Supporting Document for Guidance Levels for Radionuclides in Domestic and Imported Foods

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Food and Drug Administration

Center for Food Safety and Applied Nutrition

Office of Plant and Dairy Foods and Beverages

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I. Introduction

In the Federal Register of August 13, 1998 (63 FR 43402) (FDA 1998), FDA announced the availability of a new document entitled "Accidental Radioactive Contamination of Human Food and Animal Feeds: Recommendations to State and Local Agencies" (hereinafter 1998 FDA document) replacing an earlier 1982 FDA document (FDA 1982). The 1998 FDA document provides guidance to State and local agencies to aid in emergency response planning and execution of protective actions associated with production, processing, distribution, and use of human food and animal feeds accidentally contaminated, e.g., due to a nuclear power plant accident, with radioactive elements called radionuclides. In addition, the 1998 FDA document provides broader and more current information regarding radionuclides in food than did the 1982 FDA document.

FDA has adopted guidance levels for radionuclide activity concentration established in the 1998 FDA document in a draft Compliance Policy Guide (CPG) entitled "Guidance Levels for Radionuclides in Domestic and Imported Foods." The draft CPG, if finalized, will rescind and replace guidance levels for radionuclide activity concentration in food offered for import established in current CPG Sec. 560.750 Radionuclides in Imported Foods – Levels of Concern (CPG 7119.14) with guidance levels established in the 1998 FDA document. FDA has also adopted these same guidance levels for radionuclide activity concentration for domestic food in interstate commerce. Additionally, FDA has expanded its policy from food accidentally contaminated with radionuclides to food accidentally or intentionally contaminated with radionuclides. The 1998 FDA document remains unaffected by issuance of the draft CPG.

FDA uses guidance levels for radionuclide activity concentration in food to help determine whether domestic food in interstate commerce or food offered for import into the United States presents a safety concern. The purpose of this supporting document is to present information taken from the 1998 FDA document that explains the basis for the guidance levels in the draft CPG, and to explain how these guidance levels differ from guidance levels established in 1986, which have been superceded.

II. Protective Action Guides

The calculation of guidance levels for radionuclide activity concentration in food depends in part on Protective Action Guides (PAGs). PAGs are radiation dose levels to an individual at which protective action should be considered to limit the radiation dose to that individual. PAGs were previously defined in the1982 FDA document as "projected dose commitment values to individuals in the general population that warrant protective action following a release of radioactive material." In this context, the phrase "dose commitment" refers to the radiation dose received by an individual. The PAGs contained in the 1982 FDA document were developed from the prevailing scientific understanding of the relative risks associated with radiation as described in the 1960 and 1961 reports of the Federal Radiation Council (FRC 1960, 1961). The 1982 FDA guidance document established two levels for PAGs. The lower level, called the Preventative PAG, was a projected dose commitment of 5 mSv to the whole body, active bone marrow, or any other organ except the thyroid, or a projected dose commitment of 15 mSv to the thyroid. The upper level, called the Emergency PAG, was a projected dose commitment of 50 mSv to the whole body, active bone marrow, or any other organ except the thyroid, or a projected dose commitment of 150 mSv to the thyroid.

The 1998 FDA document redefined a PAG as the "committed effective dose equivalent[1] or committed dose equivalent[2] to an individual organ or tissue that warrants protective action following a release of radionuclides." The 1998 FDA document replaced the Preventative and Emergency PAGs with one set of PAGs for the ingestion pathway. The PAGs established in the 1998 FDA document are 5 mSv for committed effective dose equivalent or 50 mSv committed dose equivalent to an individual tissue or organ, whichever is more limiting (i.e., the most limiting PAG results in the lowest level of radionuclide activity concentration in food).

