9.0 Americium

This chapter provides technical information on the sources and characteristics of americium and summarizes the technical basis for its internal dosimetry at Hanford. Dosimetry methods used are based on the concepts of ICRP 48 (1986) and ICRP 67 (1993), as implemented using the CINDY computer code (Strenge et al. 1992).

9.1 Sources and Characteristics

Americium at Hanford can be found as the ingrown ^{241}Am progeny of ^{241}Pu in a plutonium mixture or as a separated ^{241}Am isotope that exists singly or in combination with other separated isotopes in waste mixtures. In addition, ^{243}Am has been used in some PNNL facilities as a research isotope.

The ^{241}Am existing as an ingrown progeny in a plutonium mixture is typically a small fraction of the mass of the mixture. Consequently, it is assumed to be trapped in a plutonium matrix and exhibits the basic solubility and biokinetic characteristics of plutonium, rather than of pure americium. Ingrown ^{241}Am is typically encountered at plutonium facilities such as most of the Plutonium Finishing Plant (PFP [234-5Z Building]), the Plutonium-Uranium Extraction (PUREX) Plant (202-A), the 233-S Building, or research facilities such as the former Critical Mass Laboratory (209-E).

Separated ^{241}Am can also be encountered at PFP because chemical separation of ^{241}Am from plutonium was a routine process at the Plutonium Reclamation Facility (PRF, 236-Z) or the 242-Z facility and the ^{241}Am product was handled in PFP. The 242-Z facility was the site of the 1976 americium column explosion, which resulted in extensive contamination of the facility and its subsequent physical isolation from routine entry.

Separated ^{241}Am is also a trace contaminant in many of the 200-Area tank farm waste mixtures. During routine waste management activities, the trace americium was part of an intimately mixed waste slurry from the fuel processing facilities that was pumped into the waste tanks. With time, the slurry separated into a sludge at the bottom of the tank and a supernate liquid above the sludge. The trace americium was retained primarily in the supernate, along with ^{137}Cs, while the sludge retained the majority of the trace plutonium and ^{90}Sr. Subsequent supernate concentration activities produced salt cake that could also retain the trace ^{241}Am. It is not likely that tank farm waste would contain separated ^{241}Am as a pure isotope; it can be anticipated that it would be accompanied by much larger quantities of fission product activity.

Pure isotopes of ^{241}Am and ^{243}Am can be found in analytical laboratory standard solutions and in pure isotope research applications.

The environmental levels of ^{241}Am from worldwide nuclear weapons testing fallout can be considered insignificant with regard to potential interferences with worker or workplace monitoring. The isotope has also found significant application as a sealed source for ionization in commercially manufactured smoke detectors, with the typical smoke detector containing about 1 μCi of ^{241}Am, but there have not been indications that loss of containment has occurred with these sources.

Radiological decay data for ^{241}Am and ^{243}Am are shown in Table 9.1. The data were taken directly from, or calculated based on, information contained in ICRP 38 (1983).

9.2 Biokinetic Behavior

This section discusses the inhalation transportability class, internal distribution and retention, and the urinary and fecal excretion of americium. This discussion relates to pure ^{241}Am compounds or mixtures in which the ^{241}Am component represents a predominant fraction of the mixture mass (e.g., 50% or more). Where americium is entrapped within a plutonium matrix as an ingrown progeny, it is assumed to behave characteristically with the plutonium matrix, and those properties are described in Chapter 8.0.

Table 9.1. Radiological Decay Data for Americium

Isotope	Principal Decay Mode, Energy, and Yield	Physical Half-Life		Decay Constant		Specific Activity
		Years	Days	Year^{-1}	Day^{-1}	Ci/g
^{241}Am	Alpha 5.486 MeV, 85.2% Gamma 59.54 keV, 35.7%	432.2	1.58E+05	1.60E-03	4.39E-06	3.43
^{243}Am	Alpha 5.276 MeV, 87.9% Gamma 74.67 keV, 66.0%	7380	2.69E+06	9.39E-05	2.57E-07	0.181

9.2.1 Transportability Class

All compounds of americium are assigned transportability class W by ICRP 48 (1986). The limited number of Hanford cases involving ^{241}Am compounds has supported this assignment.

The new respiratory tract model of ICRP 66 (1994a) assigned absorption type M to all forms of americium (ICRP 68 [1994b]; ICRP 78 [1997]).

9.2.2 Gastrointestinal Uptake to Blood (f_1 Factor)

The fractional uptake to blood from the GI tract is assumed to be 5×10^{-4}, as recommended in ICRP publications 67 (1993) and 78 (1997). This value was reduced from the 10^{-3} value used in earlier ICRP publications based on human studies discussed in ICRP 67, which became available in the late 1980s and early 1990s. The 5×10^{-4} value applies to both inhalation and ingestion intakes.

9.2.3 Distribution and Retention in Systemic Organs and Tissues

The choice of models for use by the HIDP is constrained somewhat by the tools routinely used by the program. For internal dose calculations, the main computer code used by the HIDP is the CINDY computer code (Strenge et al. 1992). It uses the ICRP 30 and ICRP 48 format for its models (simple first-order kinetics) for defining metabolically significant organs and tissues. CINDY allows for adjustment of the organ partition fractions and clearance half-times for those organs and tissues, but does not accommodate the addition of new organs and tissues or alternate model forms, such as the recycling models used in more recent ICRP publications (e.g., ICRP 67, [1993]). Thus, the HIDP has examined the ICRP recommendations as well as other published models and adopted a modified ICRP 48 (1986) model to approximate the dose to the liver, which would be calculated using the ICRP 67 recycling model.

The basic ICRP 48 model for distribution and retention of americium in the body is described as follows. For dissolved (ionic form) americium reaching the transfer compartment (i.e., the blood stream), this ICRP model distributes 50% to the bone with a clearance half-time of 50 years, and 30% to the liver with a clearance half-time of 20 years. The activity deposited in bone is assumed to be deposited uniformly over bone surfaces of both cortical and trabecular bone, where it remains until decayed or excreted. A small fraction is permanently retained in the gonads (0.035% for testes and 0.011% for ovaries). The remaining 20% are assumed to go directly to excretion or short-term holdup in other body tissues.

The Hanford adaptation of this model to americium is identical to the ICRP 48 description with the exception that the liver clearance half-time is reduced to 9 years. The logic for this modification is described in the following paragraphs.

The ICRP 48 model for americium metabolic distribution and retention was identical to that for plutonium, but the report noted that limited human data suggested an americium deposition in liver smaller than plutonium and with a shorter liver half-time. It concluded that for purposes of radiation protection, it was reasonable to use the same model. That position was retained in ICRP 30 Part 4 (1988a) but the partitioning between skeleton and liver was changed to 45% in each, consistent with ICRP 30 Part 1 (1979) and ICRP 19 (1972).

A departure from the simple first-order kinetics form of modeling (sum of single exponentials) to a recycling form of model occurred with ICRP 56 (1989). Two significant changes with regard to americium also occurred with that model shift. First, the skeleton-to-liver partition was changed to 30:50 (reversed from the ICRP 48 partition). Secondly, it was noted that an apparent (i.e., externally viewed) liver half-time of 2 to 8 years was appropriate. In ICRP 67 (1993) the recycling model was refined, with some additional significant differences between the plutonium and americium retention. Notably, the liver model demonstrated substantially faster clearance of 2 to 3 years as an “externally viewed half-time” for the first few years, then stabilizing to a relatively constant liver burden at decades post uptake due to the skeleton feedback to blood. The rapid clearance from the liver in the early years, combined with subsequent absorption by the skeleton of the early liver clearance to the blood resulted in an effective skeleton buildup in the first 5 years to a level approximating 50% of the initial uptake. Based on this shift, the HIDP concluded that the original partition of 50% skeleton and 30% liver was a reasonable model approximation.

The United States Transuranium and Uranium Registries (USTUR) is a DOE-funded research entity chartered to collect human data for the verification, refinement, or development of radiation protection standards. Data obtained and analyzed by the Registries suggested much smaller retention in liver than ICRP 30 Part 4, and an additional muscle component. Kathren (1994) published a USTUR model for americium that split the initial uptake fraction as follows: 45% to the skeleton (half-time of 50 years), 25% to the liver (half-time of 2.5 years), 20% to the muscle (half-time of 10 years), and 10% to the rest of the body and direct excretion (half-time of 10 years).
Both the ICRP 67 and the USTUR models for the bone surfaces showed long retention, comparable to that of ICRP 30 Part 4 and ICRP 48. The use of the ICRP 48 uptake fraction of 50% to the bone with a 50-year clearance half-time was consistent with the ICRP 67 and USTUR models

and was retained for Hanford applications. This was also consistent with Hanford practices since 1988. The ambiguity in the data discussions and interpretations by ICRP 48, ICRP 30 Part 4, ICRP 56, and ICRP 67 suggests that either a 45% or 50% fraction can adequately represent the bone uptake.

Because the recent modeling efforts of both the ICRP and the USTUR suggested substantially less retention in the liver than predicted by ICRP 48 and ICRP 30 Part 4, the HIDP sought to incorporate these conclusions into this technical basis. As a benchmark, the HIDP obtained the results of the integrated retention of the ICRP 67 liver model using Matlab/Simulink™[(a)] and then iteratively solved several single exponential component models to approximate the integrated retention. Thus, by using the single exponential liver model in the CINDY computer code, committed liver dose equivalents calculated by CINDY would be similar to those calculated using the ICRP 67 recycling model. The result of this analysis was the choice of a liver uptake fraction of 30% having a clearance half-time of 9 years.

