DOE/RL-2006-29
Revision 2

Calculating Potential-to-Emit Radiological Releases and Doses

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

U.S. DEPARTMENT OF ENERGY | Richland Operations Office

P.O. Box 550
Richland, Washington 99352

Approved for Public Release;
Further Dissemination Unlimited

DOE/RL-2006-29
Revision 2

Calculating Potential-to-Emit Radiological Releases and Doses

S. F. Snyder
Pacific Northwest National Laboratory

D. J. Rokkan
Mission Support Alliance

Date Published
January 2016

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

U.S. DEPARTMENT OF ENERGY | Richland Operations Office
P.O. Box 550
Richland, Washington 99352

APPROVED
By Julia Raymer at 3:19 pm, Jan 27, 2016

Release Approval Date

Approved for Public Release;
Further Dissemination Unlimited

TRADEMARK DISCLAIMER

Reference herein to any specific commercial product, process, or service by tradename, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof or its contractors or subcontractors.

This report has been reproduced from the best available copy.

Printed in the United States of America

CONTENTS

FIGURES iv
TABLES iv
ABBREVIATIONS AND ACRONYMS vii
ELEMENT SYMBOLS ix
DEFINITIONS xi
1.0 INTRODUCTION 1.1
2.0 ESTIMATING POTENTIAL EMISSIONS 2.1
2.1 APPROVED METHODS 2.1
2.1.1 Method 1: Annual Possession Quantity 2.1
2.1.2 Method 2: Back-Calculating Emissions and In Situ Measurements 2.2
2.1.3 Method 3: Control Device and In Situ Measurements 2.3
2.1.4 Method 4: Measurement Upstream of Control Device 2.3
2.1.5 Method 5: Release Fractions 2.3
2.2 METHODS NOT PREVIOUSLY APPROVED 2.4
3.0 CALCULATING DOSES TO THE MAXIMALLY EXPOSED INDIVIDUAL 3.1
3.1 CALCULATING RELEASES AND DOSES 3.1
3.2 SELECTING THE APPROPRIATE DOSE-PER-UNIT-RELEASE FACTORS 3.2
3.2.1 Calculating Effective Release Height 3.2
3.2.2 Using Dose-Per-Unit-Release Factor Tables 3.4
3.2.3 Handling Radioactive Decay Chains 3.5
3.3 RADIONUCLIDES WITHOUT DOSE-PER-UNIT-RELEASE FACTORS 3.6
3.4 WHEN SCENARIO-SPECIFIC CAP88-PC CALCULATIONS ARE WARRANTED 3.7
3.4.1 Emission Units Outside Emission Zones 3.7
3.4.2 Nonchronic Releases 3.7
3.4.3 Estimated Doses Near 0.1 mrem/yr 3.7
3.4.4 Default Absorption Types or Particle Sizes that are Inappropriate 3.8
3.4.5 Releases with Considerable Radioiodines 3.8
3.4.6 Releases from Area Sources 3.8
3.4.7 Releases Dominated by Short-Lived Radionuclides 3.16
3.5 CALCULATING DOSES 3.16
3.6 REPORTING RELEASES AND DOSES IN A NOTICE OF CONSTRUCTION 3.18
4.0 DOSE-PER-UNIT-RELEASE FACTORS FOR RADIONUCLIDE AIR EMISSIONS 4.1
4.1 USE OF HANFORD-SPECIFIC PARAMETERS AND DATA FOR DEMONSTRATING COMPLIANCE WITH AIR PATHWAY RADIATION DOSE STANDARDS 4.1
4.1.1 Regulatory Background 4.1
4.1.2 History of Data Used in Hanford Site Compliance Calculations 4.1

4.1.3 Hanford-Specific Parameters 4.2
4.1.4 Approval for Use of Hanford-Specific Parameters 4.2
4.1.5 Calculation of Onsite Member-of-the-Public Worker Dose-per-Unit-Release Factors Using CAP88-PC and Average 80-km Ingestion 4.2
4.2 RESULTS OF DOSE-PER-UNIT-RELEASE fACTOR CALCULATIONS FOR HANFORD SITE EMISSION ZONES 4.4
5.0 IODINE-SPECIFIC ASSESSMENTS 5.1
6.0 QUALITY ASSURANCE: POTENTIAL-TO-EMIT DETERMINATION AND PEER REVIEW 6.1
7.0 DOSE FACTOR PEER REVIEW CHECKLISTS 7.1
8.0 REFERENCES 8.1

FIGURES

Figure 4.1. Hanford Site Map of Emission Zones 4.5
Figure 4.2. Hanford Site Map of 300 Area <40-m Emission Units' East/West Boundaries and MEI Locations 4.6
Figure 4.3. Hanford Site Map of 300 Area ≥40-m Emission Units' East/West Boundaries and MEI Locations 4.6

TABLES

Table 3.1. Default FGR-13 Absorption Types and Particle Sizes in CAP88-PC 3.9
Table 3.2. Example 1: Decay-Corrected Radionuclide Inventory 3.17
Table 3.3. Example 1: PTE Calculation for an Elevated Release from the Eastern 300 Area 3.17
Table 3.4. Example 2: PTE Calculation for a Ground-Level Release from the Eastern 300 Area 3.18
Table 3.5. Example 3: Original Assessed Potential-to-Emit for the Stack 3.20
Table 3.6. Example 3: Original Assessed Potential-to-Emit for the Stack NOC 3.20
Table 3.7. Example 3: Assessed Potential-to-Emit for the New Activity 3.21
Table 3.8. Example 3: Assessed Potential-to-Emit for Stack, Including New Activity 3.21
Table 3.9. Example 3: Assessed Potential-to-Emit for the Stack NOC 3.22
Table 3.10. Example 3: Detectability Check for Biweekly Sampling When the Stack Operates at 2,500 cfm 3.22
Table 3.11. Example 3: Detectability Check for Monthly Sampling When Stack Operates at 2,500 cfm 3.23
Table 3.12. Example 3: Detectability Check for Biweekly Sampling When Stack Operates at 1,900 cfm 3.23
Table 4.1. Release Locations and Meteorological Stations Used 4.4
Table 4.2. Direction and Distance to Each MEI Location from Respective Emission Zone 4.7

Table 4.3. 100-K Area: Offsite MEI CAP88-PC Dose-per-Unit-Release Factors by Effective Release Height 4.8

Table 4.4. 200 East Area: Offsite and Onsite MEIs CAP88-PC Dose-per-Unit-Release Factors by Effective Release Height 4.21

Table 4.5. 200 West Area: Offsite and Onsite MEIs CAP88-PC Dose-per-Unit-Release Factors by Effective Release Height 4.35

Table 4.6. Eastern and Western 300 Area: Offsite MEI CAP88-PC Dose-per-Unit-Release Factors by Effective Release Height 4.49

Table 4.7. 400 Area: Offsite and Onsite MEIs CAP88-PC Dose-per-Unit-Release Factors by Effective Release Height 4.63

Table 5.1. Iodines 100-K Area: Offsite MEIs CAP88-PC Iodine Dose-per-Unit-Release Factors by Effective Release Height with Iodine MEI 5.2

Table 5.2. Iodines 200 East Area: Offsite and Onsite MEIs CAP88-PC Iodine Dose-per-Unit-Release Factors by Effective Release Height with Iodine MEI 5.3

Table 5.3. Iodines 200 West Area: Offsite and Onsite MEIs CAP88-PC Iodine Dose-per-Unit-Release Factors by Effective Release Height with Iodine MEI 5.4

This page intentionally left blank.

ABBREVIATIONS AND ACRONYMS

ANSI	American National Standards Institute
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
°C	degrees Celsius
CAP88-PC	Clean Air Act Assessment Package – 1988, Personal Computer
cfm	cubic feet per minute
CFR	Code of Federal Regulations
Ci	curie(s)
DOE	U.S. Department of Energy
EDE	effective dose equivalent
EPA	U.S. Environmental Protection Agency
FGR	Federal Guidance Report
HEPA	high-efficiency particulate air [filter]
ICRP	International Commission on Radiological Protection
K	kelvin
LIGO	Laser Interferometer Gravitational-Wave Observatory
MDA	minimum detectable activity
MDC	minimum detectable concentration
MDL	minimum detection level
MEI	maximally exposed individual
mrem	millirem
MSA	Mission Support Alliance, LLC
NCRP	National Council on Radiation Protection and Measurements
NDA	nondestructive assay
NESHAP	National Emission Standards for Hazardous Air Pollutants
NOC	Notice of Construction
PNNL	Pacific Northwest National Laboratory
PTE	potential-to-emit (radioactive materials)
PTRAEU	portable temporary radioactive air emission unit
QA	quality assurance
STP	standard temperature and pressure
TEDE	total effective dose equivalent
WAC	Washington Administrative Code
WDOH	Washington State Department of Health

This page intentionally left blank.

ELEMENT SYMBOLS

Element Abbreviation	Element Name	Element Abbreviation	Element Name
Ac	Actinium	N	Nitrogen
Ag	Silver	Na	Sodium
Al	Aluminum	Nb	Niobium
Am	Americium	Nd	Neodymium
Ar	Argon	Ni	Nickel
As	Arsenic	Np	Neptunium
At	Astatine	O	Oxygen
Au	Gold	Os	Osmium
Ba	Barium	P	Phosphorus
Be	Beryllium	Pa	Protactinium
Bi	Bismuth	Pb	Lead
Bk	Berkelium	Pd	Palladium
Br	Bromine	Pm	Promethium
C	Carbon	Po	Polonium
Ca	Calcium	Pr	Praseodymium
Cd	Cadmium	Pt	Platinum
Ce	Cerium	Pu	Plutonium
Cf	Californium	Ra	Radium
Cl	Chlorine	Rb	Rubidium
Cm	Curium	Re	Rhenium
Co	Cobalt	Rh	Rhodium
Cu	Copper	Rn	Radon
Cr	Chromium	Ru	Ruthenium
Cs	Cesium	S	Sulfur
Dy	Dysprosium	Sb	Antimony
Er	Erbium	Sc	Scandium
Es	Einsteinium	Se	Selenium
Eu	Europium	Si	Silicon
F	Fluorine	Sm	Samarium
Fr	Francium	Sn	Tin
Fe	Iron	Sr	Strontium
Ga	Gallium	Ta	Tantalum
Gd	Gadolinium	Tb	Terbium
Ge	Germanium	Tc	Technetium
H	Hydrogen	Te	Tellurium
Hf	Hafnium	Th	Thorium
Hg	Mercury	Ti	Titanium
Ho	Holmium	Tl	Thallium
I	Iodine	Tm	Thulium
In	Indium	U	Uranium
Ir	Iridium	V	Vanadium
K	Potassium	W	Tungsten
Kr	Krypton	Xe	Xenon
La	Lanthanum	Y	Yttrium
Lu	Lutetium	Yb	Ytterbium
Mg	Magnesium	Zn	Zinc
Mn	Manganese	Zr	Zirconium
Mo	Molybdenum	-	-

This page intentionally left blank.

DEFINITIONS

Acute release – A short duration release, with a potentially significant emission rate.

Chronic release – A release where emissions are effectively continuous and the emission rate is relatively constant for a period of at least 3 months.

Dose-per-unit-release factor – A value computed using appropriate software that estimates radiation dose to a maximally exposed individual (MEI) following release of a unit quantity of radioactive material to the atmosphere from a specific emission unit.

Effective dose (ED) – As applied to doses reported for compliance with Title 40 Code of Federal Regulations (CFR) Part 61, Subpart H, CAP88-PC V4.0.1.17 reports the ED. The ED updates the EDE dosimetry of ICRP Publication No. 26 in ICRP Publication No. 60.

Effective dose equivalent (EDE) – As applied in Title 40 Code of Federal Regulations (CFR) Part 61, Subpart H:

> "Effective dose equivalent means the sum of the products of absorbed dose and appropriate factors to account for differences in biological effectiveness due to the quality of radiation and its distribution in the body of reference man. The unit of the effective dose equivalent is the rem. …. The method for calculating effective dose equivalent and the definition of reference man are outlined in the International Commission on Radiological Protection's Publication No. 26."

Emission unit – As applied in Washington Administrative Code (WAC) 246-247-030[10]:

> "…any single location that emits or has the potential to emit airborne radioactive material. This may be a point source, nonpoint source, or source of fugitive emissions."

Emission zone – The Hanford Site has five major operating areas: the 100, 200 East, 200 West, 300, and 400 Areas. The 100 Areas consist of several distinct areas (100-B/C, 100-D/DR, 100-F, 100-H, 100-KE/KW, and 100-N) with only the 100-K Area continuing to have active operations. Within the operating areas, six emission zones were established based on differing receptor locations, atmospheric dispersion factors, and source locations. The emission zones are typically defined by the boundaries of each operating area, representative of their distinctly different meteorology and the location of potential receptors for airborne emissions from the area. For all facilities or activities located within an emission zone, the dose-per-unit-release factors for that zone may be used.

Facility – For regulatory purposes, in 40 CFR Section 61.91[b]:

> "*Facility* means all buildings, structures and operations on one contiguous site."
>
> In the definition from WAC 246-247-030(11):
>
> "'Facility' means all buildings, structures, plants, processes, and operations on one contiguous site under control of the same owner or operator."

Major source – An emission unit having the potential to emit radionuclides that could result in a dose to the prospective maximally exposed individual exceeding one percent of the 10 millirem/year dose standard in 40 CFR Part 61, Subpart H (i.e., greater than 0.1 millirem/year). Major sources are subject to the continuous monitoring requirements of 40 CFR Section 61.93.

Maximally exposed individual (MEI) – Regulations in WAC 246-247-030(15) define the MEI as:

> "…any member of the public (real or hypothetical) who abides or resides in an unrestricted area, and may receive the highest TEDE from the emission unit(s) under consideration, taking into account all exposure pathways affected by the radioactive air emissions."

For the purposes of this document, doses to two types of MEI receptors have been defined. They are referred to as the retrospective MEI and the prospective MEI, depending on the purpose of the dose estimates.

The retrospective MEI is a hypothetical or real member of the public located near or within the Hanford Site who by virtue of location and living habits could have received the maximum radiation dose from all sources of radioactive emissions released from the site during a previous calendar year. Attributes of doses for a retrospective MEI include:

- dose is to an actual person or location (i.e., existing school, business, or residence) that someone could have occupied for a substantial fraction of the year of interest
- receptor may be a member of the public who lives or works near the Hanford Site, or a worker who is not employed by the U.S. Department of Energy (DOE) or its contractors, but who has unrestricted access to a work location within the Hanford Site boundary
- dose is a retrospective calculation for emissions during a previous calendar year
- emissions are measured or estimated "actual" annual emissions from all Hanford facility operations, including stack effluents as well as diffuse and fugitive sources of emissions
- meteorological data from the period of interest (typically a reporting calendar year) are used to estimate atmospheric dispersion from all emission units to the receptor location
- dose estimate is typically used to demonstrate compliance with federal and state standards for releases of radioactive materials to the atmosphere.

The prospective MEI is an individual member of the public who could receive the maximum potential dose from a new or modified emission unit in the future. In previous versions of this document, the prospective MEI was referred to as the Maximum Public Receptor to distinguish this individual from the retrospective MEI described previously. Attributes of doses for a prospective MEI include:

- dose is to a real or hypothetical reference man, member of the public at a location that is currently occupied, or could be occupied for a substantial fraction of a calendar year in the future
- receptor may be a member of the public who lives or works near the Hanford Site, or a worker who is not employed by the DOE or its contractors, but who has unrestricted access to a work location within the Hanford Site boundary

- a person at a location that would receive the maximum dose from radioactive materials potentially released at a specific emission unit
- a prospective calculation for potential future emissions
- dose is estimated for a hypothetical annual emission rate: either an abated emission rate with effluent control systems in place, or a potential-to-emit (i.e., a hypothetical unabated emission rate with no effluent control systems in place, but assuming otherwise normal operations)
- long-term meteorological data (i.e., averaged over a period of at least several years) are used to estimate atmospheric dispersion from the specific emission unit to the receptor location
- estimated dose is used in a notice of construction, or an application to construct or modify the emission unit, for purposes of determining emission monitoring requirements as part of the permitting process for new emission units or modified existing emission units.

Millirem (mrem) – A unit of radiation effective dose equivalent (EDE) or total effective dose equivalent (TEDE) based on the potential for impact on human cells. One millirem equals 1/1,000 of a rem.

Minor source – An emission unit having the potential to emit radionuclides that would not result in a dose exceeding one percent of the 10 mrem/year dose standard in 40 CFR Part 61, Subpart H (i.e., less than 0.1 millirem/year) to a prospective maximally exposed individual. Minor sources are subject to the periodic confirmatory measurement requirements of 40 CFR Section 61.93.

Notice of Construction (NOC) – As defined in WAC 246-247-030(19):

> "…an application submitted to the [Washington State Department of Health] by an applicant that contains information required by WAC 246-247-060 for proposed construction or modification of a registered emission unit(s), or for modification of an existing, unregistered emission unit(s)."

Potential-to-emit (PTE) – Radionuclide emissions estimated for purposes of permitting a new or modified emission unit. As defined in WAC 246-247-030(21):

> "…the rate of release of radionuclides from an emission unit based on the actual or potential discharge of the effluent stream that would result if all abatement control equipment did not exist, but operations are otherwise normal."

Rem – A unit of radiation effective dose equivalent (EDE) or total effective dose equivalent (TEDE) based on the potential for impact on human cells. One rem equals 1,000 millirem.

Total effective dose equivalent (TEDE) – The sum of the dose equivalent (for external exposures) and the committed effective dose equivalent (for internal exposures). TEDE is expressed in units of rem or millirem. The same concept applies for ED, where TED is the sum of external and internal dose.

This page intentionally left blank.

1.0 INTRODUCTION

This document was prepared to be a handbook offered as a convenience to U.S. Department of Energy (DOE) contractors and Hanford Site personnel when they need to estimate potential radionuclide emissions to the atmosphere and subsequent radiological doses to both offsite and onsite members of the public. This document is an update to the previous version (Rhoads et al. 2010) and incorporates some significant changes as noted in subsequent sections. Information provided in this document is intended for use in estimating prospective emission rates and potential doses from new or modified emission units to determine point source categorization (i.e., "stack designation") and in a Notice of Construction (NOC). ***The information in this document is not appropriate for use in demonstrating compliance with annual air emission standards for radionuclides released from Hanford Site facilities in prior calendar years.***[1]

For the purposes of this document, doses to two types of maximally exposed individual (MEI) receptors have been defined. They are referred to as the retrospective MEI and the prospective MEI, depending on the purpose of the dose estimates. The retrospective MEI is a hypothetical or real member of the public located near or within the Hanford Site who, by virtue of location and living habits, could have received the maximum radiation dose from all sources of radioactive emissions released from the site during a previous calendar year. Dose to the retrospective MEI is estimated for a prior calendar year and is based on estimated or measured emissions from all sources of radionuclide emissions at the Hanford Site. The retrospective MEI dose estimate is typically used to demonstrate compliance with federal and state standards for releases of radioactive materials to the atmosphere. The prospective MEI is an individual member of the public who could receive the maximum potential dose from a specific single new or modified emission unit in the future. In a prior version of this document, the prospective MEI was referred to as the Maximum Public Receptor to distinguish that individual from the retrospective MEI described previously. Dose to the prospective MEI is based on estimated potential emissions from the new or modified emission unit, and is generally used in a NOC, or an application to construct or modify the emission unit, for purposes of determining emission monitoring requirements as part of the permitting process. Unless otherwise specified, information provided in this document refers to the prospective MEI for a new or modified emission unit at the Hanford Site.

For the prospective MEI, two potential receptor locations for radionuclide emissions are considered in this document – an onsite and an offsite MEI. The offsite MEI for a new or modified emission unit is a member of the public who could live or work near the potential release point but not within the Hanford Site boundaries of property controlled by DOE. The onsite MEI is a member of the public

[1] Care should be taken not to use the information in this document for applications other than those approved. A key example of an inappropriate application is using this document to estimate actual emissions for demonstration of compliance with annual dose standards. The Hanford Site effluent monitoring and reporting program annually demonstrates for both individual facilities and cumulatively for the site the measure of compliance with DOE, state, and federal requirements imposed on actual radionuclide air emissions. The dose model that uses the measured emission data focuses on the retrospective MEI for all sources at the Hanford Site, who is not necessarily the same individual as any onsite or offsite prospective MEI identified herein for a specific emission unit or source area. The dose-per-unit-release factors used in the annual compliance MEI model differ from dose-per-unit-release factors in this document because the meteorology and location associated with the retrospective MEI only apply to the calendar year being evaluated for compliance.

who has unrestricted access to a workplace within DOE-controlled property of the Hanford Site, but who is not employed by DOE or its contractors. The offsite or onsite MEI location may vary according to its geographical relationship to the specific emission unit, meteorological conditions, and levels of radionuclide emissions. Information and methods are provided for estimating emissions from facilities or emission units and the resulting effective dose equivalent (EDE) to a prospective MEI for use in regulatory NOCs, in accordance with requirements in Title 40 Code of Federal Regulations (CFR) Part 61, Subpart H, and with Washington Administrative Code (WAC) Chapter 246-247.

Hanford-specific meteorological data from a 10-year period (2004 through 2013) were used to calculate the dose-per-unit-release factors presented in this document for determining the EDE to an onsite or offsite prospective MEI. However, infrastructure failures at 100-K (station 29) occurred in early 2013, therefore, data collected between 2003 and 2012, were used. The previous revision of this document used data collected through 2006. Due to significantly reduced radiological operations and clean-up activities on the Hanford Site, 100-F/H, 100-N/D/DR areas were not evaluated for this report. While the prior report indicated 100-K Area data would be applicable to 100-B/C releases, the clean-up of 100-B/C Areas eliminates the need for such an application.

The need for this update was prompted by the approval of a significantly updated version of CAP88-PC and approval for its use in 2015. Prior versions of this document incorporated the methods and information generated according to procedures described in DOE-RL-2007-53 (Rhoads et al. 2008). A number of the Hanford-specific intake and exposure factors in DOE-RL-2007-53 are no longer amenable to customization in CAP88-PC version 4 (2015). Inputs that were retained are indicated.

2.0 ESTIMATING POTENTIAL EMISSIONS

Methods described in this section include those currently accepted by the Washington State Department of Health (WDOH) and the U.S. Environmental Protection Agency (EPA) Region 10 for estimating potential air emissions of radionuclides from new or modified emission units operated by DOE and its contractors. There may be other acceptable methods for estimating potential emissions. However, methods that differ from those described herein would require pre-approval from WDOH and EPA and would likely require additional time for the review and approval cycle.

2.1 APPROVED METHODS

Four methods are currently approved by WDOH for use in estimating potential emissions, as listed in WAC 246-247-30(21). The methods are:

1. multiply the annual possession quantity of each radionuclide by the release fractions provided in WAC 246-247-30(21)(a) and 40 CFR Part 61, Appendix D
2. back-calculate the unabated emission rate using a measured abated emission rate with in situ measurements of control device efficiencies
3. measure the quantities of radionuclides captured in each control device, coupled with in situ measurements of control equipment efficiencies
4. sample the effluent upstream from all control devices.

Both WAC 246-247-30(21)(e) and 40 CFR Part 61, Section 61.96, allow for use of alternative methods, but they must be approved by WDOH and EPA Region 10 prior to use. Both agencies have previously approved the following alternative method for estimating potential emissions, designated here as method 5:

5. multiply the annual possession quantity of each radionuclide by material-specific spill-release fractions, rather than using release fractions in WAC 246-247 and 40 CFR Part 61, Appendix D.

Method 1 above is authorized by 40 CFR Part 61, Subpart H, for use in calculating potential emissions. EPA Region 10 has also previously approved the use of Methods 2 through 5.

The use of methods other than the approved Methods 1 through 5 usually requires a more extensive review and approval process. Use of the previously approved methods should not require a review and approval cycle as extensive as a method which utilizes a new technology or methodology.

2.1.1 Method 1: Annual Possession Quantity

Method 1 is prescribed in 40 CFR Part 61, Appendix D, and in WAC 246-247-030(21). The methods described by these regulations are the same, except for a few minor differences. The method in WAC 246-247-030(21)(a) is:

> "Multiply the annual possession quantity of each radionuclide by the release fraction for that radionuclide, depending on its physical state. Use the following release fractions:

(i) 1 for gases;
(ii) 10^{-3} for liquids or particulate solids; and
(iii) 10^{-6} for solids.

Determine the physical state for each radionuclide by considering its chemical form and the highest temperature to which it is subjected. Use a release fraction of one if the radionuclide is subjected to temperatures at or above its boiling point; use a release fraction of 10^{-3} (equivalent to 1 E-03) if the radionuclide is subjected to temperatures at or above its melting point, but below its boiling point. If the chemical form is not known, use a release fraction of one for any radionuclide that is heated to a temperature of 100 degrees Celsius or more, boils at a temperature of 100 degrees Celsius or less, or is intentionally dispersed into the environment."

