



ORAU TEAM Dose Reconstruction Project for NIOSH

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Page 1 of 22

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Concurrence: <u>Signature on File</u> James P. Griffin, Deputy Project Director	Concurrence Date: <u>07/18/2008</u>
Concurrence: <u>Signature on File</u> Kate Kimpan, Project Director	Concurrence Date: <u>07/23/2008</u>
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02/14/2005	00	New technical information bulletin for the validation of thorium dose conversion factors to be used for internal dose assessment. First approved issue. Initiated by Elizabeth M. Brackett.
03/07/2005	01	Approved issue of Revision 01. Revised to add Th-228 values. Initiated by Elizabeth M. Brackett.
12/08/2006	01 PC-1	<p>Approved page change revision to correct value in Table 3-2 on page 6 in Section 3.0 and add a reference on page 7. No changes occurred as a result of formal internal and NIOSH review. There is no change to the assigned dose and no PER is required. Training required: As determined by the Task Manager. Initiated by Elizabeth M. Brackett. Approval:</p> <p><u>Signature on File</u> <u>11/29/2006</u> James P. Griffin, Document Owner</p> <p><u>Signature on File</u> <u>12/01/2006</u> Kate Kimpan, Projector Director</p> <p><u>Brant A. Ulsh Signature on File for</u> <u>12/08/2006</u> James W. Neton, Associate Director for Science</p>
07/28/2008	02	Approved revision to document all dose calculations with the DCAL computer program. No further changes occurred as a result of formal internal and NIOSH review. Constitutes a total rewrite of the document. Training required: As determined by the Task Manager. Initiated by Thomas R. LaBone.

TABLE OF CONTENTS

<u>SECTION</u>	<u>TITLE</u>	<u>PAGE</u>
Acronyms and Abbreviations		4
1.0	Introduction	5
2.0	Purpose	5
3.0	Background.....	5
4.0	Verification	6
4.1	Discussion.....	6
4.2	Results	7
5.0	Attributions and Annotations	7
References		8

LIST OF TABLES

<u>TABLE</u>	<u>TITLE</u>	<u>PAGE</u>
4-1	Comparison of ICRP and DCAL dose coefficients for ¹³¹ Te.....	9
4-2	Comparison of ICRP and DCAL dose coefficients for ^{131m} Te.....	10
4-3	Comparison of ICRP and DCAL dose coefficients for ¹⁴⁷ Pr	11
4-4	Comparison of ICRP and DCAL dose coefficients for ²¹⁰ Pb.....	12
4-5	Comparison of ICRP and DCAL dose coefficients for ²²³ Ra	13
4-6	Comparison of ICRP and DCAL dose coefficients for ²²⁴ Ra	14
4-7	Comparison of ICRP and DCAL dose coefficients for ²²⁶ Ra	15
4-8	Comparison of ICRP and DCAL dose coefficients for ²²⁸ Ac.....	16
4-9	Comparison of ICRP and DCAL dose coefficients for ²³² U	17
4-10	Comparison of ICRP and DCAL dose coefficients for ²³³ U	18
4-11	Comparison of ICRP and DCAL dose coefficients for ²³⁹ U	19
4-12	Comparison of ICRP and DCAL dose coefficients for ²²⁸ Th.....	20
4-13	Comparison of ICRP and DCAL dose coefficients for ²³² Th.....	21
4-14	Comparison of ICRP and DCAL dose coefficients for ²³⁴ Th.....	22

ACRONYMS AND ABBREVIATIONS

Bq	becquerel
DOE	U.S. Department of Energy
EEOICPA	Energy Employees Occupational Illness Compensation Program Act of 2000
IMBA	Integrated Modules for Bioassay Analysis
ICRP	International Commission on Radiological Protection
TIB	technical information bulletin
U.S.C.	United States Code
§	section or sections

1.0 INTRODUCTION

Technical information bulletins (TIBs) are not official determinations made by the National Institute for Occupational Safety and Health (NIOSH) but are rather general working documents that provide historic background information and guidance concerning the preparation of dose reconstructions at particular sites or categories of sites. They will be revised in the event additional relevant information is obtained about the affected site(s). TIBs may be used to assist NIOSH staff in the completion of individual dose reconstructions.

In this document, the word “facility” is used as a general term for an area, building, or group of buildings that served a specific purpose at a site. It does not necessarily connote an “atomic weapons employer facility” or a “Department of Energy (DOE) facility” as defined in the Energy Employees Occupational Illness Compensation Program Act of 2000 [42 U.S.C. § 7384l(5) and (12)].

2.0 PURPOSE

The Integrated Modules for Bioassay Analysis (IMBA) computer program is used for intake and dose assessments by the dose reconstructors. IMBA is known to calculate inaccurate organ doses for a small number of radionuclides. In these cases annual dose coefficients are calculated with the DCAL program (ORNL 2006). The protocol for when to use DCAL dose coefficients and verification of these dose coefficients is presented in this document.

3.0 BACKGROUND

The calculations for International Commission on Radiological Protection (ICRP) Publication 68 dose coefficients (ICRP 1994) were performed by the ICRP Task Group on Dose Calculations with four independently written programs:

- IMIE, Ukrainian Radiation Protection Institute
- DCAL, United States DOE Oak Ridge National Laboratory
- DOSAGE, German Federal Office for Radiation Protection
- PLEIADES, United Kingdom Health Protection Agency

The results of these “first-tier” codes were compared as part of the quality assurance program for the ICRP Publication 68 (ICRP 1994) dose coefficients, which are available electronically on a compact disk (ICRP 2001). DCAL can be downloaded at no charge from the U.S. Environmental Protection Agency Web site and is the only one of the first-tier codes that is freely available to internal dosimetrists outside of the ICRP task group.

The various versions of IMBA – including the IMBA Expert ORAU-Edition – are considered to constitute a second-tier dosimetry code, and 50-year committed dose coefficients from it were compared to those from PLEIADES by the authors of IMBA as part of their quality assurance program. The results of these comparisons are given in Appendix C to the IMBA user manual. The vast majority of the committed organ dose coefficients that are calculated with IMBA agree with those from PLEIADES to within $\pm 1\%$, but there are a small number of cases where the difference is larger. These differences can typically be attributed to the fact that IMBA does not accurately account for the shared biokinetics of radioactive progeny in the body after intake of the parent radionuclide. Uranium-232 is an example of such a radionuclide. An unrelated issue is that IMBA does not calculate doses properly for some short-lived radionuclides after chronic intakes. These radionuclides include ^{147}Pr , ^{228}Ac , and ^{239}U .

4.0 VERIFICATION

4.1 Discussion

Annual organ dose coefficients from IMBA are considered acceptable if the committed organ dose coefficients that are calculated with IMBA agree with the committed organ dose coefficients from PLEIADES to within $\pm 10\%$ (as discussed in Appendix C of the IMBA user documentation). Note that all comparisons are performed with 50-year committed organ dose coefficients and it is implicitly assumed that acceptable agreement between these dose coefficients means that the annual organ dose coefficients from IMBA are acceptable. In cases where there a comparison of IMBA and PLEIADES is not available (e.g., ^{233}U), committed organ dose coefficients from IMBA are to be compared to the committed organ dose coefficients from the ICRP compact disk (ICRP 2001), which is an electronic version of the dose coefficients published in Publication 68 (ICRP 1994). Dose coefficients from IMBA are considered acceptable if these dose coefficients agree with the ICRP coefficients to within $\pm 10\%$.

In general, DCAL was used to calculate organ dose coefficients in cases where the committed organ dose coefficients that are calculated with IMBA have differences greater than $\pm 10\%$ in comparison to those that were calculated with PLEIADES or those from the ICRP compact disk (ICRP 2001). The committed organ dose coefficients that were calculated with DCAL were compared to those from the ICRP as part of the quality assurance of the DCAL organ dose coefficients. The DCAL organ dose coefficients are to be used as long as they agree with the ICRP dose coefficients better than those from IMBA do; that is, no acceptable cutoff is proposed for comparison of DCAL with the ICRP coefficients. Note that if one or more committed organ dose coefficients for a radioactive material (radionuclide, intake mode, solubility type, etc.) that are calculated with IMBA have unacceptably large errors, DCAL organ dose coefficients are to be adopted for all organs for that material. In other words, all of the organ dose coefficients for a given radioactive material will usually be from either from IMBA or DCAL rather than a mixture of the two.

The comparisons of committed organ dose coefficients from DCAL and the ICRP compact disk (ICRP 2001) are documented in this technical bulletin. The annual organ dose coefficients that are calculated with DCAL are used to construct input tables for the acute/chronic intake tool CADW. Dose coefficient calculations that cannot be performed with CADW are to be handled on a case-by-case basis as directed by the Principal Internal Dosimetrist. It is important to note that IMBA will calculate the correct intake for a given bioassay dataset even though the resultant dose might have unacceptably large errors.

The relevant DCAL output file for a particular radionuclide is the dose rate file (HRT file extension). Organ doses for any period of interest after acute or chronic intakes can be derived from an appropriate integration of the organ dose coefficients in this file. These integrations and other necessary manipulations of the data were performed with a program written in the R programming language. All input parameters that were used in DCAL are those recommended by the ICRP¹. Annual organ equivalent dose coefficients for all intake modes and solubility types were calculated with DCAL for an acute intake of 1 Bq at time zero and for a chronic intake of 1 Bq over 1 year for the following radionuclides:

- Tellurium-131 and -131m
- Praseodymium-147
- Lead-210
- Radium-223, -224, and -226

¹ The systemic biokinetic model for actinium in DCAL is not the default ICRP biokinetic model for actinium. Therefore, the DCAL actinium model was changed to the default ICRP model for these calculations.

- Actinium-228
- Uranium-232, -233, and -239
- Thorium-228, -232, and -234

4.2 Results

The results from DCAL generally agree with those from the ICRP compact disk (ICRP 2001) to within a few percent. The minor differences can be attributed in part to the number of significant digits (two) with which the ICRP organ dose coefficients are reported. Larger differences on the order of 10% were observed in isolated cases (^{224}Ra ingestion for example). These differences are considered to be acceptable because the DCAL calculations are considered to be correct (Eckerman 2008) and the differences are considerably smaller than the equivalent differences between the IMBA and ICRP dose coefficients. Therefore, the agreement between DCAL and ICRP organ dose coefficients evident in Tables 4-1 through 4-14 is considered to provide verification that the DCAL calculations are correct.