Figure 9.1 illustrates the differences in these models with regard to liver retention. The curve showing a two-component Matlab™ fit to ICRP 67 represents a close approximation to the americium liver retention illustrated in ICRP 67 that was developed using the actual recycling model. By comparison, the ICRP 30 Part 4 and ICRP 48 curves show significantly greater retention, and the USTUR model shows significantly less retention. The ICRP 67 integral equivalent curve demonstrates retention both greater and less than ICRP 67 depending on the time post uptake; however, the ICRP 67 integral equivalent curve represents the same number of transformations over 50 years (i.e., the retention function integrated over 50 years) as the ICRP 67 recycling model, approximated in the figure by the Matlab™ fit curve.

In summary, the distribution and retention model used by the HIDP for intakes of americium is a modified ICRP 48 model. It assumes that for americium reaching the bloodstream, 50% is taken up by the bone surfaces from which it clears with a 50-year half-time, and 30% is taken up by the liver from which it clears with a 9-year half-time. A small fraction is permanently retained in the gonads (0.035% for testes and 0.011% for ovaries). The remaining 20% is assumed to

(a) Matlab and Simulink are registered trademarks of The MathWorks, Inc., Natick, Massachusetts.

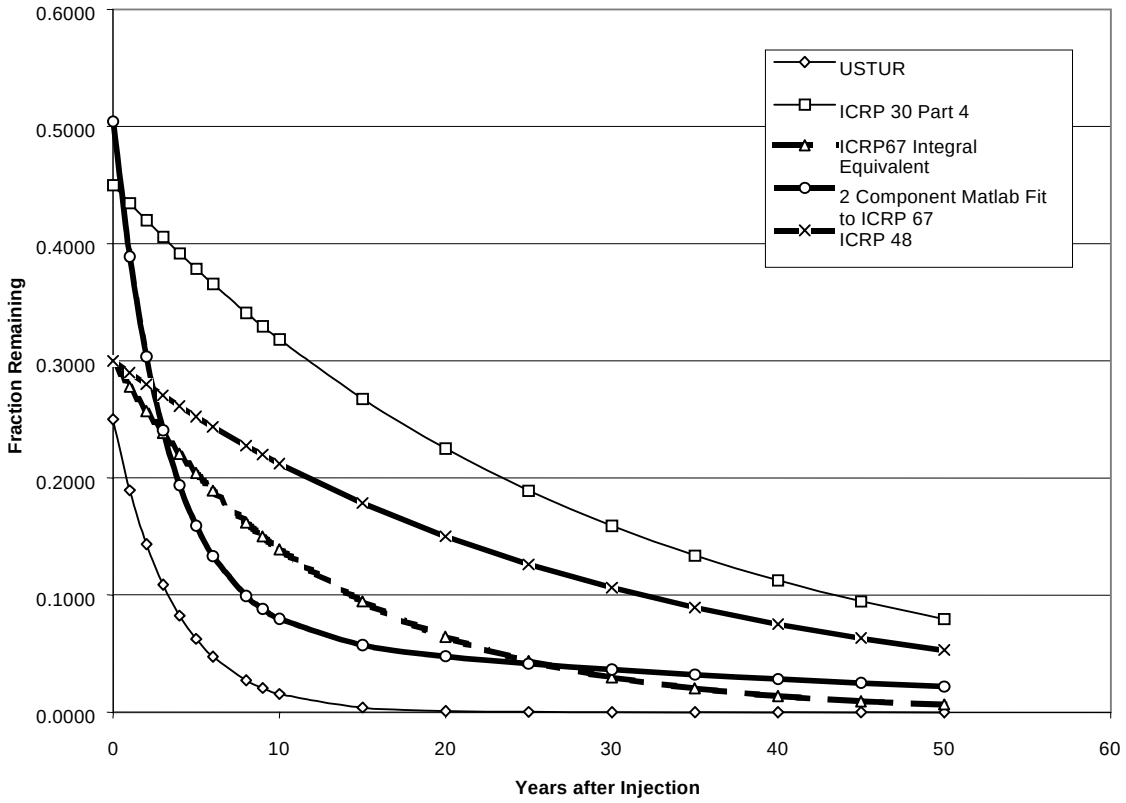

Figure 9.1. Liver Retention for Americium - Model Comparison

go directly to excretion or short-term holdup in other body tissues. For the purposes of dosimetry, this fraction is considered to be an insignificant contributor to effective dose equivalent (relative to bone marrow, liver, and gonadal contributions).

9.2.4 Urinary Excretion

In ICRP publication 54 (1988b), it was noted that there were few reports of americium excretion in humans. For that report, americium excretion used the same excretion function as for plutonium. Based on that recommendation, the HIDP uses the Jones excretion function for plutonium, as implemented using the CINDY computer code. The Jones function models urinary excretion of plutonium following systemic uptake as a four-component exponential function. Jones emphasized that his function was an empirical fit to human data and should not be interpreted as modeling retention in specifically identifiable compartments. Thus, its application at Hanford is limited to estimating uptake and predicting excretion based on uptake. Further discussion on the Jones function can be found in Section 8.2.4 of the Plutonium Chapter of this manual.

The Jones function is a four-component exponential sum, mathematically defined as follows:

$$e_u(t) = 4.75\times10^{-3}e^{-0.558t} + 2.39\times10^{-4}e^{-0.0442t} + 8.55\times10^{-5}e^{-0.00380t} + 1.42\times10^{-5}e^{-0.0000284t} \quad (9.1)$$

where $e_u(t)$ is the fraction of uptake to blood excreted in urine, and t is the days post uptake (note: t = 0 is time of uptake; t = 1 represents the first 24 hours following uptake; t = 2 represents the second day post uptake; etc.).

As a possible alternative to the Jones function, a historical model used at Hanford is described here. The 1976 americium column explosion at the Hanford 242-Z facility resulted in several workers incurring acute inhalation exposures to americium nitrate. An excretion model developed by Rosen, Cohen, and Wrenn (1972) from baboon data was applied by Hanford internal dosimetrists to the workers exposed in this case, although only the most highly exposed worker was reported in the open literature (Robinson et al. 1983). The Rosen model is described by the following power function:

$$Eu = q_0 \times 0.036\ t^{-1.3} \quad (9.2)$$

where Eu = ^{241}Am excretion via urine on day t, q_0 is the initial systemic burden, and t is the day post intake.

The HIDP will use the Jones function for americium intakes and bioassay projection unless data suggest the Rosen model or another model provides a better fit for specific cases.

9.2.5 Fecal Excretion

The excretion of bile to the GI tract provides a pathway for systemic excretion of americium to feces from the liver. Few data are available to quantify this pathway relative to urine, however the assumption of an equal amount excreted from the systemic compartment by way of feces and urine is not uncommon and is assumed at Hanford. For inhalation intakes, the fecal excretion is dominated by clearance from the respiratory tract for the first year.

9.3 Internal Dosimetry Factors

This section contains factors that are useful in making internal dosimetry calculations. The factors included in this section are derived from CINDY and incorporate the models and assumptions described in the preceding section. Their application is intended for those circumstances where such assumptions are appropriate or more specific information is

lacking. Variation from these factors is appropriate if sufficient data are available. The factors shown are for ^{241}Am, however there is no significant dosimetric difference between ^{241}Am and ^{243}Am.

9.3.1 Intake Retention and Excretion Fractions

The intake retention (or excretion) fraction expresses the fraction of intake retained in a particular compartment or excreted by a particular pathway (urine or feces) at a given time post intake. Although excretion implies elimination rather than retention, conventional models include excretion compartments under the general term retention and use the term "intake retention fraction" (IRF) to describe both. IRFs for various times post intake are tabulated as described below for ^{241}Am.

Lung retention fractions for the class W inhalations of 1-µm and 5-µm-AMAD particles of ^{241}Am are listed in Table 9.2 and plotted in Figure 9.2. Urine excretion fractions for an instantaneous uptake, acute inhalations, and acute ingestions of ^{241}Am are listed in Table 9.3 and plotted in Figure 9.3. Corresponding values for fecal excretion are listed in Table 9.4 and plotted in Figure 9.4. Values for days other than those tabulated here can be obtained by interpolation between the tabulated data, or by obtaining the values directly from CINDY.

9.3.2 Dose Coefficients

Dose coefficients, expressed as committed dose equivalent per unit activity of intake (rem per nanocurie of acute intake) are a convenient shortcut to estimating doses based on standard assumptions when the magnitude of an intake is known or assumed. Acute intake dose coefficients have been tabulated for instantaneous uptake, class W inhalation (for both 1-µm and 5-µm-AMAD particle sizes), and for ingestion. The dose coefficients shown in Table 9.5 were derived by the CINDY computer code using the previously described models.

9.3.3 Comparison of Published Dosimetry Factors

A comparison of dosimetry factors, including dose coefficients, ALIs, and DACs published in several sources is shown in Table 9.6. For Hanford applications, the DAC values of 10 CFR 835 Appendix A, are required for use to control facility operations.

