES/L
     PU240    CONCENTRATION =  1.332E-08 MOLES/L
     PU241    CONCENTRATION =  2.225E-11 MOLES/L
     PU242    CONCENTRATION =  1.026E-09 MOLES/L

AT    1000. YR        8.260E+00 CURIES/MTHM        6.140E+01 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  1.000E-04 1/YR  (BULK RATE)
     ELEMENT DISSOLUTION RATE =  6.140E-03 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  8.260E-04 CURIES/MTHM YR
           PU238    RELEASE RATE =  1.157E-05 CURIES/MTHM YR
           PU239    RELEASE RATE =  2.000E-04 CURIES/MTHM YR
           PU240    RELEASE RATE =  6.108E-04 CURIES/MTHM YR
           PU241    RELEASE RATE =  1.918E-06 CURIES/MTHM YR
           PU242    RELEASE RATE =  9.078E-07 CURIES/MTHM YR
     ELEMENT CONCENTRATION =  2.823E-08 MOLES/L
     PU238    CONCENTRATION =  3.121E-12 MOLES/L
     PU239    CONCENTRATION =  1.481E-08 MOLES/L
     PU240    CONCENTRATION =  1.227E-08 MOLES/L
     PU241    CONCENTRATION =  8.481E-14 MOLES/L
     PU242    CONCENTRATION =  1.049E-09 MOLES/L

AT   10000. YR        6.270E+00 CURIES/MTHM        7.530E+01 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  1.000E-04 1/YR  (BULK RATE)
     ELEMENT DISSOLUTION RATE =  7.530E-03 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  6.270E-04 CURIES/MTHM YR
           PU238    RELEASE RATE =  0.          CURIES/MTHM YR
           PU239    RELEASE RATE =  3.887E-04 CURIES/MTHM YR
           PU240    RELEASE RATE =  2.347E-04 CURIES/MTHM YR
           PU241    RELEASE RATE =  9.197E-07 CURIES/MTHM YR
           PU242    RELEASE RATE =  9.157E-07 CURIES/MTHM YR
     ELEMENT CONCENTRATION =  3.462E-08 MOLES/L
     PU238    CONCENTRATION =  0.          MOLES/L
     PU239    CONCENTRATION =  2.878E-08 MOLES/L
     PU240    CONCENTRATION =  4.716E-09 MOLES/L
     PU241    CONCENTRATION =  4.067E-14 MOLES/L
     PU242    CONCENTRATION =  1.058E-09 MOLES/L

AT  100000. YR        5.200E-01 CURIES/MTHM        1.030E+01 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  1.000E-04 1/YR  (BULK RATE)
     ELEMENT DISSOLUTION RATE =  1.030E-03 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  5.200E-05 CURIES/MTHM YR
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          PU238   RELEASE RATE =  0.          CURIES/MTHM YR
          PU239   RELEASE RATE =  5.111E-05 CURIES/MTHM YR
          PU240   RELEASE RATE =  1.689E-08 CURIES/MTHM YR
          PU241   RELEASE RATE =  5.970E-10 CURIES/MTHM YR
          PU242   RELEASE RATE =  7.860E-07 CURIES/MTHM YR
     ELEMENT CONCENTRATION =  4.736E-09 MOLES/L
     PU238   CONCENTRATION =  0.          MOLES/L
     PU239   CONCENTRATION =  3.784E-09 MOLES/L
     PU240   CONCENTRATION =  3.393E-13 MOLES/L
     PU241   CONCENTRATION =  2.640E-17 MOLES/L
     PU242   CONCENTRATION =  9.082E-10 MOLES/L


DATA FOR RADIUM

SOLUBILITY =  1.000E-07 MOLES/L      MOLECULAR WEIGHT =  226.00 G/MOLE

AT    100. YR       2.770E-05 CURIES/MTHM       1.480E-06 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  1.000E-04 1/YR  (BULK RATE)
     ELEMENT DISSOLUTION RATE =  1.480E-10 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  2.770E-09 CURIES/MTHM YR
          RA226   RELEASE RATE =  1.463E-10 CURIES/MTHM YR
     ELEMENT CONCENTRATION =  7.196E-16 MOLES/L
     RA226   CONCENTRATION =  7.196E-16 MOLES/L

AT   1000. YR       1.550E-04 CURIES/MTHM       7.510E-05 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  1.000E-04 1/YR  (BULK RATE)
     ELEMENT DISSOLUTION RATE =  7.510E-09 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  1.550E-08 CURIES/MTHM YR
          RA226   RELEASE RATE =  7.425E-09 CURIES/MTHM YR
     ELEMENT CONCENTRATION =  3.652E-14 MOLES/L
     RA226   CONCENTRATION =  3.652E-14 MOLES/L

AT  10000. YR       8.480E-03 CURIES/MTHM       3.170E-03 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  1.000E-04 1/YR  (BULK RATE)
     ELEMENT DISSOLUTION RATE =  3.170E-07 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  8.480E-07 CURIES/MTHM YR
          RA226   RELEASE RATE =  3.134E-07 CURIES/MTHM YR
     ELEMENT CONCENTRATION =  1.541E-12 MOLES/L
     RA226   CONCENTRATION =  1.541E-12 MOLES/L

AT 100000. YR       1.370E-01 CURIES/MTHM       2.470E-02 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  1.000E-04 1/YR  (BULK RATE)
     ELEMENT DISSOLUTION RATE =  2.470E-06 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  1.370E-05 CURIES/MTHM YR
          RA226   RELEASE RATE =  2.442E-06 CURIES/MTHM YR
     ELEMENT CONCENTRATION =  1.201E-11 MOLES/L
     RA226   CONCENTRATION =  1.201E-11 MOLES/L


DATA FOR STRONTIUM

SOLUBILITY =  9.400E-04 MOLES/L      MOLECULAR WEIGHT =  90.00 G/MOLE

AT    100. YR       1.350E+04 CURIES/MTHM       4.000E+02 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  1.000E-04 1/YR  (BULK RATE)
     ELEMENT DISSOLUTION RATE =  4.000E-02 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  1.350E+00 CURIES/MTHM YR
          SR90    RELEASE RATE =  1.354E+00 CURIES/MTHM YR
     ELEMENT CONCENTRATION =  4.884E-07 MOLES/L
     SR90    CONCENTRATION =  6.056E-08 MOLES/L

AT   1000. YR       6.720E-06 CURIES/MTHM       3.500E+02 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  1.000E-04 1/YR  (BULK RATE)
     ELEMENT DISSOLUTION RATE =  3.500E-02 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  6.720E-10 CURIES/MTHM YR
          SR90    RELEASE RATE =  6.743E-10 CURIES/MTHM YR
     ELEMENT CONCENTRATION =  4.274E-07 MOLES/L
     SR90    CONCENTRATION =  3.016E-17 MOLES/L

