Preface

The purpose of this Report is to provide guidance in the derivation of organ doses and their associated uncertainty for epidemiologic studies in general, but with a focus on the populations that make up the One Million U.S. Workers and Veterans Study of Low-Dose Radiation Health Effects (MWS) coordinated by the National Council on Radiation Protection and Measurements (NCRP). The study populations include atomic veterans, U.S. Department of Energy workers, nuclear power plant workers, medical radiation workers, and industrial radiographers. Organ doses from exposure to all the relevant external and internal sources for a given population are being derived.

Radiation protection guidance for occupationally-exposed workers is based in large part upon the risk estimates from the Japanese atomic-bomb survivor study of ~51,250 adults exposed in 1945. The predominant exposure occurred in less than a second. Generalizing the circumstances of this population to healthy Western populations is problematic. The population survived a nuclear detonation, lived in a war-torn country, and was confronted with malnutrition, deprivation, infection, and other health and psychosocial issues. The population and the exposure circumstance in Japan are not comparable to healthier worker populations for whom exposure may occur over a period of many years.

The MWS is an epidemiologic investigation of American workers exposed gradually over time and is considered more representative of worker populations, with respect to health, ethnicity and lifestyle factors, than the Japanese atomic-bomb survivors. The study population is 10 times larger than the adult Japanese study population and has more individuals with cumulative recorded doses >100 mSv, and, in comparison to other low-dose and low dose-rate studies, appreciable doses to all tissues of the body. Thus it has the potential to improve estimates of radiation risk and the related uncertainties for lower-level exposures that occur over a period of many years.

For example, the MWS will remove the need to adjust for differences in the baseline disease rates between a Japanese population and a Western population, which are substantial. Also, the current approach, while comprehensive:

- is highly subjective and adds considerable uncertainty to the estimates of risk [NCRP Report No. 171, *Uncertainties in the Estimation of Radiation Risks and Probability of Disease Causation* (2012)];
- eliminates the intractable problem that birth cohort efforts cannot be addressed in the Japanese study since the exposure was in one point in time, 1945 [ICRP Publication 99, *Low-Dose Extrapolation of Radiation-Related Cancer Risk* (2005)]; and
- will provide direct evidence on the dose-rate effectiveness factor for individual cancers that can be applied to radiation protection models for protracted exposures [NCRP Commentary No. 27, I*mplications of Recent Epidemiologic Studies for the Linear Nonthreshold Model and Radiation Protection* (2018); and Shore, R., Walsh, L., Azizova, T. and Rühm, W. "Risk of solid cancer in low dose-rate radiation epidemiologic studies and the dose-rate effectiveness factor," Int. J. Radiat. Biol. **93**(10), 1064–1078, 2017] and thus eliminate or reduce the need for a dose and dose-rate effectiveness factor.

The importance of the MWS is in providing statistically powerful estimates of organ-specific risks that can be incorporated in:

- radiation protection guidance [Boice, J.D., Jr. "The linear nonthreshold (LNT) model as used in radiation protection: An NCRP update," Int. J. Radiat. Biol. **93**(10), 1079–1092, 2017; and NCRP Commentary No. 27 (2018)];
- filling a major gap in radiation understanding about the risk of cancer in humans following gradual, chronic, protracted and fractionated exposures;
- improving computation schemes for compensation issues for workers and veterans who received exposures in years past;
- improving models to project potential risk from medical and environmental exposures;
- providing a strong epidemiologic database for applying biologically based dose-response models for improved risk estimation at low doses; and
- providing scientifically based information of radiation risks for managers and decision makers.

High-quality dosimetry is the key to achieving these goals.

This Report draws from and builds upon previous NCRP reports and a commentary on closely related topics, namely:

- Report No. 158, *Uncertainties in the Measurement and Dosimetry of External Radiation* (2007);

- Report No. 163, *Radiation Dose Reconstruction: Principles and Practice* (2009);
- Report No. 164, *Uncertainties in Internal Radiation Dose Assessment* (2009);
- Report No. 171, *Uncertainties in the Estimation of Radiation Risks and Probability of Disease Causation* (2012); and
- Commentary No. 27, *Implications of Recent Epidemiologic Studies for the Linear-Nonthreshold Model and Radiation Protection* (2018).

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