5.0 ATTRIBUTIONS AND ANNOTATIONS

No Attributions and Annotations are needed because all figure calculations and technical content were performed and authored by Thomas LaBone.

REFERENCES

- Eckerman, K. F., R. W. Leggett, M. Cristy, C. B. Nelson, J. C. Ryman, A. L. Sjoreen, and R. C. Ward, 2006, *User's Guide to the DCAL System*, ORNL/TM-2001/190, UT-Battelle, Oak Ridge National Laboratory, Oak Ridge, Tennessee, August. [SRDB Ref ID: 43944]
- LaBone, T.R., 2008, "DCF for Ra-224," documented communication with K. F. Eckerman (ORNL), Oak Ridge Associated Universities Team, Oak Ridge, Tennessee, January 28, 2008. [SRDB Ref ID: 44041]
- ICRP (International Commission on Radiological Protection), 1994, *Dose Coefficients for Intakes of Radionuclides by Workers*, Publication 68, Pergamon Press, Oxford, England.
- ICRP (International Commission on Radiological Protection), 2001, *ICRP Database of Dose Coefficients: Workers and Members of the Public*, Version 2.0.1, Pergamon Press, Oxford, England.

Table 4-1. Comparison of ICRP and DCAL dose coefficients for ^{131}Te .

	Inhalation type V			Inhalation type F			Inhalation type M			Ingestion: f1 = 0.3		
	ICRP	DCAL	Ratio	ICRP	DCAL	Ratio	ICRP	DCAL	Ratio	ICRP	DCAL	Ratio
Adrenals	3.1E-12	3.15E-12	0.98	1.4E-12	1.37E-12	1.02	7.6E-13	7.67E-13	0.99	1.5E-12	1.55E-12	0.97
Bladder wall	8.2E-12	8.26E-12	0.99	3.5E-12	3.50E-12	1.00	1.2E-12	1.17E-12	1.03	2.4E-12	2.37E-12	1.01
Bone surface	3.4E-12	3.45E-12	0.99	1.7E-12	1.72E-12	0.99	8.4E-13	8.78E-13	0.96	8.2E-13	8.62E-13	0.95
Brain	2.9E-12	2.89E-12	1.00	1.5E-12	1.52E-12	0.99	7.1E-13	7.14E-13	0.99	3.9E-13	3.88E-13	1.01
Breast	2.9E-12	2.89E-12	1.00	1.2E-12	1.19E-12	1.01	5.6E-13	5.63E-13	0.99	5.1E-13	5.14E-13	0.99
St wall	3.1E-11	3.07E-11	1.01	5.6E-11	5.59E-11	1.00	9.1E-11	9.08E-11	1.00	3.3E-10	3.29E-10	1.00
Si wall	1.1E-11	1.12E-11	0.98	1.8E-11	1.78E-11	1.01	2.8E-11	2.77E-11	1.01	1.0E-10	1.00E-10	1.00
ULI wall	6.0E-12	5.99E-12	1.00	6.4E-12	6.41E-12	1.00	8.5E-12	8.58E-12	0.99	3.0E-11	3.06E-11	0.98
LLI wall	3.2E-12	3.23E-12	0.99	1.9E-12	1.90E-12	1.00	1.5E-12	1.50E-12	1.00	4.8E-12	4.87E-12	0.99
Kidneys	3.1E-12	3.13E-12	0.99	1.4E-12	1.43E-12	0.98	6.7E-13	6.79E-13	0.99	1.7E-12	1.73E-12	0.98
Liver	3.0E-12	3.03E-12	0.99	1.3E-12	1.28E-12	1.02	6.0E-13	6.08E-13	0.99	1.1E-12	1.09E-12	1.01
Muscle	3.0E-12	3.05E-12	0.98	1.6E-12	1.57E-12	1.02	8.6E-13	8.68E-13	0.99	1.0E-12	1.04E-12	0.96
Ovaries	2.9E-12	2.97E-12	0.98	1.5E-12	1.48E-12	1.01	8.2E-13	8.29E-13	0.99	2.5E-12	2.54E-12	0.98
Pancreas	3.4E-12	3.42E-12	0.99	2.0E-12	2.01E-12	1.00	1.7E-12	1.76E-12	0.97	5.3E-12	5.33E-12	0.99
Red marrow	3.2E-12	3.17E-12	1.01	1.5E-12	1.53E-12	0.98	7.7E-13	7.78E-13	0.99	1.1E-12	1.06E-12	1.04
ET1	1.7E-08	1.71E-08	0.99	5.8E-08	5.79E-08	1.00	5.8E-08	5.79E-08	1.00	4.2E-13	4.22E-13	1.00
ET2	2.1E-10	2.14E-10	0.98	4.5E-10	4.53E-10	0.99	6.9E-10	6.92E-10	1.00	4.2E-13	4.22E-13	1.00
LNet	3.7E-11	3.68E-11	1.01	1.0E-10	1.04E-10	0.96	1.1E-10	1.14E-10	0.96	4.2E-13	4.22E-13	1.00
Lungs	1.6E-10	1.62E-10	0.99	2.5E-11	2.45E-11	1.02	8.7E-11	8.72E-11	1.00	8.0E-13	8.09E-13	0.99
LNth	4.3E-12	4.35E-12	0.99	1.6E-12	1.60E-12	1.00	1.6E-12	1.57E-12	1.02	8.0E-13	8.09E-13	0.99
Skin	2.6E-12	2.63E-12	0.99	1.2E-12	1.19E-12	1.01	4.4E-13	4.45E-13	0.99	4.9E-13	4.86E-13	1.01
Spleen	3.2E-12	3.17E-12	1.01	1.6E-12	1.65E-12	0.97	1.2E-12	1.22E-12	0.98	3.4E-12	3.42E-12	0.99
Testes	2.6E-12	2.60E-12	1.00	1.0E-12	1.04E-12	0.96	1.9E-13	1.91E-13	0.99	2.9E-13	2.86E-13	1.01
Thymus	3.4E-12	3.39E-12	1.00	1.7E-12	1.69E-12	1.01	1.0E-12	1.05E-12	0.95	6.2E-13	6.26E-13	0.99
Thyroid	8.4E-10	8.44E-10	1.00	4.4E-10	4.45E-10	0.99	3.9E-10	3.91E-10	1.00	8.9E-10	8.91E-10	1.00
Uterus	3.0E-12	2.97E-12	1.01	1.4E-12	1.44E-12	0.97	7.2E-13	7.27E-13	0.99	2.1E-12	2.16E-12	0.97
Effective dose	6.8E-11	6.79E-11	1.00	4.6E-11	4.61E-11	1.00	6.1E-11	6.08E-11	1.00	8.7E-11	8.75E-11	0.99

Table 4-2. Comparison of ICRP and DCAL dose coefficients for ^{131m}Te .

	Inhalation type V			Inhalation type F			Inhalation type M			Ingestion: f1 = 0.3		
	ICRP	DCAL	Ratio	ICRP	DCAL	Ratio	ICRP	DCAL	Ratio	ICRP	DCAL	Ratio
Adrenals	2.2E-10	2.24E-10	0.98	1.0E-10	1.02E-10	0.98	8.5E-11	8.56E-11	0.99	1.2E-10	1.24E-10	0.97
Bladder wall	7.1E-10	7.20E-10	0.99	3.2E-10	3.25E-10	0.98	1.9E-10	1.97E-10	0.96	4.3E-10	4.35E-10	0.99
Bone surface	1.3E-09	1.34E-09	0.97	5.7E-10	5.76E-10	0.99	2.7E-10	2.78E-10	0.97	5.0E-10	5.03E-10	0.99
Brain	1.7E-10	1.72E-10	0.99	9.7E-11	9.77E-11	0.99	6.1E-11	6.13E-11	1.00	5.6E-11	5.66E-11	0.99
Breast	1.4E-10	1.41E-10	0.99	6.6E-11	6.68E-11	0.99	6.4E-11	6.45E-11	0.99	5.7E-11	5.71E-11	1.00
St wall	2.4E-10	2.40E-10	1.00	2.0E-10	1.98E-10	1.01	2.9E-10	2.95E-10	0.98	6.7E-10	6.73E-10	1.00
Si wall	3.6E-10	3.63E-10	0.99	3.5E-10	3.51E-10	1.00	5.4E-10	5.46E-10	0.99	1.3E-09	1.36E-09	0.96
ULI wall	9.4E-10	9.46E-10	0.99	1.0E-09	1.06E-09	0.94	1.7E-09	1.76E-09	0.97	4.4E-09	4.43E-09	0.99
LLI wall	1.6E-09	1.59E-09	1.01	1.8E-09	1.86E-09	0.97	3.1E-09	3.14E-09	0.99	7.9E-09	7.92E-09	1.00
Kidneys	5.9E-10	5.91E-10	1.00	2.6E-10	2.59E-10	1.00	1.5E-10	1.49E-10	1.01	3.0E-10	3.00E-10	1.00
Liver	1.9E-10	1.90E-10	1.00	9.0E-11	9.15E-11	0.98	8.3E-11	8.46E-11	0.98	1.3E-10	1.35E-10	0.96
Muscle	1.9E-10	1.92E-10	0.99	1.1E-10	1.13E-10	0.97	9.6E-11	9.72E-11	0.99	1.4E-10	1.40E-10	1.00
Ovaries	3.1E-10	3.12E-10	0.99	2.3E-10	2.29E-10	1.00	2.9E-10	2.96E-10	0.98	7.2E-10	7.28E-10	0.99
Pancreas	2.1E-10	2.16E-10	0.97	1.1E-10	1.08E-10	1.02	9.8E-11	9.94E-11	0.99	1.8E-10	1.79E-10	1.01
Red marrow	4.4E-10	4.45E-10	0.99	2.1E-10	2.16E-10	0.97	1.5E-10	1.51E-10	0.99	2.6E-10	2.66E-10	0.98
ET1	4.8E-07	4.87E-07	0.99	1.6E-06	1.65E-06	0.97	1.6E-06	1.65E-06	0.97	6.2E-11	6.27E-11	0.99
ET2	2.6E-09	2.68E-09	0.97	8.1E-09	8.22E-09	0.99	8.7E-09	8.85E-09	0.98	6.2E-11	6.27E-11	0.99
LNet	2.4E-09	2.49E-09	0.96	7.7E-09	7.84E-09	0.98	7.7E-09	7.89E-09	0.98	6.2E-11	6.27E-11	0.99
Lungs	3.8E-10	3.89E-10	0.98	1.2E-10	1.21E-10	0.99	3.6E-09	3.65E-09	0.99	7.3E-11	7.42E-11	0.98
LNth	1.8E-10	1.84E-10	0.98	9.1E-11	9.23E-11	0.99	1.9E-10	1.91E-10	0.99	7.3E-11	7.42E-11	0.98
Skin	1.4E-10	1.39E-10	1.01	7.1E-11	7.15E-11	0.99	5.1E-11	5.13E-11	0.99	7.4E-11	7.48E-11	0.99
Spleen	1.9E-10	1.95E-10	0.97	9.3E-11	9.43E-11	0.99	8.3E-11	8.40E-11	0.99	1.4E-10	1.42E-10	0.99
Testes	1.6E-10	1.66E-10	0.96	7.5E-11	7.68E-11	0.98	4.9E-11	4.97E-11	0.99	1.1E-10	1.12E-10	0.98
Thymus	1.8E-10	1.88E-10	0.96	1.1E-10	1.08E-10	1.02	1.0E-10	1.01E-10	0.99	6.7E-11	6.84E-11	0.98
Thyroid	4.0E-08	4.00E-08	1.00	1.7E-08	1.72E-08	0.99	9.5E-09	9.47E-09	1.00	1.8E-08	1.85E-08	0.97
Uterus	2.5E-10	2.56E-10	0.98	1.5E-10	1.53E-10	0.98	1.6E-10	1.58E-10	1.01	3.7E-10	3.80E-10	0.97
Effective dose	2.4E-09	2.42E-09	0.99	1.2E-09	1.18E-09	1.02	1.6E-09	1.60E-09	1.00	1.9E-09	1.95E-09	0.97