AT  10000. YR       0.          CURIES/MTHM       3.500E+02 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  1.000E-04 1/YR  (BULK RATE)
     ELEMENT DISSOLUTION RATE =  3.500E-02 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  0.          CURIES/MTHM YR
          SR90    RELEASE RATE =  0.          CURIES/MTHM YR
     ELEMENT CONCENTRATION =  4.274E-07 MOLES/L
     SR90    CONCENTRATION =  0.          MOLES/L
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AT 100000. YR       0.          CURIES/MTHM       3.500E+02 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  1.000E-04 1/YR  (BULK RATE)
     ELEMENT DISSOLUTION RATE =  3.500E-02 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  0.          CURIES/MTHM YR
          SR90    RELEASE RATE =  0.          CURIES/MTHM YR
     ELEMENT CONCENTRATION =  4.274E-07 MOLES/L
     SR90    CONCENTRATION =  0.          MOLES/L


DATA FOR TECHNETIUM

SOLUBILITY =  1.000E+10 MOLES/L     MOLECULAR WEIGHT =   99.00 G/MOLE

AT    100. YR       1.310E+01 CURIES/MTHM       7.710E+02 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  1.000E-04 1/YR  (BULK RATE)
     ELEMENT DISSOLUTION RATE =  7.710E-02 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  1.310E-03 CURIES/MTHM YR
          TC99    RELEASE RATE =  1.308E-03 CURIES/MTHM YR
     ELEMENT CONCENTRATION =  8.558E-07 MOLES/L
     TC99    CONCENTRATION =  8.558E-07 MOLES/L

AT    1000. YR       1.300E+01 CURIES/MTHM       7.690E+02 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  1.000E-04 1/YR  (BULK RATE)
     ELEMENT DISSOLUTION RATE =  7.690E-02 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  1.300E-03 CURIES/MTHM YR
          TC99    RELEASE RATE =  1.304E-03 CURIES/MTHM YR
     ELEMENT CONCENTRATION =  8.536E-07 MOLES/L
     TC99    CONCENTRATION =  8.536E-07 MOLES/L

AT   10000. YR       1.270E+01 CURIES/MTHM       7.460E+02 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  1.000E-04 1/YR  (BULK RATE)
     ELEMENT DISSOLUTION RATE =  7.460E-02 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  1.270E-03 CURIES/MTHM YR
          TC99    RELEASE RATE =  1.265E-03 CURIES/MTHM YR
     ELEMENT CONCENTRATION =  8.281E-07 MOLES/L
     TC99    CONCENTRATION =  8.281E-07 MOLES/L

AT 100000. YR       9.440E+00 CURIES/MTHM       5.570E+02 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  1.000E-04 1/YR  (BULK RATE)
     ELEMENT DISSOLUTION RATE =  5.570E-02 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  9.440E-04 CURIES/MTHM YR
          TC99    RELEASE RATE =  9.447E-04 CURIES/MTHM YR
     ELEMENT CONCENTRATION =  6.183E-07 MOLES/L
     TC99    CONCENTRATION =  6.183E-07 MOLES/L


DATA FOR TIN

SOLUBILITY =  1.000E-09 MOLES/L     MOLECULAR WEIGHT =  119.00 G/MOLE

AT    100. YR       8.290E-01 CURIES/MTHM       9.000E+01 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  1.203E-06 1/YR
     ELEMENT DISSOLUTION RATE =  1.083E-04 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  9.975E-07 CURIES/MTHM YR
          SN126   RELEASE RATE =  9.355E-07 CURIES/MTHM YR
     ELEMENT CONCENTRATION =  1.000E-09 MOLES/L
     SN126   CONCENTRATION =  2.991E-10 MOLES/L

AT    1000. YR       7.720E-01 CURIES/MTHM       8.980E+01 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  1.206E-06 1/YR
     ELEMENT DISSOLUTION RATE =  1.083E-04 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  9.310E-07 CURIES/MTHM YR
          SN126   RELEASE RATE =  9.310E-07 CURIES/MTHM YR
     ELEMENT CONCENTRATION =  1.000E-09 MOLES/L
     SN126   CONCENTRATION =  2.976E-10 MOLES/L

AT   10000. YR       7.250E-01 CURIES/MTHM       8.810E+01 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  1.229E-06 1/YR
     ELEMENT DISSOLUTION RATE =  1.083E-04 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  8.911E-07 CURIES/MTHM YR
          SN126   RELEASE RATE =  8.919E-07 CURIES/MTHM YR
     ELEMENT CONCENTRATION =  1.000E-09 MOLES/L
     SN126   CONCENTRATION =  2.852E-10 MOLES/L

AT 100000. YR       3.890E-01 CURIES/MTHM       7.630E+01 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  1.419E-06 1/YR
     ELEMENT DISSOLUTION RATE =  1.083E-04 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  5.521E-07 CURIES/MTHM YR
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      SN126    RELEASE RATE =  5.537E-07 CURIES/MTHM YR
ELEMENT CONCENTRATION =  1.000E-09 MOLES/L
SN126    CONCENTRATION =  1.770E-10 MOLES/L


DATA FOR URANIUM

SOLUBILITY =  2.100E-04 MOLES/L      MOLECULAR WEIGHT =  238.00 G/MOLE

AT    100. YR       3.080E-02 CURIES/MTHM       4.780E+03 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  1.000E-04 1/YR  (BULK RATE)
     ELEMENT DISSOLUTION RATE =  4.780E-01 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  3.080E-06 CURIES/MTHM YR
          U233    RELEASE RATE =  1.380E-08 CURIES/MTHM YR
          U234    RELEASE RATE =  2.764E-06 CURIES/MTHM YR
          U235    RELEASE RATE =  8.618E-09 CURIES/MTHM YR
          U236    RELEASE RATE =  1.301E-07 CURIES/MTHM YR
          U238    RELEASE RATE =  1.586E-07 CURIES/MTHM YR
     ELEMENT CONCENTRATION =  2.207E-06 MOLES/L
     U233    CONCENTRATION =  6.744E-12 MOLES/L
     U234    CONCENTRATION =  2.080E-09 MOLES/L
     U235    CONCENTRATION =  1.866E-08 MOLES/L
     U236    CONCENTRATION =  9.359E-09 MOLES/L
     U238    CONCENTRATION =  2.179E-06 MOLES/L