This method is extremely conservative because many materials have release fractions for accident scenarios that are orders of magnitude lower than those provided in Appendix D. For example, in an accident scenario for a spill of powder from a 1-meter height, a 3 E-04 release fraction would be used when the particle size is 10-micron aerodynamic-equivalent diameter or smaller, and a 4 E-05 release fraction would be used for a liquid spill from a 3-m height (DOE-HDBK-3010-94 [DOE 2013]). The release fractions for both of these cases are lower than the Appendix D release fraction of 1 E-03 for routine handling of liquids and particulate solids. When the source-term properties are known and more realistic alternative release fractions are available, use of Method 5 should be considered.

2.1.2 Method 2: Back-Calculating Emissions and In Situ Measurements

WAC 246-247-030(21)(b) states that, with approval (see WDOH 2014), a back-calculation using measured emission rates and in situ measurements of the effluent control equipment efficiencies can be used to estimate potential emissions. Control equipment efficiencies should be obtained using the methods prescribed by the American Society of Mechanical Engineers and the American National Standards Institute in *Testing of Nuclear Air Treatment Systems* (ASME/ANSI N510).

At Hanford, most emission-control equipment consists of a system containing one or more high-efficiency particulate air (HEPA) filters. The DOE *Nuclear Air Cleaning Handbook* (DOE-HDBK-1169-2003 [DOE 2003]) provides a decontamination factor of $3{,}000^n$ for HEPA filter systems, in which "n" represents the number of HEPA filters in series. The use of a decontamination factor of $3{,}000^n$ has been allowed by WDOH and EPA for systems utilizing n banks of HEPA filters in series. The potential emissions are then calculated by multiplying the actual annual emissions by the decontamination factor (i.e., $3{,}000^n$).

Method 2 can be extremely conservative for a facility where the ventilation system has been contaminated by radioactive materials. If radioactive materials are not being actively handled in the facility, resuspension of contamination downstream from the HEPA filters can dominate the airborne releases from that facility. Multiplying the releases from resuspended material by a factor of $3{,}000^n$ can overestimate the potential unabated emissions by an order of magnitude or more (Barnett and Davis 1996).

2.1.3 Method 3: Control Device and In Situ Measurements

WAC 246-247-030(21)(c) states that, with approval, a measurement of the quantities of radionuclides captured in the control device, coupled with in situ measurements of the control equipment efficiencies, can be used to estimate potential emissions. Several variations of this method are available, as described in Sections 2.1.3.1 through 2.1.3.3.

2.1.3.1 Method 3.1: Control Device Inventory

Samples are taken from the collection media of an effluent control device, which are representative of the radionuclide inventory contained within that control device, and isotopic analyses are performed on the samples. The radionuclide inventory in the control device is estimated using the sample results, operating history of the device, and the appropriate radioactive decay corrections. An annual release rate is calculated based on the radionuclide inventory of the control device, its operating history, and its collection efficiency. The potential unabated emissions are then calculated by dividing the annual release rate by the collection efficiency of the control device.

2.1.3.2 Method 3.2: Nondestructive Assay of the Control Device

A nondestructive assay (NDA) is used to determine the radionuclide inventory of a control device. The radionuclide inventory in a control device is estimated using the NDA results, operating history for the device, and the appropriate radioactive decay corrections. An annual release rate is calculated based on the radionuclide inventory of the control device, its operating history, and its collection efficiency.

The NDA method most frequently practiced at the Hanford Site uses either a sodium iodide or high-purity germanium gamma-ray detector to quantify the gamma-emitting radionuclides collected by the control device. An annual release rate is calculated for each gamma-emitting radionuclide. Annual release rates for non-gamma-emitting radionuclides are calculated using ratios obtained from actual radionuclide emissions measurements or inventory data.

2.1.4 Method 4: Measurement Upstream of Control Device

WAC 246-247-030 (21)(d) states that, with approval, effluent samples collected upstream from all effluent control devices can be used to estimate potential emissions.

Representative air samples are collected at a location upstream from all control devices. The samples are analyzed for expected radionuclides to determine their concentrations in the effluent stream. The potential unabated emissions are then calculated by multiplying the radionuclide concentrations by the annual discharge volume.

2.1.5 Method 5: Release Fractions

WAC 246-247-030(21)(a) states that, with approval, other release fractions may be used to estimate potential emissions. This method is identical to Method 1, except that it uses material-specific release fractions to calculate potential emissions instead of the release fractions provided in WAC 246-247-030 or 40 CFR Part 61, Appendix D. Examples of release fractions for a variety of materials and scenarios may be found in documents such as *Airborne Release Fractions/Rates and Respirable*

*Fractions for Nonreactor Nuclear Facilities (*DOE-HDBK-3010-94 [DOE 2013]), *Nuclear Fuel Cycle Facility Accident Analysis Handbook* (NUREG/CR-6410 [SAIC-1998]), and *Technical Peer Review Report. Airborne Release Fractions* (ASME 2002).

2.2 METHODS NOT PREVIOUSLY APPROVED

Methods to determine potential emissions that have not been approved by WDOH and EPA will require additional time for their review and approval, in addition to approval by the appropriate DOE contractor. Developing and using a new method usually results in a greater cost to perform potential-to-emit (PTE) calculations. For these reasons, use of one of the five approved methods should be carefully considered before selecting an alternative unapproved method.

3.0 CALCULATING DOSES TO THE MAXIMALLY EXPOSED INDIVIDUAL

The method presented here simplifies dose calculations for users by eliminating the need to run the Clean Air Act Assessment Package – 1988, personal computer (CAP88-PC) software. The current CAP88-PC version 4.0.1.17 (V4) (Rosnick 2014) software package incorporates several major changes over the previous version (Rosnick 2007). Modifications include a greatly expanded radionuclide library, more rigorous methods for estimating dose from radioactive decay chains, and updated dosimetry and risk factors based on International Commission on Radiation Protection Report 72 (ICRP 1996) from Eckerman and Leggett (2008), which supersedes values in Federal Guidance Report (FGR) 13 (Eckerman et al. 1999). Environmental transport factors from the National Council on Radiation Protection and Measurements Report No. 123 (NCRP 1996) continue to be applied, as well as external dose factors based on ground surface values. Hanford Site-specific parameters are also included, particularly a multi-year profile of meteorological data, as opposed to using generic wind data supplied with CAP88-PC. The most recent data set increased the precipitation rate from 16 cm to 17.1 cm, based on 200 Area HMS data. Successfully conducting a CAP88-PC run requires familiarity with modeling assumptions used at the Hanford Site as well as site-specific wind data and some pathway parameters needed as input to the CAP88-PC software (e.g., Rhoads et al. 2008).

Components of a dose calculation are described in the sections that follow. Topics include numeric precision, radiological decay and decay chains, release height considerations, and selecting dose-per-unit-release values from the tables. Situations when no dose-per-unit-release factors are available for a nuclide of interest, or when use of the tabulated factors is not warranted, are also discussed. Finally, examples of release estimates and dose calculations for airborne releases in a NOC are provided.

Variations in wind data over time are usually relatively minor compared with other uncertainties in dose calculations. The emphasis placed on using a particular set of meteorological data is unlikely to have a significant impact on the overall conclusions of these calculations. For PTE calculations, using longer-term averaged meteorological data for the release location is more appropriate, whereas annual average meteorological data for the applicable calendar year is used for annual regulatory compliance reporting. Longer-term meteorological data are more representative of meteorological conditions for activities projected several years into the future.

When annual meteorological conditions change significantly, it is recommended that the dose-per-unit-release factors be updated. The dispersion factors generated by CAP88-PC will be checked periodically using an updated meteorological data set. If the degree of variance exceeds a factor of two between the dispersion factors used for this document and those newly generated for the periodic comparison checks, the dose-per-unit-release factors in this document should be updated.

3.1 CALCULATING RELEASES AND DOSES

Care should be taken to provide results at the appropriate level of precision. Use of significant digits should be in accordance with American Society for Testing and Materials (ASTM) *Standard Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications* (ASTM E29-13). To avoid compounding "rounding" errors, as many significant figures as possible should be carried through all calculations to the final result. Using spreadsheet software is recommended for all release calculations, since a computerized spreadsheet carries many digits but only displays the

number of significant digits specified for the cell of the spreadsheet. Final estimated doses to the MEI should be reported to no more than two significant figures, although CAP88-PC reports dose-per-unit-release factors to three significant figures.

When potential emissions are estimated from an inventory of radioactive material, the activity of each radionuclide in the inventory should be corrected for radioactive decay, if applicable. That is, if the date of the inventory estimate is prior to the date of the emissions estimate, decay correction should be considered if short-lived nuclides are involved. Significant errors may arise in the calculations if the elapsed time between the inventory estimate and the release estimate is long relative to the radionuclide half-life. Decay correction is particularly important when dealing with the ingrowth of long-lived progeny from shorter-lived parent nuclides (e.g., Am-241 from Pu-241). The following are the basic equations for radioactive decay.

$$\lambda = \frac{\ln 2}{T_{\frac{1}{2}}} \tag{3.1}$$

$$A(t) = A(0)\, e^{-\lambda t} \tag{3.2}$$

where λ = radioactive decay constant in s^{-1}, min^{-1}, hr^{-1}, day^{-1}, or yr^{-1}
$T_{1/2}$ = half-life of radionuclide in s, min, hr, day, or yr (same units as t)
$A(t)$ = current activity of a radionuclide in Ci or Bq at time t
$A(0)$ = initial activity of a radionuclide in Ci or Bq
t = time in s, min, hr, day, or yr (same units as $T_{1/2}$).

Radioactive decay data (e.g., half-lives, branching ratios, decay chains, and modes of decay) for most radionuclides can be found in ICRP 107 (ICRP 2008). While CAP88-PC (V4.0.1.17) uses a slightly older nuclide data library, the large majority of the decay chains are the same. Equations for decay chains can also be found in textbooks or reputable websites.

3.2 SELECTING THE APPROPRIATE DOSE-PER-UNIT-RELEASE FACTORS

Selecting appropriate dose-per-unit-release factors for the emission unit under consideration is extremely important. This section provides guidance for using the tables of dose-per-unit-release factors, determining effective release height, and how to handle radioactive decay chains.

3.2.1 Calculating Effective Release Height

Knowing the effective release height is necessary in order to use the tables of dose-per-unit-release factors in Section 4. In most cases, the effective release height is assumed to be the same as the physical above-grade elevation of the release point. However, when dealing with stacks and other systems that are actively ventilated, several other parameters may be considered.

Plume rise due to momentum or buoyant effects associated with the effluent stream can significantly increase the effective stack height, resulting in substantial differences in atmospheric dispersion estimates if it is not accurately accounted for. Plume rise from both buoyant and momentum effects may be added to the physical stack height to obtain the effective release height, as shown in Equation (3.3).

$$H_{eff} = H + \Delta h_m + \Delta h_b \tag{3.3}$$

where H_{eff} = effective release height for stacks in m
H = physical stack height (height above grade) in m
Δh_m = plume rise attributable to momentum in m
Δh_b = plume rise attributable to buoyancy in m.

The plume rise attributable to momentum can be determined using Equation (3.4) or Equation (3.5). Equation (3.5) is a simplified version of Equation (3.4) and thereby saves the user from calculating the velocity of stack emissions.

$$\Delta h_m = \frac{1.5\ v\ d}{\mu} \tag{3.4}$$

where Δh_m = plume rise attributable to momentum in m
v = effluent stack gas velocity in m/s
d = inside stack diameter in m
μ = average wind velocity in m/s.

When the stack flow rate and the stack diameter are known in the specified units of measurement, use Equation (3.5), which is a simplified equation for Δh_m. This equation includes all stack effluent parameters and uses 3.4 m/s (7.6 mph) for the average wind velocity (μ) at the Hanford Site (Hoitink et al. 2005).

$$\Delta h_m = (2.65E\text{-}04)\ \frac{F_{STP}}{d} \tag{3.5}$$

where Δh_m = plume rise attributable to momentum in m
d = inside stack diameter in m
F_{STP} = volumetric stack flow rate at standard temperature and pressure (STP) in cubic feet per minute (cfm).

Equations (3.6) through (3.9) can be used to calculate the plume rise attributable to plume buoyancy. Note that CAP88-PC used several equations for buoyant plume rise. The following equations apply where the distance from a source to receptor location is greater than 10 times the physical stack height and for atmospheric stability classes A, B, C, and D. This is the only buoyant plume-rise equation provided in this document, since it is the most appropriate equation for virtually every application that may be encountered at the Hanford Site. Equation (3.9) is a simplified version of Equations (3.6) through (3.8), which will save the user several calculational steps.

$$\Delta h_b = \frac{1.6\ (3.7E\text{-}05\ Q_H)^{\frac{1}{3}}\ (10\ H)^{\frac{2}{3}}}{\mu} \tag{3.6}$$

where Δh_b = plume rise attributable to buoyancy in m
Q_H = heat emission from stack in calories/second
H = physical stack height (height above grade) in m
μ = average wind velocity in m/s.

$$Q_H = 8.48E{+}04\ F_a \left(\frac{T_o}{T_a} - 1 \right) \tag{3.7}$$

where Q_H = heat emission from stack in cal/sec
T_a = ambient temperature in K
T_o = exit temperature of the stack gas in K
F_a = volumetric stack flow rate at T_a in m^3/s.

$$F_a = F_{STP} \sqrt{\frac{T_a}{T_S}} = 0.9948\ F_{STP} \tag{3.8}$$

where F_a = volumetric stack flow rate at T_a in m^3/s
F_{STP} = volumetric stack flow rate at STP in m^3/s
T_a = ambient temperature in K
T_s = standard temperature in K.

The following equation is a simplified equation for Δh_b when the physical stack height, stack flow rate, and stack temperature are known in the specified units of measurement. This equation includes all unit correction factors and uses 288.2 K (15.0°C) as standard temperature, 285.2 K (12.0°C) as the Hanford Site annual average ambient temperature, and 3.4 m/s (7.6 mph) as the average wind velocity (μ) at the Hanford Site (Hoitink et al. 2005).

$$\Delta h_b = 0.25\ H^{\frac{2}{3}} \left[F_{STP} \left(\frac{T_o}{285.2} - 1 \right) \right]^{\frac{1}{3}} \tag{3.9}$$

where Δh_b = plume rise attributable to buoyancy in m
F_{STP} = volumetric stack flow rate at STP in cfm
H = physical stack height (height above grade) in m
T_o = exit temperature of the stack gas in K.

3.2.2 Using Dose-Per-Unit-Release Factor Tables

Dose-per-unit-release factors have been calculated using CAP88-PC V4.0.1.17 for each emission zone associated with Hanford Site operations. Emission zones are associated with major operating areas on the Hanford Site, including the 100-K, 200 East, 200 West, 300, and 400 Areas. The emission zone in which an emission unit is located needs to be correctly identified to ensure accurate use of the corresponding set of dose-per-unit-release factors. Hanford Site emission zones are discussed further in Section 4.

The dose-per-unit-release factors listed in Section 4 are organized by effective release height and radionuclide. Generally, two sets of data are provided for each source and receptor combination to represent a range of effective release heights. Effective release heights less than 40 m were conservatively modeled at 10 m above grade, and should be used for release points with effective heights between ground level and 40 m above grade. Elevated releases were modeled using an effective release height of 40 m, which may be used for all effective release heights equal to or greater

than 40 m. Section 3.2.1 provides guidance on calculating the effective release height for a specific emission unit.

The results for iodine isotopes calculated by CAP88-PC version 4.0.1.17 have greater variance than those from V3. Therefore, several emission zone/release height configurations require additional review to determine radioiodine doses. These include a less-than-40-m release point in the 200-W Area and equal-to-or-greater-than-40-m release points in the 100-K, 200-E, 200-W, and 400 Areas. See Section 5.0 for details.

After the emission zone and effective release height of an emission unit are identified, the dose-per-unit-release factors for each nuclide in the source term can be obtained from the appropriate table in Section 4. If radioiodines could be significantly released, see Section 5.0. Nuclides in the tables are arranged in order of atomic number and then atomic mass. Several nuclides include variable chemical form information (i.e., hydrogen, carbon, and iodine).

3.2.3 Handling Radioactive Decay Chains

Many radionuclides decay into other radionuclides, creating a radioactive decay chain consisting of a parent nuclide and its radioactive progeny (i.e., decay products, or daughters). The current version of CAP88-PC V4 (Rosnick 2014) has an expanded radionuclide library, and it performs some radionuclide chain calculations differently than previous versions of the software. In Section 4, results of the dose calculations incorporate ingrowth of radioactive decay products following release of the parent radionuclide from the emission unit under consideration. Dose estimates that include contributions from radioactive decay products in addition to the parent radionuclide are designated with the parent radionuclide name and "+D."

The number of progeny included in the dosimetric calculation was consistent with that of DCPAK3 (Eckerman and Leggett 2013). For parent radionuclides where the decay chain contributes more than 10% of the total dose at any of the emission zones, the dose from the parent radionuclide alone is also listed (without the "+D" designation) following the dose for the entire chain. For the numerous nuclides added with CAP88-PC V4, nuclides that had used a surrogate in the prior revision of this document were assured review of appropriate parent-only dose factor reporting. Except in unusual cases, the dose for the entire decay chain (parent isotope +D) should be used in any calculation of dose. If the releases from an emission unit could include both a parent isotope and its radioactive decay products, each nuclide in the source term should be evaluated to determine if the decay products could be significant contributors to the total dose. If so, the source term should be adjusted to include significant decay products. The estimated emissions and dose-per-unit-release factors for each of the parent nuclides and each of the decay products should then be used to calculate the total dose.

Radioactive progeny are often excluded from inventories, especially if considerable time is required for significant ingrowth of the progeny. Sometimes progeny are inadvertently excluded, even when significant ingrowth could occur in a very short period of time. An example of this is Y-90, the progeny of Sr-90, which is inadvertently overlooked in many inventories and calculations. A source term of pure Sr-90 only requires 19 days for Y-90 to reach secular equilibrium with Sr-90, such that there are equal quantities present, in terms of radioactivity. Secular equilibrium is possible when the half-life of the parent nuclide is much greater than that of the progeny. The time needed for the first

decay product to reach secular equilibrium with its parent nuclide is approximately seven times the half-life of the decay product.

Branching ratios should also be accounted for in estimating radionuclide inventories. Nuclides that can decay into more than one radioactive product have characteristic branching ratios that represent the percentages of radioactive decays that transform into particular decay products. An example of this is Cs-137, which decays to Ba-137m 94.6% of the time while the other 5.4% of the time it decays to stable Ba-137. Because of the 94.6 % branching ratio, the activity of Ba-137m will approach 94.6% of the activity of Cs-137 within approximately seven half-lives (i.e., about 18 minutes).

Performing radioactive decay calculations is more difficult on more complex decay series because of branching ratios and different half-lives. Using a computer code such as Rad Toolbox Version 3.0.0 (Eckerman and Sjoreen 2013) is recommended for most radioactive decay calculations, especially when a nuclide has multiple decay products.

3.3 RADIONUCLIDES WITHOUT DOSE-PER-UNIT-RELEASE FACTORS

The radionuclide library in CAP88-PC V4.0.1.17 includes 1252 radionuclides, an almost complete set. However, some short-lived and other isotopes that could occasionally be of interest may not be available. In some cases, if no dose-per-unit-release factors were computed for a particular nuclide, the dose for another nuclide may be substituted for the nuclide not included in the CAP88-PC Library. Selection of an appropriate surrogate nuclide is very important to avoid nonconservative errors or grossly conservative errors. Ideally, the surrogate nuclide should have similar physical, radiological, and chemical characteristics to the missing isotope. The tables in Section 4.0 list recommended surrogate isotopes for some radionuclides that have been previously identified as missing from the CAP88-PC V4.0.1.17 library; other surrogate isotopes may be recommended as needed for radionuclides not currently included in the tables.

For some isotopes that are not in the CAP88-PC V4 library, surrogate radionuclides were identified to represent those isotopes when preparing dose calculations. There was no single method used in preparing the dose-per-unit-release factors for isotopes that were not in the CAP88-PC V4 library, and the approaches used are listed in order of preference below. Other methods may be applicable under some circumstances.

- Identify a surrogate radionuclide that is chemically and radiologically similar (i.e., same or related element, similar half-life, similar radiological decay mode and energy) that would result in a conservative dose estimate for the missing isotope (for example, C-15/C-11).
- Where the missing isotope has a metastable variant in the CAP88-PC V4 database, the related isotope from the library was used as a surrogate because the beginning and end states, and the total decay energy are generally the same (for example, Rh-105m/Rh-105).
- For very short-lived isotopes (i.e., half-life less than about two hours) that have complex decay chains, the first longer-lived decay product was used as the surrogate. The dose-per-unit-release factor for the surrogate was then adjusted to account for the quantity of surrogate that would result from the decay of 1 Ci of the parent isotope (no examples with V4).
- Where other options do not apply or are not viable, conservative surrogates may be used, such as Sr-90 for beta/gamma emitters and Pu-239 for alpha emitters.

3.4 WHEN SCENARIO-SPECIFIC CAP88-PC CALCULATIONS ARE WARRANTED

The following sections describe scenarios for which it is inappropriate to use the dose-per-unit-release factors in the tables of Section 4, or when calculating dose-per-unit-release factors for a specific scenario should be considered.

3.4.1 Emission Units Outside Emission Zones

When an emission unit is not located within or near one of the emission zones described in Section 4.0, CAP88-PC may be run for the specific location of the emission unit. One exception to this would be emission units between the 200 East and 200 West emission zones. For an emission unit in that location, use the dose-per-unit-release factors for the zone to which the emission unit is closest or use the table yielding the more conservative total dose.

3.4.2 Nonchronic Releases

Potential-to-emit calculations are usually performed for chronic release scenarios in which emissions are nearly continuous and the emission rate is relatively constant over an extended period of time. For purposes of this document, a chronic release is defined as nearly continuous for a period of at least 3 months. However, some of the release scenarios at the Hanford Site may occur over a relatively short period of time (i.e., less than 3 months), may be intermittent, and/or have variable emission rates. These types of releases are not considered chronic releases, which could make use of the dose-per-unit-release factors in Section 4 inappropriate.

The CAP88-PC model was designed to address only chronic releases. Currently, no regulatory-mandated, EPA-approved atmospheric-dispersion and dose-modeling codes are available to model other types of releases. Using CAP88-PC-generated dose-per-unit-release factors for short-term or high-level release scenarios could underestimate doses to the MEI in some cases.

An option for short-term releases is to use the GENII (Napier 2011) acute-release model to generate scenario-specific dose-per-unit-release factors, even when the release duration is less than one month. GENII should be used to generate dose-per-unit-release factors at the 95th percentile. The GENII model has been applied to Hanford Site radioactive emissions modeling for a number of years. However, using GENII or any model other than CAP88-PC for regulatory compliance or permitting calculations would require appropriate agency approval.

3.4.3 Estimated Doses Near 0.1 mrem/yr

When estimated doses are within an order of magnitude of 0.10 mrem/yr (i.e., 0.01 to 1.0 mrem/yr), a scenario-specific CAP88-PC run may be warranted to eliminate excess conservatism from the dose calculation. The benefits of a scenario-specific calculation should be carefully weighed because it could significantly increase the cost of performing and documenting the PTE estimates.

3.4.4 Default Absorption Types or Particle Sizes that are Inappropriate

The dose-per-unit-release factors calculated for this document use default assumptions in CAP88-PC V4 for particle size and chemical compound absorption via the lung and gastrointestinal tract. The absorption types in CAP88-PC V4 generally correspond to those recommended in FGR 13 (Eckerman et al. 1999). When the default absorption type or particle size for a nuclide is not appropriate and results in an unacceptably conservative or nonconservative dose estimate, a scenario-specific CAP88-PC calculation should be considered. In order to conduct such a calculation, the absorption type and/or the particle size in terms of activity median aerodynamic diameter must be known. The absorption types for many chemical compounds can be found in ICRP Publication 66 (ICRP 1994).

CAP88-PC V4 allows the user to toggle between the valid choices for absorption type and particle size. If no choices are evident (i.e., blank), the nuclide has no internal dose factors. Options for absorption type include F (particulate chemical forms with fast clearance rates), M (particulate chemical forms with moderate clearance rates), S (particulate chemical forms with slow clearance rates), G (gaseous compounds), and V (vapors). In addition, radiocarbon options include carbon monoxide and carbon dioxide options. Dose factors for tritium are reported based on chemical and physical form: H-3(V) = tritium as water vapor; H-3(E) = tritium as elemental gas; H-3(O) = tritium in organic compounds; H-3(F) = tritium in particulate form (fast clearance rate); H-3(M) = tritium in particulate form (moderate clearance rate); H-3(S) = tritium in particulate form (slow clearance rate).

Particle-size options in CAP88-PC V4 are limited to 1 μm for particulate isotopes, and 0 μm for gases and vapors, resulting in a single default setting for some radionuclides. The default absorption type and particle size used by CAP88-PC V4 for each nuclide are provided in Table 3.1. Additional chemical forms are available in CAP88-PC V4 for iodine (methyl iodides), mercury (inorganic, vapor, organic), and polonium (inorganic, organic), but these were not evaluated for this report.