Table 4-3. Comparison of ICRP and DCAL dose coefficients for ¹⁴⁷Pr.

	Inhalation type M			Inhalation type S			Ingestion: f1 = 0.0005		
	ICRP	DCAL	Ratio	ICRP	DCAL	Ratio	ICRP	DCAL	Ratio
Adrenals	6.3E-13	6.37E-13	0.99	5.8E-13	5.868E-13	0.99	1.7E-12	1.67E-12	1.02
Bladder wall	2.2E-13	2.17E-13	1.01	1.4E-13	1.395E-13	1.00	5.4E-13	5.41E-13	1.00
Bone surface	1.2E-12	1.21E-12	0.99	6.5E-13	6.654E-13	0.98	4.9E-13	5.02E-13	0.98
Brain	6.0E-13	6.03E-13	0.99	5.5E-13	5.547E-13	0.99	1.1E-14	1.02E-14	1.07
Breast	4.4E-13	4.41E-13	1.00	4.0E-13	4.020E-13	1.00	4.1E-13	4.02E-13	1.02
St wall	5.6E-11	5.65E-11	0.99	5.8E-11	5.857E-11	0.99	2.5E-10	2.53E-10	0.99
Si wall	1.1E-11	1.08E-11	1.02	1.1E-11	1.114E-11	0.99	4.7E-11	4.75E-11	0.99
ULI wall	4.0E-12	4.06E-12	0.98	4.1E-12	4.155E-12	0.99	1.4E-11	1.45E-11	0.97
LLI wall	4.9E-12	4.92E-12	1.00	5.1E-12	5.103E-12	1.00	1.3E-11	1.28E-11	1.01
Kidneys	6.8E-13	6.81E-13	1.00	4.8E-13	4.849E-13	0.99	1.7E-12	1.74E-12	0.98
Liver	1.3E-12	1.26E-12	1.03	4.3E-13	4.335E-13	0.99	1.0E-12	1.02E-12	0.98
Muscle	7.4E-13	7.42E-13	1.00	6.9E-13	6.992E-13	0.99	7.8E-13	7.80E-13	1.00
Ovaries	5.6E-13	5.66E-13	0.99	5.2E-13	5.215E-13	1.00	2.1E-12	2.08E-12	1.01
Pancreas	1.7E-12	1.70E-12	1.00	1.7E-12	1.693E-12	1.00	6.5E-12	6.64E-12	0.98
Red marrow	7.1E-13	7.11E-13	1.00	5.7E-13	5.716E-13	1.00	7.9E-13	7.91E-13	1.00
ET1	3.0E-08	3.14E-08	0.95	3.0E-08	3.145E-08	0.95	4.4E-14	4.26E-14	1.03
ET2	5.6E-10	5.80E-10	0.96	5.8E-10	5.990E-10	0.97	4.4E-14	4.26E-14	1.03
LNet	1.4E-10	1.43E-10	0.98	1.4E-10	1.448E-10	0.97	4.4E-14	4.26E-14	1.03
Lungs	5.2E-11	5.37E-11	0.97	5.6E-11	5.798E-11	0.97	6.5E-13	6.52E-13	1.00
LNth	1.3E-12	1.33E-12	0.98	1.4E-12	1.439E-12	0.97	6.5E-13	6.52E-13	1.00
Skin	3.5E-13	3.48E-13	1.01	3.0E-13	3.022E-13	0.99	3.1E-13	3.11E-13	1.00
Spleen	1.1E-12	1.12E-12	0.98	1.1E-12	1.100E-12	1.00	4.0E-12	4.10E-12	0.98
Testes	8.9E-14	8.89E-14	1.00	3.4E-14	3.315E-14	1.03	1.2E-13	1.21E-13	0.99
Thymus	8.9E-13	8.91E-13	1.00	8.5E-13	8.525E-13	1.00	3.0E-13	2.95E-13	1.02
Thyroid	6.6E-13	6.60E-13	1.00	6.1E-13	6.121E-13	1.00	4.4E-14	4.26E-14	1.03
Uterus	4.6E-13	4.62E-13	1.00	4.1E-13	4.137E-13	0.99	1.7E-12	1.69E-12	1.00
Effective dose	2.9E-11	2.94E-11	0.99	3.0E-11	3.060E-11	0.98	3.3E-11	3.28E-11	1.01

Table 4-4. Comparison of ICRP and DCAL dose coefficients for ^{210}Pb .

	Inhalation type F			Ingestion: f1 = 0.2		
	ICRP	DCAL	Ratio	ICRP	DCAL	Ratio
Adrenals	1.4E-07	1.42E-07	0.99	8.6E-08	8.81E-08	0.98
Bladder wall	1.4E-07	1.43E-07	0.98	8.7E-08	8.89E-08	0.98
Bone surface	3.6E-05	3.63E-05	0.99	2.3E-05	2.26E-05	1.02
Brain	1.4E-07	1.42E-07	0.99	8.6E-08	8.81E-08	0.98
Breast	1.4E-07	1.41E-07	0.99	8.6E-08	8.81E-08	0.98
St wall	1.4E-07	1.41E-07	0.99	8.6E-08	8.81E-08	0.98
Si wall	1.4E-07	1.42E-07	0.99	8.6E-08	8.82E-08	0.97
ULI wall	1.4E-07	1.45E-07	0.97	8.9E-08	9.11E-08	0.98
LLI wall	1.5E-07	1.52E-07	0.99	9.7E-08	9.88E-08	0.98
Kidneys	5.9E-06	5.99E-06	0.99	3.7E-06	3.73E-06	0.99
Liver	3.0E-06	3.09E-06	0.97	1.9E-06	1.92E-06	0.99
Muscle	1.4E-07	1.41E-07	0.99	8.6E-08	8.81E-08	0.98
Ovaries	1.4E-07	1.41E-07	0.99	8.6E-08	8.81E-08	0.98
Pancreas	1.4E-07	1.41E-07	0.99	8.6E-08	8.81E-08	0.98
Red marrow	4.0E-06	3.99E-06	1.00	2.5E-06	2.48E-06	1.01
ET1	3.7E-07	3.74E-07	0.99	8.6E-08	8.81E-08	0.98
ET2	1.4E-07	1.42E-07	0.99	8.6E-08	8.81E-08	0.98
LNet	1.4E-07	1.42E-07	0.99	8.6E-08	8.81E-08	0.98
Lungs	1.4E-07	1.41E-07	0.99	8.6E-08	8.81E-08	0.98
LNth	1.4E-07	1.41E-07	0.99	8.6E-08	8.81E-08	0.98
Skin	1.4E-07	1.41E-07	0.99	8.6E-08	8.81E-08	0.98
Spleen	4.4E-06	4.51E-06	0.98	2.8E-06	2.81E-06	1.00
Testes	1.4E-07	1.41E-07	0.99	8.6E-08	8.81E-08	0.98
Thymus	1.4E-07	1.41E-07	0.99	8.6E-08	8.81E-08	0.98
Thyroid	1.4E-07	1.41E-07	0.99	8.6E-08	8.81E-08	0.98
Uterus	1.4E-07	1.41E-07	0.99	8.6E-08	8.81E-08	0.98
Effective dose	1.1E-06	1.12E-06	0.99	6.8E-07	6.96E-07	0.98

Table 4-5. Comparison of ICRP and DCAL dose coefficients for ^{223}Ra .

