APPENDIX G - Organ/Tissue Weighting Factors and Detriment/Risk Coefficients

G.1 Introduction

In January 1977, ICRP published ICRP-26. The ICRP established risk factors for different tissues that were based upon the estimated likelihood of inducing fatal malignant disease, non-stochastic changes, or substantial hereditary disorders expressed in live-born descendents.

In November 1990, the ICRP revised the risk factors published in ICRP-26 and provided risk factors for additional organs that are listed in ICRP-60.

G.2 Organ/Tissue Weighting Factors

Table G-1 summarizes the organ/tissue weighting factors in ICRP-26. The ICRP-26 organ/tissue weighting factors are used in dose assessments. The organ/tissue weighting factors used in this report are those in Table G-1.

Table G-1. Organ/Tissue Weighting Factors

W_t	Organ/Tissue	ΣW_t
0.03	Bone surfaces, thyroid	0.06
0.12	Red bone marrow, lung	0.24
0.15	Breast	0.15
0.25	Gonads	0.25
0.30	Remainder	0.30

Reference: ICRP-26

Table G-2 summarizes the revised organ/tissue weighting factors in ICRP-60 and provides risk factors for additional organs.

Table G-2. Organ/Tissue Weighting Factors

W_t	Organ/Tissue	ΣW_t
0.01	Bone surface, skin	0.02
0.05	Bladder, breast, liver, esophagus, thyroid, remainder	0.30
0.12	Red bone marrow, colon, lung, stomach	0.48
0.20	Gonads	0.20

Reference: ICRP-60

Whether you use ICRP-26 or ICRP-60, the final dose (CEDE) will be the same. (See Appendix J for comparison of the CEDE using ICRP-26 and ICRP-60 organ weighting factors.)

The first step in the exposure assessment process is to estimate the quantity, mode, and chemical and physical form of the DU taken into the body. Once these factors have been established, organ dose equivalents and CEDEs may be calculated for the time periods of interest.

G.3 Risk Coefficients

The total detriment after low-dose and low-dose-rate (< 20 rad and < 10 rad/hr, respectively) exposure to ionizing radiation is the sum of the contributions due to fatal cancers, non-fatal cancers, and severe hereditary disorders weighted for life lost. The total detriment attributed to these stochastic effects is 7.3×10^{-4}/rem for the whole population and about 23 percent less for a working population of 20 years to 64 years of age or 5.6×10^{-4}/rem. Table G-3 provides nominal

detriment/risk coefficients for stochastic radiation effects. The values also reflect the risk coefficients in ICRP-60 and NCRP Report No. 115.

Table G-3. Nominal Detriment/Risk Coefficients for Stochastic Radiation Effects (10^{-4}/rem)

Exposed Population	Fatal Cancer	Non Fatal Cancer	Hereditary Disorders	Total Detriment
Working Population (20 to 64 yrs of age)	4.0	0.8	0.8	5.6
Whole Population (0 to 90 yrs of age)	5.0	1.0	1.3	7.3

References: ICRP-60 and NCRP Report No. 115

The nominal probability of radiation-induced fatal cancer in a lifetime is 4×10^{-4}/rem for a working population, which is about 80 percent of the total cancer risk for the general population, for doses < 20 rem and dose rates <10 rem/hr. The upper bound for the risk of fatal cancer for the working population would be 8×10^{-4}/rem and for the whole population 10×10^{-4}/rem. Therefore, the dose and dose rate effectiveness factor (DDREF) would be two[26].

The risk coefficients may be used to estimate the probability of radiogenic cancer mortality or morbidity per unit intake for a given radionuclide for internal exposures or per unit dose for external exposures. Federal Guidance Report No. 13 provides risk coefficents for specific radionuclides.

The ICRP-26 and NCRP-91 and the ICRP-60 and NCRP-115 established fatal risk coefficients. Table G-4 summarizes lifetime fatal cancer probability coefficients for specific organs.

Table G-4. Summary of the Lifetime Mortality in the Whole Population from Specific Fatal Cancers after Exposure at Low Radiation Dose and Dose Rates

Fatal Probability Coefficients ($\times 10^{-6}$/rem)		
Organ	ICRP-26 and NCRP-91	ICRP-60 and NCRP-115
Bladder	---	30
Bone Marrow	20	50
Bone Surface	5	5
Breast	25	20
Colon	---	85
Liver	---	15
Lung	20	85
Oesophagus	---	30
Ovary	---	10
Skin	---	2
Stomach	---	110
Thyroid	5	8
Remainder*	50	50
Total	**125**	**500**

*The composition of the remainder is quite different.

The USEPA, using the linear, non-threshold dose-response model, estimates an average risk for a member of the general population in the U.S. of 5.75×10^{-4} fatal cancers per rem. For example, if 100,000 people, randomly chosen from the U.S. population, were each given a uniform dose of 0.1 rem to the entire body at a low-dose rate, then approximately five to six might die of cancer during their remaining lifetime due to that exposure. This is in addition to the estimated 20,000 (20 percent) fatal cancers that would occur in the same population from other causes.

The USEPA has developed a method for estimating the lifetime excess total cancer risk per unit intake of uranium. Table G-5 summarizes the carcinogenic slope factors for the isotopes of uranium as found in the DU munitions.

Table G-5. Radionuclide Carcinogenicity of Uranium in Units of Excess Risk/pCi and Risk/µg

Radio-Isotope	Class	Inhalation		Ingestion	
		Risk/pCi ($\times 10^{-8}$)	Risk/µg ($\times 10^{-9}$)	Risk/pCi ($\times 10^{-11}$)	Risk/µg ($\times 10^{-11}$)
U-234	Y	0.00000084	0.052	0.00000266	0.166
U-235+D*	Y	0.00026	0.00562	0.0094	0.0203
U-236	Y	0.000000396	0.00256	0.0000126	0.000817
U-238+D	Y	1.24	4.16	6.19	2.08

Reference: EPA-540-R-97-036
*D = Decay Products

A recent uncertainty analysis published by NCRP (NCRP Report No. 126) estimates that the actual risk of cancer from exposure of the entire body to low doses and dose rates of radiation could be between 4.8 times lower and 1.5 times higher (at the 90-percent confidence level) than the basic estimate of 5.75×10^{-4} fatal cancers per rem.