For 5 mSv committed effective dose equivalent (the PAG adopted in the new CPG), the associated lifetime total cancer mortality would be 2.25×10^{-4} or approximately 1 in 4400. For comparison, the estimate of the normal lifetime total cancer mortality in the United States for the general population, not associated with additional radiation dose from ingestion of food contaminated with radionuclides, is 0.19 or approximately 1 in 5 (CIRRPC 1992). Thus, in a general population of 10,000 individuals, the number of cancer deaths over the lifetime of the individuals would be 1990; if each received a committed effective dose equivalent of 5 mSv, the number of

[1] Committed effective dose equivalent – Committed dose equivalents to individual organs or tissues, multiplied by weighting factors, then summed. In this document, committed effective dose is always computed to age 70 years (ICRP 1984a).
[2] Committed dose equivalent – The dose equivalent accruing in an organ or tissue up to a specified number of years after the intake of a radionuclide into the body. In this document, committed dose equivalent is always computed to age 70 years (ICRP 1984a).

cancer deaths over the lifetime of the individuals could increase in theory by about 2, for a total of 1992 cancer deaths.

The numerical estimate of cancer deaths presented above for the recommended PAG of 5 mSv was obtained by the practice of linear extrapolation from the nominal risk estimate for lifetime total cancer mortality for the general population at 100 mSv dose equivalent in the whole body.[3] Other methods of extrapolation to the low-dose region could yield higher or lower numerical estimates of cancer deaths. Studies of human populations exposed at low doses are inadequate to demonstrate the actual magnitude of risk. There is scientific uncertainty about cancer risk in the low-dose region below the range of epidemiological observation, and the possibility of no risk cannot be excluded (CIRRPC 1992).

The term "PAG" is used by FDA and other Federal and state agencies. International organizations use the term "intervention level of dose" (ICRP 1984b). The PAGs established in the 1998 FDA document and adopted in this supporting document are the same as the intervention levels of dose used by international organizations. The 1998 FDA guidance and this supporting document retain use of the term "PAG" for consistency with other U.S. Federal and state agencies.

III. FDA's Guidance Levels for Radionuclide Activity Concentrations in Food Established in 1986

[3] The current nominal estimate for the general population for lifetime total cancer mortality for low-LET (linear energy transfer) ionizing radiation, delivered at low doses and low dose rates, is 4.5×10^{-3} for a reference dose equivalent in the whole body of 100 mSv (CIRRPC 1992).

Following the Chernobyl nuclear accident in 1986, FDA that same year issued CPG Sec. 560.750 Radionuclides in Imported Foods – Levels of Concern (CPG 7119.14) which established guidance levels referred to as Levels of Concern (LOCs) for radionuclide activity concentration in food offered for import.

The LOCs in CPG 7119.14 were derived from the Preventative PAGs established in the 1982 FDA guidance document and were based on the following assumptions: 1) the entire intake of food would be contaminated, 2) Iodine-131 would be a major source of radiation dose for only 60 days following the accident, and 3) Cesium-134 + Cesium-137 could be a major source of radiation dose for up to one year. The LOCs provided such a large margin of safety that derivation of LOCs for other radionuclides, judged to be of less health significance, was considered unnecessary. The LOCs in CPG 7119.14, established in 1986, are given in Table 1.

IV. FDA's 1998 Guidance Levels for Radionuclide Activity Concentration in Food Adopted in the Draft CPG

The guidance levels for radionuclide activity concentration in food in the draft CPG are referred to in the 1998 document as "Derived Intervention Levels" or DILs. DILs are used by scientists internationally to describe the radionuclide activity concentrations at which introduction of protective measures should be considered. The term DILs as used in the draft CPG replaces the term LOCs used in CPG 7119.14 and allows for consistency in scientific terminology between the draft CPG and the internationally accepted scientific term. Efforts by international organizations to develop

DILs have been extensive. Derivations have been based on consensus values for the intervention levels of dose, called PAGs by FDA, and have been used to establish guidance levels for radionuclides in foods within individual countries and in international trade. In general, food with concentrations below the DILs is permitted to move in international trade without restriction. Food with concentrations at or above the DILs is not normally permitted into international trade.[4]

By definition, a DIL corresponds to the radionuclide activity concentration in food present throughout the relevant period of time that, in the absence of any intervention, could lead to an individual receiving a radiation dose equal to the PAG. The equation given below is the formula that the agency used for calculating recommended DILs.