	Inhalation type M			Ingestion: f1 = 0.2		
	ICRP	DCAL	Ratio	ICRP	DCAL	Ratio
Adrenals	7.1E-09	7.20E-09	0.99	1.3E-08	1.28E-08	1.02
Bladder wall	7.1E-09	7.29E-09	0.97	1.3E-08	1.30E-08	1.00
Bone surface	1.7E-06	1.66E-06	1.02	2.9E-06	2.94E-06	0.99
Brain	7.0E-09	7.16E-09	0.98	1.3E-08	1.27E-08	1.02
Breast	7.0E-09	7.19E-09	0.97	1.3E-08	1.27E-08	1.02
St wall	9.4E-09	9.72E-09	0.97	1.8E-08	1.88E-08	0.96
Si wall	1.2E-08	1.26E-08	0.95	2.5E-08	2.61E-08	0.96
ULI wall	4.7E-08	5.06E-08	0.93	1.1E-07	1.14E-07	0.96
LLI wall	1.2E-07	1.28E-07	0.94	2.7E-07	2.95E-07	0.92
Kidneys	1.0E-08	9.85E-09	1.02	1.8E-08	1.78E-08	1.01
Liver	8.1E-08	8.22E-08	0.99	1.4E-07	1.46E-07	0.96
Muscle	7.0E-09	7.19E-09	0.97	1.3E-08	1.28E-08	1.02
Ovaries	6.9E-09	7.28E-09	0.95	1.2E-08	1.30E-08	0.92
Pancreas	7.1E-09	7.19E-09	0.99	1.3E-08	1.28E-08	1.02
Red marrow	1.6E-07	1.59E-07	1.01	2.8E-07	2.83E-07	0.99
ET1	6.0E-03	6.07E-03	0.99	1.3E-08	1.27E-08	1.02
ET2	6.0E-06	6.09E-06	0.99	1.3E-08	1.27E-08	1.02
LNet	3.0E-08	3.01E-08	1.00	1.3E-08	1.27E-08	1.02
Lungs	4.7E-05	4.66E-05	1.01	1.3E-08	1.27E-08	1.02
LNth	2.0E-07	1.99E-07	1.01	1.3E-08	1.27E-08	1.02
Skin	7.0E-09	7.16E-09	0.98	1.3E-08	1.27E-08	1.02
Spleen	6.9E-09	7.19E-09	0.96	1.2E-08	1.28E-08	0.94
Testes	6.8E-09	7.16E-09	0.95	1.2E-08	1.28E-08	0.94
Thymus	7.1E-09	7.20E-09	0.99	1.3E-08	1.27E-08	1.02
Thyroid	7.0E-09	7.17E-09	0.98	1.3E-08	1.27E-08	1.02
Uterus	7.1E-09	7.21E-09	0.98	1.3E-08	1.29E-08	1.01
Effective dose	5.7E-06	5.65E-06	1.01	1.0E-07	1.04E-07	0.96

Table 4-6. Comparison of ICRP and DCAL dose coefficients for ^{224}Ra .

	Inhalation type M			Ingestion: f1 = 0.2		
	ICRP	DCAL	Ratio	ICRP	DCAL	Ratio
Adrenals	5.7E-09	5.37E-09	1.06	1.1E-08	9.77E-09	1.13
Bladder wall	5.8E-09	5.48E-09	1.06	1.1E-08	1.01E-08	1.09
Bone surface	9.5E-07	9.49E-07	1.00	1.7E-06	1.73E-06	0.98
Brain	5.6E-09	5.31E-09	1.05	1.1E-08	9.71E-09	1.13
Breast	5.7E-09	5.34E-09	1.07	1.1E-08	9.71E-09	1.13
St wall	7.4E-09	7.12E-09	1.04	1.5E-08	1.41E-08	1.06
Si wall	8.7E-09	9.27E-09	0.94	1.8E-08	1.96E-08	0.92
ULI wall	3.6E-08	3.63E-08	0.99	8.3E-08	8.35E-08	0.99
LLI wall	9.3E-08	9.34E-08	1.00	2.2E-07	2.20E-07	1.00
Kidneys	2.3E-08	2.14E-08	1.07	4.5E-08	4.05E-08	1.11
Liver	3.0E-08	2.95E-08	1.02	5.6E-08	5.42E-08	1.03
Muscle	5.7E-09	5.36E-09	1.06	1.1E-08	9.79E-09	1.12
Ovaries	5.8E-09	5.62E-09	1.03	1.1E-08	1.05E-08	1.05
Pancreas	5.7E-09	5.36E-09	1.06	1.1E-08	9.78E-09	1.12
Red marrow	9.1E-08	9.08E-08	1.00	1.7E-07	1.66E-07	1.02
ET1	3.9E-03	0.00391	1.00	1.1E-08	9.71E-09	1.13
ET2	2.1E-06	2.02E-06	1.04	1.1E-08	9.71E-09	1.13
LNet	1.3E-08	1.29E-08	1.01	1.1E-08	9.71E-09	1.13
Lungs	2.0E-05	1.87E-05	1.07	1.1E-08	9.72E-09	1.13
LNth	3.0E-08	2.89E-08	1.04	1.1E-08	9.72E-09	1.13
Skin	5.6E-09	5.31E-09	1.05	1.1E-08	9.73E-09	1.13
Spleen	5.6E-09	5.35E-09	1.05	1.1E-08	9.77E-09	1.13
Testes	5.5E-09	5.32E-09	1.03	1.0E-08	9.78E-09	1.02
Thymus	5.7E-09	5.37E-09	1.06	1.1E-08	9.71E-09	1.13
Thyroid	5.6E-09	5.33E-09	1.05	1.1E-08	9.71E-09	1.13
Uterus	5.7E-09	5.42E-09	1.05	1.1E-08	1.00E-08	1.10
Effective dose	2.4E-06	2.27E-06	1.06	6.5E-08	6.45E-08	1.01

Table 4-7. Comparison of ICRP and DCAL dose coefficients for ²²⁶Ra.

	Inhalation type M			Ingestion: f1 = 0.2		
	ICRP	DCAL	Ratio	ICRP	DCAL	Ratio
Adrenals	3.0E-08	2.98E-08	1.01	4.1E-08	4.10E-08	1.00
Bladder wall	2.9E-08	2.91E-08	1.00	4.0E-08	4.00E-08	1.00
Bone surface	9.0E-06	9.06E-06	0.99	1.2E-05	1.25E-05	0.96
Brain	2.9E-08	2.96E-08	0.98	4.1E-08	4.07E-08	1.01
Breast	2.9E-08	2.90E-08	1.00	4.0E-08	3.98E-08	1.00
St wall	2.9E-08	2.95E-08	0.98	4.1E-08	4.11E-08	1.00
Si wall	3.0E-08	3.04E-08	0.99	4.2E-08	4.31E-08	0.98
ULI wall	4.1E-08	4.18E-08	0.98	6.4E-08	6.67E-08	0.96
LLI wall	8.0E-08	8.25E-08	0.97	1.5E-07	1.52E-07	0.99
Kidneys	4.3E-08	4.32E-08	1.00	5.9E-08	5.95E-08	0.99
Liver	1.3E-07	1.30E-07	1.00	1.8E-07	1.79E-07	1.01
Muscle	2.9E-08	2.93E-08	0.99	4.0E-08	4.03E-08	0.99
Ovaries	2.9E-08	2.95E-08	0.98	4.1E-08	4.07E-08	1.01
Pancreas	2.9E-08	2.93E-08	0.99	4.0E-08	4.03E-08	0.99
Red marrow	6.4E-07	6.37E-07	1.01	8.7E-07	8.76E-07	0.99
ET1	6.4E-06	0.000536	0.01	4.0E-08	4.02E-08	0.99
ET2	1.3E-05	1.26E-05	1.03	4.0E-08	4.02E-08	0.99
LNet	5.7E-07	5.72E-07	1.00	4.0E-08	4.02E-08	0.99
Lungs	1.7E-05	1.66E-05	1.03	4.0E-08	4.02E-08	0.99
LNth	2.5E-06	2.55E-06	0.98	4.0E-08	4.02E-08	0.99
Skin	2.9E-08	2.91E-08	1.00	4.0E-08	4.00E-08	1.00
Spleen	3.9E-08	3.91E-08	1.00	5.3E-08	5.38E-08	0.99
Testes	2.9E-08	2.89E-08	1.00	4.0E-08	3.98E-08	1.00
Thymus	2.9E-08	2.91E-08	1.00	4.0E-08	4.00E-08	1.00
Thyroid	2.9E-08	2.92E-08	0.99	4.0E-08	4.02E-08	0.99
Uterus	2.9E-08	2.92E-08	0.99	4.0E-08	4.02E-08	1.00
Effective dose	2.2E-06	2.18E-06	1.01	2.8E-07	2.80E-07	1.00

Table 4-8. Comparison of ICRP and DCAL dose coefficients for ^{228}Ac .