If a user encounters a scenario that may significantly underestimate or overestimate the dose because of CAP88-PC-imposed limitations for absorption type and particle size, the user may seek approval from the regulatory agencies to use a more appropriate model.

3.4.5 Releases with Considerable Radioiodines

When developing the dose-per-unit-release factors in this document, an observation arose regarding the scenarios in which iodine nuclides are involved. The distances and directions to the MEI may be different for iodine isotopes in the following emissions zones and release heights: 100-K (≥40 m), 200 East (≥40 m), 200 West (<40 m and ≥40 m), and 400 (≥40 m) because the deposition rate differs from that assumed for other particulate and gaseous forms. For the areas indicated, alternative receptor locations and dose factors are provided for iodine isotopes only (see Section 5.0). A scenario-specific CAP88-PC run should be considered when an emission unit is located in one of these emission zones when the unabated dose attributable to a radioiodine accounts for 5% or more of the total dose for that emission source, using the dose-per-unit-release factors provided in Section 4.

3.4.6 Releases from Area Sources

When the ratio of receptor distance to source diameter for an area source is 2.5 or greater, that area source is modeled as a point source by CAP88-PC. However, the differences in the dose-per-unit-

release factors are insignificant (i.e., within a factor of two) even when the ratio is as low as 0.22. (For clarification, the "receptor distance/source diameter" ratio applies to the distance between the receptor location and the center of the area source—or for a noncircular area, the "centroid" of the source—and the "effective" diameter of the source. This would only apply to an onsite MEI because none of the offsite MEI locations are sufficiently close to Hanford emission zones for the source geometry to make a difference.) A scenario-specific CAP88-PC run is recommended when the receptor distance/source diameter ratio is less than 0.22.

$$d_{eff} = \sqrt{\frac{4\,A}{\pi}} \tag{3.10}$$

where d_{eff} = effective diameter of an area source (source diameter) in m
A = area of the source in m^2.

Table 3.1. Default FGR-13 Absorption Types and Particle Sizes in CAP88-PC

Nuclide[a]	**FGR-13 Absorption Type[a]**	**Particle size (µm)[b]**	**Nuclide**	**FGR-13 Absorption Type[a]**	**Particle size (µm) [b]**
H-3 (V)	V	0	Al-28	*b*	1
H-3 (E)	G	0	Si-31	M	1
H-3 (O)	G	0	**Si-32**	M	1
H-3 (F)	F	1	P-32	M	1
H-3 (M)	M	1	P-33	M	1
H-3 (S)	S	1	S-35	M	1
Be-7	M	1	Cl-36	M	1
Be-10	M	1	Ar-37	*b*	0
C-11	M	1	Ar-39	*b*	0
C-11 (CO)	G	0	Ar-41	*b*	0
C-11 (CO2)	G	0	Ar-42	*b*	0
C-14	M	1	K-40	M	1
C-14 (CO)	G	0	K-42	M	1
C-14 (CO2)	G	0	Ca-41	M	1
C-15(c)	-	-	Ca-45	M	1
N-13	*b*	0	Ca-47	M	1
O-15	*b*	0	**Sc-44**	M	1
O-19	b	0	**Sc-44m**	M	1
F-18	M	1	Sc-46	M	1
Na-22	M	1	Sc-47	M	1
Na-24	M	1	**Sc-48**	M	1
Mg-27	*b*	(1)	Ti-44	M	1
Mg-28	M	1	Ti-45	M	1
Al-26	M	1	Ti-51	*b*	(1)

Table 3.1. (contd)

Nuclide	FGR-13 Absorption Type[a]	Particle size (µm) [b]
V-48	M	1
V-49	M	1
Cr-49	M	1
Cr-51	M	1
Cr-55	*b*	(1)
Mn-52	M	1
Mn-52m	M	1
Mn-53	M	1
Mn-54	M	1
Mn-56	M	1
Fe-55	M	1
Fe-59	M	1
Co-56	M	1
Co-57	M	1
Co-58	M	1
Co-58m	M	1
Co-60	M	1
Co-60m	M	1
Ni-56	M	1
Ni-57	M	1
Ni-59	M	1
Ni-63	M	1
Ni-65	M	1
Cu-64	M	1
Cu-66	b	(1)
Cu-67	M	1
Zn-65	M	1
Zn-69	M	1
Zn-69m	M	1
Ga-67	M	1
Ga-68	M	1
Ga-70	M	1
Ga-72	M	1
Ge-68	M	1
Ge-69	M	1
Ge-71	M	1
Ge-75	M	1
Ge-77	M	1
As-73	M	1
As-74	M	1
As-76	M	1
As-77	M	1
Se-75	F	1
Se-77m	b	(1)
Se-79	F	1
Se-79m	*b*	(1)
Br-82	M	1
Br-82m	*b*	(1)

Nuclide	FGR-13 Absorption Type[a]	Particle size (µm) [b]
Br-83	M	1
Br-84	M	1
Br-84m	*b*	(1)
Br-85	*b*	(1)
Kr-81	*b*	0
Kr-81m	*b*	0
Kr-83m	*b*	0
Kr-85	*b*	0
Kr-85m	*b*	0
Kr-87	*b*	0
Kr-88	*b*	0
Kr-89	*b*	0
Kr-90(c)	-	-
Rb-81	M	1
Rb-81m	M	1
Rb-82	b	(1)
Rb-82m	M	1
Rb-83	M	1
Rb-84	M	1
Rb-84m	b	(1)
Rb-86	M	1
Rb-86m	b	(1)
Rb-87	M	1
Rb-88	M	1
Rb-89	M	1
Rb-90	*b*	(1)
Rb-90m	*b*	(1)
Sr-82	M	1
Sr-83	M	1
Sr-85	M	1
Sr-85m	M	1
Sr-87m	M	1
Sr-89	M	1
Sr-90	M	1
Sr-91	M	1
Sr-92	M	1
Y-88	M	1
Y-89m	b	(1)
Y-90	M	1
Y-90m	M	1
Y-91	M	1
Y-91m	M	1
Y-92	M	1
Y-93	M	1
Zr-88	M	1
Zr-89	M	1
Zr-89m	b	(1)
Zr-93	M	1

Table 3.1. (contd)

Nuclide	FGR-13 Absorption Type[a]	Particle size (µm) [b]
Zr-95	M	1
Zr-97	M	1
Nb-91	*b*	(1)
Nb-91m	*b*	(1)
Nb-92	*b*	(1)
Nb-92m	b	(1)
Nb-93m	M	1
Nb-94	M	1
Nb-94m	b	(1)
Nb-95	M	1
Nb-95m	M	1
Nb-96	M	1
Nb-97	M	1
Nb-97m	M	1
Mo-93	M	1
Mo-93m	M	1
Mo-99	M	1
Tc-95	M	1
Tc-95m	M	1
Tc-96	M	1
Tc-96m	M	1
Tc-97	M	1
Tc-97m	M	1
Tc-98	M	1
Tc-99	M	1
Tc-99m	M	1
Tc-101	M	1
Ru-97	M	1
Ru-103	M	1
Ru-105	M	1
Ru-106	M	1
Rh-101	M	1
Rh-101m	M	1
Rh-102	M	1
Rh-102m	M	1
Rh-103m	M	1
Rh-104	b	(1)
Rh-104m	b	(1)
Rh-105	M	1
Rh-105m(c)	-	-
Rh-106	*b*	1
Pd-103	M	1
Pd-107	M	1
Pd-109	M	1
Pd-109m	b	(1)
Pd-111	b	(1)
Pd-112	b	(1)
Ag-108	*b*	1

Nuclide	FGR-13 Absorption Type[a]	Particle size (µm) [b]
Ag-108m	M	1
Ag-109m	*b*	1
Ag-110	*b*	1
Ag-110m	M	1
Ag-111	M	1
Ag-111m	b	(1)
Ag-112	M	1
Cd-107	M	1
Cd-109	M	1
Cd-111m	b	1
Cd-113	M	1
Cd-113m	M	1
Cd-115	M	1
Cd-115m	M	1
Cd-117	M	1
Cd-117m	M	1
In-106	*b*	(1)
In-111	M	1
In-111m	b	(1)
In-112	M	1
In-112m	b	(1)
In-113m	M	1
In-114	*b*	1
In-114m	M	1
In-115	M	1
In-115m	M	1
In-116m	M	1
In-117	M	1
In-117m	M	1
Sn-113	M	1
Sn-113m	b	(1)
Sn-117m	M	1
Sn-119m	M	1
Sn-121	M	1
Sn-121m	M	1
Sn-123	M	1
Sn-123m	M	1
Sn-125	M	1
Sn-125m	b	(1)
Sn-126	M	1
Sb-122	M	1
Sb-122m	b	(1)
Sb-124	M	1
Sb-124m	b	(1)
Sb-124n	M	1
Sb-125	M	1
Sb-126	M	1
Sb-126m	M	1

Table 3.1. (contd)

Nuclide[a]	FGR-13 Absorption Type[a]	Particle size (µm) [b]
Sb-127	M	1
Sb-128	M	1
Sb-128m	M	1
Te-121	M	1
Te-121m	M	1
Te-123	M	1
Te-123m	M	1
Te-125m	M	1
Te-127	M	1
Te-127m	M	1
Te-129	M	1
Te-129m	M	1
Te-131	M	1
Te-131m	M	1
Te-132	M	1
Te-132	M	1
Te-133	M	1
Te-133m	M	1
Te-134	M	1
I-122	*b*	1
I-122 (V)(c)	-	-
I-123	F	1
I-123 (V)	*V*	0
I-124	F	1
I-124(V)	*V*	0
I-125	F	1
I-125 (V)	*V*	0
I-126	F	1
I-126 (V)	*V*	0
I-128	F	1
I-128 (V)	*V*	0
I-129	F	1
I-129 (V)	*V*	0
I-130	F	1
I-130 (V)	*V*	0
I-130m	*b*	(1)
I-130m (V)(c)	-	-
I-131	F	1
I-131 (V)	*V*	0
I-132	F	1
I-132 (V)	*V*	0
I-132m	F	1
I-132m (V)	*V*	0
I-133	F	1
I-133 (V)	*V*	0
I-133m(c)	-	-
I-134	F	1
I-134 (V)	*V*	0

Nuclide[a]	FGR-13 Absorption Type[a]	Particle size (µm) [b]
I-134m	*b*	(1)
I-134m (V) (c)	-	-
I-135	F	1
I-135 (V)	*V*	0
Xe-122	*b*	0
Xe-123	*b*	0
Xe-125	*b*	0
Xe-127	*b*	0
Xe-127m	*b*	0
Xe-129m	*b*	0
Xe-131m	*b*	0
Xe-133	*b*	0
Xe-133m	*b*	0
Xe-135	*b*	0
Xe-135m	*b*	0
Xe-137	*b*	0
Xe-138	*b*	0
Cs-131	F	1
Cs-132	F	1
Cs-134	F	1
Cs-134m	F	1
Cs-135	F	1
Cs-135m	F	1
Cs-136	F	1
Cs-137	F	1
Cs-138	F	1
Cs-138m	b	(1)
Cs-139	*b*	(1)
Cs-140	b	(1)
Ba-131	M	1
Ba-131m	M	1
Ba-133	M	1
Ba-133m	M	1
Ba-135m	M	1
Ba-137m	*b*	1
Ba-139	M	1
Ba-140	M	1
Ba-141	M	1
Ba-142	M	1
La-137	M	1
La-138	M	1
La-140	M	1
La-141	M	1
La-142	M	1
Ce-139	M	1
Ce-141	M	1
Ce-142(c)	-	-
Ce-143	M	1

Table 3.1. (contd)

Nuclide	FGR-13 Absorption Type[a]	Particle size (µm) [b]
Ce-144	M	1
Pr-142	M	1
Pr-142m	M	1
Pr-143	M	1
Pr-144	M	1
Pr-144m	M	1
Nd-144	*b*	(1)
Nd-147	M	1
Pm-143	M	1
Pm-144	M	1
Pm-145	M	1
Pm-146	M	1
Pm-147	M	1
Pm-148	M	1
Pm-148m	M	1
Pm-149	M	1
Pm-150	M	1
Pm-151	M	1
Sm-145	M	1
Sm-146	M	1
Sm-147	M	1
Sm-148	b	(1)
Sm-151	M	1
Sm-153	M	1
Sm-155	M	1
Sm-156	M	1
Sm-157	*b*	(1)
Eu-150	M	1
Eu-150m	M	1
Eu-152	M	1
Eu-152m	M	1
Eu-152n	b	(1)
Eu-154	M	1
Eu-154m	b	(1)
Eu-155	M	1
Eu-156	M	1
Eu-157	M	1
Gd-148	M	1
Gd-149	M	1
Gd-150	b	(1)
Gd-151	M	1
Gd-152	M	1
Gd-153	M	1
Gd-159	M	1
Tb-157	M	1
Tb-158	M	1
Tb-160	M	1
Tb-161	M	1

Nuclide	FGR-13 Absorption Type[a]	Particle size (µm) [b]
Dy-159	M	1
Dy-165	M	1
Ho-163	b	(1)
Ho-164	M	1
Ho-164m	M	1
Ho-166	M	1
Ho-166m	M	1
Er-169	M	1
Er-171	M	1
Tm-168	b	(1)
Tm-170	M	1
Tm-171	M	1
Yb-164	*b*	(1)
Yb-165	b	(1)
Yb-166	M	1
Yb-167	M	1
Yb-169	M	1
Yb-175	M	1
Yb-177	M	1
Lu-177	M	1
Lu-177m	M	1
Hf-175	M	1
Hf-177m	M	1
Hf-178(c)	n/a	n/a
Hf-178m	M	1
Hf-179m	M	1
Hf-180m	M	1
Hf-181	M	1
Hf-182	M	1
Ta-179	M	1
Ta-180	M	1
Ta-182	M	1
Ta-182m	M	1
Ta-183	M	1
W-181	M	1
W-185	M	1
W-185m	b	(1)
W-187	M	1
W-188	M	1
Re-186	M	1
Re-186m	M	1
Re-187	M	1
Re-188	M	1
Os-185	M	1
Os-191	M	1
Ir-189	M	1
Ir-190	M	1
Ir-192	M	1

Table 3.1. (contd)

Nuclide	FGR-13 Absorption Type[a]	Particle size (µm) [b]
Ir-194	M	1
Pt-191	M	1
Pt-193	M	1
Pt-193m	M	1
Pt-195m	M	1
Pt-197	M	1
Pt-197m	M	1
Pt-199	M	1
Au-193	M	1
Au-193m	b	(1)
Au-194	M	1
Au-195	M	1
Au-195m	b	(1)
Au-196	b	(1)
Au-196m	b	(1)
Au-198	M	1
Au-198m	M	1
Au-199	M	1
Hg-203	M	1
Hg-205	b	(1)
Hg-206	b	(1)
Tl-200	M	1
Tl-201	M	1
Tl-202	M	1
Tl-204	M	1
Tl-206	*b*	1
Tl-206m	b	(1)
Tl-207	*b*	1
Tl-208	*b*	1
Tl-209	*b*	1
Tl-210	b	(1)
Pb-203	M	1
Pb-204m	b	(1)
Pb-205	M	1
Pb-209	M	1
Pb-210	M	1
Pb-211	M	1
Pb-212	M	1
Pb-214	M	1
Bi-207	M	1
Bi-208	b	(1)
Bi-210	M	1
Bi-210m	M	1
Bi-211	b	1
Bi-212	M	1
Bi-212n	b	(1)
Bi-213	M	1
Bi-214	M	1

Nuclide	FGR-13 Absorption Type[a]	Particle size (µm) [b]
Po-208	*b*	(1)
Po-209	*b*	(1)
Po-210	M	1
Po-211	*b*	1
Po-212	*b*	1
Po-212m	b	(1)
Po-213	*b*	1
Po-214	*b*	1
Po-215	*b*	1
Po-216	*b*	1
Po-218	*b*	1
At-217	*b*	1
At-218	b	(1)
Rn-218	b	0
Rn-219	*b*	0
Rn-220	*b*	0
Rn-222	*b*	0
Rn-224(c)	-	-
Fr-221	*b*	1
Fr-222	M	1
Fr-223	M	1
Ra-223	M	1
Ra-224	M	1
Ra-225	M	1
Ra-226	M	1
Ra-227	M	1
Ra-228	M	1
Ac-225	M	1
Ac-226	M	1
Ac-227	M	1
Ac-228	M	1
Th-227	S	1
Th-228	S	1
Th-229	S	1
Th-230	S	1
Th-231	S	1
Th-232	S	1
Th-233	*b*	(1)
Th-234	S	1
Pa-231	M	1
Pa-232	M	1
Pa-233	M	1
Pa-234	M	1
Pa-234m	*b*	1
U-232	M	1
U-233	M	1
U-234	M	1
U-235	M	1

Table 3.1. (contd)

Nuclide	FGR-13 Absorption Type[a]	Particle size (µm) [b]	Nuclide	FGR-13 Absorption Type[a]	Particle size (µm) [b]
U-235m	b	(1)	Am-242	M	1
U-236	M	1	Am-242m	M	1
U-237	M	1	Am-243	M	1
U-238	M	1	**Am-244**	M	1
U-239	M	1	**Am-244m**	M	1
U-240	M	1	Am-245	M	1
Np-235	M	1	**Am-246**	M	1
Np-236	M	1	Cm-241	M	1
Np-236m	M	1	Cm-242	M	1
Np-237	M	1	Cm-243	M	1
Np-238	M	1	Cm-244	M	1
Np-239	M	1	Cm-245	M	1
Np-240	M	1	Cm-246	M	1
Np-240m	*b*	1	Cm-247	M	1
Pu-234	M	1	**Cm-248**	M	1
Pu-235	M	1	**Cm-249**	M	1
Pu-236	M	1	**Cm-250**	M	1
Pu-237	M	1	**Bk-247**	M	1
Pu-238	M	1	**Bk-248m**	b	(1)
Pu-239	M	1	Bk-249	M	1
Pu-240	M	1	Bk-250	M	1
Pu-241	M	1	Cf-249	M	1
Pu-242	M	1	Cf-250	M	1
Pu-243	M	1	Cf-251	M	1
Pu-244	M	1	Cf-252	*M*	1
Am-240	M	1	Es-254	M	1
Am-241	M	1	<blank>	<blank>	<blank>

Bold nuclide, shaded = new nuclide in CAP88-PC V4 or newly reported in DOE/RL-2006-29 Rev2.
Italic absorption type, shaded = new solubility class in DOE/RL-2006-29 Rev2.
Solubility class b = blank, no internal dose factors available for this (parent) nuclide.

(a) V = vapor; E = elemental; O = organic compounds; F = particulate, fast clearance rate; M = particulate, moderate clearance rate; S = particulate, slow clearance rate. Carbon isotopes are modeled as particulate (M), carbon monoxide (CO), or carbon dioxide (CO2). FGR-13 (Eckerman et al. 1999)

(b) Particle size of "(1)" is where a 1 micrometer size is the preferred option, but "0" is the only available option in CAP88-PC V4.0.1.17.

(c) Radionuclide not available in CAP88-PC V4 (Rosnick 2014)

3.4.7 Releases Dominated by Short-Lived Radionuclides

When developing the dose-per-unit-release factors for locations not included in this document, be aware that the distances and directions to MEIs may differ for predominantly long-lived and predominantly short-lived nuclide source terms. A single MEI was chosen for an emission zone, may result in an acceptably small error for most scenarios, in some cases. However, the error may become significant if releases are dominated by short-lived nuclides – now a highly unlikely scenario at the Hanford Site – other than those produced by ingrowth from longer-lived parents (e.g., Y-90 and Ba-137m, whose longer-lived parents are Sr-90 and Cs-137, respectively).

A scenario-specific CAP88-PC run should be considered when an emission unit is located in a new emission zone and the calculated unabated dose attributable to any specific short-lived nuclide accounts for 5% or more of the total dose for that emission source. This does not apply to the 200 East, 200 West, 300, and 400 Area emission zones, because the distances and directions to respective MEIs are the same for both short-lived and long-lived nuclides. The 100-K Area emission zone would apply a closer, 8,900 m NNW receptor location if short-lived nuclides account for the majority of the dose.

3.5 CALCULATING DOSES

The dose-per-unit-release factors in this document were calculated using CAP88-PC V4.0.1.17, a computer model developed for chronic release scenarios (i.e., nearly continuous for a period of at least 3 months). These dose-per-unit-release factors are not appropriate for acute-release scenarios (releases lasting a few hours to days). The user should refer to Section 3.4.2 when a release cannot be considered chronic.

EXAMPLE 1

The PTE is calculated using Method 1 for a facility located in the eastern 300 Area and greater than 250 m away from the Columbia River. Emissions will be ventilated at an average stack flow rate of 2,000 cfm (0.944 m^3/s) from a 6-in.- (0.1524-m-) diameter stack that is 82 ft (25 m) above grade. The stack effluent control system consists of a single bank of HEPA filters. The facility has an inventory of liquid radioactive material, last determined 10 years ago. The process used by the facility heats the source term to a temperature of 150ºC (423 K), which produces emissions that exit the stack at an average temperature of 100ºC (373 K). The boiling point for the entire source term is 100ºC (373 K).

Table 3.2 lists the radionuclide inventory from 10 years ago and the current inventory corrected for radioactive decay and ingrowth using Equations (3.1) and (3.2). Note the increase in the inventory of Am-241 due to the decay of the parent nuclide, Pu-241.

Using Appendix D from 40 CFR Part 61, the release fraction for this inventory is 1 because the source term is heated to over 100ºC. For gases, 1 is the appropriate release fraction. In addition, unabated PTE calculations assume no effluent control devices exist; therefore, a HEPA filter removal factor of 1 is used. Using the release fraction of 1 results in the annual release being equivalent to the radionuclide inventory.

Plume rise attributable to momentum and buoyancy was estimated for this stack because of the small stack diameter and high temperature of the emissions. Using Equation (3.5), the plume rise

attributable to momentum was calculated to be 3.5 m, and using Equation (3.9), the plume rise attributable to buoyancy was calculated to be 17.4 m. Using Equation (3.3), the effective stack height (H_{eff}) was calculated to be 45.9 m. As a result, the dose-per-unit-release factors for elevated releases may be used because the H_{eff} is ≥ 40 m, even though the physical stack height is only 25 m. Table 3.3 provides the PTE data and subsequent doses to the MEI for Example 1.

Table 3.2. Example 1: Decay-Corrected Radionuclide Inventory

Nuclide	Inventory Determined 10 years ago, Ci	Decay-Corrected Inventory, Ci
H-3	2.00 E+01	1.14 E+01
Co-60	1.0 E-03	2.7 E-04
Sr-90	3.0 E-04	2.4 E-04
Y-90	3.0 E-04	2.4 E-04
Zr-95	2.0 E-04	0.0
Cs-137	5.0 E-03	4.0 E-03
Ba-137m	5.0 E-03	3.8 E-03
Pu-239	9.0 E-06	9.0 E-06
Pu-241	8.5 E-04	5.2 E-04
Am-241	0.0	1.1 E-05

Table 3.3. Example 1: PTE Calculation for an Elevated Release from the Eastern 300 Area

Nuclide[(a)b)]	Unabated Annual Releases, Ci/yr	Release Fraction [(b)]	HEPA Filter Removal Factor	Unabated and Abated Annual Release, Ci/yr	300 Area ≥40-m Dose-per-Unit-Release Factor, mrem/Ci	Unabated PTE to Offsite MEI, mrem/yr
H-3 (V)	1.1 E+01	1	1	1.1 E+01	5.59 E-05	6.1 E-04
Co-60	2.7 E-04	1	1	2.7 E-04	1.03 E+00	2.8 E-04
Sr-90+D	2.4 E-04	1	1	2.4 E-04	1.18 E+00	2.8 E-04
Y-90	2.4 E-04	1	1	2.4 E-04	4.86 E-04	1.2 E-07
Zr-95+D	0.0	1	1	0.0	2.49 E-02	0
Cs-137+D	4.0 E-03	1	1	4.0 E-03	1.47 E+00	5.9 E-03
Ba-137m	3.8 E-03	1	1	3.8 E-03	1.23 E-05	4.7 E-08
Pu-239+D	9.0 E-06	1	1	9.0 E-06	1.62 E+01	1.5 E-04
Pu-241+D	5.3 E-04	1	1	5.3 E-04	3.03 E-01	1.6 E-04
Am-241+D	1.1 E-05	1	1	1.1 E-05	1.34 E+01	1.5 E-04
					Total offsite dose ►	7.5 E-03

(a) +D = Dose-per-unit-release factor includes decay products ingrown following release of the parent radionuclide.
(b) The release fraction and the unabated HEPA filter removal factor are both 1 because the source term is heated to ≥100ºC and the temperature of the emissions is assumed to be ≥100ºC, making them behave as a gas.