AT    1000. YR       5.220E-02 CURIES/MTHM       4.790E+03 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  1.000E-04 1/YR  (BULK RATE)
     ELEMENT DISSOLUTION RATE =  4.790E-01 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  5.220E-06 CURIES/MTHM YR
          U233    RELEASE RATE =  1.448E-07 CURIES/MTHM YR
          U234    RELEASE RATE =  4.749E-06 CURIES/MTHM YR
          U235    RELEASE RATE =  8.770E-09 CURIES/MTHM YR
          U236    RELEASE RATE =  1.470E-07 CURIES/MTHM YR
          U238    RELEASE RATE =  1.586E-07 CURIES/MTHM YR
     ELEMENT CONCENTRATION =  2.212E-06 MOLES/L
     U233    CONCENTRATION =  7.074E-11 MOLES/L
     U234    CONCENTRATION =  3.574E-09 MOLES/L
     U235    CONCENTRATION =  1.899E-08 MOLES/L
     U236    CONCENTRATION =  1.057E-08 MOLES/L
     U238    CONCENTRATION =  2.179E-06 MOLES/L

AT   10000. YR       6.570E-02 CURIES/MTHM       4.820E+03 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  1.000E-04 1/YR  (BULK RATE)
     ELEMENT DISSOLUTION RATE =  4.820E-01 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  6.570E-06 CURIES/MTHM YR
          U233    RELEASE RATE =  1.496E-06 CURIES/MTHM YR
          U234    RELEASE RATE =  4.636E-06 CURIES/MTHM YR
          U235    RELEASE RATE =  1.158E-08 CURIES/MTHM YR
          U236    RELEASE RATE =  2.518E-07 CURIES/MTHM YR
          U238    RELEASE RATE =  1.586E-07 CURIES/MTHM YR
     ELEMENT CONCENTRATION =  2.226E-06 MOLES/L
     U233    CONCENTRATION =  7.310E-10 MOLES/L
     U234    CONCENTRATION =  3.489E-09 MOLES/L
     U235    CONCENTRATION =  2.506E-08 MOLES/L
     U236    CONCENTRATION =  1.811E-08 MOLES/L
     U238    CONCENTRATION =  2.179E-06 MOLES/L

AT 100000. YR       1.650E-01 CURIES/MTHM       4.930E+03 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  1.000E-04 1/YR  (BULK RATE)
     ELEMENT DISSOLUTION RATE =  4.930E-01 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  1.650E-05 CURIES/MTHM YR
          U233    RELEASE RATE =  1.226E-05 CURIES/MTHM YR
          U234    RELEASE RATE =  3.632E-06 CURIES/MTHM YR
          U235    RELEASE RATE =  3.002E-08 CURIES/MTHM YR
          U236    RELEASE RATE =  3.166E-07 CURIES/MTHM YR
          U238    RELEASE RATE =  1.586E-07 CURIES/MTHM YR
     ELEMENT CONCENTRATION =  2.276E-06 MOLES/L
     U233    CONCENTRATION =  5.990E-09 MOLES/L
     U234    CONCENTRATION =  2.733E-09 MOLES/L
     U235    CONCENTRATION =  6.500E-08 MOLES/L
     U236    CONCENTRATION =  2.277E-08 MOLES/L
     U238    CONCENTRATION =  2.179E-06 MOLES/L


DATA FOR SIO2(AMORPHOUS)

SOLUBILITY =  1.000E-03 MOLES/L      MOLECULAR WEIGHT =   60.09 G/MOLE
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AT     100. YR        0.          CURIES/MTHM        1.500E+05 G/MTHM
       FRACTIONAL DISSOLUTION RATE =  1.000E-04 1/YR  (BULK RATE)
       ELEMENT DISSOLUTION RATE =  1.500E+01 G/MTHM YR
       RADIOACTIVITY RELEASE RATE =  0.          CURIES/MTHM YR
       ELEMENT CONCENTRATION =  2.743E-04 MOLES/L

AT    1000. YR        0.          CURIES/MTHM        1.500E+05 G/MTHM
       FRACTIONAL DISSOLUTION RATE =  1.000E-04 1/YR  (BULK RATE)
       ELEMENT DISSOLUTION RATE =  1.500E+01 G/MTHM YR
       RADIOACTIVITY RELEASE RATE =  0.          CURIES/MTHM YR
       ELEMENT CONCENTRATION =  2.743E-04 MOLES/L

AT   10000. YR        0.          CURIES/MTHM        1.500E+05 G/MTHM
       FRACTIONAL DISSOLUTION RATE =  1.000E-04 1/YR  (BULK RATE)
       ELEMENT DISSOLUTION RATE =  1.500E+01 G/MTHM YR
       RADIOACTIVITY RELEASE RATE =  0.          CURIES/MTHM YR
       ELEMENT CONCENTRATION =  2.743E-04 MOLES/L

AT  100000. YR        0.          CURIES/MTHM        1.500E+05 G/MTHM
       FRACTIONAL DISSOLUTION RATE =  1.000E-04 1/YR  (BULK RATE)
       ELEMENT DISSOLUTION RATE =  1.500E+01 G/MTHM YR
       RADIOACTIVITY RELEASE RATE =  0.          CURIES/MTHM YR
       ELEMENT CONCENTRATION =  2.743E-04 MOLES/L


TOTAL RADIOACTIVITY RELEASE RATES

AT     100. YR        3.373E+00 CURIES/MTHM YR
       CS137     ( 59.6 PER CENT)
       SR90      ( 40.1 PER CENT)
       PU238     (   .2 PER CENT)

AT    1000. YR        5.311E-03 CURIES/MTHM YR
       NP239     ( 29.2 PER CENT)
       TC99      ( 24.6 PER CENT)
       AM241     ( 19.5 PER CENT)
       PU240     ( 11.5 PER CENT)
       AM243     (  7.2 PER CENT)
       PU239     (  3.8 PER CENT)
       C14       (  2.6 PER CENT)
       NP237     (   .7 PER CENT)

AT   10000. YR        3.127E-03 CURIES/MTHM YR
       TC99      ( 40.5 PER CENT)
       NP239     ( 21.4 PER CENT)
       AM243     ( 14.1 PER CENT)
       PU239     ( 12.4 PER CENT)
       PU240     (  7.5 PER CENT)
       C14       (  1.5 PER CENT)
       NP237     (  1.1 PER CENT)
       CS135     (  1.1 PER CENT)
       U234      (   .1 PER CENT)

AT  100000. YR        1.095E-03 CURIES/MTHM YR
       TC99      ( 86.3 PER CENT)
       PU239     (  4.7 PER CENT)
       NP237     (  3.1 PER CENT)
       CS135     (  3.1 PER CENT)
       U233      (  1.1 PER CENT)
       U234      (   .3 PER CENT)
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PWR HIGH-LEVEL WASTE
DIFFUSION-LIMITED DISSOLUTION MODEL