	Inhalation type F			Inhalation type M			Inhalation type S			Ingestion: f1 = 0.0005		
	ICRP	DCAL	Ratio	ICRP	DCAL	Ratio	ICRP	DCAL	Ratio	ICRP	DCAL	Ratio
Adrenals	4.5E-11	4.56E-11	0.99	1.8E-11	1.86E-11	0.97	1.4E-11	1.36E-11	1.03	1.9E-11	1.94E-11	0.98
Bladder wall	3.7E-11	3.72E-11	0.99	1.9E-11	1.95E-11	0.97	1.7E-11	1.67E-11	1.02	4.1E-11	4.11E-11	1.00
Bone surface	8.4E-07	8.44E-07	1.00	1.7E-07	1.72E-07	0.99	7.9E-09	7.92E-09	1.00	1.5E-09	1.51E-09	0.99
Brain	2.2E-11	2.26E-11	0.97	1.1E-11	1.11E-11	0.99	8.9E-12	8.91E-12	1.00	1.6E-13	1.55E-13	1.04
Breast	1.8E-11	1.86E-11	0.97	1.0E-11	1.03E-11	0.97	9.4E-12	9.43E-12	1.00	4.3E-12	4.28E-12	1.00
St wall	1.4E-10	1.43E-10	0.98	2.4E-10	2.40E-10	1.00	2.5E-10	2.50E-10	1.00	6.1E-10	6.17E-10	0.99
Si wall	2.3E-10	2.29E-10	1.00	4.0E-10	4.01E-10	1.00	4.2E-10	4.18E-10	1.00	1.0E-09	1.05E-09	0.96
ULI wall	5.2E-10	5.27E-10	0.99	9.2E-10	9.24E-10	1.00	9.6E-10	9.67E-10	0.99	2.4E-09	2.41E-09	0.99
LLI wall	4.1E-10	4.08E-10	1.01	7.1E-10	7.17E-10	0.99	7.5E-10	7.52E-10	1.00	1.9E-09	1.87E-09	1.02
Kidneys	3.8E-11	3.82E-11	0.99	2.1E-11	2.10E-11	1.00	1.7E-11	1.73E-11	0.98	3.7E-11	3.73E-11	0.99
Liver	2.2E-07	2.23E-07	0.99	4.5E-08	4.55E-08	0.99	2.1E-09	2.11E-09	1.00	4.2E-10	4.23E-10	0.99
Muscle	2.8E-11	2.87E-11	0.98	1.9E-11	1.94E-11	0.98	1.8E-11	1.76E-11	1.02	2.2E-11	2.22E-11	0.99
Ovaries	9.2E-09	9.40E-09	0.98	1.9E-09	1.97E-09	0.96	1.5E-10	1.51E-10	0.99	1.7E-10	1.74E-10	0.98
Pancreas	4.3E-11	4.32E-11	1.00	2.6E-11	2.65E-11	0.98	2.3E-11	2.30E-11	1.00	4.6E-11	4.65E-11	0.99
Red marrow	6.7E-08	6.76E-08	0.99	1.4E-08	1.38E-08	1.01	6.5E-10	6.54E-10	0.99	1.5E-10	1.52E-10	0.98
ET1	8.1E-07	8.30E-07	0.98	8.1E-07	8.30E-07	0.98	8.1E-07	8.30E-07	0.98	6.9E-13	6.72E-13	1.03
ET2	2.6E-09	2.65E-09	0.98	2.5E-08	2.48E-08	1.01	8.5E-08	8.56E-08	0.99	6.9E-13	6.72E-13	1.03
LNet	2.2E-09	2.24E-09	0.98	3.2E-09	3.22E-09	0.99	2.1E-08	2.16E-08	0.97	6.9E-13	6.72E-13	1.03
Lungs	6.4E-11	6.48E-11	0.99	4.9E-08	4.91E-08	1.00	8.0E-08	8.09E-08	0.99	6.4E-12	6.38E-12	1.00
LNth	3.0E-11	3.03E-11	0.99	4.7E-09	4.78E-09	0.98	5.3E-08	5.44E-08	0.97	6.4E-12	6.38E-12	1.00
Skin	1.8E-11	1.81E-11	1.00	9.3E-12	9.34E-12	1.00	7.7E-12	7.66E-12	1.00	8.5E-12	8.48E-12	1.00
Spleen	2.4E-11	2.45E-11	0.98	1.8E-11	1.79E-11	1.00	1.7E-11	1.68E-11	1.01	3.1E-11	3.13E-11	0.99
Testes	9.2E-09	9.37E-09	0.98	1.9E-09	1.91E-09	0.99	9.1E-11	9.22E-11	0.99	2.7E-11	2.75E-11	0.98
Thymus	2.7E-11	2.67E-11	1.01	1.8E-11	1.77E-11	1.02	1.7E-11	1.69E-11	1.01	3.1E-12	3.07E-12	1.01
Thyroid	2.2E-11	2.26E-11	0.97	1.2E-11	1.24E-11	0.97	1.1E-11	1.08E-11	1.02	6.9E-13	6.72E-13	1.03
Uterus	3.6E-11	3.59E-11	1.00	3.7E-11	3.77E-11	0.98	3.7E-11	3.69E-11	1.00	9.0E-11	9.13E-11	0.99
Effective dose	2.9E-08	2.97E-08	0.98	1.2E-08	1.21E-08	0.99	1.2E-08	1.23E-08	0.98	4.3E-10	4.30E-10	1.00

Table 4-9. Comparison of ICRP and DCAL dose coefficients for ²³²U.

	Inhalation type F			Inhalation type M			Inhalation type S			Ingestion: f1 = 0.02			Ingestion: f1 = 0.002		
	ICRP	DCAL	Ratio	ICRP	DCAL	Ratio	ICRP	DCAL	Ratio	ICRP	DCAL	Ratio	ICRP	DCAL	Ratio
Adrenals	2.3E-06	2.34E-06	0.98	6.1E-07	6.29E-07	0.97	1.0E-07	1.06E-07	0.95	1.6E-07	1.64E-07	0.97	1.6E-08	1.64E-08	0.97
Bladder wall	2.3E-06	2.34E-06	0.98	6.1E-07	6.29E-07	0.97	9.7E-08	9.99E-08	0.97	1.6E-07	1.64E-07	0.97	1.6E-08	1.64E-08	0.97
Bone surface	1.0E-04	1.03E-04	0.97	4.6E-05	4.64E-05	0.99	2.0E-05	2.01E-05	1.00	7.2E-06	7.21E-06	1.00	7.2E-07	7.21E-07	1.00
Brain	2.3E-06	2.34E-06	0.98	6.1E-07	6.28E-07	0.97	9.7E-08	9.99E-08	0.97	1.6E-07	1.64E-07	0.98	1.6E-08	1.64E-08	0.98
Breast	2.3E-06	2.34E-06	0.98	6.1E-07	6.27E-07	0.97	1.0E-07	1.06E-07	0.95	1.6E-07	1.64E-07	0.98	1.6E-08	1.64E-08	0.98
St wall	2.3E-06	2.34E-06	0.98	6.1E-07	6.28E-07	0.97	1.0E-07	1.03E-07	0.97	1.6E-07	1.65E-07	0.97	1.7E-08	1.76E-08	0.96
Si wall	2.3E-06	2.34E-06	0.98	6.1E-07	6.29E-07	0.97	9.9E-08	1.02E-07	0.97	1.6E-07	1.67E-07	0.96	1.9E-08	1.95E-08	0.97
ULI wall	2.3E-06	2.40E-06	0.96	6.5E-07	6.73E-07	0.97	1.3E-07	1.32E-07	0.99	1.8E-07	1.87E-07	0.96	3.5E-08	3.57E-08	0.98
LLI wall	2.4E-06	2.52E-06	0.95	7.4E-07	7.61E-07	0.97	1.9E-07	1.92E-07	0.99	2.2E-07	2.30E-07	0.96	7.2E-08	7.30E-08	0.99
Kidneys	9.5E-06	9.73E-06	0.98	2.9E-06	2.93E-06	0.99	6.8E-07	6.95E-07	0.98	6.7E-07	6.83E-07	0.98	6.7E-08	6.83E-08	0.98
Liver	1.0E-05	1.03E-05	0.98	3.3E-06	3.39E-06	0.97	9.6E-07	9.79E-07	0.98	7.0E-07	7.19E-07	0.97	7.0E-08	7.20E-08	0.97
Muscle	2.3E-06	2.34E-06	0.98	6.1E-07	6.28E-07	0.97	9.9E-08	1.02E-07	0.97	1.6E-07	1.64E-07	0.98	1.6E-08	1.64E-08	0.98
Ovaries	2.4E-06	2.58E-06	0.93	7.7E-07	8.18E-07	0.94	2.1E-07	2.14E-07	0.98	1.7E-07	1.81E-07	0.94	1.7E-08	1.81E-08	0.94
Pancreas	2.3E-06	2.34E-06	0.98	6.1E-07	6.28E-07	0.97	1.0E-07	1.04E-07	0.96	1.6E-07	1.64E-07	0.98	1.6E-08	1.64E-08	0.98
Red marrow	9.9E-06	1.01E-05	0.99	4.1E-06	4.13E-06	0.99	1.6E-06	1.63E-06	0.98	7.0E-07	7.05E-07	0.99	7.0E-08	7.06E-08	0.99
ET1	9.7E-06	1.01E-05	0.96	8.0E-06	8.37E-06	0.96	7.6E-06	7.89E-06	0.96	1.6E-07	1.64E-07	0.98	1.6E-08	1.64E-08	0.98
ET2	2.3E-06	2.34E-06	0.98	2.4E-05	2.32E-05	1.03	2.8E-04	0.000267	1.05	1.6E-07	1.64E-07	0.98	1.6E-08	1.64E-08	0.98
LNet	2.3E-06	2.34E-06	0.98	2.2E-06	2.17E-06	1.02	8.2E-04	0.000799	1.03	1.6E-07	1.64E-07	0.98	1.6E-08	1.64E-08	0.98
Lungs	2.3E-06	2.35E-06	0.98	2.7E-05	2.68E-05	1.01	1.5E-04	0.000148	1.01	1.6E-07	1.64E-07	0.98	1.6E-08	1.64E-08	0.98
LNth	2.3E-06	2.34E-06	0.98	7.0E-06	6.94E-06	1.01	2.8E-03	0.002703	1.04	1.6E-07	1.64E-07	0.98	1.6E-08	1.64E-08	0.98
Skin	2.3E-06	2.34E-06	0.98	6.1E-07	6.27E-07	0.97	9.8E-08	1.01E-07	0.97	1.6E-07	1.64E-07	0.98	1.6E-08	1.64E-08	0.98
Spleen	2.2E-06	2.35E-06	0.94	6.0E-07	6.30E-07	0.95	9.9E-08	1.04E-07	0.95	1.6E-07	1.65E-07	0.97	1.6E-08	1.65E-08	0.97
Testes	2.4E-06	2.58E-06	0.93	7.8E-07	8.21E-07	0.95	2.1E-07	2.15E-07	0.98	1.7E-07	1.81E-07	0.94	1.7E-08	1.81E-08	0.94
Thymus	2.3E-06	2.34E-06	0.98	6.1E-07	6.27E-07	0.97	1.0E-07	1.07E-07	0.94	1.6E-07	1.64E-07	0.98	1.6E-08	1.64E-08	0.98
Thyroid	2.3E-06	2.34E-06	0.98	6.1E-07	6.27E-07	0.97	9.9E-08	1.02E-07	0.97	1.6E-07	1.64E-07	0.98	1.6E-08	1.64E-08	0.98
Uterus	2.3E-06	2.34E-06	0.98	6.1E-07	6.28E-07	0.97	9.7E-08	9.96E-08	0.97	1.6E-07	1.64E-07	0.98	1.6E-08	1.64E-08	0.98
Effective dose	4.7E-06	4.73E-06	0.99	4.8E-06	4.83E-06	0.99	2.6E-05	2.50E-05	1.04	3.3E-07	3.36E-07	0.98	3.7E-08	3.75E-08	0.99

Table 4-10. Comparison of ICRP and DCAL dose coefficients for ²³³U.