EXAMPLE 2

The PTE is calculated using Method 1 for a contaminated burial ground located in the eastern 300 Area. All releases occur at ground level with no effluent control technology in use. The burial

ground is a 1,000-m-by-500-m area (i.e., 5.0 E+05 m^2). The radioactive source term within the burial ground is contaminated soil, recently determined from the analysis of soil samples.

Using Appendix D of 40 CFR Part 61, the release fraction for this inventory is 1.0 E-03 because the source term is a particulate solid. The effective diameter of the burial ground calculated to be 798 m using Equation (3.10). The receptor distance/source diameter ratio is 1.50, which is well above the 0.22 minimum recommended in Section 3.4.6. Table 3.4 provides the PTE data and subsequent doses to the MEI for Example 2.

Table 3.4. Example 2: PTE Calculation for a Ground-Level Release from the Eastern 300 Area

Nuclide	Inventory in Soil, Ci	Appendix D Release Fraction	Unabated and Abated Release Rate, Ci/yr	300 Area 10-m Dose-per-Unit-Release Factor, mrem/Ci	Unabated and Abated PTE to MEI, mrem/yr
U-234+D	2.5 E+00	1 E-03	2.5 E-03	3.56 E+00	8.9 E-03
U-235+D	1.2 E-01	1 E-03	1.2 E-04	4.25 E+00	5.1 E-04
U-238+D	2.5 E+00	1 E-03	2.5 E-03	3.76 E+00	9.4 E-03
				Total dose ►	1.9 E-02
+D = Dose-per-unit-release factor includes decay products ingrown following release of the parent radionuclide.					

3.6 REPORTING RELEASES AND DOSES IN A NOTICE OF CONSTRUCTION

Once the PTE is determined, it is critical that the releases and doses reported in the NOC be put into terms consistent with the measurement method. The PTE values generally become the emission limits for an NOC, making this conversion essential for purposes of demonstrating compliance to the emission limits.

If the NOC addresses a new activity associated with an existing emission unit, it is necessary to establish the release limits for the entire emission unit in addition to those for the new activity. In such cases, one would need to add the releases and doses associated with the proposed new activity to the releases and doses related to other activities affecting the same emission unit. It is usually very difficult or impossible to demonstrate compliance to an NOC when the emission limits are for a specific activity and the compliance measurement is for the entire emission unit and all the activities ventilated by that emission unit.

Emission limits should be checked for detectability prior to specifying the limits and measurement method in the NOC. Measurement methods specified in the NOC must be sufficiently sensitive to demonstrate that emission limits have not been exceeded. The method for determining whether or not a record sampling method is sensitive enough to verify emission limits for a stack is outlined in Equations (3.11) and (3.12). Equation 3.11 only applies to emission units using record sampling.

$$MDL = 0.02832\ (MDC)(V_{stk}) \tag{3.11}$$

where MDL = minimum detection level for an analyte on a specific stack in Ci/yr
MDC = minimum detectable concentration for an analyte in µCi/mL
V_{stk} = annual stack discharge volume in ft^3/yr

In Equation (3.11), 0.02832 is a conversion constant comprising the conversion factors between ft^3 and mL (i.e., 1 ft^3 = 28,320 mL, in which the multiplier factor of 28,320 is used when converting ft^3 to mL) and between µCi and Ci (i.e., 1 µCi = 1 E-6 Ci, in which the multiplier factor of 1 E-6 is used when converting µCi to Ci); thus, the overall conversion constant is the product of 28,320 x 1 E-6.

$$MDC = 3.531E\text{-}11 \left(\frac{MDA}{V_s} \right) \tag{3.12}$$

where MDC = minimum detectable concentration for an analyte in µCi/mL
MDA = minimum detectable activity for an analyte in pCi [from the lab providing the analysis, or other applicable criteria established by contract.]
V_s = sample volume in ft^3.

When measurement methods other than record sampling are used, it is essential that the measurement used to demonstrate compliance with emission limits be specified in the NOC. As an example, the NOC for a portable temporary radioactive air emission unit (PTRAEU) uses handling limits to link the measurements to the emission limits. The PTRAEU NOC uses smear data to verify the handling limits specified in the NOC. The handling limits were established such that the emission limits would not be exceeded as long as the handling limits are observed. Example 3 illustrates why these considerations are significant.

EXAMPLE 3

A hypothetical facility located in the 200 East Area contains contaminated equipment. The main building of the facility is ventilated by a single 30-m stack equipped with a single HEPA filter and operating continuously at 2,500 cfm (1.18 m^3/s). The temperature of stack effluent is less than 25ºC, which results in an effective stack height less than 40 m. The stack has a PTE of less than or equal to 0.1 mrem/yr. Record sampling is used as the periodic confirmatory measurement method. The facility is planning to sample the stack continuously and collect record samples biweekly. Only 4 of the 26 record samples collected annually will be analyzed to demonstrate compliance with the permit limits. Each of the samples used for the periodic confirmatory measurements will analyzed for gross alpha and gross beta activity. The stack has been assessed with the PTE shown in Table 3.5.

The measurement method only includes total alpha and total beta analyses. Therefore, the radionuclide-specific information in Table 3.5 must be put into terms of total alpha activity and total beta activity to allow comparison with the sampling results. Table 3.6 contains the converted data. The unabated releases for all of the alpha-emitting and beta-emitting nuclides listed in Table 3.5 were summed separately to obtain the totals in Table 3.6. The most conservative dose-per-unit-release factors for the alpha- and beta-emitting nuclides in this example (Pu-239 and Pu-241, respectively) were used to calculate the doses. Note that Ba-137m was not included in the beta release totals in the table because it only emits gamma rays and its unabated PTE accounts for less than 10% of the total potential-to-emit for the stack, less than 0.1 mrem/yr, and less than 25% of the abated PTE.

Table 3.5. Example 3: Original Assessed Potential-to-Emit for the Stack

Nuclide	Unabated Release Rate, Ci/yr	HEPA Filter Removal Factor	Abated Release Rate, Ci/yr	200 East Area 10-m (Onsite) Dose-per-Unit-Release Factor, mrem/Ci	Unabated Dose to Onsite MEI, mrem/yr	Abated Dose to Onsite MEI, mrem/yr
Sr-90+D$^{\beta}$	2.2 E-05	3,000	7.3 E-09	4.0 E-02	8.8 E-07	2.9 E-10
Y-90$^{\beta}$	2.2 E-05	3,000	7.3 E-09	9.3 E-05	2.0 E-09	6.8 E-13
Cs-137+D$^{\beta}$	5.3 E-05	3,000	1.8 E-08	7.8 E-03	4.1 E-07	1.4 E-10
Ba-137m	5.0 E-05	3,000	1.7 E-08	1.8 E-15	9.0 E-20	3.1 E-23
Pu-239+D$^{\alpha}$	1.6 E-06	3,000	5.3 E-10	3.3 E+00	5.3 E-06	1.7 E-09
Pu-240+D$^{\alpha}$	1.6 E-06	3,000	5.3 E-10	3.3 E+00	5.3 E-06	1.7 E-09
Pu-241+D$^{\beta}$	3.0 E-04	3,000	1.0 E-07	6.0 E-02	1.8 E-05	6.0 E-09
Am-241+D$^{\alpha}$	1.5 E-04	3,000	5.0 E-08	2.7 E+00	4.1 E-04	1.4 E-07
				Total dose ►	4.3 E-04	1.4 E-07

$^{\alpha}$ = Nuclide is an alpha emitter.
$^{\beta}$ = Nuclide is a beta emitter.
+D = Dose-per-unit-release factor includes decay products ingrown following release of the parent radionuclide.

Table 3.6. Example 3: Original Assessed Potential-to-Emit for the Stack NOC

Type of Activity	Unabated Release Rate, Ci/yr	HEPA Filter Removal Factor	Abated Release Rate, Ci/yr	200 East Area 10-m (Onsite) Dose-per-Unit-Release Factor, mrem/Ci	Unabated Dose to Onsite MEI, mrem/yr	Abated Dose to Onsite MEI, mrem/yr
Gross alpha (as Pu-239)	1.5 E-04	3,000	5.1 E-08	3.3 E+00	5.1 E-04	1.7 E-07
Gross beta (as Pu-241)	4.0 E-04	3,000	1.3 E-07	6.0 E-02	2.4 E-05	8.0 E-09
				Total dose ►	5.3 E-04	1.8 E-07

A new activity is proposed for the facility, which will be used to repackage material sent to it over the course of several months. The PTE releases and doses associated with the material involved in the new activity have been assessed and are included as Table 3.7. For this assessment, doses to both an offsite and onsite MEI were considered, in accordance with WDOH and EPA guidance. The offsite MEI dose for the new activity exceeds the dose for the onsite MEI; however, the PTE for this new activity needs to be added into the original PTE for the stack in order to determine its designation and emission limits. Table 3.8 provides the assessed PTE for all activities that will be ventilated by this stack. When all radionuclides potentially released from the facility are considered, the unabated dose for the greater receptor estimate (onsite or offsite) is reported for purposes of permitting the facility in the NOC.

Table 3.7. Example 3: Assessed Potential-to-Emit for the New Activity

Nuclide	Unabated Release Rate, Ci/yr	HEPA Filter Removal Factor	Abated Release Rate, Ci/yr	200 East Area 10-m (Offsite) Dose-per-Unit-Release Factor, mrem/Ci	Unabated Dose to Offsite MEI, mrem/yr	Abated Dose to Offsite MEI, mrem/yr
H-3 (V) [β]	1.0 E+00	1	1.0 E+00	1.2 E-05	1.2 E-05	1.2 E-05
Cs-137+D [β]	4.3 E-04	3,000	1.4 E-07	2.4 E-01	1.0 E-04	3.4 E-08
Ba-137m	4.1 E-04	3,000	1.4 E-07	5.2 E-17	2.1 E-20	7.3 E-24
Eu-152+D [β]	6.2 E-05	3,000	2.1 E-08	1.5 E-01	9.5 E-06	3.2 E-10
				Total dose ►	1.2 E-04	1.2 E-05

[β] = Nuclide is a beta emitter; Eu-152 decays by β emission 27.9% of the time.
+D = Dose-per-unit-release factor includes decay products ingrown following release of the parent radionuclide.

Again, the measurement method only includes gross alpha and gross beta analyses for particulate radionuclides, so the nuclide-specific information in Table 3.8 must be put in terms of gross alpha activity and gross beta activity. Table 3.9 contains the converted particulate data and also tritium results. For purposes of the assessment, tritium (H-3), a beta-emitting nuclide, is treated as a vapor that would not be removed by HEPA filtration. Separate sampling for H-3 may be required because it accounts for greater than 25% of the abated PTE; although it contributes 10% of the total unabated PTE, the PTE dose is much less than 0.1 mrem/yr. Also, because Eu-152 only decays by beta emission 27.9% of the time, its activity was adjusted by a factor of 0.279 in the total beta release calculation. As before, Ba-137m was not included in the beta totals because it only emits gamma rays and did not require sampling. In this case, the dose-per-unit-release factors for Pu-239+D and Cs-137+D were used to calculate the particulate doses to an offsite MEI, the maximum unabated dose receptor, because they represented the maximums for the alpha- and beta-emitting constituents, respectively.

Table 3.8. Example 3: Assessed Potential-to-Emit for Stack, Including New Activity

Nuclide	Unabated Release Rate, Ci/yr	HEPA Filter Removal Factor	Abated Release Rate, Ci/yr	200 East Area 10-m (Offsite) Dose-per-Unit-Release Factor, mrem/Ci	Unabated Dose to Offsite MEI, mrem/yr	Abated Dose to Offsite MEI, mrem/yr
H-3 (V)	1.0 E+00	1	1.0 E+00	1.2 E-05	1.2 E-05	1.2 E-05
Sr-90+D	2.2 E-05	3,000	7.3 E-09	1.9 E-01	4.2 E-06	1.4 E-09
Y-90	2.2 E-05	3,000	7.3 E-09	8.1 E-05	1.8 E-09	5.9 E-13
Cs-137+D	4.8 E-04	3,000	1.6 E-07	2.4 E-01	1.2 E-04	3.8 E-08
Ba-137m	4.6 E-04	3,000	1.5 E-07	5.2 E-17	2.4 E-20	7.8 E-24
Eu-152+D	6.2 E-05	3,000	2.1 E-08	1.5 E-01	9.5 E-06	3.2 E-09
Pu-239+D	1.6 E-06	3,000	5.3 E-10	2.8 E+00	4.5 E-06	1.5 E-09
Pu-240+D	1.6 E-06	3,000	5.3 E-10	2.8 E+00	4.5 E-06	1.5 E-09
Pu-241+D	3.0 E-04	3,000	1.0 E-07	5.2 E-02	1.6 E-05	5.2 E-09
Am-241+D	1.5 E-04	3,000	5.0 E-08	2.3 E+00	3.5 E-04	1.2 E-07
				Total dose ►	5.1 E-04	1.2 E-05

+D = Dose-per-unit-release factor includes decay products ingrown following release of the parent radionuclide.

Table 3.9. Example 3: Assessed Potential-to-Emit for the Stack NOC

Type of Activity	Unabated Release Rate, Ci/yr	HEPA Filter Removal Factor	Abated Release Rate, Ci/yr	200 East Area 10-m (Offsite) Dose-per-Unit-Release Factor, mrem/Ci	Unabated Dose to Offsite MEI, mrem/yr	Abated Dose to Offsite MEI, mrem/yr
Gross alpha (as Pu-239)	1.5 E-04	3,000	5.1 E-08	2.8 E+00	4.3 E-04	1.4 E-07
Gross beta (as Cs-137)	8.4 E-04	3,000	2.8 E-07	2.4 E-01	2.0 E-04	6.7 E-08
H-3	1.0 E+00	1	1.0 E+00	1.2 E-05	1.2 E-05	1.2 E-05
				Total dose ►	6.4 E-04	1.2 E-05
				Total particulate-only dose ►	6.3 E-04	2.1 E-07

The final step is to check the detectability of the measurement method. A 2-week stack emission sample typically has a volume of approximately 40,000 ft^3 (1,133 m^3). The minimum detectable concentrations (MDC) for a 2-week sample are 1.0 E-15 µCi/mL for gross alpha activity and 9.5 E-15 µCi/mL for gross beta activity. The MDL values can be determined from Equation (3.11). The stack operates continuously at 2,500 cfm (1.18 m^3/s). As before, the dose-per-unit-release factors for Pu-239+D and Cs-137+D were used to calculate the gross alpha and gross beta doses, respectively, because they were the most conservative for all the nuclides included in the assessment. Table 3.10 displays the data and the results of the detectability calculations when the sampling frequency is biweekly and the stack operates at 2,500 cfm (1.18 m^3/s).

Table 3.10. Example 3: Detectability Check for Biweekly Sampling When the Stack Operates at 2,500 cfm

Type of Activity	Average Stack Flow Rate, cfm	Annual Operating Time, hr	Biweekly Analysis MDC, µCi/mL	Annual Discharge Volume, mL	MDL Activity, Ci/yr	200 East Area 10-m (Offsite) Dose-per-Unit-Release Factor, mrem/Ci	MDL Dose, mrem/yr
Gross alpha	2,500	8,760	1.0 E-15	3.7 E+13	3.7 E-08	2.8 E+00	1.0 E-07
Gross beta	2,500	8,760	9.5 E-15	3.7 E+13	3.5 E-07	2.4 E-01	8.5 E-08

Note, for example, that the measurement method has a gross beta MDL (3.5 E-07 Ci/yr) that is not low enough that the gross beta PTE emissions levels (abated release rate of 2.8 E-07 Ci/yr from Table 3.9) would be detected, but the estimated unabated release rate (8.4 E-4 Ci/yr) would be easily detectable. Both the abated and unabated gross alpha MDLs and release rates would be detectable with the gross alpha measurement method. Compliance is based on the PTE values, which result from unabated emissions. The measurement method must, at a minimum, be able to detect the unabated emissions and emissions below compliance points (e.g., 0.1 mrem/yr). Detection of the estimated abated emissions is preferred.

If the measurement method could not verify that the stack met the PTE value, the sampling period could be lengthened (e.g., to monthly [4-week] sampling) or the flow rate for the stack could be reduced. A monthly sampling period would double the sample volume and lower the MDCs by 50%. Table 3.11 displays the results based on a monthly sampling frequency which reduce the MDL activity of Table 3.10 also by half. Table 3.12 indicates how results based on a reduced stack flow rate of 1,900 cfm (0.90 m^3/s) with biweekly sampling can reduce the MDL activity. Note that a reduced stack flow rate can be effectively implemented by not operating the stack for planned time intervals.

Table 3.11. Example 3: Detectability Check for Monthly Sampling When Stack Operates at 2,500 cfm

Type of Activity	Average Stack Flow Rate, cfm	Annual Operating Time, hr	Monthly Analysis MDC, µCi/mL	Annual Discharge Volume, mL	MDL Activity, Ci/yr	200 East Area 10-m (Offsite) Dose-per-Unit-Release Factor, mrem/Ci	MDL Dose, mrem/yr
Gross alpha	2,500	8,760	5.0 E-16	3.7 E+13	1.9 E-08	2.8 E+00	5.3 E-08
Gross beta	2,500	8,760	4.8 E-15	3.7 E+13	1.8 E-07	2.4 E-01	4.3 E-08

Table 3.12. Example 3: Detectability Check for Biweekly Sampling When Stack Operates at 1,900 cfm

Type of Activity	Average Stack Flow Rate, cfm	Annual Operating Time, hr	Biweekly Analysis MDC, µCi/mL	Annual Discharge Volume, mL	MDL Activity, Ci/yr	200 East Area 10-m (Offsite) Dose-per-Unit-Release Factor, mrem/Ci	MDL Dose, mrem/yr
Gross alpha	1,900	8,760	1.0 E-15	2.8 E+13	2.8 E-08	2.8 E+00	7.9 E-08
Gross beta	1,900	8,760	9.5 E-15	2.8 E+13	2.7 E-07	2.4 E-01	6.4 E-08

This page intentionally left blank.

4.0 DOSE-PER-UNIT-RELEASE FACTORS FOR RADIONUCLIDE AIR EMISSIONS

This section presents the background, methods, and results for calculations of dose-per-unit-release factors for both offsite and onsite MEIs, relative to eight Hanford emission zones and for two release heights.

4.1 USE OF HANFORD-SPECIFIC PARAMETERS AND DATA FOR DEMONSTRATING COMPLIANCE WITH AIR PATHWAY RADIATION DOSE STANDARDS

The following information describes the methods used to calculate public doses from radionuclide air emissions at the Hanford Site. This information summarizes the regulatory background for the standards, outlines the history of the site-specific data, and describes the justification for its use. Additional information may be found in Rhoads et al. 2008.

4.1.1 Regulatory Background

DOE Facilities are required to demonstrate compliance with the *Clean Air Act* National Emission Standards for Hazardous Air Pollutants (NESHAP) for radionuclides, as published in the 1989 amendments to 40 CFR Part 61, Subpart H, "National Emission Standards for Emissions of Radionuclides Other Than Radon From Department of Energy Facilities." The corresponding Washington State regulations appear in WAC 246-247, "Radiation Protection – Air Emissions," and WAC 173-480, "Ambient Air Quality Standards and Emission Limits for Radionuclides." Both WAC 246-247 and WAC 173-480 incorporate by reference any more restrictive standards in other federal and state regulations.

Regulatory requirements for determining compliance with the radionuclide air emissions standards are specified in 40 CFR Part 61, Subpart H, Section 61.92(a), which includes:

> "…EPA-approved sampling procedures, computer models CAP-88 or AIRDOS-PC, or other procedures for which EPA has granted prior approval. DOE facilities for which the maximally exposed individual lives within 3 kilometers of all sources of emissions in the facility, may use EPA's COMPLY model and associated procedures for determining dose for purposes of compliance."

EPA approved CAP88-PC V4 for demonstrating compliance with the standard on February 10, 2015 (80 FR 7461-7465). WAC 246-247 adopts by reference the approved methods specified in 40 CFR Part 61, Subparts H and I. WAC 173-480-070 refers to methods specified in WAC 246-247, or to "other procedures, including those based on environmental measurements that department of health has determined to be suitable."

4.1.2 History of Data Used in Hanford Site Compliance Calculations

Since the 1970s, the DOE Richland Operations Office has maintained a program for developing and recommending standard methods for performing environmental radiation dose evaluations at the Hanford Site. As part of that program, a number of software packages and associated data libraries (e.g., Napier 2011) have been developed to implement regulatory requirements, based on recommendations of national and international standards organizations for radiological protection. In association with that effort, publications that described the recommended input parameters for various

types of dose calculations were issued and periodically updated (PNL-3509 PT1; PNL-3777, Rev. 0; PNL-3777, Rev. 1; PNL-3777, Rev. 2; DOE/RL-2007-53, respectively, Napier 1981, McCormack 1982; McCormack et al. 1984; Schreckhise et al. 1993; and Rhoads et al. 2008). These recommendations were based on data collected at the Hanford Site or on information obtained in surveys of the area and nearby communities.

Site-specific parameters for a "maximally exposed individual" have historically been used at Hanford for calculating dose to the MEI in demonstrating compliance with radionuclide air emission standards in 40 CFR Part 61, Subpart H, and in WAC 246-247. These parameters have also been used for calculating dose to the MEI in "applications to construct or modify" and NOCs for new or modified emission units at Hanford (for example, HNF-3602, Rev. 0 and Rev. 1 [respectively, Hill and Rittmann 1999; and Diedeker et al. 2002]; DOE/RL-2006-29, Rev. 0 and Rev. 1 [respectively, Diediker et al. 2006; and Rhoads et al. 2010]) in earlier versions of CAP88-PC. Individual parameters may differ for collective dose assessments and for evaluating doses to individuals whose exposure is more representative of the population as a whole.

Site-specific parameters had been used routinely in CAP88-PC V3 for various types of Hanford Site assessments, such as the annually published *Radionuclide Air Emissions Report for the Hanford Site, Calendar Year 2014* (e.g., Rokkan et al. 2015) and the *Hanford Site Environmental Report for Calendar Year 2014* (e.g., DOE 2015) and environmental evaluations for site activities prepared under the *National Environmental Policy Act of 1969* (NEPA 1969).

4.1.3 Hanford-Specific Parameters

Hanford-specific values were used in CAP88-PC V3 calculations and these were consistent with the most recent recommendations in DOE/RL-2007-53 (Rhoads et al. 2008), as approved by EPA Region 10 and WDOH for use in Hanford Site analyses. The code architecture of CAP88-PC V4 limits the use of many of the Hanford-specific values. Code application adheres to EPA default values for most parameters. Site-specific data developed for use at Hanford that is applied in CAP88-PC V4 includes:

- onsite meteorological data (data collection methods, annual and historical summaries may be found in e.g., Hoitink et al. 2005; data used with specific software are re-formatted as required)
- population within 50 miles (80 kilometers) of major operating areas (Hamilton and Snyder 2011, or updated census data as it becomes available)
- other exposure parameters.

4.1.4 Approval for Use of Hanford-Specific Parameters

Hanford-specific parameters have been approved by both EPA and WDOH for use in compliance, permitting, and reporting calculations. The dose-per-unit-release factors in this document were calculated using Hanford-specific parameters that were modifiable in CAP88-PC V4.

4.1.5 Calculation of Onsite Member-of-the-Public Worker Dose-per-Unit-Release Factors Using CAP88-PC and Average 80-km Ingestion

CAP88-PC V4.0.1.17 (Rosnick 2014) was used to estimate the dose-per-unit-release factors in this document for radionuclides for a member of the public who works within the Hanford Site boundary. Traditionally, the dose to the worker has been evaluated exclusively for inhalation and external pathways because food is not produced at the work location. In order to more fully evaluate public

worker doses, ingestion doses were included in assessments for the onsite public worker presented in this document. However, food that the public worker ingests was not assumed to be grown at the onsite business location. Ingestion dose for a worker whose business location is known but whose residence location is not known was evaluated using a regional ingestion dose estimated by a method not directly available in CAP88-PC. Regional ingestion is defined here as the consumption of produce and animal products grown outside the Hanford exclusion area, but within 80 kilometers (50 miles) of the source facility.

Several limitations of the CAP88-PC software require that the onsite MEI dose calculation be performed in several steps. First, CAP88-PC was not designed to model ingestion of food produced at a location different from the full-time location of the individual. Second, although it is possible to turn the ingestion pathway calculation off by using the "imported" food option, CAP88-PC does not have the option of evaluating the ingestion pathway independent of other exposure pathways. Third, the "regional" food-production option in CAP88-PC assumes that food is grown uniformly around the source location beginning at a distance of 500 meters out to 80 kilometers. This option would not be appropriate for emission units within the Hanford Site because no food is produced within 500 m of any onsite facility. The "local" food-production option takes into account the Hanford exclusion zone by assuming that food is produced only where the population is located.