Table 9.2. Lung Retention Fractions for Class W Inhalation of ^{241}Am

Days Post Intake	1-µm AMAD	5-µm AMAD
0	3.3E-01	1.7E-01
1	2.1E-01	7.5E-02
2	1.8E-01	6.3E-02
5	1.5E-01	5.1E-02
7	1.4E-01	4.9E-02
14	1.3E-01	4.4E-02
30	1.0E-01	3.6E-02
60	7.0E-02	2.5E-02
90	4.8E-02	1.7E-02
180	1.5E-02	5.3E-03
365	1.4E-03	4.8E-04
730	1.1E-05	3.9E-06

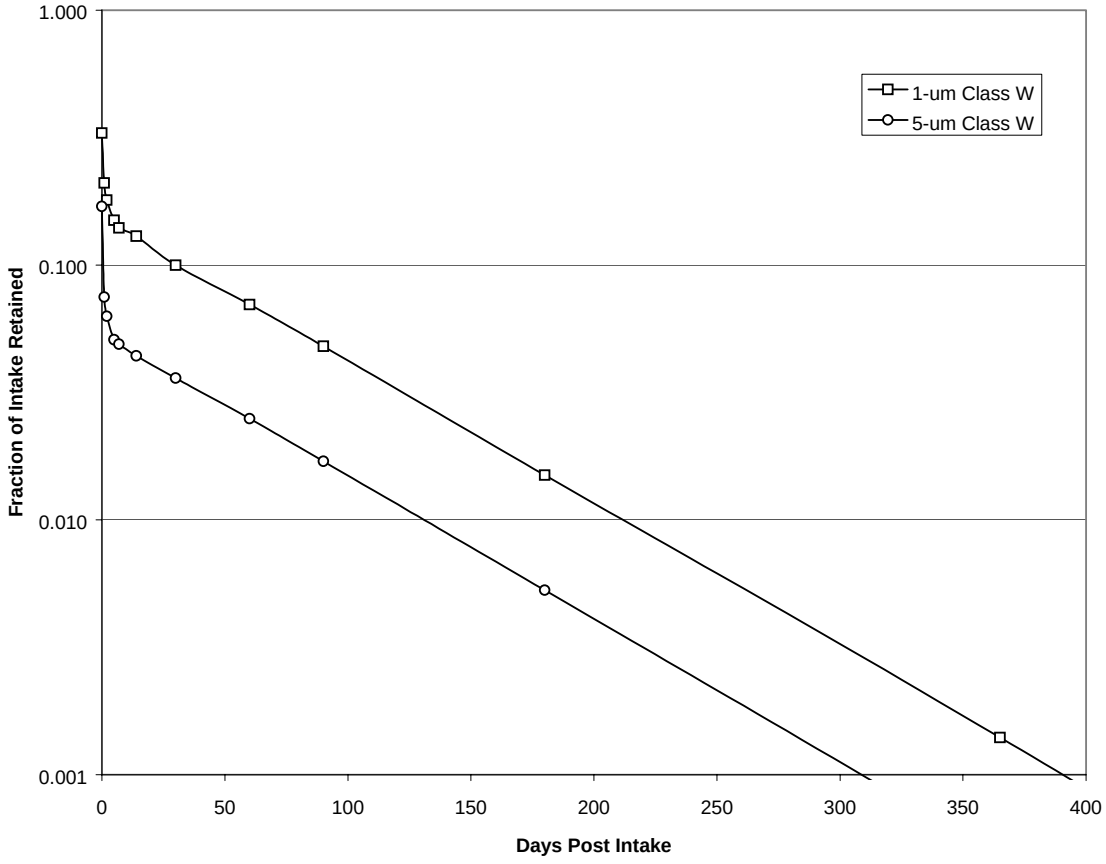

Figure 9.2. ^{241}Am Lung Retention

Table 9.3. Urine Excretion Fractions for ^{241}Am Intakes

Days Post Intake	Instant Uptake	Ingestion	Inhalation	
			1-μm Class W	5-μm Class W
1	3.1E-03	1.7E-06	2.2E-04	3.5E-04
2	1.9E-03	1.0E-06	1.4E-04	2.2E-04
5	5.8E-04	3.1E-07	4.6E-05	6.9E-05
7	3.7E-04	1.9E-07	3.1E-05	4.4E-05
14	2.3E-04	1.1E-07	2.2E-05	2.8E-05
30	1.5E-04	7.7E-08	1.7E-05	2.0E-05
60	9.9E-05	5.0E-08	1.3E-05	1.4E-05
90	7.9E-05	4.0E-08	1.1E-05	1.1E-05
180	5.7E-05	2.9E-08	8.3E-06	8.1E-06
365	3.5E-05	1.8E-08	4.8E-06	4.9E-06
730	1.9E-05	9.6E-09	2.4E-06	2.6E-06
1,825	1.3E-05	6.7E-09	1.6E-06	1.8E-06
3,650	1.3E-05	6.3E-09	1.5E-06	1.7E-06
7,300	1.1E-05	5.6E-09	1.3E-06	1.5E-06
18,250	7.8E-06	3.9E-09	9.4E-07	1.0E-06

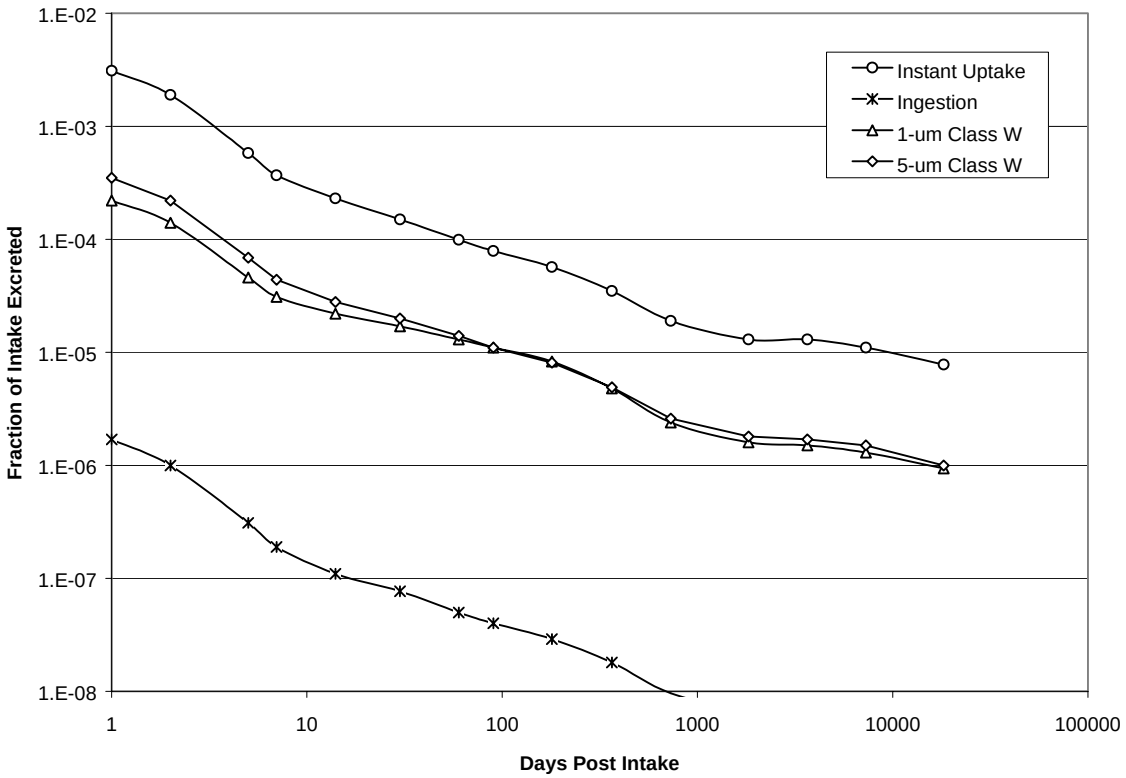

Figure 9.3. ^{241}Am Urine Excretion Fractions

Table 9.4. Fecal Excretion Fractions for ^{241}Am Intakes

Days Post Intake	Instant Uptake	Ingestion	Inhalation	
			1-μm Class W	5-μm Class W
1	3.1E-03	4.7E-01	1.1E-01	2.2E-01
2	1.9E-03	2.8E-01	1.3E-01	2.6E-01
5	5.8E-04	1.8E-02	2.3E-02	3.1E-02
7	3.7E-04	2.5E-03	6.3E-03	5.6E-03
14	2.3E-04	2.4E-06	1.2E-03	4.6E-04
30	1.5E-04	7.7E-08	9.6E-04	3.5E-04
60	9.9E-05	5.0E-08	6.3E-04	2.3E-04
90	7.9E-05	4.0E-08	4.2E-04	1.6E-04
180	5.7E-05	2.9E-08	1.3E-04	4.9E-05
365	3.5E-05	1.8E-08	1.4E-05	8.1E-06
730	1.9E-05	9.6E-09	2.5E-06	2.6E-06
1,825	1.3E-05	6.7E-09	1.6E-06	1.8E-06
3,650	1.3E-05	6.3E-09	1.5E-06	1.7E-06
7,300	1.1E-05	5.6E-09	1.3E-06	1.5E-06
18,250	7.8E-06	3.9E-09	9.4E-07	1.0E-06