$$\text{DILs (Bq/kg)} = \frac{\text{PAG (mSv)}}{\text{f x FI (kg) x DC (mSv/Bq)}}$$

Where:

DC	= Dose Coefficient; the radiation dose received per unit of radionuclide activity ingested (mSv/Bq)
f	= Fraction of the food intake assumed to be contaminated
FI	= Food Intake; the quantity of food consumed in an appropriate period of time (kg)

[4] The DILs adopted in the draft CPG are not binding on FDA, the regulated industry, or the courts. In any given case, FDA may decide to initiate an enforcement action against food with concentrations below the DILs or decide not to initiate an enforcement action against food with concentrations that meet or exceed the DILs.

Guidance levels or LOCs contained in CPG 7119.14 addressed only I-131, Cs-134 and Cs-137 because these radionuclides were known at that time to be the principal radionuclides that contribute to radiation dose by ingestion following a nuclear reactor accident. Information gained following the Chernobyl accident determined that Ru-103 and Ru-106 could also contribute to radiation dose and, therefore, these radionuclides were included in the 1998 FDA document. In addition, other radionuclides were included in the 1998 FDA document to address other radiological emergencies where there is a possibility of accidental radioactive contamination of food. This approach provides the flexibility necessary to respond to special circumstances that may be unique to a particular accident. The types of accidents and the principle radionuclides for which DILs were developed are:

?? Nuclear reactors (I-131; Cs-134 + Cs-137; Ru-103 + Ru-106)

?? Nuclear fuel processing plants (St-90; Cs-137; Pu-238 + Pu-239 + Am-241)

?? Nuclear waste storage facilities (Sr-90; Cs-137; Pu-238 + Pu-239 + Am-241)

?? Nuclear weapons (i.e., dispersal of nuclear weapon material without nuclear detonation) (Pu-239), and

?? Radioisotope thermoelectric generators and radioisotope heater units used in space vehicles (Pu-238).

The DILs are for radionuclides expected to deliver the major portion of the radiation dose from ingestion during the first year following an accidental episode of radiological food contamination. If there is concern that food will continue to be significantly contaminated beyond the first year, the long-term circumstances need to be evaluated to determine whether the recommended DILs would be appropriate or if other guidance is more applicable.

Detailed information on derivation of DILs is presented in the appendix. The DILs are based upon calculations for nine radionuclides expected to be the predominant contributors to radiation dose through ingestion (Sr-90, I-131, Cs-134, Cs-137, Ru-103, Ru-106, Pu-238, Pu-239, and Am-241). For each radionuclide, DILs were calculated for six age groups using PAGs, dose coefficients relevant to each radionuclide and age group, and dietary intakes relevant to each age group. The age groups include 3 months, 1 year, 5 years, 10 years, 15 years and adult (>17 years). The dose coefficients were adopted by FDA from the International Commission on Radiological Protection Publication 56 (ICRP 1989). The dietary intakes were derived from a 1984 EPA report which presented average daily food intake by age and gender (EPA 1984a, EPA 1984b).

The nine radionuclides listed above comprise five radionuclide groups, each having common characteristics. The five groups are: Strontium-90; Iodine-131; Cesium-134 + Cesium-137; Ruthenium-103 + Ruthenium-106; and Plutonium-238 + Plutonium-239 + Americium-241. An accident could involve more than one of the five groups. A single DIL for each radionuclide group was chosen based on the most limiting PAG and age group for the radionuclide group (i.e., the most limiting PAG and age group result in the lowest DIL). These five DILs are the ones incorporated into the new CPG.

The calculations underlying the DILs are based on the entire diet for each age group, not for individual foods or food groups. Unlike the previous LOCs that assumed

100 percent radionuclide contamination of the diet, DILs assume ten percent radionuclide contamination of the diet which is then multiplied by a factor of three. Use of ten percent of the dietary intake as the portion contaminated is consistent with recommendations made by a group of experts to the Commission of the European Communities (CEC 1986b) and by the Nuclear Energy Agency (NEA) of the Organization for Economic Cooperation and Development (NEA 1989). FDA applied an additional factor of three to account for limited sub-populations that might be more dependent on specific food supplies. Therefore, a value of thirty percent is the fraction of food intake that FDA presumed to be contaminated. For infants, (i.e., the 3-months and 1-year age groups) DILs were calculated assuming 100 percent radionuclide contamination of the infant diet.