In order to calculate the onsite public MEI dose, it was necessary to perform three separate sets of calculations. The first set was for the onsite MEI with inhalation and external exposure pathways only (imported food option). Then two sets of population dose calculations were performed, both with and without the ingestion pathway, using the local and imported food options, respectively. By subtracting the dose without ingestion from the dose with ingestion it was possible to assess the population dose from the ingestion pathway only. The population doses were calculated using average individual exposure and consumption parameters. The average individual ingestion dose was then estimated by dividing the total population ingestion dose by the number of individuals within the 80-kilometer region. The average individual ingestion dose was then added to the inhalation and external dose estimate for the onsite MEI location to obtain the total dose to an onsite worker (Equation 3.13).

The formula describing the worker dose with regional ingestion is as follows:

$$\text{Total } D_{Worker} = D_{Worker(ext+inh)} + ([Pop_{ext+inh+ing} - Pop_{ext+inh}]/N) * 1{,}000 \qquad (4.1)$$

where

D_{Worker}	=	Worker Dose is the total EDE from all exposure pathways in mrem/yr per Ci/yr released
$D_{Worker(ext+inh)}$	=	Individual EDE from the external and inhalation pathways, only, at onsite non-DOE-business location having unrestricted access in mrem/yr per Ci/yr released
$Pop_{ext+inh+ing}$	=	Population collective EDE from external, inhalation, and ingestion pathways in person-rem/yr per Ci/yr released
$Pop_{ext+inh}$	=	Population collective EDE from external and inhalation pathways, only, in person-rem/y per Ci/y released
N	=	Number of people within 80 kilometers (50 miles) of the source
1,000	=	Conversion factor in mrem per rem.

4.2 RESULTS OF DOS E-PER-UNIT-RELEASE FACTOR CALCULATIONS FOR HANFORD SITE EMISSION ZONES

The following section summarizes the methods used to calculate dose-per-unit-release factors for the Hanford Site and presents the tabular results of the calculations. Figure 4.1 displays the Hanford Site emission zones and MEI locations. The seven offsite PTE receptor MEI locations are each designated with a solid green triangle and an identifier for the emission zone to which it applies. In addition, there are four iodine-specific receptor locations that may require evaluation that are marked with green triangles with dots; reactive iodine emissions require special consideration when significant contributors to dose. The two onsite MEI locations, LIGO and EnergyNW are each designated with a circled capital letter. While, the B Reactor could be staffed by a full-time public staff-person with open access to the site in the future, it was not considered a potential onsite receptor location for this document revision. The determinant release locations and the meteorological stations used in calculating the dose-per-unit-release factors for each emission zone are listed in Table 4.1. The distance and direction to the offsite and onsite MEI for each emission zone for each release height evaluated are listed in Table 4.2. The PTE receptor locations identified in Figure 4.1 correspond to respective distance and direction information in Table 4.2. The eastern and western 300 Area receptors are indicated in Figure 4.2 and Figure 4.3. The emission source locations differ slightly for shorter and taller stacks, as indicated by the respective “s” and “t” boundaries indicated in Figures 4.2 and 4.3. Table 4.3 through Table 4.7 contain the dose-per-unit-release factors for each of the five emission zones at two representative effective release heights. Dose-per-unit-release factors are provided for 551 radionuclides (some with more than one chemical form), sorted first by atomic number and then by atomic mass. For all emission zones other than the 200 East, 200 West, and 400 Areas, the dose to an offsite MEI from any mix of radionuclides was greater than the dose to a MEI at the two onsite locations. Therefore, doses to an onsite MEI are only included in the tables for those three emission zones where the onsite dose could potentially exceed the dose to an offsite MEI.

Table 4.1. Release Locations and Meteorological Stations Used

Release Locations[a]		**Meteorological Station[b]**
Emission Zone (building/facility)	**Geographic Coordinates**	
100-K (K East Basin area)[c]	46.6486, -119.5959	100-K (#29) 2003-2012
200 West (REDOX and 222-S Lab area)	46.5348, -119.6203	200-W (#7) 2004-2013
200 East (ETF)	46.5663, -119.5113	200-E (#6) 2004-2013
Eastern 300 Area (331 Building) **Western 300 Area** <40-m release (361 Building) ≥40-m release (325 Building)	46.3649, -119.2715 46.3636, -119.2822 46.3688, -119.2789	300 (#11) 2004-2013
400 Area (FFTF)	46.4353, -119.3600	400 (#9) 2004-2013

ETF = Effluent Treatment Facility
FFTF = Fast Flux Test Facility.
REDOX = Reduction-Oxidation (S Plant).
(a) The coordinates provided are accurate to ±100 m.
(b) The years during which data were collected are specified below each station.
(c) Iodine emissions have a maximum receptor (1KtI in Figure 4.1) based on emissions from 100-K ≥40 m release at 105-KW Building (46.6473, -119.6033)

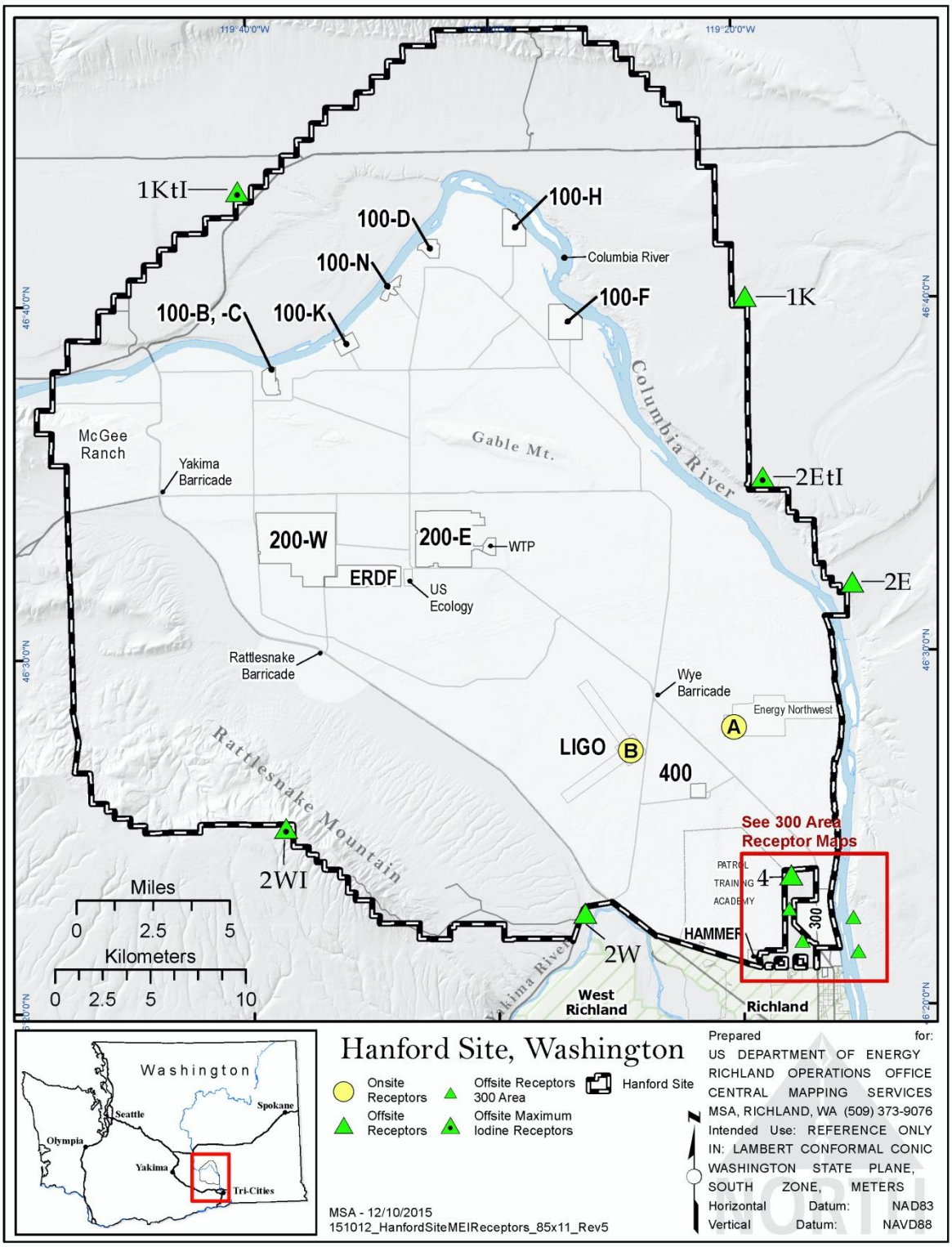

Figure 4.1. Hanford Site Map of Emission Zones (See Table 4.2 for geographical information on MEI locations, symbolized with identifying numerals and letters alongside them, respectively.)

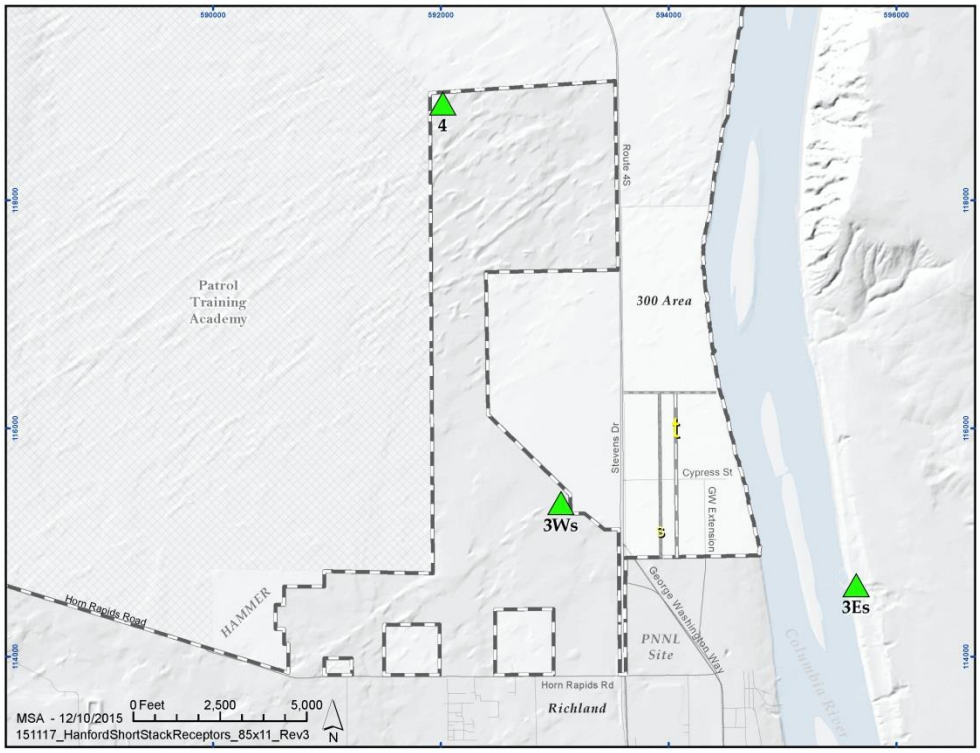

Figure 4.2. Hanford Site Map of 300 Area <40-m Emission (shorter) Units' East/West Boundaries and MEI Locations (See Figure 4.1 and Table 4.2 for legend.)

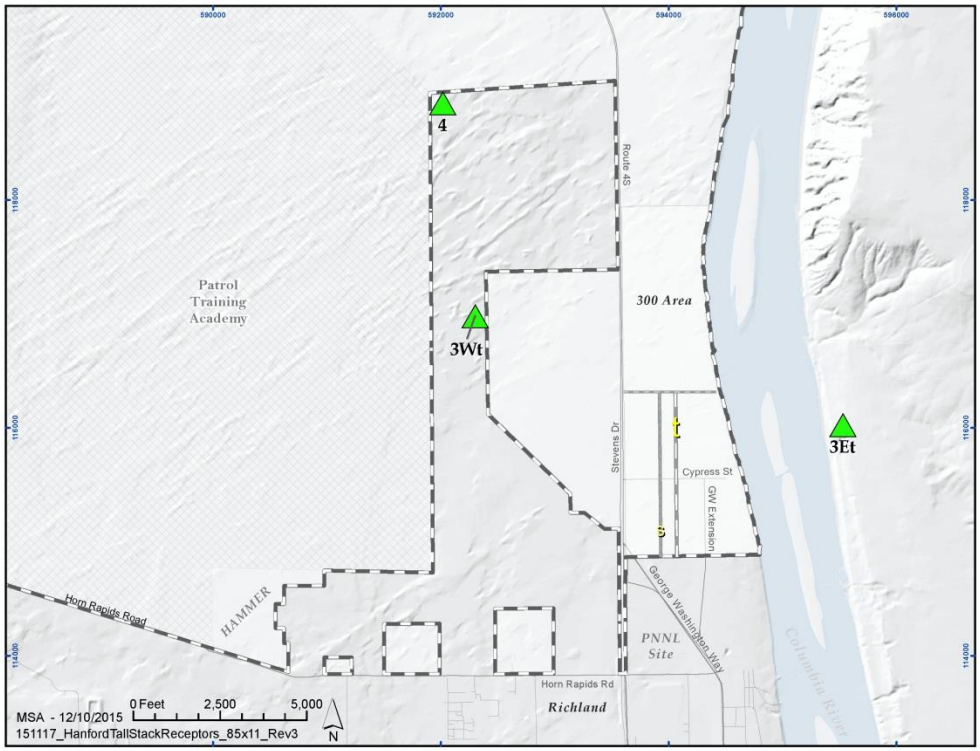

Figure 4.3. Hanford Site Map of 300 Area ≥40-m Emission (taller) Units' East/West Boundaries and MEI Locations (See Figure 4.1 and Table 4.2 for legend.)

Table 4.2. Direction and Distance to Each MEI Location from Respective Emission Zone

Emission Zone	Offsite MEI		Onsite MEI[a]	
	Map ID from Figure 4.1, 4.2, or 4.3	**Distance and Direction[b]**	**Map ID from Figure 4.1**	**Facility/ Distance and Direction[b]**
100-K <40-m release height ≥40-m release height	 1K 1K, 1KtI	 20,300 m E 20,300 m E[c]	N/A	N/A
200 East <40-m release height ≥40-m release height	 2E 2E, 2EtI	 19,350 m ESE 19,350 m ESE[d]	A	Energy NW 16,650 m ESE 16,650 m ESE
200 West <40-m release height ≥40-m release height	 2W,2WI 2W,2WI	 22,000 m SE[e] 22,000 m SE[e]	B	LIGO 18,520 m ESE 18,520 m ESE
Eastern 300 Area <40-m release height ≥40-m release height **Western 300 Area** <40-m release height ≥40-m release height	 3Es 3Et 3Ws 3Wt	 1,250 m SE 1,100 m NE 600 m WNW 1,860m NW	N/A	N/A
400 Area <40-m release height ≥40-m release height	 4 4	 6,040 m SE 6,040 m SE	A	Energy NW 3,200 m NNE 3,200 m NNE

N/A = Not applicable.
Energy NW = Energy Northwest Columbia Generating Station
LIGO = Laser Interferometer Gravitational-Wave Observatory

(a) The dose-per-unit-release factors for offsite MEIs were always greater than those for current potential onsite MEIs for the 300 Area emission zone. Therefore, calculations for the onsite MEI are only presented for the 100-K, 200 East, 200 West, and 400 Area emission zones.
(b) These values represent the shortest distance from the respective point of release to the Hanford Site boundary in a specific sector of the wind rose. The specific sector of the wind rose was determined from CAP88-PC V4 lowest dispersion value results at boundary distances and emission zone meteorology.
(c) For 100-K iodine emissions from ≥40-m sources, additionally consider an Offsite receptor (1KtI) 8,900 m NNW of 100-K. See Section 5.0 for dose factors for this location.
(d) For 200-E iodine emissions from ≥40-m sources, additionally consider an Offsite receptor (2EtI) 14,350 m E of 200 East. See Section 5.0 for dose factors for this location.
(e) For 200-W iodine emissions from either <40-m or ≥40-m sources, additionally consider an Offsite receptor (2WI) 12,650 m S of 200-W. See Section 5.0 for dose factors for this location. CAP88-PC V4 does not consider terrain effects.

Table 4.3. **100-K Area**: Offsite MEI CAP88-PC Dose-per-Unit-Release Factors (mrem/Ci) by Effective Release Height

Nuclide[a,b]	Effective Release Height <40 m mrem/yr per Ci/yr[c] 100-K Offsite MEI	Effective Release Height ≥40 m mrem/yr per Ci/yr[c] 100-K Offsite MEI
H-3 (V)	1.43 E-05	7.69 E-06
H-3 (E)	1.28 E-05	6.87 E-06
H-3 (O)	3.13 E-05	1.68 E-05
H-3 (F)	8.71 E-06	6.10 E-06
H-3 (M)	1.09 E-05	7.61 E-06
H-3 (S)	2.30 E-05	1.61 E-05
Be-7	1.11 E-04	8.17 E-05
Be-10	2.34 E-03	1.70 E-03
C-11	9.65 E-08	9.05 E-08
C-11 (CO)	1.07 E-07	9.40 E-08
C-11 (CO2)	1.07 E-07	9.44 E-08
C-14	1.11 E-03	7.76 E-04
C-14 (CO)	1.54 E-03	8.30 E-04
C-14 (CO2)	1.54 E-03	8.30 E-04
C-15	C-11	C-11
N-13	1.24 E-09	1.13 E-09
O-15	2.92 E-18	1.98 E-18
O-19	6.86 E-19	6.14 E-19
F-18	6.46 E-06	5.09 E-06
Na-22	9.28 E-02	6.81 E-02
Na-24	1.56 E-04	1.14 E-04
Mg-27	6.23 E-10	5.92 E-10
Mg-28+D	1.90 E-04	1.37 E-04
Mg-28	1.10 E-04	7.89 E-05
Al-26	7.88 E-01	5.79 E-01
Al-28	2.48 E-18	2.12 E-18
Si-31	1.67 E-06	1.27 E-06
Si-32+D	2.54 E-02	1.87 E-02
Si-32	1.12 E-03	7.95 E-04
P-32	9.52 E-04	6.94 E-04
P-33	2.14 E-04	1.55 E-04
S-35	8.92 E-04	6.53 E-04
Cl-36	7.56 E-01	5.55 E-01
Ar-37	0.00 E+00	0.00 E+00
Ar-39	5.70 E-08	3.07 E-08
Ar-41	9.34 E-06	5.96 E-06
Ar-42+D	4.60 E-06	2.94 E-06
Ar-42	6.24 E-08	3.36 E-08
K-40	1.46 E-01	1.08 E-01
K-42	2.44 E-05	1.77 E-05
Ca-41	1.33 E-03	9.76 E-04
Ca-45	4.86 E-04	3.53 E-04
Ca-47+D	3.17 E-04	2.30 E-04
Sc-44	3.18 E-05	2.38 E-05
Sc-44m+D	3.01 E-04	2.18 E-04
Sc-44m	8.73 E-05	6.23 E-05
Sc-46	6.96 E-03	5.10 E-03
Sc-47	4.33 E-05	3.10 E-05
Ti-44+D	5.73 E-01	4.20 E-01
Ti-44	4.56 E-02	3.34 E-02
Ti-45	1.07 E-05	8.13 E-06
Ti-51	8.64 E-13	8.23 E-13
V-48	2.13 E-03	1.56 E-03
V-49	1.60 E-05	1.17 E-05

Table 4.3. (contd)

Nuclide[a,b]	Effective Release Height <40 m mrem/yr per Ci/yr[c] 100-K Offsite MEI	Effective Release Height ≥40 m mrem/yr per Ci/yr[c] 100-K Offsite MEI
Cr-49+D	1.21 E-06	1.06 E-06
Cr-51	4.97 E-05	3.65 E-05
Cr-55	5.03 E-18	4.83 E-18
Mn-52	8.53 E-04	6.23 E-04
Mn-52m+D	3.13 E-07	2.85 E-07
Mn-53	1.30 E-04	9.51 E-05
Mn-54	9.99 E-03	7.33 E-03
Mn-56	1.76 E-05	1.35 E-05
Fe-55	6.75 E-04	4.95 E-04
Fe-59	3.22 E-03	2.36 E-03
Co-56	1.29 E-02	9.46 E-03
Co-57	1.58 E-03	1.16 E-03
Co-58	3.40 E-03	2.49 E-03
Co-58m+D	1.51 E-05	1.11 E-05
Co-58m	5.07 E-07	3.64 E-07
Co-60	1.66 E-01	1.22 E-01
Co-60m+D	6.26 E-07	4.59 E-07
Co-60m	1.19 E-11	1.13 E-11
Ni-56+D	1.30 E-03	9.52 E-04
Ni-56	5.11 E-04	3.73 E-04
Ni-57+D	1.61 E-04	1.18 E-04
Ni-59	2.57 E-04	1.88 E-04
Ni-63	5.63 E-04	4.12 E-04
Ni-65	6.63 E-06	5.08 E-06
Cu-64	9.40 E-06	6.81 E-06
Cu-66	4.60 E-14	4.38 E-14
Cu-67	3.47 E-05	2.48 E-05
Zn-65	2.63 E-02	1.93 E-02
Zn-69	1.49 E-07	1.26 E-07
Zn-69m+D	2.44 E-05	1.77 E-05
Ga-67	3.04 E-05	2.20 E-05
Ga-68	3.12 E-06	2.58 E-06
Ga-70	6.96 E-09	6.52 E-09
Ga-72	1.07 E-04	7.79 E-05
Ge-68+D	2.72 E-02	1.99 E-02
Ge-68	1.67 E-02	1.22 E-02
Ge-69	8.22 E-05	5.98 E-05
Ge-71	6.13 E-06	4.49 E-06
Ge-75	5.38 E-07	4.34 E-07
Ge-77+D	4.49 E-05	3.26 E-05
As-73	2.51 E-04	1.83 E-04
As-74	8.72 E-04	6.37 E-04
As-76	5.79 E-05	4.16 E-05
As-77	1.67 E-05	1.18 E-05
Se-75	1.17 E-02	8.61 E-03
Se-77m	6.95 E-22	6.18 E-22
Se-79	4.02 E-02	2.95 E-02
Se-79m+D	1.01 E-12	7.45 E-13
Se-79m	2.15 E-17	2.06 E-17
Br-82	2.04 E-04	1.49 E-04
Br-82m+D	5.79 E-07	4.22 E-07
Br-82m	1.94 E-14	1.85 E-14
Br-83+D	9.87 E-07	7.56 E-07
Br-84	9.86 E-07	8.92 E-07
Br-84m	1.18 E-11	1.12 E-11
Br-85+D	2.25 E-08	1.31 E-08
Br-85	4.78 E-19	4.54 E-19
Kr-81	1.89 E-08	1.02 E-08
Kr-81m+D	3.43 E-20	1.85 E-20

Table 4.3. (contd)

Nuclide[a,b]	Effective Release Height <40 m mrem/yr per Ci/yr[c] 100-K Offsite MEI	Effective Release Height ≥40 m mrem/yr per Ci/yr[c] 100-K Offsite MEI
Kr-83m	1.67 E-10	1.07 E-10
Kr-85	1.19 E-07	6.43 E-08
Kr-85m+D	2.07 E-06	1.20 E-06
Kr-87+D	3.71 E-06	2.52 E-06
Kr-88+D	2.89 E-05	1.85 E-05
Kr-88	2.22 E-05	1.34 E-05
Kr-89+D	7.78 E-08	5.95 E-08
Kr-89	4.72 E-17	4.38 E-17
Kr-90	6.77 E-09	4.96 E-09
Rb-81+D	1.12 E-05	8.10 E-06
Rb-81	9.07 E-06	6.74 E-06
Rb-81m+D	1.36 E-06	9.75 E-07
Rb-81m	2.83 E-08	2.57 E-08
Rb-82	1.12 E-19	4.45 E-20
Rb-82m	5.76 E-05	4.24 E-05
Rb-83+D	4.04 E-03	2.97 E-03
Rb-84	2.76 E-03	2.03 E-03
Rb-84m+D	1.21 E-06	8.97 E-07
Rb-84m	3.30 E-08	3.09 E-08
Rb-86	1.13 E-03	8.21 E-04
Rb-86m+D	4.27 E-08	3.11 E-08
Rb-86m	4.53 E-19	4.33 E-19
Rb-87	1.93 E-02	1.41 E-02
Rb-88	3.95 E-08	3.72 E-08
Rb-89+D	3.61 E-07	2.74 E-07
Rb-90+D	3.31 E-08	2.43 E-08
Rb-90	2.19 E-18	2.05 E-18
Rb-90m+D	5.41 E-08	3.97 E-08
Rb-90m	6.20 E-14	5.92 E-14
Sr-82+D	3.09 E-03	2.25 E-03
Sr-82	1.86 E-03	1.35 E-03
Sr-83+D	9.14 E-05	6.64 E-05
Sr-83	6.42 E-05	4.66 E-05
Sr-85	1.53 E-03	1.12 E-03
Sr-85m+D	1.55 E-06	1.19 E-06
Sr-85m	6.26 E-07	5.18 E-07
Sr-87m+D	3.31 E-06	2.52 E-06
Sr-89	1.50 E-03	1.09 E-03
Sr-90+D	1.90 E-01	1.39 E-01
Sr-91+D	4.15 E-05	3.01 E-05
Sr-92+D	2.13 E-05	1.60 E-05
Y-88	1.08 E-02	7.92 E-03
Y-89m	0.00 E+00	0.00 E+00
Y-90	7.87 E-05	5.59 E-05
Y-90m+D	1.09 E-05	8.07 E-06
Y-91	1.12 E-03	8.09 E-04
Y-91m+D	1.46 E-06	1.17 E-06
Y-92	7.87 E-06	5.90 E-06
Y-93+D	1.92 E-05	1.38 E-05
Zr-88+D	9.33 E-03	6.86 E-03
Zr-88	1.46 E-03	1.07 E-03
Zr-89	1.82 E-04	1.33 E-04
Zr-89m+D	1.51 E-07	1.10 E-07
Zr-93+D	9.86 E-04	7.06 E-04
Zr-95+D	4.03 E-03	2.96 E-03
Zr-97+D	9.69 E-05	6.99 E-05
Zr-97	7.04 E-05	5.08 E-05
Nb-91	1.48 E-03	1.08 E-03
Nb-91m+D	6.37 E-05	4.69 E-05