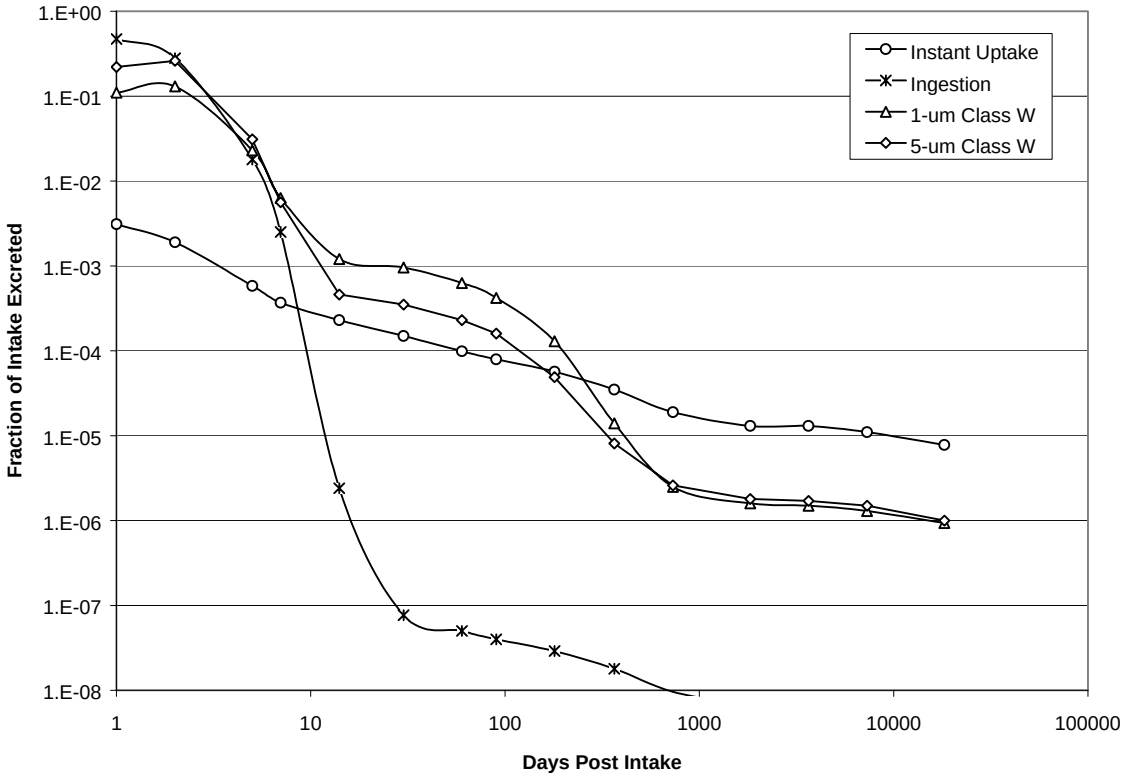

Figure 9.4. ^{241}Am Fecal Excretion Fractions

Table 9.5. Committed Dose Coefficients for Acute Intakes of ^{241}Am (rem/nCi)

Organ or Tissue	Instantaneous Uptake	Ingestion f_1 = 5E-04	Class W Inhalation	
			1-μm	5-μm
Effective	3.5E+00	1.8E-03	4.3E-01	4.6E-01
Bone Surface	7.5E+01	3.7E-02	9.0E+00	9.9E+00
Red Marrow	5.9E+00	2.9E-03	7.0E-01	7.7E-01
Liver	4.3E+00	2.2E-03	5.2E-01	5.7E-01
Lung	8.5E-05	4.4E-08	6.7E-02	2.4E-02
Gonads	1.0E+00	5.0E-04	1.2E-01	1.3E-01

Table 9.6. Comparison of Dosimetric Factors for ^{241}Am

Reference Source	Class W Inhalation 1-μm AMAD	Class W Inhalation 5-μm AMAD	Soluble Ingestion
Dose Coefficients			
CINDY ($h_{E,50}$)	0.43 rem/nCi 1.2E-04 Sv/Bq	0.46 rem/nCi 1.2E-04 Sv/Bq	0.0018 rem/nCi 4.9E-07 Sv/Bq
ICRP 54 ($h_{E,50}$)	1.2E-04 Sv/Bq (0.44 rem/nCi)	NA	NA
EPA Federal Guidance Report No. 11 ($h_{E,50}$)	1.20E-04 Sv/Bq (0.44 rem/nCi)	NA	9.84E-07 Sv/Bq (3.64E-03 rem/nCi)
ICRP 68 [e(50)]	3.9E-05 Sv/Bq (0.14 rem/nCi)	2.7E-05 Sv/Bq (0.10 rem/nCi)	2.0E-07 Sv/Bq (7.4E-04 rem/nCi)
Bone Surface DAC			
10 CFR 835, App. A	2E-12 μCi/ml and 8E-02 Bq/m^3	NA	NA
EPA Federal Guidance Report No. 11	3E-12 μCi/ml and 1E-07 Bq/m^3	NA	NA
ICRP 30, ICRP 54	1E-01 Bq/m^3	NA	NA
Annual Limit on Intake, ALI (Bone Surface)			
Calculated from 10 CFR 835 DAC	4.8E-03 μCi/ml and 190 Bq	NA	NA
ICRP 30, ICRP 54	2E+02 Bq	NA	3E+04 Bq
EPA Federal Guidance Report No. 11	2.0E-04 MBq and 0.006 μCi	NA	0.03 MBq and 0.8 μCi
NA = not applicable			

9.3.4 Derived Reference Levels

Derived screening, investigation, and compliance levels (based on committed effective dose equivalents of 10-mrem, 100-mrem, and a committed bone surface dose equivalent of 50,000 mrem, respectively) have been calculated for 1-μm and 5-μm class W inhalations of pure ^{241}Am. The urine excretion levels are shown in Table 9.7 and chest count levels are shown in Table 9.8. These levels are sufficiently low that, from a practical standpoint, any detected result is likely to result in investigation and dose assessment. This is particularly the case because ^{241}Am at Hanford is usually used as an indicator of potential plutonium intake.

9.4 Bioassay for Americium

This section discusses the general techniques and applicability of bioassay monitoring and describes the capabilities of excreta sample bioassay and in vivo measurements. General recommendations are also provided for routine bioassay monitoring for americium. Techniques are similar for both ^{241}Am and ^{243}Am.

9.4.1 Excreta Bioassay Techniques for Americium

The typical urine sampling practice is to collect a urine sample over a specified time interval and perform a chemical separation for americium using an added tracer to determine the chemical yield of the process. This technique is followed by electroplating and quantitative alpha spectrometry. Where the analyte is ^{241}Am, the tracer added to the chemical process is ^{243}Am. If the analyte is ^{243}Am, a ^{241}Am tracer is added. Because of the tracers used, if a worker is to be monitored for both ^{241}Am and ^{243}Am, two samples will have to be collected and analyzed (or alternatively, a single sample must be split prior to adding the tracer and two different analyses performed.)

Fecal sample analysis follows a process similar to urine sample analysis.

Less sensitive, rapid analytical procedures are available for special circumstances. These procedures can be executed and results obtained in substantially shorter times than the routine procedure, but they are less sensitive. Their use is primarily for diagnostic bioassay of suspected internal contamination related to unplanned exposures (incidents). The decision to use such procedures involves considering the probability and potential magnitude of the exposure. Of particular interest as an alternative to the electroplating and alpha spectrometry procedure is direct counting of the low-energy ^{241}Am

Table 9.7. ^{241}Am Reference Levels and Urine Excretion Derived Reference Levels for Class W Inhalation

	10-mrem $H_{E,50}$ Screening Level		**100-mrem $H_{E,50}$ Investigation Level**		**50-rem $H_{T,50}$ Compliance Level**	
	1-µm	**5-µm**	**1-µm**	**5-µm**	**1-µm**	**5-µm**
Intake (nCi)	2.3E-02	2.2E-02	2.3E-01	2.2E-01	5.6E+00	5.1E+00
	Derived Screening Level (dpm/d)		**Derived Investigation Level (dpm/d)**		**Derived Compliance Level (dpm/d)**	
Days Post Intake	**1-µm**	**5-µm**	**1-µm**	**5-µm**	**1-µm**	**5-µm**
1	1.1E-02	1.7E-02	1.1E-01	1.7E-01	2.7E+00	3.9E+00
2	7.2E-03	1.1E-02	7.2E-02	1.1E-01	1.7E+00	2.5E+00
5	2.4E-03	3.3E-03	2.4E-02	3.3E-02	5.7E-01	7.7E-01
7	1.6E-03	2.1E-03	1.6E-02	2.1E-02	3.8E-01	4.9E-01
14	1.1E-03	1.4E-03	1.1E-02	1.4E-02	2.7E-01	3.1E-01
30	8.8E-04	9.7E-04	8.8E-03	9.7E-03	2.1E-01	2.2E-01
60	6.7E-04	6.8E-04	6.7E-03	6.8E-03	1.6E-01	1.6E-01
90	5.7E-04	5.3E-04	5.7E-03	5.3E-03	1.4E-01	1.2E-01
180	4.3E-04	3.9E-04	4.3E-03	3.9E-03	1.0E-01	9.1E-02
365	2.5E-04	2.4E-04	2.5E-03	2.4E-03	5.9E-02	5.5E-02
730	1.2E-04	1.3E-04	1.2E-03	1.3E-03	3.0E-02	2.9E-02
1825	8.3E-05	8.7E-05	8.3E-04	8.7E-04	2.0E-02	2.0E-02
3650	7.7E-05	8.2E-05	7.7E-04	8.2E-04	1.9E-02	1.9E-02
7300	6.7E-05	7.2E-05	6.7E-04	7.2E-04	1.6E-02	1.7E-02
18250	4.9E-05	4.8E-05	4.9E-04	4.8E-04	1.2E-02	1.1E-02

Table 9.8. ^{241}Am Reference Levels and Chest Count Derived Reference Levels for Class W Inhalation