With one exception (LOCs for I-131 in non-infant food), guidance levels or DILs for radionuclides established in the 1998 FDA document that FDA has adopted in the draft CPG are higher than guidance levels or LOCs for those same radionuclides contained in the CPG 7119.14. In deriving guidance levels or DILs contained in the 1998 FDA document, FDA employed updated international consensus values for intervention levels of dose (called PAGs by FDA) as well as updated dose coefficients and food intake estimates. In addition, information gained by FDA and others following the Chernobyl accident determined that the amount of food affected by an accident would be significantly lower than the level originally estimated. For this reason, DILs contained in the 1998 FDA document assume thirty percent of the dietary intake would be contaminated after a nuclear accident, compared to the 100 percent assumption of contamination employed in deriving LOCs. FDA's decision to reduce the assumption for dietary intake contamination from 100 percent to thirty percent is the main reason that the guidance levels established in the 1998 FDA document and adopted in the draft CPG are higher than the guidance levels contained in CPG 7119.14.

The 1998 FDA document established guidance levels only for food accidentally contaminated with radionuclides in domestic interstate commerce. In the draft CPG, FDA has adopted those same guidance levels for food either accidentally or intentionally contaminated with radionuclides, regardless of whether that food is in domestic interstate commerce or offered for import. FDA has taken this action because radionuclides that could be implicated in an event involving the accidental contamination of food could also be implicated in an event involving the intentional contamination of food. The radionuclides addressed in the 1998 FDA document are widely used and available. Furthermore, an incident resulting in release of radionuclides from one of the nuclear facilities addressed in the 1998 FDA document would likely result in the release of the same radionuclides regardless of whether the cause of the release was accidental or intentional. FDA has therefore concluded that the assumptions used in establishing the DILs in the 1998 FDA document and adopted in the draft CPG are appropriate for both accidental as well as intentional radionuclide contamination of food.

The DILs established in the 1998 FDA document and contained in the draft CPG for food offered for import and food in domestic interstate commerce are given in Table 2.

TABLE 1

LEVELS OF CONCERN (LOCS) FOR RADIONUCLIDE ACTIVITY CONCENTRATION IN IMPORTED FOOD FROM CPG SEC. 560.750 RADIONUCLIDES IN IMPORTED FOODS – LEVELS OF CONCERN (CPG 7119.14) WHICH HAVE BEEN SUPERCEDED BY DERIVED INTERVENTION LEVELS (DILS) IN CPG SEC. <ADD SECTION NUMBER> GUIDANCE LEVELS FOR RADIONUCLIDES IN DOMESTIC AND IMPORTED FOODS (CPG <ADD CPG NUMBER>).[a]

Radionuclide Group	LOCs (Bq/kg)
A. Infant Food	
Iodine-131	55
Cesium-134 + Cesium-137	370
B. Other Food	
Iodine-131	300
Cesium-134 + Cesium-137	370

[a]For consistency with current recommendations, LOCs in this table are expressed in Bq/kg. In CPG 7119.14, LOCs were expressed in pCi/kg.

TABLE 2

DERIVED INTERVENTION LEVELS (DILS) IN THE NEW CPG FOR FOOD IN DOMESTIC COMMERCE AND FOOD OFFERED FOR IMPORT[a,b]. THESE VALUES, WHICH ARE INCLUDED IN CPG SEC. <ADD SECTION NUMBER> GUIDANCE LEVELS FOR RADIONUCLIDES IN DOMESTIC AND IMPORTED FOODS (CPG <ADD CPG NUMBER>), SUPERCEDE LEVELS OF CONCERN (LOCS) IN CPG SEC. 560.750 RADIONUCLIDES IN IMPORTED FOODS – LEVELS OF CONCERN (CPG 7119.14).