Table 4.3. (contd)

Nuclide[a,b]	Effective Release Height <40 m mrem/yr per Ci/yr[c] 100-K Offsite MEI	Effective Release Height ≥40 m mrem/yr per Ci/yr[c] 100-K Offsite MEI
Nb-92	4.52 E-01	3.32 E-01
Nb-92m	3.75 E-04	2.76 E-04
Nb-93m	1.69 E-04	1.24 E-04
Nb-94	4.72 E-01	3.47 E-01
Nb-94m+D	2.75 E-10	2.02 E-10
Nb-95	1.18 E-03	8.68 E-04
Nb-95m+D	1.44 E-04	1.05 E-04
Nb-95m	4.53 E-05	3.22 E-05
Nb-96	1.41 E-04	1.03 E-04
Nb-97	2.51 E-06	2.06 E-06
Mo-93+D	5.52 E-03	4.05 E-03
Mo-93m+D	4.94 E-05	3.63 E-05
Mo-99+D	7.27 E-05	5.21 E-05
Mo-99	6.12 E-05	4.37 E-05
Tc-95	3.73 E-05	2.72 E-05
Tc-95m+D	1.96 E-03	1.43 E-03
Tc-96	4.77 E-04	3.49 E-04
Tc-96m+D	3.97 E-06	2.90 E-06
Tc-96m	1.08 E-07	9.26 E-08
Tc-97	4.41 E-03	3.24 E-03
Tc-97m+D	5.20 E-04	3.77 E-04
Tc-98	5.12 E-01	3.76 E-01
Tc-99	2.81 E-02	2.06 E-02
Tc-99m+D	2.59 E-06	1.91 E-06
Tc-101	5.12 E-09	4.85 E-09
Ru-97+D	3.24 E-05	2.36 E-05
Ru-103+D	1.00 E-03	7.32 E-04
Ru-105+D	1.60 E-05	1.18 E-05
Ru-106+D	9.20 E-03	6.70 E-03
Ru-106	4.20 E-03	3.03 E-03
Rh-101	1.16 E-02	8.53 E-03
Rh-101m+D	6.22 E-05	4.53 E-05
Rh-102	5.33 E-03	3.91 E-03
Rh-102m+D	1.01 E-01	7.40 E-02
Rh-103m	1.24 E-08	1.04 E-08
Rh-104	1.60 E-20	1.52 E-20
Rh-104m+D	1.20 E-15	1.14 E-15
Rh-104m	4.17 E-16	3.99 E-16
Rh-105	1.78 E-05	1.27 E-05
Rh-105m	Rh-105	Rh-105
Rh-106	0.00 E+00	0.00 E+00
Pd-103+D	4.19 E-05	3.03 E-05
Pd-107	4.57 E-05	3.35 E-05
Pd-109	1.31 E-05	9.35 E-06
Pd-109m+D	7.52 E-08	5.37 E-08
Pd-111+D	3.31 E-07	2.40 E-07
Pd-111	1.10 E-08	1.02 E-08
Pd-112+D	3.47 E-05	2.49 E-05
Pd-112	7.79 E-08	5.76 E-08
Ag-108	4.37 E-20	3.67 E-20
Ag-108m+D	4.78 E-01	3.51 E-01
Ag-109m	1.17 E-21	1.11 E-21
Ag-110	2.88 E-20	2.73 E-20
Ag-110m+D	2.73 E-02	2.00 E-02
Ag-111	1.49 E-04	1.07 E-04
Ag-111m+D	1.49 E-08	1.07 E-08
Ag-111m	6.55 E-21	6.22 E-21
Ag-112	1.16 E-05	8.79 E-06
Cd-107	2.71 E-06	1.97 E-06

Table 4.3. (contd)

Nuclide[a,b]	Effective Release Height <40 m mrem/yr per Ci/yr[c] 100-K Offsite MEI	Effective Release Height ≥40 m mrem/yr per Ci/yr[c] 100-K Offsite MEI
Cd-109	1.85 E-03	1.35 E-03
Cd-111m	3.93 E-07	3.39 E-07
Cd-113	1.18 E-01	8.64 E-02
Cd-113m	5.56 E-02	4.08 E-02
Cd-115+D	7.91 E-05	5.66 E-05
Cd-115	6.40 E-05	4.57 E-05
Cd-115m+D	1.30 E-03	9.44 E-04
Cd-117+D	1.74 E-05	1.30 E-05
Cd-117m+D	3.67 E-05	2.75 E-05
In-106	2.30 E-11	2.19 E-11
In-111	5.58 E-05	4.06 E-05
In-111m+D	1.07 E-07	7.76 E-08
In-112	5.38 E-09	5.10 E-09
In-112m+D	8.15 E-08	7.62 E-08
In-112m	2.09 E-09	1.96 E-09
In-113m	1.54 E-06	1.22 E-06
In-114	1.13 E-19	1.06 E-19
In-114m+D	1.78 E-03	1.29 E-03
In-115	2.85 E-02	2.06 E-02
In-115m+D	3.69 E-06	2.74 E-06
In-116m	5.11 E-06	4.34 E-06
In-117+D	8.53 E-07	7.44 E-07
In-117m+D	4.54 E-06	3.50 E-06
In-117m	1.67 E-06	1.31 E-06
Sn-113+D	1.79 E-03	1.31 E-03
Sn-113	6.74 E-04	4.90 E-04
Sn-113m+D	2.11 E-07	1.54 E-07
Sn-113m	2.87 E-10	2.68 E-10
Sn-117m	2.59 E-04	1.87 E-04
Sn-119m	5.08 E-04	3.70 E-04
Sn-121	8.61 E-06	6.09 E-06
Sn-121m+D	2.46 E-03	1.79 E-03
Sn-123	2.13 E-03	1.55 E-03
Sn-123m	1.97 E-07	1.74 E-07
Sn-125+D	6.68 E-04	4.86 E-04
Sn-125m+D	1.07 E-07	7.84 E-08
Sn-126+D	6.50 E-01	4.77 E-01
Sn-126	3.87 E-02	2.84 E-02
Sb-122	1.06 E-04	7.66 E-05
Sb-122m+D	1.14 E-07	8.20 E-08
Sb-122m	4.12 E-16	3.94 E-16
Sb-124	5.06 E-03	3.70 E-03
Sb-124m+D	6.78 E-08	4.97 E-08
Sb-124n+D	9.26 E-07	6.86 E-07
Sb-124n	1.38 E-09	1.29 E-09
Sb-125+D	1.62 E-02	1.19 E-02
Sb-126	1.65 E-03	1.21 E-03
Sb-126m+D	3.59 E-07	2.86 E-07
Sb-127+D	1.98 E-04	1.43 E-04
Sb-128	8.59 E-05	6.29 E-05
Sb-128m+D	6.37 E-08	4.73 E-08
Te-121	5.07 E-04	3.71 E-04
Te-121m+D	5.63 E-03	4.12 E-03
Te-121m	2.70 E-03	1.97 E-03
Te-123	1.19 E-02	8.74 E-03
Te-123m+D	1.50 E-03	1.09 E-03
Te-125m	5.11 E-04	3.71 E-04
Te-127	4.39 E-06	3.15 E-06
Te-127m+D	1.56 E-03	1.13 E-03

Table 4.3. (contd)

Nuclide[a,b]	Effective Release Height <40 m mrem/yr per Ci/yr[c] 100-K Offsite MEI	Effective Release Height ≥40 m mrem/yr per Ci/yr[c] 100-K Offsite MEI
Te-129+D	5.02 E-07	4.14 E-07
Te-129m+D	1.21 E-03	8.77 E-04
Te-129m	1.11 E-03	8.05 E-04
Te-131+D	3.14 E-06	8.11 E-06
Te-131	1.07 E-07	9.88 E-08
Te-131m+D	1.61 E-04	1.43 E-04
Te-131m	1.27 E-04	9.20 E-05
Te-132+D	4.08 E-04	3.04 E-04
Te-132	1.35 E-04	9.60 E-05
Te-133+D	1.93 E-07	4.86 E-07
Te-133	7.93 E-09	7.53 E-09
Te-133m+D	5.56 E-06	5.96 E-06
Te-134+D	2.17 E-06	3.08 E-06
Te-134	1.07 E-06	9.42 E-07
I-122	1.17 E-16	1.54 E-16
I-122(V)	n/a	n/a
I-123+D	2.06 E-06	5.26 E-06
I-123(V)+D	1.77 E-05	9.77 E-06
I-124	3.39 E-04	8.86 E-04
I-124(V)	9.83 E-04	5.31 E-04
I-125	1.07 E-02	2.81 E-02
I-125(V)	1.15 E-03	6.22 E-04
I-126	3.80 E-03	9.94 E-03
I-126(V)	2.18 E-03	1.17 E-03
I-128	3.81 E-09	7.20 E-09
I-128(V)	7.78 E-08	6.65 E-08
I-129	2.46 E-01	6.46 E-01
I-129(V)	7.94 E-03	4.28 E-03
I-130	2.49 E-05	6.36 E-05
I-130(V)	1.69 E-04	9.35 E-05
I-130m+D	2.53 E-07	6.44 E-07
I-130m	5.13 E-12	8.79 E-12
I-130m(V)	n/a	n/a
I-131+D	1.44 E-03	3.77 E-03
I-131(V)+D	1.63 E-03	8.80 E-04
I-132	3.34 E-06	7.73 E-06
I-132(V)	2.98 E-05	1.84 E-05
I-132m+D	2.66 E-06	6.38 E-06
I-132m	2.52 E-07	5.50 E-07
I-132m(V)+D	7.26 E-06	7.70 E-06
I-132m(V)	5.76 E-06	3.85 E-06
I-133+D	1.83 E-05	4.73 E-05
I-133(V)+D	3.08 E-04	1.69 E-04
I-133m	I-133+D	I-133+D
I-134	6.76 E-07	1.39 E-06
I-134(V)	6.84 E-06	5.02 E-06
I-134m+D	4.86 E-08	9.98 E-08
I-134m	2.65 E-17	3.48 E-17
I-134m(V)	n/a	n/a
I-135+D	1.27 E-05	2.75 E-05
I-135(V)+D	8.32 E-05	4.71 E-05
Xe-122+D	1.48 E-06	1.84 E-06
Xe-122	9.70 E-07	5.32 E-07
Xe-123+D	5.14 E-06	3.61 E-06
Xe-123	4.97 E-06	3.11 E-06
Xe-125+D	1.53 E-05	3.67 E-05
Xe-125	4.69 E-06	2.57 E-06
Xe-127	5.58 E-06	3.01 E-06
Xe-127m+D	1.23 E-10	6.62 E-11

Table 4.3. (contd)

Nuclide[a,b]	Effective Release Height <40 m mrem/yr per Ci/yr[c] 100-K Offsite MEI	Effective Release Height ≥40 m mrem/yr per Ci/yr[c] 100-K Offsite MEI
Xe-127m	1.95 E-18	1.91 E-18
Xe-129m	4.50 E-07	2.43 E-07
Xe-131m	1.75 E-07	9.46 E-08
Xe-133	6.67 E-07	3.60 E-07
Xe-133m+D	6.24 E-07	3.37 E-07
Xe-135+D	4.27 E-06	2.38 E-06
Xe-135m+D	1.31 E-07	7.70 E-08
Xe-137+D	5.71 E-08	4.19 E-08
Xe-137	4.11 E-16	3.77 E-16
Xe-138+D	1.05 E-06	9.45 E-07
Xe-138	1.82 E-08	1.65 E-08
Cs-131	1.70 E-05	1.25 E-05
Cs-132	2.31 E-04	1.69 E-04
Cs-134	1.19 E-01	8.75 E-02
Cs-134m+D	1.35 E-05	9.59 E-06
Cs-134m	4.86 E-07	3.68 E-07
Cs-135	2.43 E-02	1.78 E-02
Cs-135m+D	2.94 E-06	2.51 E-06
Cs-136	1.84 E-03	1.35 E-03
Cs-137+D	2.37 E-01	1.74 E-01
Cs-137	1.24 E-01	9.14 E-02
Cs-138	1.45 E-06	1.31 E-06
Cs-138m+D	1.12 E-07	1.01 E-07
Cs-138m	1.36 E-18	1.30 E-18
Cs-139+D	1.09 E-07	8.80 E-08
Cs-139	2.08 E-10	1.98 E-10
Cs-140+D	9.44 E-08	6.89 E-08
Ba-131+D	2.81 E-04	2.05 E-04
Ba-131	2.73 E-04	1.99 E-04
Ba-131m+D	2.50 E-07	1.83 E-07
Ba-131m	1.28 E-09	1.21 E-09
Ba-133	4.38 E-02	3.22 E-02
Ba-133m+D	3.98 E-05	2.87 E-05
Ba-135m	1.60 E-05	1.14 E-05
Ba-137m	2.61 E-19	2.51 E-19
Ba-139	8.65 E-07	6.99 E-07
Ba-140+D	1.63 E-03	1.19 E-03
Ba-140	5.40 E-04	3.89 E-04
Ba-141+D	5.29 E-07	4.00 E-07
Ba-142+D	1.68 E-06	1.35 E-06
Ba-142	2.01 E-09	1.91 E-09
La-137	6.63 E-03	4.86 E-03
La-138	3.60 E-01	2.65 E-01
La-140	2.17 E-04	1.57 E-04
La-141+D	5.75 E-06	4.23 E-06
La-142	1.28 E-05	1.02 E-05
Ce-139	9.22 E-04	6.75 E-04
Ce-141	3.46 E-04	2.49 E-04
Ce-142	Ce-144+D	Ce-144+D
Ce-143+D	5.27 E-05	3.76 E-05
Ce-144+D	5.30 E-03	3.82 E-03
Pr-142	2.60 E-05	1.86 E-05
Pr-142m+D	3.35 E-07	2.39 E-07
Pr-142m	3.18 E-10	3.01 E-10
Pr-143	2.09 E-04	1.50 E-04
Pr-144	4.55 E-09	4.30 E-09
Pr-144m+D	3.25 E-09	3.07 E-09
Pr-144m	2.35 E-13	2.24 E-13
Nd-144	0.00 E+00	0.00 E+00

Table 4.3. (contd)

Nuclide[a,b]	Effective Release Height <40 m mrem/yr per Ci/yr[c] 100-K Offsite MEI	Effective Release Height ≥40 m mrem/yr per Ci/yr[c] 100-K Offsite MEI
Nd-147+D	2.26 E-04	1.63 E-04
Pm-143	3.23 E-03	2.37 E-03
Pm-144+D	2.17 E-02	1.60 E-02
Pm-145	4.50 E-03	3.30 E-03
Pm-146+D	5.11 E-02	3.75 E-02
Pm-147+D	3.44 E-04	2.44 E-04
Pm-148	2.76 E-04	1.99 E-04
Pm-148m+D	3.79 E-03	2.78 E-03
Pm-149	3.24 E-05	2.29 E-05
Pm-150	1.61 E-05	1.23 E-05
Pm-151+D	3.59 E-05	2.58 E-05
Sm-145+D	1.10 E-03	8.08 E-04
Sm-146	5.92 E-01	4.15 E-01
Sm-147	5.34 E-01	3.75 E-01
Sm-148+D	0.00 E+00	0.00 E+00
Sm-151	2.54 E-04	1.80 E-04
Sm-153	3.08 E-05	2.18 E-05
Sm-155+D	5.33 E-08	4.29 E-08
Sm-156+D	3.02 E-05	2.19 E-05
Sm-156	1.01 E-05	7.31 E-06
Sm-157+D	1.86 E-07	1.34 E-07
Sm-157	5.87 E-11	5.58 E-11
Eu-150	3.30 E-01	2.42 E-01
Eu-150m+D	8.87 E-06	6.36 E-06
Eu-152+D	1.53 E-01	1.12 E-01
Eu-152m+D	1.54 E-05	1.12 E-05
Eu-152n+D	2.34 E-06	1.73 E-06
Eu-152n	2.92 E-07	2.33 E-07
Eu-154	1.20 E-01	8.80 E-02
Eu-154m+D	1.28 E-06	9.48 E-07
Eu-154m	6.35 E-08	5.51 E-08
Eu-155	3.76 E-03	2.75 E-03
Eu-156	1.09 E-03	7.97 E-04
Eu-157	2.09 E-05	1.51 E-05
Gd-148	6.26 E-01	4.39 E-01
Gd-149+D	2.65 E-04	1.93 E-04
Gd-150+D	1.40 E-12	8.72 E-13
Gd-150	0.00 E+00	0.00 E+00
Gd-151+D	4.06 E-04	2.97 E-04
Gd-152	4.43 E-01	3.11 E-01
Gd-153	1.06 E-03	7.77 E-04
Gd-159	1.30 E-05	9.30 E-06
Tb-157	1.13 E-03	8.31 E-04
Tb-158	2.24 E-01	1.65 E-01
Tb-160	3.80 E-03	2.78 E-03
Tb-161	8.24 E-05	5.89 E-05
Dy-159	2.75 E-04	2.02 E-04
Dy-165	1.36 E-06	1.05 E-06
Ho-163	0.00 E+00	0.00 E+00
Ho-164	1.46 E-08	1.33 E-08
Ho-164m+D	1.22 E-07	1.07 E-07
Ho-164m	4.46 E-08	3.96 E-08
Ho-166	3.17 E-05	2.25 E-05
Ho-166m	4.88 E-01	3.58 E-01
Er-169	6.16 E-05	4.39 E-05
Er-171+D	1.45 E-05	1.06 E-05
Tm-168	4.31 E-03	3.17 E-03
Tm-170	8.82 E-04	6.37 E-04
Tm-171	1.23 E-04	8.82 E-05

Table 4.3. (contd)

Nuclide[a,b]	Effective Release Height <40 m mrem/yr per Ci/yr[c] 100-K Offsite MEI	Effective Release Height ≥40 m mrem/yr per Ci/yr[c] 100-K Offsite MEI
Yb-164+D	2.94 E-06	2.41 E-06
Yb-164	1.29 E-07	1.05 E-07
Yb-165+D	1.84 E-07	1.35 E-07
Yb-166+D	2.15 E-04	1.57 E-04
Yb-166	3.89 E-05	2.76 E-05
Yb-167+D	1.76 E-07	1.30 E-07
Yb-169	6.16 E-04	4.49 E-04
Yb-175	3.69 E-05	2.62 E-05
Yb-177+D	2.78 E-06	2.12 E-06
Lu-177	6.76 E-05	4.82 E-05
Lu-177m+D	7.07 E-03	5.17 E-03
Hf-175	1.07 E-03	7.82 E-04
Hf-177m	4.04 E-06	3.45 E-06
Hf-178	n/a	n/a
Hf-178m	4.49 E-01	3.30 E-01
Hf-179m	1.21 E-03	8.82 E-04
Hf-180m	1.92 E-05	1.42 E-05
Hf-181	1.28 E-03	9.34 E-04
Hf-182+D	4.52 E-01	3.32 E-01
Hf-182	7.88 E-02	5.76 E-02
Ta-179	5.63 E-04	4.13 E-04
Ta-180	2.34 E-04	1.69 E-04
Ta-182	6.11 E-03	4.48 E-03
Ta-182m+D	5.94 E-07	4.37 E-07
Ta-182m	7.48 E-09	7.08 E-09
Ta-183	1.57 E-04	1.13 E-04
W-181	3.11 E-04	2.28 E-04
W-185	7.03 E-04	5.12 E-04
W-185m+D	1.04 E-08	7.56 E-09
W-185m	1.26 E-21	1.04 E-21
W-187+D	3.91 E-05	2.82 E-05
W-188+D	3.51 E-03	2.56 E-03
W-188	3.10 E-03	2.26 E-03
Re-186	6.72 E-05	4.79 E-05
Re-186m+D	2.73 E-02	2.00 E-02
Re-186m	1.35 E-02	9.89 E-03
Re-187	2.04 E-05	1.50 E-05
Re-188	2.60 E-05	1.86 E-05
Os-185	2.65 E-03	1.94 E-03
Os-191	1.68 E-04	1.22 E-04
Ir-189+D	7.95 E-05	5.77 E-05
Ir-190	8.54 E-04	6.24 E-04
Ir-192	2.89 E-03	2.11 E-03
Ir-194	2.76 E-05	1.97 E-05
Pt-191	4.58 E-05	3.32 E-05
Pt-193	5.96 E-05	4.36 E-05
Pt-193m+D	4.07 E-05	2.87 E-05
Pt-195m	5.66 E-05	4.02 E-05
Pt-197	1.27 E-05	9.05 E-06
Pt-197m+D	1.96 E-06	1.46 E-06
Pt-199+D	3.98 E-07	3.05 E-07
Au-193+D	9.83 E-06	7.10 E-06
Au-193m+D	6.03 E-10	4.36 E-10
Au-193m	3.64 E-22	3.35 E-22
Au-194	8.13 E-05	5.92 E-05
Au-195	6.82 E-04	4.99 E-04
Au-195m+D	1.29 E-09	9.47 E-10
Au-195m	2.46 E-21	2.34 E-21
Au-196	1.14 E-04	8.35 E-05

Table 4.3. (contd)

Nuclide[a,b]	Effective Release Height <40 m mrem/yr per Ci/yr[c] 100-K Offsite MEI	Effective Release Height ≥40 m mrem/yr per Ci/yr[c] 100-K Offsite MEI
Au-196m+D	1.24 E-05	9.12 E-06
Au-196m	5.31 E-06	3.90 E-06
Au-198	8.23 E-05	5.94 E-05
Au-198m+D	1.58 E-04	1.14 E-04
Au-198m	1.20 E-04	8.58 E-05
Au-199	4.11 E-05	2.93 E-05
Hg-203	7.10 E-04	5.18 E-04
Hg-205	6.85 E-15	6.54 E-15
Hg-206+D	2.32 E-11	2.21 E-11
Tl-200	7.42 E-05	5.41 E-05
Tl-201	1.79 E-05	1.29 E-05
Tl-202	2.92 E-04	2.14 E-04
Tl-204	3.22 E-03	2.35 E-03
Tl-206	1.59 E-13	1.05 E-13
Tl-206m	2.37 E-15	2.27 E-15
Tl-207+D	1.05 E-14	9.50 E-15
Tl-208	1.19 E-10	8.58 E-11
Tl-209+D	1.40 E-08	1.04 E-08
Tl-210+D	3.57 E-08	2.60 E-08
Pb-203	3.64 E-05	2.64 E-05
Pb-204m	5.88 E-06	4.87 E-06
Pb-205	1.83 E-04	1.34 E-04
Pb-209	1.25 E-06	9.33 E-07
Pb-210+D	3.20 E-01	2.34 E-01
Pb-210	3.14 E-01	2.29 E-01
Pb-211+D	2.25 E-05	2.00 E-05
Pb-212+D	6.37 E-03	4.53 E-03
Pb-214+D	3.82 E-05	3.47 E-05
Pb-214	9.21 E-06	8.46 E-06
Bi-207	3.11 E-01	2.29 E-01
Bi-208	7.03 E-01	5.16 E-01
Bi-210+D	3.94 E-03	2.76 E-03
Bi-210	3.79 E-03	2.66 E-03
Bi-210m+D	2.62 E-01	1.87 E-01
Bi-211+D	9.85 E-16	9.41 E-16
Bi-211	3.51 E-23	3.46 E-23
Bi-212+D	1.73 E-04	1.45 E-04
Bi-212n+D	3.21 E-12	3.05 E-12
Bi-212n	2.77 E-13	2.64 E-13
Bi-213+D	9.39 E-05	8.13 E-05
Bi-214+D	3.74 E-06	3.41 E-06
Po-208+D	7.77 E-07	5.71 E-07
Po-209+D	1.60 E-03	1.18 E-03
Po-210	2.42 E-01	1.73 E-01
Po-211	0.00 E+00	0.00 E+00
Po-212	0.00 E+00	0.00 E+00
Po-212m	5.71 E-20	5.40 E-20
Po-213+D	0.00 E+00	0.00 E+00
Po-214+D	7.48 E-14	5.45 E-14
Po-215+D	1.85 E-11	1.65 E-11
Po-215	2.20 E-27	1.61 E-27
Po-216+D	2.40 E-08	1.71 E-08
Po-216	0.00 E+00	0.00 E+00
Po-218+D	4.91 E-06	4.48 E-06
Po-218	4.06 E-22	2.99 E-22
At-217+D	1.10 E-09	9.60 E-10
At-217	0.00 E+00	0.00 E+00
At-218+D	4.03 E-09	3.78 E-09
At-218	8.67 E-29	7.15 E-29