	10-mrem $H_{E,50}$ Screening Level		**100-mrem $H_{E,50}$ Investigation Level**		**50-rem $H_{T,50}$ Compliance Level**	
	1-µm	**5-µm**	**1-µm**	**5-µm**	**1-µm**	**5-µm**
Intake (nCi)	2.3E-02	2.2E-02	2.3E-01	2.2E-01	5.6E+00	5.1E+00
	Derived Screening Level (nCi)		**Derived Investigation Level (nCi)**		**Derived Compliance Level (nCi)**	
Days Post Intake	**1-µm**	**5-µm**	**1-µm**	**5-µm**	**1-µm**	**5-µm**
0	7.7E-03	3.7E-03	7.7E-02	3.7E-02	1.8E+00	8.6E-01
1	4.9E-03	1.6E-03	4.9E-02	1.6E-02	1.2E+00	3.8E-01
2	4.2E-03	1.4E-03	4.2E-02	1.4E-02	1.0E+00	3.2E-01
5	3.5E-03	1.1E-03	3.5E-02	1.1E-02	8.3E-01	2.6E-01
7	3.3E-03	1.1E-03	3.3E-02	1.1E-02	7.8E-01	2.5E-01
14	3.0E-03	9.6E-04	3.0E-02	9.6E-03	7.2E-01	2.2E-01
30	2.3E-03	7.8E-04	2.3E-02	7.8E-03	5.6E-01	1.8E-01
60	1.6E-03	5.4E-04	1.6E-02	5.4E-03	3.9E-01	1.3E-01
90	1.1E-03	3.7E-04	1.1E-02	3.7E-03	2.7E-01	8.6E-02
180	3.5E-04	1.2E-04	3.5E-03	1.2E-03	8.3E-02	2.7E-02
365	3.3E-05	1.0E-05	3.3E-04	1.0E-04	7.8E-03	2.4E-03
730	2.6E-07	8.5E-08	2.6E-06	8.5E-07	6.1E-05	2.0E-05

photon using a germanium detector. This protocol is substantially less sensitive than the alpha spectrometry, but is not subject to the difficulties associated with americium chemical separation. This analysis is an appropriate quick-turnaround emergency analysis procedure that could be used as an indicator for a plutonium intake based on fecal sampling and reasonable knowledge of the americium-to-plutonium ratio.

The contractual detection limits for americium in urine or feces can be found in the radiochemistry bioassay laboratory statement of work (available from the HIDP) and in the *Hanford Internal Dosimetry Project Manual* (PNL-MA-552).[(a)]

The minimum detectable intakes based on a 0.02 dpm/d urinalysis sensitivity are shown in Table 9.9. The committed effective and bone surface dose equivalents associated with those intakes are shown in Tables 9.10 and 9.11, respectively. Figures 9.5 and 9.6 show graphical presentations of the minimum detectable doses. Corresponding data based on a 0.8 dpm/d fecal analysis sensitivity, are shown in Tables 9.12 through 9.14 and Figures 9.7 and 9.8.

Table 9.9. Minimum Detectable Intakes (nCi) for ^{241}Am Based on Detection of 0.02 dpm/d ^{241}Am in Urine

Days Post Intake	Instant Uptake	Ingestion	Class W Inhalation	
			1-μm	5-μm
1	2.9E-03	5.3E+00	4.1E-02	2.6E-02
2	4.7E-03	9.0E+00	6.4E-02	4.1E-02
5	1.6E-02	2.9E+01	2.0E-01	1.3E-01
7	2.4E-02	4.7E+01	2.9E-01	2.0E-01
14	3.9E-02	8.2E+01	4.1E-01	3.2E-01
30	6.0E-02	1.2E+02	5.3E-01	4.5E-01
60	9.1E-02	1.8E+02	6.9E-01	6.4E-01
90	1.1E-01	2.3E+02	8.2E-01	8.2E-01
180	1.6E-01	3.1E+02	1.1E+00	1.1E+00
365	2.6E-01	5.0E+02	1.9E+00	1.8E+00
730	4.7E-01	9.4E+02	3.8E+00	3.5E+00
1825	6.9E-01	1.3E+03	5.6E+00	5.0E+00
3650	6.9E-01	1.4E+03	6.0E+00	5.3E+00
7300	8.2E-01	1.6E+03	6.9E+00	6.0E+00
18250	1.2E+00	2.3E+03	9.6E+00	9.0E+00

(a) Pacific Northwest National Laboratory (PNNL). *Hanford Internal Dosimetry Project Manual*. PNNL-MA-552, Richland, Washington. (Internal manual.) Available URL: http://www.pnl.gov/eshs/pub/pnnl552.html

Table 9.10. Minimum Detectable Committed Effective Dose Equivalent (rem) for ^{241}Am Based on Detection of 0.02 dpm/d ^{241}Am in Urine

Days Post Intake	Instant Uptake	Ingestion	Class W Inhalation	
			1-μm	5-μm
1	1.0E-02	9.5E-03	1.8E-02	1.2E-02
2	1.7E-02	1.6E-02	2.8E-02	1.9E-02
5	5.4E-02	5.2E-02	8.4E-02	6.0E-02
7	8.5E-02	8.5E-02	1.2E-01	9.4E-02
14	1.4E-01	1.5E-01	1.8E-01	1.5E-01
30	2.1E-01	2.1E-01	2.3E-01	2.1E-01
60	3.2E-01	3.2E-01	3.0E-01	3.0E-01
90	4.0E-01	4.1E-01	3.5E-01	3.8E-01
180	5.5E-01	5.6E-01	4.7E-01	5.1E-01
365	9.0E-01	9.0E-01	8.1E-01	8.5E-01
730	1.7E+00	1.7E+00	1.6E+00	1.6E+00
1825	2.4E+00	2.4E+00	2.4E+00	2.3E+00
3650	2.4E+00	2.6E+00	2.6E+00	2.4E+00
7300	2.9E+00	2.9E+00	3.0E+00	2.8E+00
18250	4.0E+00	4.2E+00	4.1E+00	4.1E+00

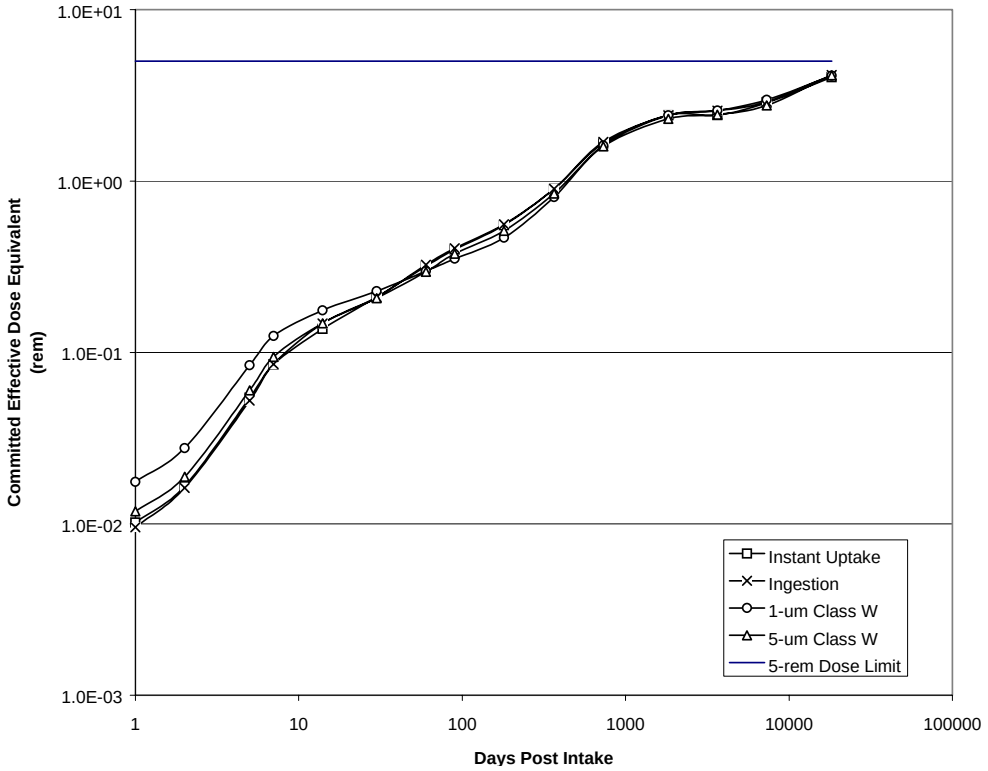

Figure 9.5. Minimum Detectable Committed Effective Dose Equivalent (rem) for ^{241}Am Based on Detection of 0.02 dpm/d ^{241}Am in Urine

Table 9.11. Minimum Detectable Bone Surfaces Dose Equivalent (rem) for ^{241}Am Based on Detection of 0.02 dpm/d ^{241}Am in Urine

Days Post Intake	Instant Uptake	Ingestion	Class W Inhalation	
			1-μm	5-μm
1	2.2E-01	2.0E-01	3.7E-01	2.5E-01
2	3.6E-01	3.3E-01	5.8E-01	4.1E-01
5	1.2E+00	1.1E+00	1.8E+00	1.3E+00
7	1.8E+00	1.8E+00	2.6E+00	2.0E+00
14	2.9E+00	3.0E+00	3.7E+00	3.2E+00
30	4.5E+00	4.3E+00	4.8E+00	4.5E+00
60	6.8E+00	6.7E+00	6.2E+00	6.4E+00
90	8.6E+00	8.3E+00	7.4E+00	8.1E+00
180	1.2E+01	1.1E+01	9.8E+00	1.1E+01
365	1.9E+01	1.9E+01	1.7E+01	1.8E+01
730	3.6E+01	3.5E+01	3.4E+01	3.4E+01
1825	5.2E+01	5.0E+01	5.1E+01	5.0E+01
3650	5.2E+01	5.3E+01	5.4E+01	5.2E+01
7300	6.1E+01	6.0E+01	6.2E+01	5.9E+01
18250	8.7E+01	8.5E+01	8.6E+01	8.9E+01