Radionuclide Group	DIL (Bq/kg)
Strontium-90	160
Iodine-131	170
Cesium-134 + Cesium-137	1200
Plutonium-238 + Plutonium-239 + Americium-241	2
Ruthenium-103 + Ruthenium-106[c]	$\frac{C_3}{6800} + \frac{C_6}{450} < 1$

[a]The DIL for each radionuclide group is applied independently. Each DIL applies to the sum of the concentrations of the radionuclides in the group at the time of measurement.

[b]Applicable to foods as prepared for consumption. For dried or concentrated products such as powdered milk or concentrated juices, adjust by a factor appropriate to reconstitution, and assume the reconstitution water is not contaminated. For spices, which are consumed in very small quantities, use a dilution factor of 10.

[c]Due to the large differences in DILs for Ruthenium-103 and Ruthenium-106, the individual concentrations of Ruthenium-103 and Ruthenium-106 are divided by their respective DILs and then summed. The sum must be less than one. C_3 and C_6 are the concentrations, at the time of measurement, for Ruthenium-103 and Ruthenium-106, respectively.

Appendix – Derivation of Recommended Derived Intervention Levels

The Derived Intervention Level (DIL) for a specific radionuclide is calculated as follows:

$$\text{DILs (Bq/kg)} = \frac{\text{PAG (mSv)}}{\text{f x FI (kg) x DC (mSv/Bq)}}$$

Where:

DC	= Dose Coefficient; the radiation dose received per unit of radionuclide activity ingested (mSv/Bq)
f	= Fraction of the food intake assumed to be contaminated
FI	= Food Intake; the quantity of food consumed in an appropriate period of time (kg)

The Protective Action Guides (PAGs)used are 5 mSv committed effective dose equivalent, or 50 mSv committed dose equivalent to individual tissues and organs, whichever is more limiting.

Dose coefficients (DCs) are given in Table 3 and food intakes are given in Tables D-2 and D-3. The fraction of food intake assumed to be contaminated (f) equals 0.3, except for I-131 in infant diets where f equals 1.0.

(a) Radionuclides

Based upon data on radionuclides in human food following the Chernobyl accident, DILs for I-131, Cs-134, Cs-137, Ru-103 and Ru-106 would apply following incidents involving nuclear reactors. For incidents at nuclear fuel reprocessing facilities and nuclear waste storage facilities, DILs for Sr-90, Cs-137, Pu-239, and Am-241 would apply. For nuclear weapons incidents and incidents involving radioisotope thermal generators (RTGs) and radioisotope heater units (RHUs) used in space vehicles, DILs for Pu-239 and Pu-238, respectively, would apply. The selection of these radionuclides as the major contributors to radiation dose through ingestion is consistent with recommendations on DILs published by NEA, WHO, CODEX, and CEC (NEA 1989, WHO 1988, CODEX 1989, CEC 1989a, IAEA 1994).

(b) Age Groups and Dose Coefficients (DCs)

The general population was divided into six age groups ranging from infants to adults and corresponding to the age groups in ICRP Publication 56 (ICRP 1989) for which ICRP has published DCs. The age groups are 3 months, 1 year, 5 years, 10 years, 15 years, and adult. The radionuclides, age groups and dose coefficients used in the calculations are presented in Table 3.

(c) Food Intake

Food intake included all dietary components including tap water used for drinking, and is the overall quantity consumed in one year, with exceptions in the period of time for I-131 ($T_{1/2}$ = 8.04 days) and Ru-103 ($T_{1/2}$ = 39.3 days). For these radionuclides, the quantities consumed were for a 60-day period and a 280-day period, respectively, due to the more rapid decay of these radionuclides. The intake periods for I-131 and Ru-103 are the nearest whole number of days for decay of these radionuclides to less than 1% of the initial activities.