WASTE CONTAINER IS    .160 M RADIUS AND  3.000 M LONG
WITH   2.000 MTHM OF WASTE

APPARENT DIFFUSION COEFFICIENT =  1.000E-10 M**2/S
ROCK POROSITY =    .1000
WATER VELOCITY =  8.000E-02 M/YR
PENETRATION DEPTH =  3.783E-01 M
DISSOLUTION INCREASED BY     9.69 PER CENT FOR FLOW THROUGH WASTE


DATA FOR AMERICIUM

SOLUBILITY =  1.000E-08 MOLES/L      MOLECULAR WEIGHT =  242.00 G/MOLE

AT     100. YR       2.010E+02 CURIES/MTHM       1.370E+02 G/MTHM
      FRACTIONAL DISSOLUTION RATE =  2.948E-08 1/YR
      ELEMENT DISSOLUTION RATE =  4.038E-06 G/MTHM YR
      RADIOACTIVITY RELEASE RATE =  5.925E-06 CURIES/MTHM YR
            AM241   RELEASE RATE =  5.288E-06 CURIES/MTHM YR
            AM243   RELEASE RATE =  4.999E-07 CURIES/MTHM YR
      ELEMENT CONCENTRATION =  1.834E-11 MOLES/L
      AM241   CONCENTRATION =  7.000E-12 MOLES/L
      AM243   CONCENTRATION =  1.130E-11 MOLES/L

AT    1000. YR       5.810E+01 CURIES/MTHM       9.030E+01 G/MTHM
      FRACTIONAL DISSOLUTION RATE =  4.472E-08 1/YR
      ELEMENT DISSOLUTION RATE =  4.038E-06 G/MTHM YR
      RADIOACTIVITY RELEASE RATE =  2.598E-06 CURIES/MTHM YR
            AM241   RELEASE RATE =  1.902E-06 CURIES/MTHM YR
            AM243   RELEASE RATE =  6.967E-07 CURIES/MTHM YR
      ELEMENT CONCENTRATION =  1.834E-11 MOLES/L
      AM241   CONCENTRATION =  2.518E-12 MOLES/L
      AM243   CONCENTRATION =  1.575E-11 MOLES/L

AT   10000. YR       6.680E+00 CURIES/MTHM       3.350E+01 G/MTHM
      FRACTIONAL DISSOLUTION RATE =  1.205E-07 1/YR
      ELEMENT DISSOLUTION RATE =  4.038E-06 G/MTHM YR
      RADIOACTIVITY RELEASE RATE =  8.052E-07 CURIES/MTHM YR
            AM241   RELEASE RATE =  1.112E-09 CURIES/MTHM YR
            AM243   RELEASE RATE =  8.076E-07 CURIES/MTHM YR
      ELEMENT CONCENTRATION =  1.834E-11 MOLES/L
      AM241   CONCENTRATION =  1.472E-15 MOLES/L
      AM243   CONCENTRATION =  1.826E-11 MOLES/L

AT 100000. YR       1.420E-03 CURIES/MTHM       7.120E-03 G/MTHM
      FRACTIONAL DISSOLUTION RATE =  1.000E-04 1/YR  (BULK RATE)
      ELEMENT DISSOLUTION RATE =  7.120E-07 G/MTHM YR
      RADIOACTIVITY RELEASE RATE =  1.420E-07 CURIES/MTHM YR
            AM241   RELEASE RATE =  5.968E-10 CURIES/MTHM YR
            AM243   RELEASE RATE =  1.422E-07 CURIES/MTHM YR
      ELEMENT CONCENTRATION =  3.233E-12 MOLES/L
      AM241   CONCENTRATION =  7.901E-16 MOLES/L
      AM243   CONCENTRATION =  3.215E-12 MOLES/L


DATA FOR CARBON

SOLUBILITY =  1.000E+10 MOLES/L      MOLECULAR WEIGHT =   12.00 G/MOLE

AT     100. YR       1.530E+00 CURIES/MTHM       1.670E+02 G/MTHM
      FRACTIONAL DISSOLUTION RATE =  1.000E-04 1/YR  (BULK RATE)
      ELEMENT DISSOLUTION RATE =  1.670E-02 G/MTHM YR
      RADIOACTIVITY RELEASE RATE =  1.530E-04 CURIES/MTHM YR
            C14     RELEASE RATE =  1.529E-04 CURIES/MTHM YR
      ELEMENT CONCENTRATION =  1.529E-06 MOLES/L
      C14     CONCENTRATION =  3.141E-09 MOLES/L

AT    1000. YR       1.370E+00 CURIES/MTHM       1.670E+02 G/MTHM
      FRACTIONAL DISSOLUTION RATE =  1.000E-04 1/YR  (BULK RATE)
      ELEMENT DISSOLUTION RATE =  1.670E-02 G/MTHM YR
      RADIOACTIVITY RELEASE RATE =  1.370E-04 CURIES/MTHM YR
            C14     RELEASE RATE =  1.373E-04 CURIES/MTHM YR
      ELEMENT CONCENTRATION =  1.529E-06 MOLES/L
      C14     CONCENTRATION =  2.821E-09 MOLES/L
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AT  10000. YR       4.620E-01 CURIES/MTHM       1.670E+02 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  1.000E-04 1/YR  (BULK RATE)
     ELEMENT DISSOLUTION RATE =  1.670E-02 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  4.620E-05 CURIES/MTHM YR
          C14      RELEASE RATE =  4.635E-05 CURIES/MTHM YR
     ELEMENT CONCENTRATION =  1.529E-06 MOLES/L
     C14      CONCENTRATION =  9.524E-10 MOLES/L

AT 100000. YR       8.620E-06 CURIES/MTHM       1.670E+02 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  1.000E-04 1/YR  (BULK RATE)
     ELEMENT DISSOLUTION RATE =  1.670E-02 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  8.620E-10 CURIES/MTHM YR
          C14      RELEASE RATE =  8.602E-10 CURIES/MTHM YR
     ELEMENT CONCENTRATION =  1.529E-06 MOLES/L
     C14      CONCENTRATION =  1.767E-14 MOLES/L


DATA FOR CESIUM

SOLUBILITY =  1.000E+10 MOLES/L      MOLECULAR WEIGHT =  137.00 G/MOLE

AT    100. YR       2.010E+04 CURIES/MTHM       1.550E+03 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  1.000E-04 1/YR  (BULK RATE)
     ELEMENT DISSOLUTION RATE =  1.550E-01 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  2.010E+00 CURIES/MTHM YR
          CS135    RELEASE RATE =  3.456E-05 CURIES/MTHM YR
          CS137    RELEASE RATE =  2.011E+00 CURIES/MTHM YR
     ELEMENT CONCENTRATION =  1.243E-06 MOLES/L
     CS135    CONCENTRATION =  2.442E-07 MOLES/L
     CS137    CONCENTRATION =  9.545E-08 MOLES/L