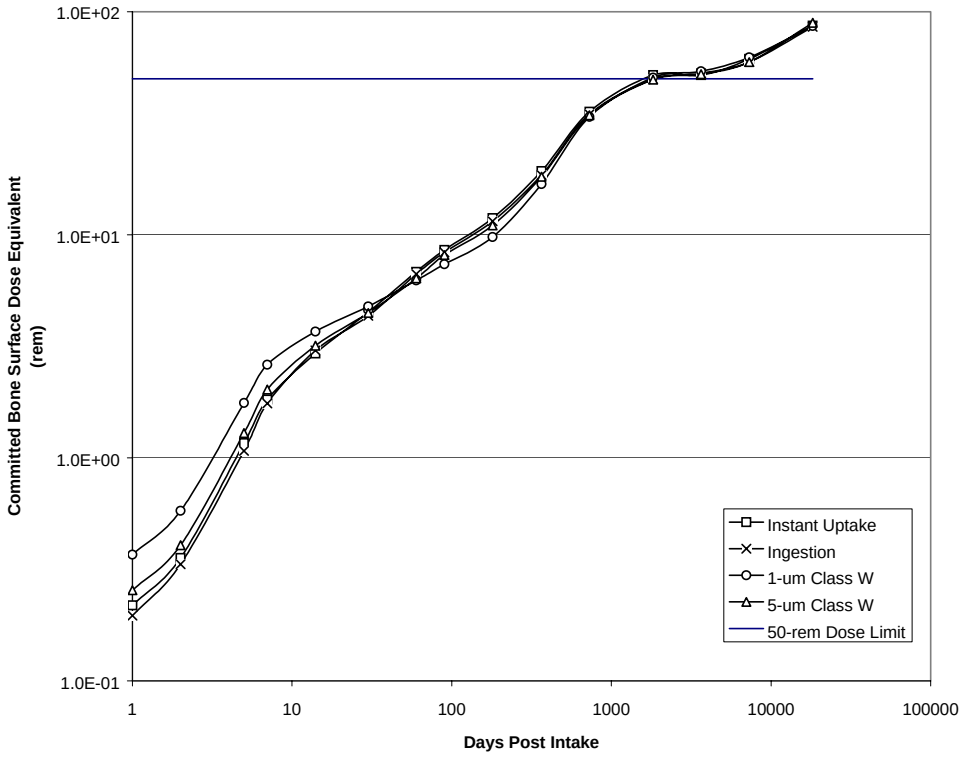

Figure 9.6. Minimum Detectable Bone Surfaces Dose Equivalent (rem) for ^{241}Am Based on Detection of 0.02 dpm/d ^{241}Am in Urine

Table 9.12. Minimum Detectable Intakes (nCi) for ^{241}Am Based on Detection of 0.8 dpm/d ^{241}Am in Feces

Days Post Intake	Instant Uptake	Ingestion	Class W Inhalation	
			1-μm	5-μm
1	1.2E-01	7.7E-04	3.3E-03	1.6E-03
2	1.9E-01	1.3E-03	2.8E-03	1.4E-03
5	6.2E-01	2.0E-02	1.6E-02	1.2E-02
7	9.7E-01	1.4E-01	5.7E-02	6.4E-02
14	1.6E+00	1.5E+02	3.0E-01	7.8E-01
30	2.4E+00	4.7E+03	3.8E-01	1.0E+00
60	3.6E+00	7.2E+03	5.7E-01	1.6E+00
90	4.6E+00	9.0E+03	8.6E-01	2.3E+00
180	6.3E+00	1.2E+04	2.8E+00	7.4E+00
365	1.0E+01	2.0E+04	2.6E+01	4.4E+01
730	1.9E+01	3.8E+04	1.4E+02	1.4E+02
1825	2.8E+01	5.4E+04	2.3E+02	2.0E+02
3650	2.8E+01	5.7E+04	2.4E+02	2.1E+02
7300	3.3E+01	6.4E+04	2.8E+02	2.4E+02
18250	4.6E+01	9.2E+04	3.8E+02	3.6E+02

9.4.2 In Vivo Bioassay Techniques for Americium

In vivo measurement of americium is available for both ^{241}Am and ^{243}Am, though it is not routinely performed for ^{243}Am. Hanford in vivo measurements for americium include chest counts, skeleton measurements by head counting, liver counts, and wound counts. Brief descriptions of the measurements are contained in Section 8.4.3 of the Plutonium Chapter of this manual. Minimum detectable activities for these measurements are described in the *Hanford In Vivo Monitoring Program Manual* (PNL-MA-574)[(a)] and the *Hanford Internal Dosimetry Program Manual* (PNL-MA-552).[(b)]

The minimum detectable intakes of ^{241}Am and associated committed doses as determined by detection of 0.16 nCi ^{241}Am by chest counting are described in Table 9.15 and illustrated in Figure 9.9.

(a) Pacific Northwest National Laboratory (PNNL). *Hanford In Vivo Monitoring Program Manual*. PNNL-MA-574, Richland, Washington. (Internal manual.)
(b) Pacific Northwest National Laboratory (PNNL). *Hanford Internal Dosimetry Project Manual*. PNNL-MA-552, Richland, Washington. (Internal manual.) Available URL: http://www.pnl.gov/eshs/pub/pnnl552.html

Table 9.13. Minimum Detectable Committed Effective Dose Equivalent (rem) for ^{241}Am Based on Detection of 0.8 dpm/d ^{241} Am in Feces

Days Post Intake	Instant Uptake	Ingestion	Class W Inhalation	
			1-µm	5-µm
1	4.1E-01	1.4E-06	1.4E-03	7.5E-04
2	6.6E-01	2.3E-06	1.2E-03	6.4E-04
5	2.2E+00	3.6E-05	6.7E-03	5.3E-03
7	3.4E+00	2.6E-04	2.5E-02	3.0E-02
14	5.5E+00	2.7E-01	1.3E-01	3.6E-01
30	8.4E+00	8.4E+00	1.6E-01	4.7E-01
60	1.3E+01	1.3E+01	2.5E-01	7.2E-01
90	1.6E+01	1.6E+01	3.7E-01	1.0E+00
180	2.2E+01	2.2E+01	1.2E+00	3.4E+00
365	3.6E+01	3.6E+01	1.1E+01	2.0E+01
730	6.6E+01	6.8E+01	6.2E+01	6.4E+01
1825	9.7E+01	9.7E+01	9.7E+01	9.2E+01
3650	9.7E+01	1.0E+02	1.0E+02	9.8E+01
7300	1.1E+02	1.2E+02	1.2E+02	1.1E+02
18250	1.6E+02	1.7E+02	1.6E+02	1.7E+02

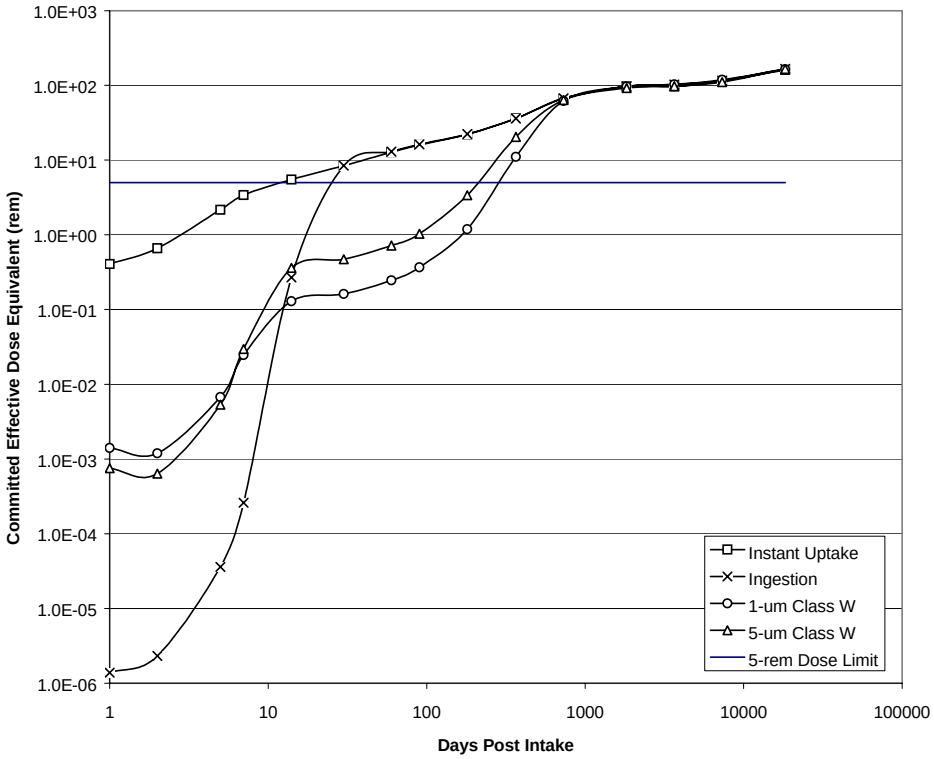

Figure 9.7. Minimum Detectable Committed Effective Doses for ^{241}Am Based on Detection of 0.8 dpm/d ^{241}Am in Feces

Table 9.14. Minimum Detectable Committed Bone Surface Dose Equivalents (rem) for ^{241}Am Based on Detection of 0.8 dpm/d ^{241}Am in Feces