Dietary intakes were derived from a 1984 EPA report which presented average daily food intake by age and gender (EPA 1984a, EPA 1984b). The EPA intakes were based on data from the 1977-1978 Nationwide Food Consumption Survey published by the U. S. Department of Agriculture (USDA 1982, USDA 1983). The age groups and annual dietary intakes for various food classes and the total, calculated from data in the EPA report, are given in Table 4. The dietary intakes derived for the ICRP age groups for which DCs are available, using the results in Table 4, are presented in Table 5.

(d) Fractions of Food Intake Assumed to be Contaminated

For food consumed by most members of the general public, ten percent of the dietary intakes was assumed to be contaminated. This assumption recognizes the ready availability of uncontaminated food from unaffected areas of the United States or through importation from other countries, and also that many factors could reduce or eliminate contamination of local food by the time it reaches the market.

Use of ten percent of the dietary intake as the portion contaminated was consistent with recommendations made by a Group of Experts to the Commission of the European Communities (CEC 1986a) and by the Nuclear Energy Agency (NEA) of the Organization for Economic Cooperation and Development (NEA 1989). The NEA noted that modification of this value would be appropriate if justified by detailed local findings.

FDA applied an additional factor of three to account for the fact that sub-populations might be more dependent on local food supplies. Therefore, during the immediate period after a nuclear accident, a value of 0.3 (i.e., thirty percent) is the fraction of food intake presumed to be contaminated. If, subsequently, there is convincing local information that the actual fraction of food intake that is contaminated (f) is considerably higher or lower, there will be adequate time to determine whether to adjust the value of f (and therefore adjust the values of the DILs) for the affected area.

For infants, (i.e., the 3-months and 1-year age groups) the diet consists of a high percentage of milk and the entire milk intake of some infants over a short period of time might come from supplies directly impacted by an accident. Therefore, f was set equal to 1.0 (100%) for the infant diet.

(e) Selection of Recommended Derived Intervention Levels

DILs are presented in Table 6 for Sr-90, I-131, Cs-134, Cs-137, Ru-103, Ru-106, Pu-238, Pu-239, and Am-241 for six population age groups and applicable PAGs.

Two criteria were used in selecting a single DIL for each radionuclide for inclusion in the new CPG.

First, the most limiting DIL for either of the applicable PAGs was selected for each of the nine radionuclides. These DILs are presented in Table 7 for each of the six age groups. In addition, the average DIL is presented for the radionuclide group Pu + Am, composed of Pu-238, Pu-239, and Am-241, and the radionuclide group Cs, composed of Cs-134 + Cs-137. The three radionuclides in the Pu + Am group deposit on the bone surface and are alpha-particle emitters. The radionuclides in the Cs group are deposited throughout the body and are beta-particle and gamma-ray emitters. The average values are used for these groups because the calculated DILs for radionuclides in each group are similar.

The radionuclides Ru-103 and Ru-106 are chemically identical, are deposited throughout the body, and are beta-particle and gamma-ray emitters. However, their widely differing half lives (i.e., 39.3 days and 373 days, respectively) result in markedly differing individual DILs which do not permit simple averaging. Instead, the concentrations of Ru-103 (C3) and Ru-106 (C6) are divided by their respective DILs and are then summed. The DIL for the Ruthenium group is set at less than one.

Therefore, $$\frac{C3}{DIL3} + \frac{C6}{DIL6} < 1.0 \qquad \text{(equation 1)}$$

This assures that the sum of the separate radiation dose contributions from the Ru-103 and Ru-106 concentrations will be less than that contemplated by the Protective Action Guide during the first year after an accident.

Second, there are dietary components which are common to all six age groups. A principal example is fresh milk, for which the consumer of particular supplies cannot be identified in advance. Therefore, the most limiting DIL for all age groups in Table 7, for each radionuclide or radionuclide group, was selected and is applicable to all components of the diet.

These DILs are presented in Table 8 and were rounded to two significant figures (one significant figure for the Pu + Am group). These are the DILs adopted in the new CPG. The DILs in Table 8 apply independently to each radionuclide or radionuclide group, because they apply to different types of incidents, or in the case of a nuclear reactor incident, to different limiting age groups. However, the DILs for Ru-103 and Ru-106 are used in equation 1 to evaluate that criterion for the radionuclide group Ru-103 + Ru-106. The DILs in Table 8 are given in Table 2 in the main text.