	Inhalation type F			Inhalation type M			Inhalation type S			Ingestion: f1 = 0.02			Ingestion: f1 = 0.002		
	ICRP	DCAL	Ratio	ICRP	DCAL	Ratio	ICRP	DCAL	Ratio	ICRP	DCAL	Ratio	ICRP	DCAL	Ratio
Adrenals	4.0E-07	4.05E-07	0.99	9.7E-08	9.89E-08	0.98	9.3E-09	9.52E-09	0.98	2.8E-08	2.84E-08	0.99	2.8E-09	2.84E-09	0.99
Bladder wall	4.0E-07	4.06E-07	0.98	9.7E-08	9.93E-08	0.98	9.4E-09	9.55E-09	0.98	2.8E-08	2.85E-08	0.98	2.8E-09	2.85E-09	0.98
Bone surface	1.2E-05	1.20E-05	1.00	3.0E-06	2.98E-06	1.01	4.2E-07	4.20E-07	1.00	8.3E-07	8.38E-07	0.99	8.3E-08	8.38E-08	0.99
Brain	4.0E-07	4.05E-07	0.99	9.7E-08	9.89E-08	0.98	9.3E-09	9.51E-09	0.98	2.8E-08	2.84E-08	0.99	2.8E-09	2.84E-09	0.99
Breast	4.0E-07	4.05E-07	0.99	9.7E-08	9.89E-08	0.98	9.3E-09	9.52E-09	0.98	2.8E-08	2.84E-08	0.99	2.8E-09	2.84E-09	0.99
St wall	4.0E-07	4.05E-07	0.99	9.7E-08	9.94E-08	0.98	9.9E-09	1.01E-08	0.99	2.9E-08	2.95E-08	0.98	3.9E-09	3.96E-09	0.99
Si wall	4.0E-07	4.05E-07	0.99	9.8E-08	1.00E-07	0.98	1.1E-08	1.08E-08	1.01	3.1E-08	3.11E-08	1.00	5.6E-09	5.63E-09	0.99
ULI wall	4.0E-07	4.08E-07	0.98	1.0E-07	1.06E-07	0.94	1.7E-08	1.76E-08	0.97	4.4E-08	4.50E-08	0.98	2.0E-08	1.98E-08	1.01
LLI wall	4.1E-07	4.15E-07	0.99	1.2E-07	1.20E-07	1.00	3.3E-08	3.31E-08	1.00	7.6E-08	7.72E-08	0.99	5.2E-08	5.25E-08	0.99
Kidneys	4.1E-06	4.15E-06	0.99	1.0E-06	1.02E-06	0.98	1.1E-07	1.07E-07	1.03	2.9E-07	2.91E-07	1.00	2.9E-08	2.91E-08	1.00
Liver	1.5E-06	1.58E-06	0.95	3.8E-07	3.89E-07	0.98	4.4E-08	4.52E-08	0.97	1.1E-07	1.11E-07	0.99	1.1E-08	1.11E-08	0.99
Muscle	4.0E-07	4.05E-07	0.99	9.7E-08	9.89E-08	0.98	9.3E-09	9.52E-09	0.98	2.8E-08	2.84E-08	0.99	2.8E-09	2.84E-09	0.99
Ovaries	4.0E-07	4.07E-07	0.98	9.8E-08	9.99E-08	0.98	1.0E-08	1.04E-08	0.96	2.8E-08	2.86E-08	0.98	2.8E-09	2.86E-09	0.98
Pancreas	4.0E-07	4.05E-07	0.99	9.7E-08	9.89E-08	0.98	9.3E-09	9.52E-09	0.98	2.8E-08	2.84E-08	0.99	2.8E-09	2.84E-09	0.99
Red marrow	1.2E-06	1.20E-06	1.00	2.9E-07	2.96E-07	0.98	3.6E-08	3.63E-08	0.99	8.3E-08	8.40E-08	0.99	8.3E-09	8.40E-09	0.99
ET1	4.3E-07	4.17E-07	1.03	1.4E-07	1.11E-07	1.27	4.8E-08	2.19E-08	2.19	2.8E-08	2.84E-08	0.99	2.8E-09	2.84E-09	0.99
ET2	4.0E-07	4.06E-07	0.99	1.3E-05	1.27E-05	1.02	7.6E-05	7.64E-05	1.00	2.8E-08	2.84E-08	0.99	2.8E-09	2.84E-09	0.99
LNet	4.0E-07	4.05E-07	0.99	6.3E-07	6.41E-07	0.98	1.3E-04	1.37E-04	0.95	2.8E-08	2.84E-08	0.99	2.8E-09	2.84E-09	0.99
Lungs	4.1E-07	4.16E-07	0.98	1.7E-05	1.67E-05	1.02	4.2E-05	4.21E-05	1.00	2.8E-08	2.84E-08	0.99	2.8E-09	2.84E-09	0.99
LNth	4.0E-07	4.05E-07	0.99	2.6E-06	2.63E-06	0.99	4.6E-04	4.72E-04	0.97	2.8E-08	2.84E-08	0.99	2.8E-09	2.84E-09	0.99
Skin	4.0E-07	4.05E-07	0.99	9.7E-08	9.89E-08	0.98	9.3E-09	9.51E-09	0.98	2.8E-08	2.84E-08	0.99	2.8E-09	2.84E-09	0.99
Spleen	4.0E-07	4.05E-07	0.99	9.7E-08	9.90E-08	0.98	9.3E-09	9.52E-09	0.98	2.8E-08	2.84E-08	0.99	2.8E-09	2.84E-09	0.99
Testes	4.0E-07	4.07E-07	0.98	9.8E-08	9.99E-08	0.98	1.0E-08	1.04E-08	0.96	2.8E-08	2.86E-08	0.98	2.8E-09	2.86E-09	0.98
Thymus	4.0E-07	4.05E-07	0.99	9.7E-08	9.89E-08	0.98	9.3E-09	9.52E-09	0.98	2.8E-08	2.84E-08	0.99	2.8E-09	2.84E-09	0.99
Thyroid	4.0E-07	4.05E-07	0.99	9.7E-08	9.89E-08	0.98	9.3E-09	9.51E-09	0.98	2.8E-08	2.84E-08	0.99	2.8E-09	2.84E-09	0.99
Uterus	4.0E-07	4.05E-07	0.99	9.7E-08	9.89E-08	0.98	9.3E-09	9.51E-09	0.98	2.8E-08	2.84E-08	0.99	2.8E-09	2.84E-09	0.99
Effective dose	6.6E-07	6.79E-07	0.97	2.2E-06	2.16E-06	1.02	6.9E-06	6.98E-06	0.99	5.0E-08	5.13E-08	0.98	8.5E-09	8.61E-09	0.99

Table 4-11. Comparison of ICRP and DCAL dose coefficients for ²³⁹U.