Days Post Intake	Instant Uptake	Ingestion	Class W Inhalation	
			1-µm	5-µm
1	8.7E+00	2.8E-05	2.9E-02	1.6E-02
2	1.4E+01	4.8E-05	2.5E-02	1.4E-02
5	4.7E+01	7.4E-04	1.4E-01	1.2E-01
7	7.3E+01	5.3E-03	5.1E-01	6.4E-01
14	1.2E+02	5.6E+00	2.7E+00	7.8E+00
30	1.8E+02	1.7E+02	3.4E+00	1.0E+01
60	2.7E+02	2.7E+02	5.1E+00	1.6E+01
90	3.4E+02	3.3E+02	7.7E+00	2.2E+01
180	4.7E+02	4.6E+02	2.5E+01	7.3E+01
365	7.7E+02	7.4E+02	2.3E+02	4.4E+02
730	1.4E+03	1.4E+03	1.3E+03	1.4E+03
1825	2.1E+03	2.0E+03	2.0E+03	2.0E+03
3650	2.1E+03	2.1E+03	2.2E+03	2.1E+03
7300	2.5E+03	2.4E+03	2.5E+03	2.4E+03
18250	3.5E+03	3.4E+03	3.5E+03	3.6E+03

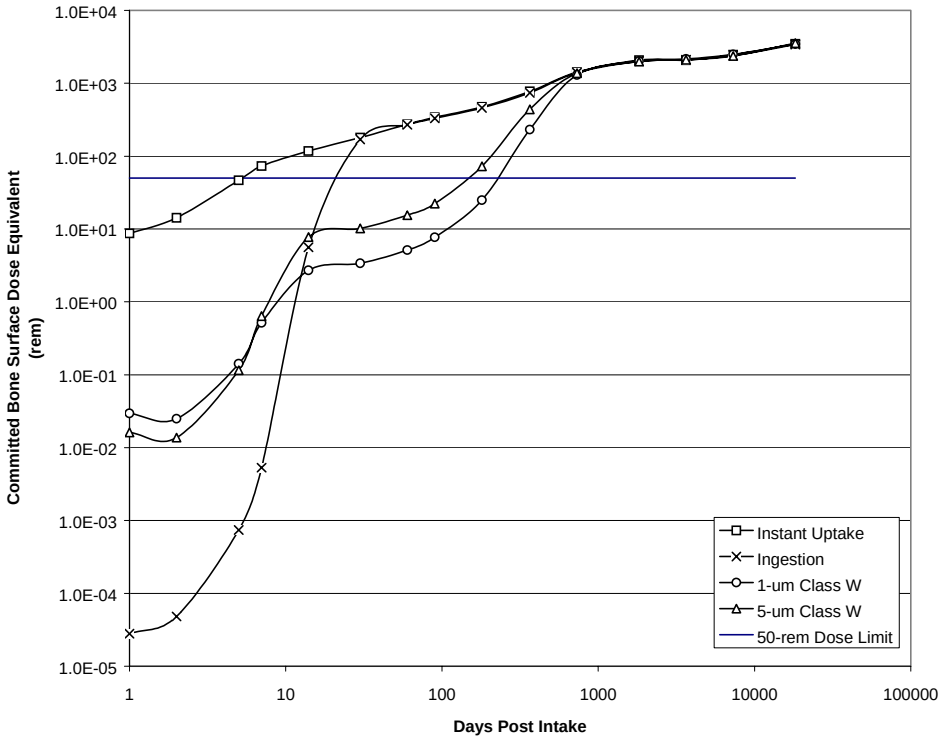

Figure 9.8. Minimum Detectable Committed Bone Surface Doses for ^{241}Am Based on Detection of 0.8 dpm/d ^{241}Am in Feces

Table 9.15. Minimum Detectable Intakes and Committed Doses for Class W Inhalation of ^{241}Am Based on Detection of 0.16 nCi ^{241}Am by Chest Counting

Days Post Intake	Minimum Detectable Values for 1-µm AMAD Particles			Minimum Detectable Values for 5-µm AMAD Particles		
	Intake (nCi)	Effective Dose (rem)	Bone Surface Dose (rem)	Intake (nCi)	Effective Dose (rem)	Bone Surface Dose (rem)
0	4.8E-01	2.1E-01	4.4E+00	9.4E-01	4.3E-01	9.3E+00
1	7.6E-01	3.3E-01	6.9E+00	2.1E+00	9.8E-01	2.1E+01
2	8.9E-01	3.8E-01	8.0E+00	2.5E+00	1.2E+00	2.5E+01
5	1.1E+00	4.6E-01	9.6E+00	3.1E+00	1.4E+00	3.1E+01
7	1.1E+00	4.9E-01	1.0E+01	3.3E+00	1.5E+00	3.2E+01
14	1.2E+00	5.3E-01	1.1E+01	3.6E+00	1.7E+00	3.6E+01
30	1.6E+00	6.9E-01	1.4E+01	4.4E+00	2.0E+00	4.4E+01
60	2.3E+00	9.8E-01	2.1E+01	6.4E+00	2.9E+00	6.3E+01
90	3.3E+00	1.4E+00	3.0E+01	9.4E+00	4.3E+00	9.3E+01
180	1.1E+01	4.6E+00	9.6E+01	3.0E+01	1.4E+01	3.0E+02
365	1.1E+02	4.9E+01	1.0E+03	3.3E+02	1.5E+02	3.3E+03
730	1.5E+04	6.3E+03	1.3E+05	4.1E+04	1.9E+04	4.1E+05

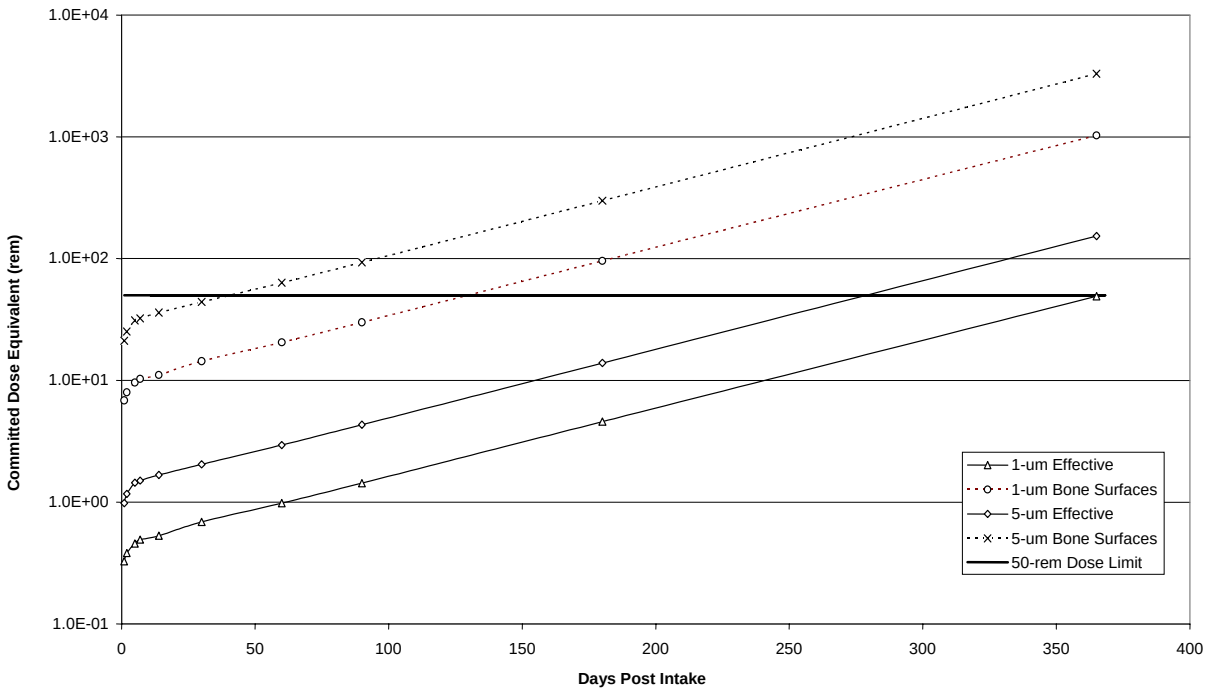

Figure 9.9. Minimum Detectable Committed Doses for ^{241}Am Based on Detection of 0.16 nCi ^{241}Am in the Lung

9.4.3 Recommended Periodic Bioassay Monitoring Protocol

Based on Tables 9.10 and 9.11, an annual urine-sampling program is recommended for monitoring intakes of pure ^{241}Am. Such a program is capable of demonstrating regulatory compliance with both stochastic and deterministic dose limits, but is not capable of demonstrating compliance with administrative control levels of 500-mrem committed effective dose equivalent or lower. More frequent urinalysis can provide some improvement in sensitivity, but primary reliance must be placed on prompt detection of potential intakes by workplace indicators and special bioassay monitoring to provide low-level dosimetry.

Annual chest counting is appropriate as an augmentation, particularly when ^{241}Am is used as an indicator for plutonium.

9.4.4 Special Monitoring for Suspected Intakes

Special bioassay monitoring for suspected inhalation or ingestion intakes should include a chest count, urine sample, and at least one (preferably two or more) fecal samples. If these measurements are obtained within the first 3 to 5 days, committed effective dose equivalents in the range of a few millirem can be detected.

For potential wound intakes, special bioassay should consist of a wound count and a urine sample. Fecal sampling is not necessary for wound dosimetry, however data on the fecal excretion following a wound can provide information that may be valuable for improving americium metabolic models.

9.4.5 Bioassay Monitoring Capability for Workers with Known Americium Depositions

The capability of a bioassay program is directly dependent upon the magnitude of an identifiable increase in a bioassay measurement. When a worker has a detectable baseline bioassay level due to a previous intake, the ability to detect a subsequent increase in the bioassay level from an additional intake is more dependent on the variability of current bioassay levels and less dependent on analytical capability. In other words, to be detected, subsequent intakes must result in increases in bioassay measurements that exceed the baseline or background “noise” level. Guidance concerning the potential dose from potentially undetected intakes must be developed on a case-by-case basis. Appropriate adjustments to measurement frequencies can then be determined based on the potential undetected dose. As an approximate rule-of-thumb, a single bioassay measurement will probably have to be at least twice the baseline level to be readily recognized, due to the substantial variability in single bioassay measurements on individual people. For many situations, this may imply that a normally detectable intake may not be detectable on top

of a pre-existing internal plutonium deposition. Like most rules-of-thumb, this is only a rough suggestion; cases of significance must be addressed individually.