Table 4.3. (contd)

Nuclide[a,b]	Effective Release Height <40 m mrem/yr per Ci/yr[c] 100-K Offsite MEI	Effective Release Height ≥40 m mrem/yr per Ci/yr[c] 100-K Offsite MEI
Rn-218+D	1.60 E-11	1.16 E-11
Rn-218	0.00 E+00	0.00 E+00
Rn-219+D	4.12 E-08	3.68 E-08
Rn-219	7.80 E-18	5.73 E-18
Rn-220+D	9.26 E-06	6.59 E-06
Rn-220	6.14 E-25	6.14 E-25
Rn-222+D	1.07 E-03	7.39 E-04
Rn-222	8.36 E-09	4.52 E-09
Rn-224+D	2.37 E-03	1.65 E-03
Fr-221+D	1.13 E-05	9.79 E-06
Fr-221	5.02 E-15	4.78 E-15
Fr-222+D	1.33 E-06	1.18 E-06
Fr-223+D	4.02 E-04	2.83 E-04
Fr-223	3.42 E-06	3.19 E-06
Ra-223+D	3.01 E-01	2.10 E-01
Ra-224+D	1.16 E-01	8.14 E-02
Ra-225+D	2.65 E-01	1.86 E-01
Ra-226+D	9.08 E-01	6.62 E-01
Ra-227+D	1.48 E-05	1.04 E-05
Ra-228+D	6.54 E-01	4.76 E-01
Ac-225+D	2.94 E-01	2.07 E-01
Ac-226+D	4.39 E-02	3.10 E-02
Ac-227+D	3.98 E+00	2.79 E+00
Ac-228+D	6.11 E-04	4.27 E-04
Th-227+D	4.20 E-01	2.94 E-01
Th-228+D	1.89 E+00	1.32 E+00
Th-229+D	3.98 E+00	2.80 E+00
Th-230+D	7.93 E-01	5.58 E-01
Th-231+D	1.31 E-05	9.25 E-06
Th-232+D	1.92 E+00	1.37 E+00
Th-233+D	2.86 E-07	2.08 E-07
Th-233	5.48 E-09	5.12 E-09
Th-234+D	9.59 E-04	6.92 E-04
Th-234	8.50 E-04	6.12 E-04
Pa-231+D	5.24 E+00	3.67 E+00
Pa-232m+D	1.13 E-04	8.15 E-05
Pa-232	9.41 E-05	6.79 E-05
Pa-233+D	4.91 E-04	3.56 E-04
Pa-234+D	3.92 E-05	2.87 E-05
Pa-234m+D	1.87 E-10	1.36 E-10
U-232+D	8.24 E-01	5.93 E-01
U-233+D	1.71 E-01	1.20 E-01
U-234+D	1.67 E-01	1.18 E-01
U-235+D	2.02 E-01	1.44 E-01
U-235m+D	1.39 E-14	9.92 E-15
U-235m	0.00 E+00	0.00 E+00
U-236+D	1.54 E-01	1.09 E-01
U-237+D	1.23 E-04	8.86 E-05
U-238+D	1.78 E-01	1.27 E-01
U-239+D	3.94 E-07	2.85 E-07
U-239	1.80 E-08	1.68 E-08
U-240+D	3.22 E-05	2.33 E-05
U-240	2.03 E-05	1.45 E-05
Np-235	7.26 E-05	5.26 E-05
Np-236+D	2.28 E-01	1.62 E-01
Np-236m+D	2.82 E-04	1.96 E-04
Np-237+D	1.30 E+00	9.19 E-01
Np-238+D	1.62 E-04	1.15 E-04
Np-239+D	5.48 E-05	3.91 E-05

Table 4.3. (contd)

Nuclide[a,b]	Effective Release Height <40 m mrem/yr per Ci/yr[c] 100-K Offsite MEI	Effective Release Height ≥40 m mrem/yr per Ci/yr[c] 100-K Offsite MEI
Np-240+D	3.11 E-06	2.59 E-06
Np-240m+D	6.16 E-09	4.39 E-09
Pu-234+D	7.83 E-04	5.52 E-04
Pu-235+D	1.97 E-01	1.40 E-01
Pu-236+D	1.03 E+00	7.25 E-01
Pu-237+D	1.13 E-04	8.25 E-05
Pu-238+D	2.50 E+00	1.75 E+00
Pu-239+D	2.73 E+00	1.91 E+00
Pu-240+D	2.73 E+00	1.91 E+00
Pu-241+D	5.09 E-02	3.57 E-02
Pu-242+D	2.59 E+00	1.81 E+00
Pu-243+D	2.64 E-06	1.93 E-06
Pu-244+D	2.67 E+00	1.88 E+00
Am-240+D	1.11 E-04	8.09 E-05
Am-241+D	2.26 E+00	1.58 E+00
Am-242+D	7.51 E-04	5.26 E-04
Am-242m+D	2.05 E+00	1.43 E+00
Am-243+D	2.29 E+00	1.61 E+00
Am-244+D	1.18 E-04	8.37 E-05
Am-244m+D	3.86 E-06	2.71 E-06
Am-244m	7.22 E-08	6.65 E-08
Am-245+D	1.08 E-06	8.35 E-07
Am-246+D	8.10 E-07	7.09 E-07
Cm-241+D	2.37 E-03	1.69 E-03
Cm-242+D	2.27 E-01	1.59 E-01
Cm-243+D	1.70 E+00	1.20 E+00
Cm-244+D	1.41 E+00	9.88 E-01
Cm-245+D	2.32 E+00	1.63 E+00
Cm-246+D	2.28 E+00	1.60 E+00
Cm-247+D	2.19 E+00	1.54 E+00
Cm-248+D	8.55 E+00	6.01 E+00
Cm-249+D	1.34 E-06	9.58 E-07
Cm-250+D	5.04 E+01	3.55 E+01
Bk-247+D	3.81 E+00	2.67 E+00
Bk-248m+D	7.68 E-05	4.85 E-05
Bk-248m	2.75 E-06	2.01 E-06
Bk-249+D	9.14 E-03	6.41 E-03
Bk-250+D	6.11 E-05	4.34 E-05
Cf-249+D	3.90 E+00	2.74 E+00
Cf-250+D	1.81 E+00	1.27 E+00
Cf-251+D	3.90 E+00	2.74 E+00
Cf-252+D	1.03 E+00	7.25 E-01
Es-254+D	4.13 E-01	2.90 E-01

MEI = Maximally exposed individual
Bold nuclides are newly available in CAP88-PC version 4.
n/a = nuclide or indicated solubility class is not available in CAP88-PC version 4.
(a) +D indicates that the listed radionuclide dose includes the contribution from the parent radionuclide plus decay products grown in during transit and the build-up period.
(b) If the *nuclide+D* is followed by the nuclide without the +D, the decay chain members contribute greater than 10% of the *nuclide+D* dose. V = vapor; E = elemental; O = organic compounds; F = particulate, fast clearance rate; M = particulate, moderate clearance rate; S = particulate, slow clearance rate. Carbon isotopes are modeled as particulate (M), carbon monoxide (CO), or carbon dioxide (CO2).
(c) If a radionuclide is indicated rather than a dose factor value, the nuclide is used as a surrogate. See Table 3.4 for additional details.

This page intentionally left blank.

Table 4.4. **200 East Area**: Offsite and Onsite MEIs CAP88-PC Dose-per-Unit-Release Factors (mrem/Ci) by Effective Release Height

	Effective Release Height <40 m		**Effective Release Height ≥40 m**	
	mrem/yr per Ci/yr[c]		**mrem/yr per Ci/yr[c]**	
Nuclide[a,b]	**200-E Offsite MEI**	**200-E Onsite MEI[d]**	**200-E Offsite MEI**	**200-E Onsite MEI[d]**
H-3 (V)	1.21 E-05	2.77 E-06	6.94 E-06	1.65 E-06
H-3 (E)	1.08 E-05	1.25 E-06	6.20 E-06	7.84 E-07
H-3 (O)	2.65 E-05	4.92 E-06	1.52 E-05	2.87 E-06
H-3 (F)	8.88 E-06	1.02 E-06	5.80 E-06	7.91 E-07
H-3 (M)	1.11 E-05	3.68 E-06	7.24 E-06	2.51 E-06
H-3 (S)	2.35 E-05	1.87 E-05	1.53 E-05	1.22 E-05
Be-7	1.13 E-04	1.27 E-04	7.70 E-05	8.56 E-05
Be-10	2.37 E-03	1.97 E-03	1.61 E-03	1.32 E-03
C-11	4.26 E-07	8.46 E-07	3.19 E-07	6.14 E-07
C-11 (CO)	4.79 E-07	9.37 E-07	3.23 E-07	6.14 E-07
C-11 (CO2)	4.80 E-07	9.40 E-07	3.24 E-07	6.16 E-07
C-14	1.13 E-03	1.66 E-04	7.37 E-04	1.22 E-04
C-14 (CO)	1.31 E-03	1.15 E-04	7.49 E-04	7.34 E-05
C-14 (CO2)	1.31 E-03	1.16 E-04	7.49 E-04	7.38 E-05
C-15	C-11	C-11	C-11	C-11
N-13	1.26 E-08	3.94 E-08	9.83 E-09	2.96 E-08
O-15	2.04 E-18	2.20 E-17	1.44 E-18	2.00 E-17
O-19	1.17 E-18	2.64 E-19	5.13 E-19	1.35 E-19
F-18	1.00 E-05	1.33 E-05	6.73 E-06	8.81 E-06
Na-22	9.39 E-02	8.98 E-02	6.42 E-02	6.09 E-02
Na-24	1.67 E-04	2.04 E-04	1.12 E-04	1.35 E-04
Mg-27	6.90 E-09	2.27 E-08	5.83 E-09	1.86 E-08
Mg-28+D	2.00 E-04	2.42 E-04	1.34 E-04	1.60 E-04
Mg-28	1.16 E-04	1.39 E-04	7.72 E-05	9.12 E-05
Al-26	7.98 E-01	9.61 E-01	5.45 E-01	6.48 E-01
Al-28	1.22 E-17	3.37 E-16	1.15 E-17	3.10 E-16
Si-31	2.30 E-06	2.97 E-06	1.53 E-06	1.95 E-06
Si-32+D	2.57 E-02	3.08 E-02	1.76 E-02	2.07 E-02
Si-32	1.14 E-03	1.09 E-03	7.54 E-04	7.07 E-04
P-32	9.67 E-04	3.04 E-04	6.56 E-04	2.12 E-04
P-33	2.18 E-04	8.49 E-05	1.47 E-04	5.75 E-05
S-35	9.04 E-04	1.15 E-04	6.16 E-04	8.70 E-05
Cl-36	7.65 E-01	4.86 E-02	5.23 E-01	4.47 E-02
Ar-37	0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00
Ar-39	4.83 E-08	5.72 E-08	2.77 E-08	3.25 E-08
Ar-41	1.28 E-05	1.67 E-05	7.55 E-06	9.74 E-06
Ar-42+D	2.94 E-06	3.08 E-06	1.88 E-06	1.95 E-06
Ar-42	5.30 E-08	6.27 E-08	3.03 E-08	3.56 E-08
K-40	1.48 E-01	8.48 E-02	1.01 E-01	5.84 E-02
K-42	2.66 E-05	3.25 E-05	1.77 E-05	2.13 E-05
Ca-41	1.35 E-03	9.78 E-05	9.20 E-04	9.06 E-05
Ca-45	4.93 E-04	1.69 E-04	3.33 E-04	1.17 E-04
Ca-47+D	3.24 E-04	3.61 E-04	2.18 E-04	2.41 E-04
Sc-44	3.97 E-05	5.01 E-05	2.65 E-05	3.30 E-05
Sc-44m+D	3.02 E-04	3.61 E-04	2.05 E-04	2.40 E-04
Sc-44m	9.01 E-05	1.06 E-04	5.97 E-05	6.93 E-05
Sc-46	7.04 E-03	8.02 E-03	4.81 E-03	5.41 E-03
Sc-47	4.45 E-05	5.13 E-05	2.96 E-05	3.36 E-05
Ti-44+D	5.79 E-01	6.84 E-01	3.96 E-01	4.62 E-01
Ti-44	4.62 E-02	4.15 E-02	3.15 E-02	2.82 E-02

Table 4.4. (contd)

Nuclide[a,b]	Effective Release Height <40 m mrem/yr per Ci/yr[c] 200-E Offsite MEI	Effective Release Height <40 m mrem/yr per Ci/yr[c] 200-E Onsite MEI[d]	Effective Release Height ≥40 m mrem/yr per Ci/yr[c] 200-E Offsite MEI	Effective Release Height ≥40 m mrem/yr per Ci/yr[c] 200-E Onsite MEI[d]
Ti-45	1.41 E-05	1.81 E-05	9.45 E-06	1.19 E-05
Ti-51	3.17 E-11	1.84 E-10	2.88 E-11	1.64 E-10
V-48	2.16 E-03	2.31 E-03	1.47 E-03	1.56 E-03
V-49	1.62 E-05	3.06 E-06	1.10 E-05	2.22 E-06
Cr-49+D	3.06 E-06	4.74 E-06	2.14 E-06	3.24 E-06
Cr-51	5.04 E-05	4.36 E-05	3.44 E-05	2.95 E-05
Cr-55	1.45 E-15	2.18 E-14	1.36 E-15	2.02 E-14
Mn-52	8.69 E-04	1.01 E-03	5.91 E-04	6.78 E-04
Mn-52m+D	1.21 E-06	2.34 E-06	9.00 E-07	1.69 E-06
Mn-53	1.31 E-04	1.20 E-05	8.96 E-05	1.03 E-05
Mn-54	1.01 E-02	1.18 E-02	6.91 E-03	7.97 E-03
Mn-56	2.43 E-05	3.14 E-05	1.63 E-05	2.07 E-05
Fe-55	6.83 E-04	5.89 E-05	4.66 E-04	4.81 E-05
Fe-59	3.26 E-03	2.66 E-03	2.22 E-03	1.80 E-03
Co-56	1.31 E-02	1.27 E-02	8.92 E-03	8.61 E-03
Co-57	1.60 E-03	1.46 E-03	1.10 E-03	9.93 E-04
Co-58	3.44 E-03	3.31 E-03	2.35 E-03	2.24 E-03
Co-58m+D	1.51 E-05	1.76 E-05	1.03 E-05	1.19 E-05
Co-58m	5.67 E-07	6.99 E-07	3.72 E-07	4.52 E-07
Co-60	1.68 E-01	1.88 E-01	1.15 E-01	1.27 E-01
Co-60m+D	6.33 E-07	7.08 E-07	4.33 E-07	4.79 E-07
Co-60m	1.12 E-10	3.37 E-10	9.27 E-11	2.71 E-10
Ni-56+D	1.32 E-03	1.52 E-03	8.98 E-04	1.02 E-03
Ni-56	5.21 E-04	5.61 E-04	3.54 E-04	3.77 E-04
Ni-57+D	1.67 E-04	1.95 E-04	1.12 E-04	1.30 E-04
Ni-59	2.60 E-04	3.11 E-05	1.78 E-04	2.53 E-05
Ni-63	5.69 E-04	6.49 E-05	3.89 E-04	5.30 E-05
Ni-65	9.22 E-06	1.20 E-05	6.17 E-06	7.88 E-06
Cu-64	1.02 E-05	1.25 E-05	6.79 E-06	8.20 E-06
Cu-66	2.52 E-12	1.76 E-11	2.31 E-12	1.58 E-11
Cu-67	3.58 E-05	4.22 E-05	2.38 E-05	2.76 E-05
Zn-65	2.66 E-02	7.44 E-03	1.82 E-02	5.31 E-03
Zn-69	3.17 E-07	4.62 E-07	2.18 E-07	3.11 E-07
Zn-69m+D	2.62 E-05	3.18 E-05	1.75 E-05	2.09 E-05
Ga-67	3.12 E-05	3.69 E-05	2.09 E-05	2.45 E-05
Ga-68	5.99 E-06	8.45 E-06	4.08 E-06	5.66 E-06
Ga-70	2.98 E-08	5.82 E-08	2.22 E-08	4.21 E-08
Ga-72	1.15 E-04	1.41 E-04	7.72 E-05	9.32 E-05
Ge-68+D	2.76 E-02	1.46 E-02	1.88 E-02	1.00 E-02
Ge-68	1.69 E-02	1.69 E-03	1.15 E-02	1.33 E-03
Ge-69	8.52 E-05	1.02 E-04	5.75 E-05	6.80 E-05
Ge-71	6.22 E-06	1.00 E-06	4.24 E-06	7.33 E-07
Ge-75	9.37 E-07	1.29 E-06	6.34 E-07	8.55 E-07
Ge-77+D	4.87 E-05	5.97 E-05	3.25 E-05	3.92 E-05
As-73	2.55 E-04	8.44 E-05	1.73 E-04	5.82 E-05
As-74	8.86 E-04	7.93 E-04	6.02 E-04	5.35 E-04
As-76	6.08 E-05	7.39 E-05	4.04 E-05	4.85 E-05
As-77	1.74 E-05	2.11 E-05	1.14 E-05	1.36 E-05
Se-75	1.19 E-02	2.63 E-03	8.11 E-03	1.92 E-03
Se-77m	1.43 E-21	9.51 E-21	9.61 E-22	8.36 E-21

Table 4.4. (contd)

Nuclide[a,b]	Effective Release Height <40 m mrem/yr per Ci/yr[c] 200-E Offsite MEI	Effective Release Height <40 m mrem/yr per Ci/yr[c] 200-E Onsite MEI[d]	Effective Release Height ≥40 m mrem/yr per Ci/yr[c] 200-E Offsite MEI	Effective Release Height ≥40 m mrem/yr per Ci/yr[c] 200-E Onsite MEI[d]
Se-79	4.06 E-02	2.13 E-03	2.78 E-02	2.00 E-03
Se-79m+D	1.03 E-12	9.55 E-14	7.05 E-13	8.87 E-14
Se-79m	3.58 E-15	4.14 E-14	3.34 E-15	3.82 E-14
Br-82	2.12 E-04	2.53 E-04	1.43 E-04	1.68 E-04
Br-82m+D	6.01 E-07	7.17 E-07	4.06 E-07	4.77 E-07
Br-82m	5.88 E-13	3.14 E-12	5.30 E-13	2.76 E-12
Br-83+D	1.39 E-06	1.81 E-06	9.30 E-07	1.19 E-06
Br-84	3.06 E-06	5.12 E-06	2.18 E-06	3.56 E-06
Br-84m	3.80 E-10	2.09 E-09	3.44 E-10	1.84 E-09
Br-85+D	2.35 E-08	2.90 E-08	1.36 E-08	1.66 E-08
Br-85	1.38 E-16	3.40 E-15	1.30 E-16	3.17 E-15
Kr-81	1.61 E-08	1.90 E-08	9.19 E-09	1.08 E-08
Kr-81m+D	2.91 E-20	3.44 E-20	1.67 E-20	1.96 E-20
Kr-83m	2.29 E-10	2.99 E-10	1.35 E-10	1.74 E-10
Kr-85	1.01 E-07	1.20 E-07	5.80 E-08	6.81 E-08
Kr-85m+D	2.16 E-06	2.66 E-06	1.25 E-06	1.53 E-06
Kr-87+D	6.10 E-06	8.30 E-06	3.64 E-06	4.89 E-06
Kr-88+D	3.49 E-05	4.40 E-05	2.10 E-05	2.62 E-05
Kr-88	2.60 E-05	3.27 E-05	1.51 E-05	1.89 E-05
Kr-89+D	1.42 E-07	2.04 E-07	1.04 E-07	1.53 E-07
Kr-89	2.04 E-14	3.99 E-13	1.85 E-14	3.59 E-13
Kr-90	6.85 E-09	1.41 E-09	4.68 E-09	1.04 E-09
Rb-81+D	1.34 E-05	1.67 E-05	8.78 E-06	1.09 E-05
Rb-81	1.10 E-05	1.38 E-05	7.35 E-06	9.09 E-06
Rb-81m+D	1.58 E-06	1.96 E-06	1.04 E-06	1.27 E-06
Rb-81m	9.08 E-08	1.54 E-07	6.49 E-08	1.07 E-07
Rb-82	6.52 E-19	2.06 E-18	6.12 E-19	1.93 E-18
Rb-82m	6.64 E-05	8.25 E-05	4.44 E-05	5.44 E-05
Rb-83+D	4.10 E-03	2.15 E-03	2.80 E-03	1.48 E-03
Rb-84	2.80 E-03	1.61 E-03	1.91 E-03	1.11 E-03
Rb-84m+D	1.33 E-06	9.83 E-07	9.17 E-07	6.87 E-07
Rb-84m	1.46 E-07	2.91 E-07	1.10 E-07	2.12 E-07
Rb-86	1.14 E-03	4.41 E-04	7.76 E-04	3.03 E-04
Rb-86m+D	4.33 E-08	1.67 E-08	2.94 E-08	1.15 E-08
Rb-86m	4.81 E-19	4.79 E-19	2.67 E-19	4.47 E-19
Rb-87	1.95 E-02	1.35 E-03	1.33 E-02	1.19 E-03
Rb-88	1.97 E-07	4.19 E-07	1.50 E-07	3.09 E-07
Rb-89+D	6.06 E-07	8.04 E-07	4.40 E-07	5.99 E-07
Rb-90+D	3.34 E-08	6.89 E-09	2.29 E-08	5.08 E-09
Rb-90	4.35 E-16	1.38 E-14	4.10 E-16	1.29 E-14
Rb-90m+D	5.46 E-08	1.13 E-08	3.74 E-08	8.37 E-09
Rb-90m	6.80 E-12	6.50 E-11	6.32 E-12	5.96 E-11
Sr-82+D	3.14 E-03	2.17 E-03	2.13 E-03	1.46 E-03
Sr-82	1.89 E-03	6.56 E-04	1.28 E-03	4.51 E-04
Sr-83+D	9.34 E-05	1.11 E-04	6.30 E-05	7.43 E-05
Sr-83	6.68 E-05	8.08 E-05	4.49 E-05	5.36 E-05
Sr-85	1.55 E-03	1.55 E-03	1.06 E-03	1.05 E-03
Sr-85m+D	2.11 E-06	2.66 E-06	1.44 E-06	1.79 E-06
Sr-85m	1.20 E-06	1.70 E-06	8.21 E-07	1.14 E-06
Sr-87m+D	4.46 E-06	5.75 E-06	2.99 E-06	3.79 E-06

Table 4.4. (contd)