	Inhalation type F			Inhalation type M			Inhalation type S			Ingestion: f1 = 0.02			Ingestion: f1 = 0.002		
	ICRP	DCAL	Ratio	ICRP	DCAL	Ratio	ICRP	DCAL	Ratio	ICRP	DCAL	Ratio	ICRP	DCAL	Ratio
Adrenals	5.1E-13	5.11E-13	1.00	1.7E-13	1.74E-13	0.98	1.3E-13	1.34E-13	0.97	2.4E-13	2.38E-13	1.01	2.3E-13	2.31E-13	1.00
Bladder wall	2.2E-11	2.22E-11	0.99	2.4E-12	2.43E-12	0.99	1.8E-13	1.85E-13	0.97	5.9E-13	5.93E-13	1.00	4.1E-13	4.16E-13	0.99
Bone surface	5.6E-12	5.68E-12	0.99	9.4E-13	9.56E-13	0.98	2.8E-13	2.99E-13	0.94	5.7E-13	5.81E-13	0.98	2.9E-13	2.96E-13	0.98
Brain	4.5E-13	4.51E-13	1.00	1.1E-13	1.13E-13	0.98	7.5E-14	7.33E-14	1.02	5.3E-15	5.34E-15	0.99	8.1E-16	8.00E-16	1.01
Breast	4.0E-13	4.00E-13	1.00	1.2E-13	1.15E-13	1.04	8.3E-14	8.25E-14	1.01	4.2E-14	4.07E-14	1.03	3.8E-14	3.66E-14	1.04
St wall	3.0E-11	2.96E-11	1.01	4.8E-11	4.81E-11	1.00	5.0E-11	5.01E-11	1.00	1.8E-10	1.76E-10	1.02	1.8E-10	1.76E-10	1.02
Si wall	1.0E-11	1.04E-11	0.96	1.7E-11	1.68E-11	1.01	1.8E-11	1.76E-11	1.02	5.9E-11	5.94E-11	0.99	5.9E-11	5.96E-11	0.99
ULI wall	8.2E-12	8.22E-12	1.00	1.4E-11	1.44E-11	0.97	1.5E-11	1.53E-11	0.98	4.1E-11	4.08E-11	1.01	4.1E-11	4.13E-11	0.99
LLI wall	1.3E-11	1.26E-11	1.03	2.4E-11	2.39E-11	1.00	2.6E-11	2.56E-11	1.02	6.1E-11	6.09E-11	1.00	6.2E-11	6.19E-11	1.00
Kidneys	1.2E-11	1.19E-11	1.01	1.5E-12	1.53E-12	0.98	1.7E-13	1.69E-13	1.01	8.7E-13	8.75E-13	0.99	4.0E-13	4.01E-13	1.00
Liver	6.1E-13	6.15E-13	0.99	1.8E-13	1.80E-13	1.00	1.3E-13	1.26E-13	1.03	2.2E-13	2.21E-13	1.00	2.1E-13	2.08E-13	1.01
Muscle	5.1E-13	5.12E-13	1.00	2.1E-13	2.13E-13	0.98	1.8E-13	1.79E-13	1.00	2.1E-13	2.15E-13	0.98	2.1E-13	2.12E-13	0.99
Ovaries	6.9E-13	6.92E-13	1.00	5.4E-13	5.45E-13	0.99	5.3E-13	5.34E-13	0.99	1.4E-12	1.38E-12	1.02	1.4E-12	1.39E-12	1.01
Pancreas	6.0E-13	6.09E-13	0.99	3.5E-13	3.65E-13	0.96	3.2E-13	3.36E-13	0.95	9.3E-13	9.72E-13	0.96	9.2E-13	9.66E-13	0.95
Red marrow	1.3E-12	1.33E-12	0.98	3.0E-13	3.02E-13	0.99	1.7E-13	1.71E-13	0.99	3.0E-13	3.04E-13	0.99	2.7E-13	2.67E-13	1.01
ET1	6.0E-08	5.99E-08	1.00	6.0E-08	5.99E-08	1.00	6.0E-08	5.99E-08	1.00	7.3E-15	7.17E-15	1.02	2.7E-15	2.62E-15	1.03
ET2	3.2E-10	3.22E-10	0.99	5.1E-10	5.12E-10	1.00	5.3E-10	5.34E-10	0.99	7.3E-15	7.17E-15	1.02	2.7E-15	2.62E-15	1.03
LNet	3.3E-11	3.42E-11	0.97	3.5E-11	3.63E-11	0.96	3.5E-11	3.68E-11	0.95	7.3E-15	7.17E-15	1.02	2.7E-15	2.62E-15	1.03
Lungs	2.0E-11	1.97E-11	1.02	9.1E-11	9.14E-11	1.00	1.0E-10	9.98E-11	1.00	8.5E-14	8.57E-14	0.99	8.0E-14	8.09E-14	0.99
LNth	4.9E-13	4.97E-13	0.99	5.2E-13	5.29E-13	0.98	1.4E-12	1.45E-12	0.96	8.5E-14	8.57E-14	0.99	8.0E-14	8.09E-14	0.99
Skin	4.1E-13	4.11E-13	1.00	9.4E-14	9.47E-14	0.99	5.8E-14	5.83E-14	1.00	6.6E-14	6.56E-14	1.01	6.2E-14	6.19E-14	1.00
Spleen	5.4E-13	5.51E-13	0.98	2.6E-13	2.62E-13	0.99	2.2E-13	2.28E-13	0.96	5.9E-13	6.09E-13	0.97	5.8E-13	6.03E-13	0.96
Testes	4.1E-13	4.12E-13	1.00	7.5E-14	7.49E-14	1.00	3.7E-14	3.64E-14	1.02	9.3E-14	9.20E-14	1.01	9.0E-14	8.88E-14	1.01
Thymus	4.8E-13	4.78E-13	1.00	2.0E-13	1.97E-13	1.02	1.7E-13	1.65E-13	1.03	2.8E-14	2.64E-14	1.06	2.3E-14	2.19E-14	1.05
Thyroid	4.5E-13	4.55E-13	0.99	1.3E-13	1.30E-13	1.00	9.4E-14	9.22E-14	1.02	7.3E-15	7.17E-15	1.02	2.7E-15	2.62E-15	1.03
Uterus	6.0E-13	6.05E-13	0.99	3.1E-13	3.20E-13	0.97	2.8E-13	2.89E-13	0.97	7.7E-13	7.83E-13	0.98	7.7E-13	7.85E-13	0.98
Effective dose	1.8E-11	1.83E-11	0.99	3.3E-11	3.36E-11	0.98	3.5E-11	3.54E-11	0.99	2.7E-11	2.76E-11	0.98	2.8E-11	2.76E-11	1.01

Table 4-12. Comparison of ICRP and DCAL dose coefficients for ²²⁸Th.

	Inhalation type M			Inhalation type S			Ingestion: f1 = 0.0005			Ingestion: f1 = 0.0002		
	ICRP	DCAL	Ratio	ICRP	DCAL	Ratio	ICRP	DCAL	Ratio	ICRP	DCAL	Ratio
Adrenals	7.7E-07	7.74E-07	0.99	3.7E-08	3.79E-08	0.98	7.1E-09	7.13E-09	1.00	3.1E-09	3.09E-09	1.00
Bladder wall	7.8E-07	7.78E-07	1.00	3.4E-08	3.47E-08	0.98	7.2E-09	7.24E-09	0.99	3.2E-09	3.17E-09	1.01
Bone surface	2.8E-04	2.81E-04	1.00	1.2E-05	1.23E-05	0.97	2.5E-06	2.52E-06	0.99	1.0E-06	1.05E-06	0.95
Brain	7.7E-07	7.71E-07	1.00	3.4E-08	3.45E-08	0.98	7.1E-09	7.10E-09	1.00	3.1E-09	3.07E-09	1.01
Breast	7.7E-07	7.71E-07	1.00	3.7E-08	3.80E-08	0.97	7.1E-09	7.10E-09	1.00	3.1E-09	3.07E-09	1.01
St wall	7.7E-07	7.72E-07	1.00	3.6E-08	3.71E-08	0.97	8.4E-09	8.44E-09	1.00	4.4E-09	4.41E-09	1.00
Si wall	7.8E-07	7.75E-07	1.01	3.7E-08	3.70E-08	1.00	1.1E-08	1.08E-08	1.02	6.7E-09	6.75E-09	0.99
ULI wall	1.1E-06	1.09E-06	1.01	6.5E-08	6.53E-08	1.00	4.0E-08	3.99E-08	1.00	3.4E-08	3.43E-08	0.99
LLI wall	1.7E-06	1.73E-06	0.98	1.4E-07	1.42E-07	0.98	1.5E-07	1.45E-07	1.03	1.4E-07	1.37E-07	1.02
Kidneys	7.3E-06	7.33E-06	1.00	3.2E-07	3.24E-07	0.99	6.5E-08	6.53E-08	1.00	2.7E-08	2.69E-08	1.00
Liver	1.2E-05	1.17E-05	1.03	5.1E-07	5.15E-07	0.99	1.0E-07	1.04E-07	0.96	4.3E-08	4.29E-08	1.00
Muscle	7.7E-07	7.71E-07	1.00	3.5E-08	3.58E-08	0.98	7.1E-09	7.13E-09	1.00	3.1E-09	3.10E-09	1.00
Ovaries	2.3E-06	2.34E-06	0.98	1.0E-07	1.03E-07	0.97	2.1E-08	2.10E-08	1.00	8.8E-09	8.76E-09	1.00
Pancreas	7.7E-07	7.72E-07	1.00	3.6E-08	3.69E-08	0.98	7.1E-09	7.13E-09	1.00	3.1E-09	3.09E-09	1.00
Red marrow	2.2E-05	2.16E-05	1.02	9.4E-07	9.53E-07	0.99	2.0E-07	1.95E-07	1.02	8.2E-08	8.19E-08	1.00
ET1	7.6E-04	7.57E-04	1.00	7.6E-04	7.56E-04	1.00	7.1E-09	7.10E-09	1.00	3.1E-09	3.07E-09	1.01
ET2	5.7E-05	5.73E-05	1.00	2.1E-04	2.14E-04	0.98	7.1E-09	7.10E-09	1.00	3.1E-09	3.07E-09	1.01
LNet	3.2E-06	3.22E-06	0.99	5.0E-05	4.99E-05	1.00	7.1E-09	7.10E-09	1.00	3.1E-09	3.07E-09	1.01
Lungs	1.3E-04	1.27E-04	1.03	2.1E-04	2.08E-04	1.01	7.1E-09	7.11E-09	1.00	3.1E-09	3.08E-09	1.01
LNth	1.3E-05	1.31E-05	1.00	1.4E-04	1.41E-04	1.00	7.1E-09	7.11E-09	1.00	3.1E-09	3.08E-09	1.01
Skin	7.7E-07	7.70E-07	1.00	3.4E-08	3.50E-08	0.97	7.1E-09	7.10E-09	1.00	3.1E-09	3.08E-09	1.01
Spleen	7.7E-07	7.73E-07	1.00	3.6E-08	3.69E-08	0.98	7.1E-09	7.13E-09	1.00	3.1E-09	3.09E-09	1.00
Testes	2.4E-06	2.37E-06	1.01	1.0E-07	1.04E-07	0.96	2.1E-08	2.11E-08	1.00	8.7E-09	8.67E-09	1.00
Thymus	7.7E-07	7.71E-07	1.00	3.8E-08	3.87E-08	0.98	7.1E-09	7.10E-09	1.00	3.1E-09	3.07E-09	1.01
Thyroid	7.7E-07	7.71E-07	1.00	3.5E-08	3.58E-08	0.98	7.1E-09	7.10E-09	1.00	3.1E-09	3.07E-09	1.01
Uterus	7.7E-07	7.72E-07	1.00	3.4E-08	3.45E-08	0.99	7.2E-09	7.19E-09	1.00	3.2E-09	3.16E-09	1.01
Effective dose	2.2E-05	2.21E-05	0.99	2.5E-05	2.53E-05	0.99	7.2E-08	7.20E-08	1.00	3.5E-08	3.54E-08	0.99

Table 4-13. Comparison of ICRP and DCAL dose coefficients for ²³²Th.