AT    1000. YR       3.450E-01 CURIES/MTHM       1.430E+03 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  1.000E-04 1/YR  (BULK RATE)
     ELEMENT DISSOLUTION RATE =  1.430E-01 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  3.450E-05 CURIES/MTHM YR
          CS135    RELEASE RATE =  3.456E-05 CURIES/MTHM YR
          CS137    RELEASE RATE =  1.876E-09 CURIES/MTHM YR
     ELEMENT CONCENTRATION =  1.147E-06 MOLES/L
     CS135    CONCENTRATION =  2.442E-07 MOLES/L
     CS137    CONCENTRATION =  8.904E-17 MOLES/L

AT  10000. YR       3.440E-01 CURIES/MTHM       1.430E+03 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  1.000E-04 1/YR  (BULK RATE)
     ELEMENT DISSOLUTION RATE =  1.430E-01 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  3.440E-05 CURIES/MTHM YR
          CS135    RELEASE RATE =  3.444E-05 CURIES/MTHM YR
          CS137    RELEASE RATE =  0.        CURIES/MTHM YR
     ELEMENT CONCENTRATION =  1.147E-06 MOLES/L
     CS135    CONCENTRATION =  2.434E-07 MOLES/L
     CS137    CONCENTRATION =  0.        MOLES/L

AT 100000. YR       3.350E-01 CURIES/MTHM       1.420E+03 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  1.000E-04 1/YR  (BULK RATE)
     ELEMENT DISSOLUTION RATE =  1.420E-01 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  3.350E-05 CURIES/MTHM YR
          CS135    RELEASE RATE =  3.352E-05 CURIES/MTHM YR
          CS137    RELEASE RATE =  0.        CURIES/MTHM YR
     ELEMENT CONCENTRATION =  1.139E-06 MOLES/L
     CS135    CONCENTRATION =  2.369E-07 MOLES/L
     CS137    CONCENTRATION =  0.        MOLES/L


DATA FOR NEPTUNIUM

SOLUBILITY =  3.000E-03 MOLES/L      MOLECULAR WEIGHT =  237.00 G/MOLE

AT    100. YR       1.720E+01 CURIES/MTHM       4.510E+02 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  1.000E-04 1/YR  (BULK RATE)
     ELEMENT DISSOLUTION RATE =  4.510E-02 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  1.720E-03 CURIES/MTHM YR
          NP237    RELEASE RATE =  3.181E-05 CURIES/MTHM YR
          NP239    RELEASE RATE =  1.689E-03 CURIES/MTHM YR
     ELEMENT CONCENTRATION =  2.091E-07 MOLES/L
     NP237    CONCENTRATION =  2.091E-07 MOLES/L
     NP239    CONCENTRATION =  3.338E-14 MOLES/L

AT    1000. YR       1.590E+01 CURIES/MTHM       4.900E+02 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  1.000E-04 1/YR  (BULK RATE)
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     ELEMENT DISSOLUTION RATE =  4.900E-02 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  1.590E-03 CURIES/MTHM YR
           NP237   RELEASE RATE =  3.463E-05 CURIES/MTHM YR
           NP239   RELEASE RATE =  1.552E-03 CURIES/MTHM YR
     ELEMENT CONCENTRATION =  2.272E-07 MOLES/L
     NP237   CONCENTRATION =  2.277E-07 MOLES/L
     NP239   CONCENTRATION =  3.067E-14 MOLES/L

AT   10000. YR       7.020E+00 CURIES/MTHM       5.010E+02 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  1.000E-04 1/YR  (BULK RATE)
     ELEMENT DISSOLUTION RATE =  5.010E-02 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  7.020E-04 CURIES/MTHM YR
           NP237   RELEASE RATE =  3.534E-05 CURIES/MTHM YR
           NP239   RELEASE RATE =  6.678E-04 CURIES/MTHM YR
     ELEMENT CONCENTRATION =  2.323E-07 MOLES/L
     NP237   CONCENTRATION =  2.323E-07 MOLES/L
     NP239   CONCENTRATION =  1.320E-14 MOLES/L

AT 100000. YR       3.450E-01 CURIES/MTHM       4.870E+02 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  1.000E-04 1/YR  (BULK RATE)
     ELEMENT DISSOLUTION RATE =  4.870E-02 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  3.450E-05 CURIES/MTHM YR
           NP237   RELEASE RATE =  3.435E-05 CURIES/MTHM YR
           NP239   RELEASE RATE =  1.422E-07 CURIES/MTHM YR
     ELEMENT CONCENTRATION =  2.258E-07 MOLES/L
     NP237   CONCENTRATION =  2.258E-07 MOLES/L
     NP239   CONCENTRATION =  2.809E-18 MOLES/L


DATA FOR PLUTONIUM

SOLUBILITY =  1.800E-06 MOLES/L     MOLECULAR WEIGHT =  239.00 G/MOLE

AT    100. YR       6.570E+01 CURIES/MTHM       6.070E+01 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  1.183E-05 1/YR
     ELEMENT DISSOLUTION RATE =  7.179E-04 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  7.770E-04 CURIES/MTHM YR
           PU238   RELEASE RATE =  6.192E-04 CURIES/MTHM YR
           PU239   RELEASE RATE =  1.917E-05 CURIES/MTHM YR
           PU240   RELEASE RATE =  7.843E-05 CURIES/MTHM YR
           PU241   RELEASE RATE =  5.951E-05 CURIES/MTHM YR
           PU242   RELEASE RATE =  1.050E-07 CURIES/MTHM YR
     ELEMENT CONCENTRATION =  3.301E-09 MOLES/L
     PU238   CONCENTRATION =  1.671E-10 MOLES/L
     PU239   CONCENTRATION =  1.419E-09 MOLES/L
     PU240   CONCENTRATION =  1.576E-09 MOLES/L
     PU241   CONCENTRATION =  2.632E-12 MOLES/L
     PU242   CONCENTRATION =  1.214E-10 MOLES/L