TABLE 3
DOSE COEFFICIENTS (mSv/Bq)[(a)]

	Age Group					
Radionuclide	3 month	1 year	5 years	10 years	15 years	Adult
Sr-90 bone surface	1.0E-03	7.4E-04	3.9E-04	5.5E-04	1.2E-03	3.8E-04
Sr-90	1.3E-04	9.1E-05	4.1E-05	4.3E-05	6.7E-05	3.5E-05
I-131 thyroid	3.7E-03	3.6E-03	2.1E-03	1.1E-03	6.9E-04	4.4E-04
I-131	1.1E-04	1.1E-04	6.3E-05	3.2E-05	2.1E-05	1.3E-05
Cs-134	2.5E-05	1.5E-05	1.3E-05	1.4E-05	2.0E-05	1.9E-05
Cs-137	2.0E-05	1.1E-05	9.0E-06	9.8E-06	1.4E-05	1.3E-05
Ru-103	7.7E-06	5.1E-06	2.7E-06	1.7E-06	1.0E-06	8.1E-07
Ru-106	8.9E-05	5.3E-05	2.7E-05	1.6E-05	9.2E-06	7.5E-06
Pu-238 bone surface	1.6E-01	1.6E-02	1.5E-02	1.5E-02	1.6E-02	1.7E-02
Pu-238	1.3E-02	1.2E-03	1.0E-03	8.8E-04	8.7E-04	8.8E-04
Pu-239 bone surface	1.8E-01	1.8E-02	1.8E-02	1.7E-02	1.9E-02	1.8E-02
Pu-239	1.4E-02	1.4E-03	1.1E-03	1.0E-03	9.8E-04	9.8E-04
Am-241 bone surface	2.0E-01	1.9E-02	1.9E-02	1.9E-02	2.1E-02	2.0E-02
Am-241	1.2E-02	1.2E-03	1.0E-03	9.0E-04	9.1E-04	8.9E-04

[(a)]Dose coefficients are from ICRP Publication 56 (ICRP 1989). The committed effective dose equivalents or committed dose equivalents are computed to age 70 years.

TABLE 4
ANNUAL DIETARY INTAKES (kg/y)[a,b]

Food Class	< 1	1-4	5-9	10-14	15-19	20-24	25-29	30-39	40-59	60 & up
	Age Group									
Dairy (fresh milk)	208 (99.3)	153 (123)	180 (163)	186 (167)	167 (148)	112 (96.5)	98.2 (79.4)	86.4 (66.8)	80.8 (61.7)	90.6 (70.2)
Egg	1.8	7.2	6.2	7.0	9.1	10.3	10.2	11.0	11.4	10.5
Meat	16.5	33.7	46.9	58.4	69.2	71.2	72.6	73.4	70.7	56.3
Fish	0.3	2.5	4.0	4.6	6.1	6.8	7.6	7.1	8.0	6.3
Produce	56.6	59.9	82.3	96.0	97.1	91.4	99.1	102	115	121
Grain	20.4	57.6	79.0	90.6	89.4	77.3	78.4	73.7	70.2	67.1
Beverage (tap water)	112 (62.3)	271 (159)	314 (190)	374 (226)	453 (243)	542 (240)	559 (226)	599 (232)	632 (268)	565
Misc	2.0	9.3	13.3	14.8	13.9	10.9	11.9	12.5	13.3	13.0
TOTAL ANNUAL INTAKE, (kg/y)	418	594	726	832	905	922	937	965	1001	930

[a]Computed from daily intake values in grams per day provided in (EPA 1984b). The total annual intakes are rounded to nearest 1 kg/y.
[b]Fresh milk is included in the dairy entry, and tap water used for drinking is included in the beverage entry. The total annual intakes (kg/y) for fresh milk and tap water are also given separately in parentheses.