	Inhalation type M			Inhalation type S			Ingestion: f1 = 0.0005			Ingestion: f1 = 0.0002		
	ICRP	DCAL	Ratio	ICRP	DCAL	Ratio	ICRP	DCAL	Ratio	ICRP	DCAL	Ratio
Adrenals	4.4E-06	4.37E-06	1.01	4.1E-07	4.12E-07	0.99	3.6E-08	3.57E-08	1.01	1.4E-08	1.43E-08	0.98
Bladder wall	4.4E-06	4.36E-06	1.01	4.0E-07	4.05E-07	0.99	3.6E-08	3.56E-08	1.01	1.4E-08	1.42E-08	0.98
Bone surface	1.5E-03	1.45E-03	1.03	1.4E-04	1.42E-04	0.99	1.2E-05	1.18E-05	1.02	4.7E-06	4.73E-06	0.99
Brain	4.4E-06	4.37E-06	1.01	4.0E-07	4.06E-07	0.99	3.6E-08	3.56E-08	1.01	1.4E-08	1.43E-08	0.98
Breast	4.4E-06	4.36E-06	1.01	4.1E-07	4.11E-07	1.00	3.6E-08	3.55E-08	1.01	1.4E-08	1.42E-08	0.98
St wall	4.4E-06	4.36E-06	1.01	4.1E-07	4.08E-07	1.00	3.6E-08	3.65E-08	0.99	1.5E-08	1.52E-08	0.99
Si wall	4.4E-06	4.36E-06	1.01	4.1E-07	4.07E-07	1.01	3.8E-08	3.80E-08	1.00	1.7E-08	1.66E-08	1.02
ULI wall	4.5E-06	4.45E-06	1.01	4.3E-07	4.31E-07	1.00	5.0E-08	5.05E-08	0.99	2.9E-08	2.87E-08	1.01
LLI wall	4.6E-06	4.64E-06	0.99	4.8E-07	4.80E-07	1.00	7.9E-08	7.93E-08	1.00	5.7E-08	5.67E-08	1.00
Kidneys	2.3E-05	2.26E-05	1.02	2.4E-06	2.36E-06	1.02	1.8E-07	1.84E-07	0.98	7.4E-08	7.36E-08	1.01
Liver	2.3E-05	2.28E-05	1.01	2.5E-06	2.51E-06	1.00	1.9E-07	1.85E-07	1.03	7.4E-08	7.41E-08	1.00
Muscle	4.4E-06	4.36E-06	1.01	4.1E-07	4.08E-07	1.01	3.6E-08	3.56E-08	1.01	1.4E-08	1.43E-08	0.98
Ovaries	1.3E-05	1.32E-05	0.98	1.3E-06	1.28E-06	1.02	1.1E-07	1.08E-07	1.02	4.3E-08	4.30E-08	1.00
Pancreas	4.4E-06	4.36E-06	1.01	4.1E-07	4.09E-07	1.00	3.6E-08	3.56E-08	1.01	1.4E-08	1.43E-08	0.98
Red marrow	5.7E-05	5.74E-05	0.99	6.1E-06	6.16E-06	0.99	4.7E-07	4.67E-07	1.01	1.9E-07	1.87E-07	1.02
ET1	4.4E-06	4.37E-06	1.01	4.7E-07	4.75E-07	0.99	3.6E-08	3.56E-08	1.01	1.4E-08	1.42E-08	0.98
ET2	1.5E-05	1.48E-05	1.01	1.1E-04	1.05E-04	1.05	3.6E-08	3.56E-08	1.01	1.4E-08	1.42E-08	0.98
LNet	4.9E-06	4.89E-06	1.00	7.1E-04	7.09E-04	1.00	3.6E-08	3.56E-08	1.01	1.4E-08	1.42E-08	0.98
Lungs	1.6E-05	1.58E-05	1.01	7.7E-05	7.73E-05	1.00	3.6E-08	3.56E-08	1.01	1.4E-08	1.42E-08	0.98
LNth	6.7E-06	6.71E-06	1.00	2.6E-03	2.61E-03	1.00	3.6E-08	3.56E-08	1.01	1.4E-08	1.42E-08	0.98
Skin	4.4E-06	4.36E-06	1.01	4.0E-07	4.06E-07	0.99	3.6E-08	3.56E-08	1.01	1.4E-08	1.42E-08	0.98
Spleen	4.4E-06	4.37E-06	1.01	4.1E-07	4.10E-07	1.00	3.6E-08	3.56E-08	1.01	1.4E-08	1.43E-08	0.98
Testes	1.3E-05	1.34E-05	0.97	1.3E-06	1.30E-06	1.00	1.1E-07	1.09E-07	1.01	4.4E-08	4.36E-08	1.01
Thymus	4.4E-06	4.36E-06	1.01	4.1E-07	4.13E-07	0.99	3.6E-08	3.56E-08	1.01	1.4E-08	1.42E-08	0.98
Thyroid	4.4E-06	4.36E-06	1.01	4.1E-07	4.08E-07	1.01	3.6E-08	3.56E-08	1.01	1.4E-08	1.42E-08	0.98
Uterus	4.4E-06	4.36E-06	1.01	4.0E-07	4.05E-07	0.99	3.6E-08	3.56E-08	1.01	1.4E-08	1.42E-08	0.98
Effective dose	2.9E-05	2.93E-05	0.99	1.2E-05	1.20E-05	1.00	2.2E-07	2.31E-07	0.95	9.2E-08	9.42E-08	0.98

Table 4-14. Comparison of ICRP and DCAL dose coefficients for ²³⁴Th.

	Inhalation type M			Inhalation type S			Ingestion: f1 = 0.0005			Ingestion: f1 = 0.0002		
	ICRP	DCAL	Ratio	ICRP	DCAL	Ratio	ICRP	DCAL	Ratio	ICRP	DCAL	Ratio
Adrenals	5.3E-11	5.34E-11	0.99	8.1E-12	8.14E-12	1.00	2.1E-12	2.12E-12	0.99	1.7E-12	1.72E-12	0.99
Bladder wall	6.0E-11	5.99E-11	1.00	4.8E-12	4.90E-12	0.98	9.8E-12	9.92E-12	0.99	9.3E-12	9.45E-12	0.98
Bone surface	3.1E-09	3.09E-09	1.00	5.4E-11	5.46E-11	0.99	4.7E-11	4.72E-11	1.00	2.1E-11	2.11E-11	0.99
Brain	4.6E-11	4.66E-11	0.99	1.8E-12	1.78E-12	1.01	6.5E-13	6.50E-13	1.00	2.6E-13	2.65E-13	0.98
Breast	5.0E-11	5.07E-11	0.99	8.0E-12	8.08E-12	0.99	8.8E-13	8.83E-13	1.00	5.1E-13	5.05E-13	1.01
St wall	4.6E-10	4.62E-10	1.00	4.4E-10	4.42E-10	0.99	1.0E-09	9.99E-10	1.00	1.0E-09	9.98E-10	1.00
Si wall	1.1E-09	1.08E-09	1.02	1.1E-09	1.10E-09	1.00	2.5E-09	2.55E-09	0.98	2.5E-09	2.55E-09	0.98
ULI wall	6.2E-09	6.19E-09	1.00	6.5E-09	6.50E-09	1.00	1.5E-08	1.51E-08	0.99	1.5E-08	1.51E-08	0.99
LLI wall	1.7E-08	1.76E-08	0.97	1.8E-08	1.85E-08	0.97	4.3E-08	4.31E-08	1.00	4.3E-08	4.32E-08	1.00
Kidneys	1.1E-09	1.10E-09	1.00	2.1E-11	2.06E-11	1.02	1.9E-11	1.89E-11	1.00	9.6E-12	9.63E-12	1.00
Liver	4.0E-10	4.03E-10	0.99	1.3E-11	1.32E-11	0.98	7.9E-12	7.92E-12	1.00	4.5E-12	4.56E-12	0.99
Muscle	5.0E-11	4.99E-11	1.00	5.7E-12	5.83E-12	0.98	3.8E-12	3.87E-12	0.98	3.4E-12	3.49E-12	0.97
Ovaries	1.6E-10	1.61E-10	0.99	1.6E-11	1.59E-11	1.01	3.2E-11	3.30E-11	0.97	3.1E-11	3.18E-11	0.98
Pancreas	5.1E-11	5.15E-11	0.99	7.0E-12	7.06E-12	0.99	3.8E-12	3.78E-12	1.01	3.4E-12	3.39E-12	1.00
Red marrow	1.7E-09	1.72E-09	0.99	3.2E-11	3.23E-11	0.99	2.9E-11	2.91E-11	1.00	1.4E-11	1.46E-11	0.96
ET1	2.4E-06	2.34E-06	1.03	2.4E-06	2.34E-06	1.03	6.8E-13	6.81E-13	1.00	3.0E-13	2.98E-13	1.01
ET2	3.4E-09	3.47E-09	0.98	4.1E-09	4.15E-09	0.99	6.8E-13	6.81E-13	1.00	3.0E-13	2.98E-13	1.01
LNet	5.6E-10	5.71E-10	0.98	6.2E-10	6.29E-10	0.99	6.8E-13	6.81E-13	1.00	3.0E-13	2.98E-13	1.01
Lungs	3.0E-08	2.97E-08	1.01	3.7E-08	3.66E-08	1.01	1.0E-12	1.04E-12	0.96	6.6E-13	6.58E-13	1.00
LNth	6.3E-10	6.30E-10	1.00	9.7E-10	9.70E-10	1.00	1.0E-12	1.04E-12	0.96	6.6E-13	6.58E-13	1.00
Skin	4.6E-11	4.65E-11	0.99	2.7E-12	2.76E-12	0.98	1.7E-12	1.68E-12	1.01	1.3E-12	1.30E-12	1.00
Spleen	5.0E-11	5.05E-11	0.99	6.7E-12	6.74E-12	0.99	3.1E-12	3.08E-12	1.01	2.7E-12	2.69E-12	1.00
Testes	1.5E-10	1.51E-10	1.00	3.4E-12	3.43E-12	0.99	4.6E-12	4.63E-12	0.99	3.3E-12	3.37E-12	0.98
Thymus	5.3E-11	5.28E-11	1.00	1.0E-11	1.01E-11	0.99	8.2E-13	8.19E-13	1.00	4.4E-13	4.37E-13	1.01
Thyroid	4.8E-11	4.81E-11	1.00	4.0E-12	4.05E-12	0.99	6.8E-13	6.81E-13	1.00	3.0E-13	2.98E-13	1.01
Uterus	5.1E-11	5.10E-11	1.00	6.4E-12	6.47E-12	0.99	1.3E-11	1.35E-11	0.96	1.3E-11	1.32E-11	0.99
Effective dose	5.3E-09	5.26E-09	1.01	5.8E-09	5.85E-09	0.99	3.4E-09	3.40E-09	1.00	3.4E-09	3.40E-09	1.00