AT    1000. YR       8.260E+00 CURIES/MTHM       6.140E+01 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  1.169E-05 1/YR
     ELEMENT DISSOLUTION RATE =  7.179E-04 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  9.657E-05 CURIES/MTHM YR
           PU238   RELEASE RATE =  1.352E-06 CURIES/MTHM YR
           PU239   RELEASE RATE =  2.338E-05 CURIES/MTHM YR
           PU240   RELEASE RATE =  7.141E-05 CURIES/MTHM YR
           PU241   RELEASE RATE =  2.242E-07 CURIES/MTHM YR
           PU242   RELEASE RATE =  1.061E-07 CURIES/MTHM YR
     ELEMENT CONCENTRATION =  3.301E-09 MOLES/L
     PU238   CONCENTRATION =  3.649E-13 MOLES/L
     PU239   CONCENTRATION =  1.731E-09 MOLES/L
     PU240   CONCENTRATION =  1.435E-09 MOLES/L
     PU241   CONCENTRATION =  9.916E-15 MOLES/L
     PU242   CONCENTRATION =  1.226E-10 MOLES/L

AT   10000. YR       6.270E+00 CURIES/MTHM       7.530E+01 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  9.533E-06 1/YR
     ELEMENT DISSOLUTION RATE =  7.179E-04 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  5.977E-05 CURIES/MTHM YR
           PU238   RELEASE RATE =  0.         CURIES/MTHM YR
           PU239   RELEASE RATE =  3.706E-05 CURIES/MTHM YR
           PU240   RELEASE RATE =  2.238E-05 CURIES/MTHM YR
           PU241   RELEASE RATE =  8.768E-08 CURIES/MTHM YR
           PU242   RELEASE RATE =  8.730E-08 CURIES/MTHM YR
     ELEMENT CONCENTRATION =  3.301E-09 MOLES/L
     PU238   CONCENTRATION =  0.         MOLES/L
     PU239   CONCENTRATION =  2.744E-09 MOLES/L
     PU240   CONCENTRATION =  4.496E-10 MOLES/L
     PU241   CONCENTRATION =  3.877E-15 MOLES/L
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     PU242   CONCENTRATION =  1.009E-10 MOLES/L

AT 100000. YR       5.200E-01 CURIES/MTHM       1.030E+01 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  6.970E-05 1/YR
     ELEMENT DISSOLUTION RATE =  7.179E-04 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  3.624E-05 CURIES/MTHM YR
           PU238   RELEASE RATE =  0.         CURIES/MTHM YR
           PU239   RELEASE RATE =  3.562E-05 CURIES/MTHM YR
           PU240   RELEASE RATE =  1.177E-08 CURIES/MTHM YR
           PU241   RELEASE RATE =  4.161E-10 CURIES/MTHM YR
           PU242   RELEASE RATE =  5.478E-07 CURIES/MTHM YR
     ELEMENT CONCENTRATION =  3.301E-09 MOLES/L
     PU238   CONCENTRATION =  0.        MOLES/L
     PU239   CONCENTRATION =  2.637E-09 MOLES/L
     PU240   CONCENTRATION =  2.365E-13 MOLES/L
     PU241   CONCENTRATION =  1.840E-17 MOLES/L
     PU242   CONCENTRATION =  6.330E-10 MOLES/L


DATA FOR RADIUM

SOLUBILITY =  1.000E-07 MOLES/L     MOLECULAR WEIGHT =  226.00 G/MOLE

AT    100. YR       2.770E-05 CURIES/MTHM       1.480E-06 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  1.000E-04 1/YR  (BULK RATE)
     ELEMENT DISSOLUTION RATE =  1.480E-10 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  2.770E-09 CURIES/MTHM YR
           RA226   RELEASE RATE =  1.463E-10 CURIES/MTHM YR
     ELEMENT CONCENTRATION =  7.196E-16 MOLES/L
     RA226   CONCENTRATION =  7.196E-16 MOLES/L

AT    1000. YR       1.550E-04 CURIES/MTHM       7.510E-05 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  1.000E-04 1/YR  (BULK RATE)
     ELEMENT DISSOLUTION RATE =  7.510E-09 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  1.550E-08 CURIES/MTHM YR
           RA226   RELEASE RATE =  7.425E-09 CURIES/MTHM YR
     ELEMENT CONCENTRATION =  3.652E-14 MOLES/L
     RA226   CONCENTRATION =  3.652E-14 MOLES/L

AT   10000. YR       8.480E-03 CURIES/MTHM       3.170E-03 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  1.000E-04 1/YR  (BULK RATE)
     ELEMENT DISSOLUTION RATE =  3.170E-07 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  8.480E-07 CURIES/MTHM YR
           RA226   RELEASE RATE =  3.134E-07 CURIES/MTHM YR
     ELEMENT CONCENTRATION =  1.541E-12 MOLES/L
     RA226   CONCENTRATION =  1.541E-12 MOLES/L

AT 100000. YR       1.370E-01 CURIES/MTHM       2.470E-02 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  1.000E-04 1/YR  (BULK RATE)
     ELEMENT DISSOLUTION RATE =  2.470E-06 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  1.370E-05 CURIES/MTHM YR
           RA226   RELEASE RATE =  2.442E-06 CURIES/MTHM YR
     ELEMENT CONCENTRATION =  1.201E-11 MOLES/L
     RA226   CONCENTRATION =  1.201E-11 MOLES/L


DATA FOR STRONTIUM

SOLUBILITY =  9.400E-04 MOLES/L     MOLECULAR WEIGHT =   90.00 G/MOLE

AT    100. YR       1.350E+04 CURIES/MTHM       4.000E+02 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  1.000E-04 1/YR  (BULK RATE)
     ELEMENT DISSOLUTION RATE =  4.000E-02 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  1.350E+00 CURIES/MTHM YR
           SR90    RELEASE RATE =  1.354E+00 CURIES/MTHM YR
     ELEMENT CONCENTRATION =  4.884E-07 MOLES/L
     SR90    CONCENTRATION =  6.056E-08 MOLES/L

AT    1000. YR       6.720E-06 CURIES/MTHM       3.500E+02 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  1.000E-04 1/YR  (BULK RATE)
     ELEMENT DISSOLUTION RATE =  3.500E-02 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  6.720E-10 CURIES/MTHM YR
           SR90    RELEASE RATE =  6.743E-10 CURIES/MTHM YR
     ELEMENT CONCENTRATION =  4.274E-07 MOLES/L
     SR90    CONCENTRATION =  3.016E-17 MOLES/L

AT   10000. YR       0.         CURIES/MTHM       3.500E+02 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  1.000E-04 1/YR  (BULK RATE)
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      ELEMENT DISSOLUTION RATE =  3.500E-02 G/MTHM YR
      RADIOACTIVITY RELEASE RATE =  0.        CURIES/MTHM YR
            SR90    RELEASE RATE =  0.        CURIES/MTHM YR
      ELEMENT CONCENTRATION =  4.274E-07 MOLES/L
      SR90    CONCENTRATION =  0.        MOLES/L