TABLE 5
DIETARY INTAKES FOR ICRP AGE GROUPS

ICRP Age Group	Annual Intake[a] (kg)	280-Day Intake Ru-103 (kg)	60-Day Intake I-131 (kg)
3 months	418	320	69
1 year	506	387	83
5 years	660	506	109
10 years	779	597	128
15 years	869	666	143
Adult	943	723	155

[a] The annual dietary intake for the ICRP age groups was obtained by assigning or averaging the appropriate annual dietary intakes given in Table 4 for the EPA age groups, as follows:

3 months:	used <1
1 year:	average of <1 and 1-4
5 years:	average of 1-4 and 5-9
10 years:	average of 5-9 and 10-14
15 years:	average of 10-14 and 15-19
Adult:	average of 15-19, 20-24, 25-29, 30-39, 40-59 and 60 and up

TABLE 6
PAGs AND DERIVED INTERVENTION LEVELS[(a)]
(individual radionuclides, by age groups)

Radionuclide	PAG (mSv)	Devived Intervention Levels (Bq/kg) 3 month	1 yr	5 years	10 years	15 years	Adult
Sr-90 bone surface[(b)]	50	400	445	648	389	160	465
Sr-90	5	308	362	616	497	286	505
I-131 thyroid	50	196	167	722	1200	1690	2420
I-131	5	659	548	2410	4110	5540	8180
Cs-134	5	1600	2190	1940	1530	958	930
Cs-137	5	2000	2990	2810	2180	1370	1360
Ru-103	5	6770	8410	12200	16400	25000	28400
Ru-106	5	449	621	935	1340	2080	2360
Pu-238 bone surface	50	2.5	21	17	14	12	10
Pu-238	5	3.1	27	25	24	22	20
Pu-239 bone surface	50	2.2	18	14	13	10	9.8
Pu-239	5	2.9	24	23	21	20	18
Am-241 bone surface	50	2.0	17	13	11	9.1	8.8
Am-241	5	3.3	27	25	24	21	20

[(a)]Derived Intervention Levels were computed using dose coefficients from Table 3, dietary intakes from Table 5, and "f" as given below:

0.3 (except for I-131 in infant diets, i.e., the 3-month and 1-year age groups)

1.0 (I-131 in infant diets)

[(b)]The observed trend in Derived Intervention Levels for Sr-90 as a function of age, i.e., minimum values at 15 years, results primarily from mass of exchangeable strontium in bone as a function of age (Legget et al. 1982).

TABLE 7
DERIVED INTERVENTION LEVELS (Bq/kg)
(individual radionuclides, by age group, most limiting of either PAG)

Radionuclide	3 months	1 year	5 years	10 years	15 years	Adult
Sr-90	308	362	616	389	160	465
I-131	196	167	722	1200	1690	2420
Cs-134	1600	2190	1940	1530	958	930
Cs-137	2000	2990	2810	2180	1370	1360
Cs-group[a]	1800	2590	2380	1880	1160	1150
Ru-103	6770	8410	12200	16400	25000	28400
Ru-106	449	621	935	1340	2080	2360
Pu-238	2.5	21	17	14	12	10
Pu-239	2.2	18	14	13	10	9.8
Am-241	2.0	17	13	11	9.1	8.8
Pu + Am group[b]	2.2	19	15	13	9.6	9.3

[a]Computed as: (DIL for Cs-134 + DIL for Cs-137)/2
[b]Computed as: (DIL for Pu-238 + DIL for Pu-239 + DIL for Am-241)/3

TABLE 8
DERIVED INTERVENTION LEVELS (Bq/kg)
(radionuclide groups, most limiting of all diets)

Radionuclide Group	Derived Intervention Levels
Sr-90	160 (15 years)
I-131	170 (1 year)
Cs group	1200 (adult)
Ru-103[(a)]	6800 (3 months)
Ru-106[(a)]	450 (3 months)
Pu + Am group	2 (3 months)

[(a)]Due to large differences in DILs for Ru-103 and Ru-106, the individual concentrations of Ru-103 and Ru-106, the individual concentrations of Ru-103 and Ru-106 are divided by their respective DILs and summed. The DIL for the Ruthenium group is set at less than one.

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