9.5 Assessment of Internal Dose

Assessments of internal dose for americium rely on evaluations of intake or deposition. Current practice for such evaluations is to perform an intake assessment. Prior to 1988, the common Hanford approach was a deposition assessment based on urine data. For significant cases, it may be possible to directly measure americium retention in the organ or tissue of interest using in vivo monitoring. In such cases, individual-specific retention parameters are appropriate for dosimetry.

9.5.1 Intake Assessment

An americium intake can be estimated by fitting the bioassay data to the appropriate retention or excretion function, using manual or computerized techniques. For a single data point, the intake can be estimated by dividing the measured excretion by the value of the retention function for the appropriate day after intake represented by the sample in a manner similar to Equation 2.5. Values for the retention function can be obtained from those tabulated in this chapter, or directly from running the CINDY computer code. For multiple data points, the CINDY code provides a choice of fitting routines, or a manually determined fit of the data to the expected function can be performed. Once the intake is calculated, appropriate internal doses may be calculated by applying the dose coefficients of this chapter to Equations 2.10 or 2.11. The CINDY computer code may also be used to directly calculate internal doses, and is particularly appropriate for complex cases.

9.5.2 Deposition Assessment

Deposition assessment involves determining the amount of material deposited in a body or tissue compartment of interest. Whereas the term “intake” includes all material taken into the body regardless of its subsequent fate, “deposition” is a more limited quantity that excludes material not retained (e.g., material that is immediately exhaled) and material not systemically absorbed (e.g., material cleared to the GI tract and excreted in feces without absorption). The HIDP coined the term “presystemic deposition” in the mid-1980s to precisely define what was being evaluated and avoid terms that had developed generic, ill-defined, or varied meanings (e.g., deposition, uptake, burden). In addition, the term “deposition” was gaining preference in the field of internal dosimetry as a process term associated with the respiratory tract, rather than a retained quantity. The HIDP defined presystemic deposition as the total radioactivity that will ultimately translocate into the transfer

compartment from a metabolically isolated pool; in other words, the activity ultimately reaching the blood. Historically at Hanford, this was the quantity compared with the MPBB of 0.05 μCi (^{241}Am) as listed in ICRP 2 (1959). It is related to, but significantly different from intake, lung deposition, long-term lung burden, and instantaneous body burden (or retained quantity).

Activity is deposited in presystemic compartments at the time of intake. From there, systemic uptake may be essentially instantaneous or it may occur gradually over an extended period of time. Transfer from the presystemic compartment into systemic circulation is assumed to be governed by linear first-order kinetics, and can be described in terms of a transfer rate constant. A urine excretion function such as described in Section 9.2.4 is typically used to estimate the presystemic deposition.

9.5.3 Assessing Organ and Effective Dose Equivalents

The organs of primary interest for americium dose evaluations are the bone surface, red marrow, liver, and gonads. The lung is also an organ of general interest for inhalations, even though its contribution to effective dose for class W intakes is relatively insignificant. Other organs or tissues may be of interest depending on the nature of an intake. For example, the dose to a specific lymph node or small volume of tissue as the result of a wound intake of slowly transportable materials may be of academic interest, but is not a regulatory concern. Such cases can be dealt with as they arise and are beyond the general scope of this technical basis.

Once the magnitude of an intake, presystemic deposition, or initial lung deposition has been determined, organ dose equivalents and the effective dose equivalent can be assessed using hand-calculation techniques or computer codes. The HIDP uses the CINDY computer code to aid in dose calculations. More detailed explanations and copies of the code are maintained in the Hanford Radiation Protection Historical Files. The tabulated dose coefficients of Section 9.3 are useful for hand calculations.

9.6 Management of Internal Contamination Cases

This section discusses the diagnostic procedures, therapeutic actions, and long-term monitoring of internal depositions.

9.6.1 Diagnostic Procedures

The diagnosis of an intake involves a combination of workplace monitoring to identify on-the-job potential intakes and bioassay measurements to confirm and quantify internal contamination.

The primary method of identifying potential intakes is by workplace monitoring, such as personal contamination surveys, nasal smear analyses, air sample results, or workers' identifications of unusual conditions. These techniques provide qualitative screening to alert radiation protection staff about potential internal exposure, rather than absolute confirmation that exposure has or has not occurred. For example, activity detected on nasal smears is usually an indication of an inhalation intake; however, the absence of activity does not necessarily mean that an intake did not occur. The absence of nasal smear activity following an inhalation intake can be explained by a sufficient delay between the time of intake and the collection of nasal smears to allow for complete clearance of activity from the nares. The ICRP 30 (1979) respiratory tract model indicates that a delay of as little as 30 to 60 minutes may be adequate for this in some cases. Alternatively, some individuals are mouth-breathers, whose noses are partially or completely bypassed in the respiratory process, hence no activity may be deposited in the nares, despite the occurrence of an inhalation intake. Particle size can also significantly affect nasal deposition and clearance.

Once a worker has been identified as having incurred a potential intake, the initial diagnostic measurements are arranged. These may include a chest count, wound count, single voiding (spot) urine sample analysis, first-day fecal sampling, and overnight urine sampling. The purpose of these initial procedures is to provide an order-of-magnitude estimate of the potential internal exposure and dose. Initial diagnostic measurements are usually sufficient for final evaluations only when all results collectively rule out the possibility of an intake. In reality, initial measurements are not generally expected to do this, and follow-up measurements are necessary.

Follow-up diagnostic measurements may include additional urine and fecal samples, chest counts, liver counts, head counts, and lymph node counts. These analyses aid in determining the magnitude, location, and retention characteristics of the deposited material. In some cases, blood samples or tissue specimens may also be appropriate. In addition, workplace or clothing contamination analyses, air sample analyses,

particle size analyses, and/or solubility analyses may be performed to more clearly define the physical and radiological characteristics of the material to which the worker was exposed.

It is the responsibility of the exposure evaluator, working closely with contractor radiation protection staff, to determine the appropriate diagnostic protocols. Scheduling of follow-up measurements will normally be done by the appropriate contractor radiation protection staff.

9.6.2 Therapeutic Actions

Therapeutic actions for potential internal contamination include the use of decorporation agents, catharsis, and surgical excision. For the purposes of this discussion, the normal skin decontamination procedures of Hanford contractors are not considered therapeutic actions, although it is acknowledged that these procedures can be quite effective in preventing the intake of radioactivity. The decision to undertake one or more of these therapeutic actions is the responsibility of the participating HEHF Occupational Medicine care provider with the concurrence of the patient. The exposure evaluator will provide advice and consultation to the physician and patient regarding the potential dose implications and efficacy of alternative actions. Guidance for the methods of therapy can be found in NCRP Report No. 65 (1980) and in the "Guidebook for the Treatment of Accidental Internal Radionuclid Contamination of Workers" (Bhattacharyya et al. 1992). Guidance for circumstances under which therapy may be warranted is contained in PNL-MA-552, but was established as a good practice based on experience rather than a detailed technical analysis.

Decorporation therapy is also referred to as chelation therapy, and involves the chemical removal of radioactivity from the bloodstream through drug administration. The drug diethylenetriaminepenta-acetic acid (DTPA) has U.S. Food and Drug Administration approval as an investigational new drug for use in removing americium. Under the investigational new drug category, the patient must provide informed consent to HEHF before the drug may be administered. Decorporation therapy significantly enhances urinary excretion of americium, a point that must be considered when interpreting urine samples affected by therapy. ICRP 78 (1997) suggests that urinary excretion may be increased by as much as a factor of 50.

Following the 1976 americium column explosion at the 242-Z facility, the most exposed worker received extensive therapy using DTPA (Breitenstein 1983; Robinson et al. 1983). This therapy is generally recognized as having been life-saving, owing to the dose to the liver that was averted by the DTPA. Without the DTPA therapy it is generally considered that doses would have been sufficiently high as to ultimately result in liver failure. There was no evidence of liver disorder either during or following the DTPA therapy.

Catharsis involves accelerating the passage of material through the GI tract by means of laxative drugs or physical means such as an enema. Catharsis has potential value in reducing the adsorption of material into the bloodstream from the GI tract and in reducing the dose to the GI tract organs from material passing through the GI tract. These measures are not generally considered for occupational exposures to americium, because the GI tract adsorption of americium is slight, and the dose to the GI tract organs is an insignificant fraction of the total effective dose.

Surgical excision following wounds can be extremely effective in reducing the potential uptake, particularly when coupled with decorporation therapy. Minor excisions are usually performed at the Emergency Decontamination Facility (EDF) by HEHF Occupational Medicine staff, assisted by a PNNL exposure evaluation and radiation protection personnel.

9.6.3 Long-Term Monitoring of Internal Depositions

Once an internal dosimetry evaluation has been completed, it may be recommended that the worker be placed on a specialized long-term bioassay monitoring schedule. The reasons for this are twofold: first, long-term follow-up monitoring results that are consistent with the projected results verify the conclusions of the evaluation. Second, if long-term results are projected to be detectable, and the worker returns to americium work, then the capability of a routine bioassay monitoring program to detect an additional intake may be affected. This issue must be addressed on an individual-specific basis.

9.7 References

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