AT 100000. YR       0.        CURIES/MTHM       3.500E+02 G/MTHM
      FRACTIONAL DISSOLUTION RATE =  1.000E-04 1/YR  (BULK RATE)
      ELEMENT DISSOLUTION RATE =  3.500E-02 G/MTHM YR
      RADIOACTIVITY RELEASE RATE =  0.        CURIES/MTHM YR
            SR90    RELEASE RATE =  0.        CURIES/MTHM YR
      ELEMENT CONCENTRATION =  4.274E-07 MOLES/L
      SR90    CONCENTRATION =  0.        MOLES/L


DATA FOR TECHNETIUM

SOLUBILITY =  1.000E+10 MOLES/L     MOLECULAR WEIGHT =   99.00 G/MOLE

AT    100. YR       1.310E+01 CURIES/MTHM       7.710E+02 G/MTHM
      FRACTIONAL DISSOLUTION RATE =  1.000E-04 1/YR  (BULK RATE)
      ELEMENT DISSOLUTION RATE =  7.710E-02 G/MTHM YR
      RADIOACTIVITY RELEASE RATE =  1.310E-03 CURIES/MTHM YR
            TC99    RELEASE RATE =  1.308E-03 CURIES/MTHM YR
      ELEMENT CONCENTRATION =  8.558E-07 MOLES/L
      TC99    CONCENTRATION =  8.558E-07 MOLES/L

AT    1000. YR       1.300E+01 CURIES/MTHM       7.690E+02 G/MTHM
      FRACTIONAL DISSOLUTION RATE =  1.000E-04 1/YR  (BULK RATE)
      ELEMENT DISSOLUTION RATE =  7.690E-02 G/MTHM YR
      RADIOACTIVITY RELEASE RATE =  1.300E-03 CURIES/MTHM YR
            TC99    RELEASE RATE =  1.304E-03 CURIES/MTHM YR
      ELEMENT CONCENTRATION =  8.536E-07 MOLES/L
      TC99    CONCENTRATION =  8.536E-07 MOLES/L

AT   10000. YR       1.270E+01 CURIES/MTHM       7.460E+02 G/MTHM
      FRACTIONAL DISSOLUTION RATE =  1.000E-04 1/YR  (BULK RATE)
      ELEMENT DISSOLUTION RATE =  7.460E-02 G/MTHM YR
      RADIOACTIVITY RELEASE RATE =  1.270E-03 CURIES/MTHM YR
            TC99    RELEASE RATE =  1.265E-03 CURIES/MTHM YR
      ELEMENT CONCENTRATION =  8.281E-07 MOLES/L
      TC99    CONCENTRATION =  8.281E-07 MOLES/L

AT 100000. YR       9.440E+00 CURIES/MTHM       5.570E+02 G/MTHM
      FRACTIONAL DISSOLUTION RATE =  1.000E-04 1/YR  (BULK RATE)
      ELEMENT DISSOLUTION RATE =  5.570E-02 G/MTHM YR
      RADIOACTIVITY RELEASE RATE =  9.440E-04 CURIES/MTHM YR
            TC99    RELEASE RATE =  9.447E-04 CURIES/MTHM YR
      ELEMENT CONCENTRATION =  6.183E-07 MOLES/L
      TC99    CONCENTRATION =  6.183E-07 MOLES/L


DATA FOR TIN

SOLUBILITY =  1.000E-09 MOLES/L     MOLECULAR WEIGHT =  119.00 G/MOLE

AT    100. YR       8.290E-01 CURIES/MTHM       9.000E+01 G/MTHM
      FRACTIONAL DISSOLUTION RATE =  2.206E-09 1/YR
      ELEMENT DISSOLUTION RATE =  1.986E-07 G/MTHM YR
      RADIOACTIVITY RELEASE RATE =  1.829E-09 CURIES/MTHM YR
            SN126   RELEASE RATE =  1.715E-09 CURIES/MTHM YR
      ELEMENT CONCENTRATION =  1.834E-12 MOLES/L
      SN126   CONCENTRATION =  5.494E-13 MOLES/L

AT    1000. YR       7.720E-01 CURIES/MTHM       8.980E+01 G/MTHM
      FRACTIONAL DISSOLUTION RATE =  2.211E-09 1/YR
      ELEMENT DISSOLUTION RATE =  1.986E-07 G/MTHM YR
      RADIOACTIVITY RELEASE RATE =  1.707E-09 CURIES/MTHM YR
            SN126   RELEASE RATE =  1.707E-09 CURIES/MTHM YR
      ELEMENT CONCENTRATION =  1.834E-12 MOLES/L
      SN126   CONCENTRATION =  5.458E-13 MOLES/L

AT   10000. YR       7.250E-01 CURIES/MTHM       8.810E+01 G/MTHM
      FRACTIONAL DISSOLUTION RATE =  2.254E-09 1/YR
      ELEMENT DISSOLUTION RATE =  1.986E-07 G/MTHM YR
      RADIOACTIVITY RELEASE RATE =  1.634E-09 CURIES/MTHM YR
            SN126   RELEASE RATE =  1.636E-09 CURIES/MTHM YR
      ELEMENT CONCENTRATION =  1.834E-12 MOLES/L
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     SN126    CONCENTRATION =  5.229E-13 MOLES/L

AT 100000. YR        3.890E-01 CURIES/MTHM        7.630E+01 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  2.603E-09 1/YR
     ELEMENT DISSOLUTION RATE =  1.986E-07 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  1.012E-09 CURIES/MTHM YR
        SN126    RELEASE RATE =  1.015E-09 CURIES/MTHM YR
     ELEMENT CONCENTRATION =  1.834E-12 MOLES/L
     SN126    CONCENTRATION =  3.246E-13 MOLES/L


DATA FOR URANIUM

SOLUBILITY =  2.100E-04 MOLES/L      MOLECULAR WEIGHT =  238.00 G/MOLE

AT    100. YR        3.080E-02 CURIES/MTHM        4.780E+03 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  1.745E-05 1/YR
     ELEMENT DISSOLUTION RATE =  8.340E-02 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  5.374E-07 CURIES/MTHM YR
           U233    RELEASE RATE =  2.408E-09 CURIES/MTHM YR
           U234    RELEASE RATE =  4.823E-07 CURIES/MTHM YR
           U235    RELEASE RATE =  1.504E-09 CURIES/MTHM YR
           U236    RELEASE RATE =  2.270E-08 CURIES/MTHM YR
           U238    RELEASE RATE =  2.767E-08 CURIES/MTHM YR
     ELEMENT CONCENTRATION =  3.851E-07 MOLES/L
     U233    CONCENTRATION =  1.177E-12 MOLES/L
     U234    CONCENTRATION =  3.630E-10 MOLES/L
     U235    CONCENTRATION =  3.255E-09 MOLES/L
     U236    CONCENTRATION =  1.633E-09 MOLES/L
     U238    CONCENTRATION =  3.802E-07 MOLES/L

AT    1000. YR        5.220E-02 CURIES/MTHM        4.790E+03 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  1.741E-05 1/YR
     ELEMENT DISSOLUTION RATE =  8.340E-02 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  9.089E-07 CURIES/MTHM YR
           U233    RELEASE RATE =  2.520E-08 CURIES/MTHM YR
           U234    RELEASE RATE =  8.268E-07 CURIES/MTHM YR
           U235    RELEASE RATE =  1.527E-09 CURIES/MTHM YR
           U236    RELEASE RATE =  2.559E-08 CURIES/MTHM YR
           U238    RELEASE RATE =  2.761E-08 CURIES/MTHM YR
     ELEMENT CONCENTRATION =  3.851E-07 MOLES/L
     U233    CONCENTRATION =  1.232E-11 MOLES/L
     U234    CONCENTRATION =  6.222E-10 MOLES/L
     U235    CONCENTRATION =  3.306E-09 MOLES/L
     U236    CONCENTRATION =  1.840E-09 MOLES/L
     U238    CONCENTRATION =  3.794E-07 MOLES/L

AT   10000. YR        6.570E-02 CURIES/MTHM        4.820E+03 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  1.730E-05 1/YR
     ELEMENT DISSOLUTION RATE =  8.340E-02 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  1.137E-06 CURIES/MTHM YR
           U233    RELEASE RATE =  2.589E-07 CURIES/MTHM YR
           U234    RELEASE RATE =  8.022E-07 CURIES/MTHM YR
           U235    RELEASE RATE =  2.003E-09 CURIES/MTHM YR
           U236    RELEASE RATE =  4.358E-08 CURIES/MTHM YR
           U238    RELEASE RATE =  2.744E-08 CURIES/MTHM YR
     ELEMENT CONCENTRATION =  3.851E-07 MOLES/L
     U233    CONCENTRATION =  1.265E-10 MOLES/L
     U234    CONCENTRATION =  6.037E-10 MOLES/L
     U235    CONCENTRATION =  4.337E-09 MOLES/L
     U236    CONCENTRATION =  3.134E-09 MOLES/L
     U238    CONCENTRATION =  3.771E-07 MOLES/L

AT 100000. YR        1.650E-01 CURIES/MTHM        4.930E+03 G/MTHM
     FRACTIONAL DISSOLUTION RATE =  1.692E-05 1/YR
     ELEMENT DISSOLUTION RATE =  8.340E-02 G/MTHM YR
     RADIOACTIVITY RELEASE RATE =  2.791E-06 CURIES/MTHM YR
           U233    RELEASE RATE =  2.073E-06 CURIES/MTHM YR
           U234    RELEASE RATE =  6.144E-07 CURIES/MTHM YR
           U235    RELEASE RATE =  5.079E-09 CURIES/MTHM YR
           U236    RELEASE RATE =  5.355E-08 CURIES/MTHM YR
           U238    RELEASE RATE =  2.683E-08 CURIES/MTHM YR
     ELEMENT CONCENTRATION =  3.851E-07 MOLES/L
     U233    CONCENTRATION =  1.013E-09 MOLES/L
     U234    CONCENTRATION =  4.624E-10 MOLES/L
     U235    CONCENTRATION =  1.100E-08 MOLES/L
     U236    CONCENTRATION =  3.852E-09 MOLES/L
     U238    CONCENTRATION =  3.687E-07 MOLES/L
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DATA FOR SIO2(AMORPHOUS)

SOLUBILITY = 1.000E-03 MOLES/L MOLECULAR WEIGHT = 60.09 G/MOLE

AT 100. YR 0. CURIES/MTHM 1.500E+05 G/MTHM
FRACTIONAL DISSOLUTION RATE = 6.684E-07 1/YR
ELEMENT DISSOLUTION RATE = 1.003E-01 G/MTHM YR
RADIOACTIVITY RELEASE RATE = 0. CURIES/MTHM YR
ELEMENT CONCENTRATION = 1.834E-06 MOLES/L

AT 1000. YR 0. CURIES/MTHM 1.500E+05 G/MTHM
FRACTIONAL DISSOLUTION RATE = 6.684E-07 1/YR
ELEMENT DISSOLUTION RATE = 1.003E-01 G/MTHM YR
RADIOACTIVITY RELEASE RATE = 0. CURIES/MTHM YR
ELEMENT CONCENTRATION = 1.834E-06 MOLES/L

AT 10000. YR 0. CURIES/MTHM 1.500E+05 G/MTHM
FRACTIONAL DISSOLUTION RATE = 6.684E-07 1/YR
ELEMENT DISSOLUTION RATE = 1.003E-01 G/MTHM YR
RADIOACTIVITY RELEASE RATE = 0. CURIES/MTHM YR
ELEMENT CONCENTRATION = 1.834E-06 MOLES/L

AT 100000. YR 0. CURIES/MTHM 1.500E+05 G/MTHM
FRACTIONAL DISSOLUTION RATE = 6.684E-07 1/YR
ELEMENT DISSOLUTION RATE = 1.003E-01 G/MTHM YR
RADIOACTIVITY RELEASE RATE = 0. CURIES/MTHM YR
ELEMENT CONCENTRATION = 1.834E-06 MOLES/L

TOTAL RADIOACTIVITY RELEASE RATES

AT 100. YR 3.364E+00 CURIES/MTHM YR
CS137 (59.8 PER CENT)
SR90 (40.3 PER CENT)
NP239 (.1 PER CENT)

AT 1000. YR 3.162E-03 CURIES/MTHM YR
NP239 (49.1 PER CENT)
TC99 (41.3 PER CENT)
C14 (4.3 PER CENT)
PU240 (2.3 PER CENT)
NP237 (1.1 PER CENT)
CS135 (1.1 PER CENT)
PU239 (.7 PER CENT)

AT 10000. YR 2.115E-03 CURIES/MTHM YR
TC99 (59.8 PER CENT)
NP239 (31.6 PER CENT)
C14 (2.2 PER CENT)
PU239 (1.8 PER CENT)
NP237 (1.7 PER CENT)
CS135 (1.6 PER CENT)
PU240 (1.1 PER CENT)
AM243 (.0 PER CENT)

AT 100000. YR 1.065E-03 CURIES/MTHM YR
TC99 (88.7 PER CENT)
PU239 (3.3 PER CENT)
NP237 (3.2 PER CENT)
CS135 (3.1 PER CENT)
RA226 (.2 PER CENT)

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