Nuclide[a,b]	Effective Release Height <40 m mrem/yr per Ci/yr[c] 200-E Offsite MEI	Effective Release Height <40 m mrem/yr per Ci/yr[c] 200-E Onsite MEI[d]	Effective Release Height ≥40 m mrem/yr per Ci/yr[c] 200-E Offsite MEI	Effective Release Height ≥40 m mrem/yr per Ci/yr[c] 200-E Onsite MEI[d]
Sr-89	1.52 E-03	6.05 E-04	1.03 E-03	4.14 E-04
Sr-90+D	1.93 E-01	3.96 E-02	1.32 E-01	2.93 E-02
Sr-91+D	4.47 E-05	5.43 E-05	2.97 E-05	3.57 E-05
Sr-92+D	2.70 E-05	3.42 E-05	1.80 E-05	2.25 E-05
Y-88	1.09 E-02	1.27 E-02	7.46 E-03	8.59 E-03
Y-89m	0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00
Y-90	8.12 E-05	9.31 E-05	5.36 E-05	6.05 E-05
Y-90m+D	1.31 E-05	1.65 E-05	8.75 E-06	1.08 E-05
Y-91	1.13 E-03	6.86 E-04	7.64 E-04	4.60 E-04
Y-91m+D	2.52 E-06	3.28 E-06	1.72 E-06	2.22 E-06
Y-92	1.01 E-05	1.28 E-05	6.70 E-06	8.39 E-06
Y-93+D	2.12 E-05	2.61 E-05	1.40 E-05	1.70 E-05
Zr-88+D	9.45 E-03	1.13 E-02	6.45 E-03	7.61 E-03
Zr-88	1.48 E-03	1.67 E-03	1.00 E-03	1.12 E-03
Zr-89	1.87 E-04	2.22 E-04	1.26 E-04	1.48 E-04
Zr-89m+D	1.55 E-07	1.84 E-07	1.05 E-07	1.23 E-07
Zr-93+D	1.00 E-03	8.31 E-04	6.68 E-04	5.47 E-04
Zr-95+D	4.09 E-03	4.70 E-03	2.79 E-03	3.17 E-03
Zr-97+D	1.01 E-04	1.23 E-04	6.75 E-05	8.08 E-05
Zr-97	7.53 E-05	9.20 E-05	5.00 E-05	6.03 E-05
Nb-91	1.49 E-03	1.80 E-03	1.02 E-03	1.22 E-03
Nb-91m+D	6.46 E-05	7.79 E-05	4.41 E-05	5.26 E-05
Nb-92	4.57 E-01	5.52 E-01	3.13 E-01	3.72 E-01
Nb-92m	3.81 E-04	4.61 E-04	2.60 E-04	3.10 E-04
Nb-93m	1.72 E-04	1.61 E-04	1.17 E-04	1.08 E-04
Nb-94	4.77 E-01	5.76 E-01	3.26 E-01	3.88 E-01
Nb-94m+D	2.80 E-10	3.41 E-10	1.91 E-10	2.32 E-10
Nb-95	1.20 E-03	1.34 E-03	8.18 E-04	8.98 E-04
Nb-95m+D	1.46 E-04	1.73 E-04	9.87 E-05	1.15 E-04
Nb-95m	4.65 E-05	5.29 E-05	3.07 E-05	3.45 E-05
Nb-96	1.49 E-04	1.81 E-04	1.00 E-04	1.20 E-04
Nb-97	4.66 E-06	6.52 E-06	3.17 E-06	4.36 E-06
Mo-93+D	5.59 E-03	1.94 E-03	3.82 E-03	1.39 E-03
Mo-93m+D	5.66 E-05	7.02 E-05	3.78 E-05	4.62 E-05
Mo-99+D	7.45 E-05	8.76 E-05	4.96 E-05	5.75 E-05
Mo-99	6.30 E-05	7.38 E-05	4.18 E-05	4.83 E-05
Tc-95	3.95 E-05	4.81 E-05	2.65 E-05	3.19 E-05
Tc-95m+D	1.98 E-03	2.07 E-03	1.35 E-03	1.40 E-03
Tc-96	4.87 E-04	5.72 E-04	3.31 E-04	3.84 E-04
Tc-96m+D	4.09 E-06	4.88 E-06	2.78 E-06	3.27 E-06
Tc-96m	2.43 E-07	3.60 E-07	1.68 E-07	2.43 E-07
Tc-97	4.46 E-03	2.01 E-03	3.05 E-03	1.41 E-03
Tc-97m+D	5.27 E-04	2.10 E-04	3.56 E-04	1.44 E-04
Tc-98	5.18 E-01	5.27 E-01	3.54 E-01	3.58 E-01
Tc-99	2.84 E-02	2.31 E-03	1.94 E-02	2.11 E-03
Tc-99m+D	3.02 E-06	3.76 E-06	2.02 E-06	2.47 E-06
Tc-101	3.21 E-08	7.78 E-08	2.53 E-08	5.93 E-08
Ru-97+D	3.32 E-05	3.98 E-05	2.25 E-05	2.65 E-05
Ru-103+D	1.01 E-03	1.05 E-03	6.91 E-04	7.07 E-04
Ru-105+D	1.91 E-05	2.39 E-05	1.28 E-05	1.57 E-05

Table 4.4. (contd)

Nuclide[a,b]	Effective Release Height <40 m mrem/yr per Ci/yr[c] 200-E Offsite MEI	Effective Release Height <40 m mrem/yr per Ci/yr[c] 200-E Onsite MEI[d]	Effective Release Height ≥40 m mrem/yr per Ci/yr[c] 200-E Offsite MEI	Effective Release Height ≥40 m mrem/yr per Ci/yr[c] 200-E Onsite MEI[d]
Ru-106+D	9.32 E-03	8.12 E-03	6.33 E-03	5.48 E-03
Ru-106	4.26 E-03	2.02 E-03	2.87 E-03	1.36 E-03
Rh-101	1.18 E-02	1.39 E-02	8.03 E-03	9.38 E-03
Rh-101m+D	6.35 E-05	7.41 E-05	4.30 E-05	4.96 E-05
Rh-102	5.40 E-03	5.42 E-03	3.68 E-03	3.66 E-03
Rh-102m+D	1.02 E-01	1.22 E-01	6.97 E-02	8.24 E-02
Rh-103m	2.64 E-08	3.85 E-08	1.81 E-08	2.58 E-08
Rh-104	3.00 E-20	5.71 E-21	1.78 E-20	4.00 E-21
Rh-104m+D	1.26 E-13	1.18 E-12	1.17 E-13	1.08 E-12
Rh-104m	4.40 E-14	4.13 E-13	4.09 E-14	3.78 E-13
Rh-105	1.85 E-05	2.24 E-05	1.22 E-05	1.46 E-05
Rh-105m	Rh-105	Rh-105	Rh-105	Rh-105
Rh-106	9.43 E-21	6.40 E-20	8.87 E-21	6.00 E-20
Pd-103+D	4.26 E-05	2.82 E-05	2.86 E-05	1.88 E-05
Pd-107	4.63 E-05	8.60 E-06	3.15 E-05	6.46 E-06
Pd-109	1.42 E-05	1.74 E-05	9.32 E-06	1.13 E-05
Pd-109m+D	8.15 E-08	9.98 E-08	5.35 E-08	6.46 E-08
Pd-111+D	3.62 E-07	3.09 E-07	2.45 E-07	2.08 E-07
Pd-111	4.32 E-08	8.07 E-08	3.18 E-08	5.78 E-08
Pd-112+D	3.31 E-05	3.93 E-05	2.24 E-05	2.62 E-05
Pd-112	8.21 E-08	1.00 E-07	5.60 E-08	6.72 E-08
Ag-108	4.91 E-19	1.68 E-17	4.64 E-19	1.57 E-17
Ag-108m+D	4.83 E-01	5.82 E-01	3.31 E-01	3.92 E-01
Ag-109m	2.89 E-21	1.62 E-21	2.03 E-21	9.16 E-22
Ag-110	3.76 E-20	2.95 E-21	1.94 E-20	2.96 E-21
Ag-110m+D	2.76 E-02	3.15 E-02	1.89 E-02	2.12 E-02
Ag-111	1.52 E-04	1.09 E-04	1.02 E-04	7.18 E-05
Ag-111m+D	1.52 E-08	1.09 E-08	1.01 E-08	7.17 E-09
Ag-111m	1.28 E-20	0.00 E+00	6.63 E-21	0.00 E+00
Ag-112	1.53 E-05	1.95 E-05	1.02 E-05	1.28 E-05
Cd-107	3.14 E-06	3.90 E-06	2.07 E-06	2.54 E-06
Cd-109	1.88 E-03	8.32 E-04	1.27 E-03	5.74 E-04
Cd-111m	9.13 E-07	1.37 E-06	6.32 E-07	9.29 E-07
Cd-113	1.19 E-01	1.20 E-02	8.14 E-02	1.03 E-02
Cd-113m	5.63 E-02	7.53 E-03	3.84 E-02	6.03 E-03
Cd-115+D	8.10 E-05	9.46 E-05	5.39 E-05	6.22 E-05
Cd-115	6.62 E-05	7.69 E-05	4.39 E-05	5.03 E-05
Cd-115m+D	1.32 E-03	6.55 E-04	8.92 E-04	4.46 E-04
Cd-117+D	2.20 E-05	2.78 E-05	1.46 E-05	1.83 E-05
Cd-117m+D	4.60 E-05	5.79 E-05	3.07 E-05	3.80 E-05
In-106	6.71 E-10	3.53 E-09	6.05 E-10	3.10 E-09
In-111	5.73 E-05	6.86 E-05	3.87 E-05	4.58 E-05
In-111m+D	1.10 E-07	1.34 E-07	7.45 E-08	8.97 E-08
In-112	3.19 E-08	7.47 E-08	2.49 E-08	5.65 E-08
In-112m+D	3.27 E-07	6.03 E-07	2.40 E-07	4.29 E-07
In-112m	9.17 E-09	1.81 E-08	6.85 E-09	1.32 E-08
In-113m	2.47 E-06	3.32 E-06	1.67 E-06	2.20 E-06
In-114	3.27 E-19	1.07 E-19	2.05 E-19	1.01 E-19
In-114m+D	1.81 E-03	9.23 E-04	1.23 E-03	6.29 E-04
In-115	2.89 E-02	1.20 E-02	1.95 E-02	8.11 E-03

Table 4.4. (contd)

Nuclide[a,b]	Effective Release Height <40 m mrem/yr per Ci/yr[c] 200-E Offsite MEI	Effective Release Height <40 m mrem/yr per Ci/yr[c] 200-E Onsite MEI[d]	Effective Release Height ≥40 m mrem/yr per Ci/yr[c] 200-E Offsite MEI	Effective Release Height ≥40 m mrem/yr per Ci/yr[c] 200-E Onsite MEI[d]
In-115m+D	4.50 E-06	5.66 E-06	2.99 E-06	3.71 E-06
In-116m	1.11 E-05	1.63 E-05	7.64 E-06	1.10 E-05
In-117+D	2.13 E-06	3.28 E-06	1.49 E-06	2.24 E-06
In-117m+D	6.24 E-06	7.93 E-06	4.16 E-06	5.19 E-06
In-117m	2.53 E-06	3.36 E-06	1.70 E-06	2.21 E-06
Sn-113+D	1.81 E-03	1.65 E-03	1.24 E-03	1.11 E-03
Sn-113	6.83 E-04	2.83 E-04	4.63 E-04	1.94 E-04
Sn-113m+D	2.12 E-07	1.96 E-07	1.45 E-07	1.32 E-07
Sn-113m	1.21 E-09	2.35 E-09	9.02 E-10	1.70 E-09
Sn-117m	2.64 E-04	2.25 E-04	1.77 E-04	1.49 E-04
Sn-119m	5.15 E-04	2.69 E-04	3.49 E-04	1.83 E-04
Sn-121	9.06 E-06	1.10 E-05	5.93 E-06	7.07 E-06
Sn-121m+D	2.49 E-03	1.40 E-03	1.69 E-03	9.63 E-04
Sn-123	2.16 E-03	9.91 E-04	1.47 E-03	6.77 E-04
Sn-123m	5.19 E-07	8.13 E-07	3.63 E-07	5.57 E-07
Sn-125+D	6.79 E-04	5.71 E-04	4.60 E-04	3.84 E-04
Sn-125m+D	1.10 E-07	1.36 E-07	7.60 E-08	9.32 E-08
Sn-126+D	6.57 E-01	7.68 E-01	4.49 E-01	5.18 E-01
Sn-126	3.92 E-02	2.19 E-02	2.67 E-02	1.51 E-02
Sb-122	1.09 E-04	1.29 E-04	7.32 E-05	8.50 E-05
Sb-122m+D	1.17 E-07	1.38 E-07	7.83 E-08	9.10 E-08
Sb-122m	5.06 E-14	5.09 E-13	4.71 E-14	4.67 E-13
Sb-124	5.12 E-03	5.50 E-03	3.49 E-03	3.71 E-03
Sb-124m+D	6.87 E-08	7.38 E-08	4.68 E-08	4.97 E-08
Sb-124n+D	1.08 E-06	1.34 E-06	7.50 E-07	9.23 E-07
Sb-124n	6.14 E-09	1.22 E-08	4.59 E-09	8.88 E-09
Sb-125+D	1.64 E-02	1.94 E-02	1.13 E-02	1.30 E-02
Sb-126	1.68 E-03	1.81 E-03	1.14 E-03	1.21 E-03
Sb-126m+D	7.66 E-07	1.32 E-06	5.58 E-07	9.52 E-07
Sb-127+D	2.02 E-04	2.32 E-04	1.36 E-04	1.53 E-04
Sb-128	9.57 E-05	1.18 E-04	6.40 E-05	7.78 E-05
Sb-128m+D	9.60 E-08	1.70 E-07	6.89 E-08	1.24 E-07
Te-121	5.14 E-04	5.45 E-04	3.50 E-04	3.68 E-04
Te-121m+D	5.69 E-03	5.36 E-03	3.89 E-03	3.63 E-03
Te-121m	2.73 E-03	1.78 E-03	1.86 E-03	1.22 E-03
Te-123	1.21 E-02	8.34 E-04	8.24 E-03	7.48 E-04
Te-123m+D	1.51 E-03	1.01 E-03	1.03 E-03	6.88 E-04
Te-125m	5.19 E-04	2.68 E-04	3.50 E-04	1.81 E-04
Te-127	4.89 E-06	6.03 E-06	3.21 E-06	3.90 E-06
Te-127m+D	1.59 E-03	5.75 E-04	1.07 E-03	3.95 E-04
Te-129+D	9.52 E-07	1.34 E-06	6.48 E-07	8.95 E-07
Te-129m+D	1.23 E-03	6.38 E-04	8.28 E-04	4.32 E-04
Te-129m	1.13 E-03	5.18 E-04	7.60 E-04	3.51 E-04
Te-131+D	5.40 E-06	1.29 E-06	1.30 E-05	1.78 E-06
Te-131	3.98 E-07	7.25 E-07	2.91 E-07	5.15 E-07
Te-131m+D	1.70 E-04	1.93 E-04	1.41 E-04	1.30 E-04
Te-131m	1.33 E-04	1.61 E-04	8.90 E-05	1.06 E-04
Te-132+D	4.19 E-04	4.89 E-04	2.92 E-04	3.37 E-04
Te-132	1.38 E-04	1.49 E-04	9.18 E-05	9.74 E-05
Te-133+D	3.80 E-07	5.61 E-07	8.50 E-07	1.12 E-06

Table 4.4. (contd)

Nuclide[a,b]	Effective Release Height <40 m mrem/yr per Ci/yr[c] 200-E Offsite MEI	Effective Release Height <40 m mrem/yr per Ci/yr[c] 200-E Onsite MEI[d]	Effective Release Height ≥40 m mrem/yr per Ci/yr[c] 200-E Offsite MEI	Effective Release Height ≥40 m mrem/yr per Ci/yr[c] 200-E Onsite MEI[d]
Te-133	5.79 E-08	1.53 E-07	4.66 E-08	1.19 E-07
Te-133m+D	1.15 E-05	1.65 E-05	9.82 E-06	1.33 E-05
Te-134+D	5.10 E-06	7.93 E-06	6.77 E-06	1.05 E-05
Te-134	2.75 E-06	4.27 E-06	1.92 E-06	2.92 E-06
I-122	2.20 E-14	3.35 E-13	3.44 E-14	5.37 E-13
I-122(V)	n/a	n/a	n/a	n/a
I-123+D	3.62 E-06	5.36 E-06	9.02 E-06	1.31 E-05
I-123(V)+D	1.61 E-05	1.93 E-05	9.27 E-06	1.10 E-05
I-124	5.83 E-04	2.99 E-04	1.46 E-03	7.27 E-04
I-124(V)	8.42 E-04	1.01 E-03	4.82 E-04	5.84 E-04
I-125	1.83 E-02	5.58 E-04	4.59 E-02	1.01 E-03
I-125(V)	9.80 E-04	1.58 E-03	5.61 E-04	1.33 E-03
I-126	6.51 E-03	5.37 E-04	1.63 E-02	1.18 E-03
I-126(V)	1.85 E-03	2.36 E-03	1.06 E-03	1.50 E-03
I-128	1.48 E-08	3.15 E-08	3.12 E-08	6.68 E-08
I-128(V)	2.91 E-07	5.22 E-07	1.90 E-07	3.33 E-07
I-129	4.22 E-01	1.92 E-02	1.06 E+00	3.94 E-02
I-129(V)	6.74 E-03	1.72 E-02	3.86 E-03	1.92 E-02
I-130	4.40 E-05	6.56 E-05	1.09 E-04	1.61 E-04
I-130(V)	1.55 E-04	1.86 E-04	8.90 E-05	1.06 E-04
I-130m+D	4.45 E-07	6.64 E-07	1.11 E-06	1.63 E-06
I-130m	7.57 E-11	3.01 E-10	1.35 E-10	5.44 E-10
I-130m(V)	n/a	n/a	n/a	n/a
I-131+D	2.47 E-03	2.72 E-04	6.20 E-03	6.17 E-04
I-131(V)+D	1.39 E-03	1.65 E-03	7.96 E-04	9.36 E-04
I-132	6.69 E-06	1.06 E-05	1.62 E-05	2.54 E-05
I-132(V)	3.74 E-05	4.78 E-05	2.19 E-05	2.77 E-05
I-132m+D	4.97 E-06	7.64 E-06	1.22 E-05	1.86 E-05
I-132m	5.58 E-07	9.26 E-07	1.32 E-06	2.17 E-06
I-132m(V)+D	1.14 E-05	1.55 E-05	1.15 E-05	1.57 E-05
I-132m(V)	9.02 E-06	1.21 E-05	5.37 E-06	7.14 E-06
I-133+D	3.19 E-05	4.06 E-05	7.98 E-05	9.95 E-05
I-133(V)+D	2.74 E-04	3.27 E-04	1.57 E-04	1.86 E-04
I-133m	I-133+D	I-133+D	I-133+D	I-133+D
I-134	1.73 E-06	3.05 E-06	3.96 E-06	6.97 E-06
I-134(V)	1.42 E-05	2.06 E-05	8.67 E-06	1.24 E-05
I-134m+D	1.24 E-07	2.20 E-07	2.85 E-07	5.01 E-07
I-134m	5.14 E-15	7.97 E-14	8.03 E-15	1.28 E-13
I-134m(V)	n/a	n/a	n/a	n/a
I-135+D	2.08 E-05	3.11 E-05	4.83 E-05	7.21 E-05
I-135(V)+D	8.11 E-05	9.85 E-05	4.67 E-05	5.64 E-05
Xe-122+D	1.75 E-06	2.37 E-06	2.72 E-06	3.87 E-06
Xe-122	8.63 E-07	1.03 E-06	4.96 E-07	5.87 E-07
Xe-123+D	6.71 E-06	8.65 E-06	4.45 E-06	5.68 E-06
Xe-123	6.46 E-06	8.33 E-06	3.80 E-06	4.84 E-06
Xe-125+D	1.82 E-05	6.05 E-06	4.00 E-05	4.65 E-06
Xe-125	4.21 E-06	5.03 E-06	2.42 E-06	2.87 E-06
Xe-127	4.74 E-06	5.61 E-06	2.72 E-06	3.19 E-06
Xe-127m+D	1.04 E-10	1.24 E-10	5.98 E-11	7.02 E-11
Xe-127m	9.25 E-18	2.70 E-17	8.45 E-18	1.16 E-17

Table 4.4. (contd)

Nuclide[a,b]	Effective Release Height <40 m mrem/yr per Ci/yr[c] 200-E Offsite MEI	Effective Release Height <40 m mrem/yr per Ci/yr[c] 200-E Onsite MEI[d]	Effective Release Height ≥40 m mrem/yr per Ci/yr[c] 200-E Offsite MEI	Effective Release Height ≥40 m mrem/yr per Ci/yr[c] 200-E Onsite MEI[d]
Xe-129m	3.84 E-07	4.54 E-07	2.20 E-07	2.58 E-07
Xe-131m	1.49 E-07	1.77 E-07	8.56 E-08	1.01 E-07
Xe-133	5.70 E-07	6.75 E-07	3.27 E-07	3.84 E-07
Xe-133m+D	5.35 E-07	6.34 E-07	3.06 E-07	3.60 E-07
Xe-135+D	4.02 E-06	4.85 E-06	2.31 E-06	2.77 E-06
Xe-135m+D	1.74 E-07	2.74 E-07	1.08 E-07	1.72 E-07
Xe-137+D	5.78 E-08	3.50 E-08	3.95 E-08	2.40 E-08
Xe-137	7.54 E-14	9.16 E-13	6.80 E-14	8.15 E-13
Xe-138+D	3.12 E-06	5.10 E-06	2.20 E-06	3.51 E-06
Xe-138	1.17 E-07	2.82 E-07	8.47 E-08	1.97 E-07
Cs-131	1.73 E-05	1.06 E-05	1.18 E-05	7.26 E-06
Cs-132	2.35 E-04	2.39 E-04	1.60 E-04	1.61 E-04
Cs-134	1.21 E-01	5.57 E-02	8.24 E-02	3.87 E-02
Cs-134m+D	1.19 E-05	9.58 E-06	8.03 E-06	6.58 E-06
Cs-134m	6.51 E-07	8.37 E-07	4.34 E-07	5.49 E-07
Cs-135	2.46 E-02	1.38 E-03	1.68 E-02	1.29 E-03
Cs-135m+D	6.48 E-06	9.55 E-06	4.47 E-06	6.46 E-06
Cs-136	1.87 E-03	1.42 E-03	1.28 E-03	9.67 E-04
Cs-137+D	2.40 E-01	1.46 E-01	1.64 E-01	9.99 E-02
Cs-137	1.26 E-01	7.78 E-03	8.61 E-02	7.06 E-03
Cs-138	4.35 E-06	7.16 E-06	3.09 E-06	4.97 E-06
Cs-138m+D	3.36 E-07	5.54 E-07	2.39 E-07	3.84 E-07
Cs-138m	7.07 E-16	1.74 E-14	6.65 E-16	1.62 E-14
Cs-139+D	1.91 E-07	2.66 E-07	1.30 E-07	1.79 E-07
Cs-139	2.39 E-09	8.02 E-09	2.03 E-09	6.58 E-09
Cs-140+D	9.57 E-08	1.02 E-07	6.50 E-08	6.83 E-08
Ba-131+D	2.85 E-04	3.08 E-04	1.94 E-04	2.07 E-04
Ba-131	2.77 E-04	2.98 E-04	1.88 E-04	2.00 E-04
Ba-131m+D	2.59 E-07	2.90 E-07	1.77 E-07	1.97 E-07
Ba-131m	7.79 E-09	1.85 E-08	6.11 E-09	1.41 E-08
Ba-133	4.43 E-02	5.29 E-02	3.03 E-02	3.56 E-02
Ba-133m+D	4.08 E-05	4.92 E-05	2.74 E-05	3.26 E-05
Ba-135m	1.68 E-05	2.04 E-05	1.11 E-05	1.32 E-05
Ba-137m	5.16 E-17	1.77 E-15	4.87 E-17	1.66 E-15
Ba-139	1.50 E-06	2.06 E-06	1.02 E-06	1.37 E-06
Ba-140+D	1.66 E-03	1.76 E-03	1.12 E-03	1.18 E-03
Ba-140	5.49 E-04	4.27 E-04	3.68 E-04	2.83 E-04
Ba-141+D	8.30 E-07	1.26 E-06	5.77 E-07	8.69 E-07
Ba-142+D	2.82 E-06	3.85 E-06	1.91 E-06	2.56 E-06
Ba-142	1.85 E-08	5.52 E-08	1.53 E-08	4.42 E-08
La-137	6.71 E-03	8.05 E-03	4.58 E-03	5.42 E-03
La-138	3.65 E-01	4.40 E-01	2.49 E-01	2.96 E-01
La-140	2.25 E-04	2.72 E-04	1.51 E-04	1.81 E-04
La-141+D	6.79 E-06	8.35 E-06	4.51 E-06	5.47 E-06
La-142	2.13 E-05	2.90 E-05	1.44 E-05	1.92 E-05
Ce-139	9.34 E-04	1.06 E-03	6.36 E-04	7.07 E-04
Ce-141	3.51 E-04	2.88 E-04	2.36 E-04	1.91 E-04
Ce-142	Ce-144+D	Ce-144+D	Ce-144+D	Ce-144+D
Ce-143+D	5.44 E-05	6.56 E-05	3.61 E-05	4.30 E-05
Ce-144+D	5.38 E-03	4.85 E-03	3.62 E-03	3.22 E-03

Table 4.4. (contd)

Nuclide[a,b]	Effective Release Height <40 m mrem/yr per Ci/yr[c] 200-E Offsite MEI	Effective Release Height <40 m mrem/yr per Ci/yr[c] 200-E Onsite MEI[d]	Effective Release Height ≥40 m mrem/yr per Ci/yr[c] 200-E Offsite MEI	Effective Release Height ≥40 m mrem/yr per Ci/yr[c] 200-E Onsite MEI[d]
Pr-142	2.77 E-05	3.38 E-05	1.83 E-05	2.20 E-05
Pr-142m+D	3.57 E-07	4.36 E-07	2.36 E-07	2.83 E-07
Pr-142m	1.94 E-09	4.61 E-09	1.52 E-09	3.50 E-09
Pr-143	2.13 E-04	1.38 E-04	1.42 E-04	9.20 E-05
Pr-144	2.34 E-08	5.04 E-08	1.79 E-08	3.73 E-08
Pr-144m+D	1.66 E-08	3.57 E-08	1.27 E-08	2.64 E-08
Pr-144m	4.59 E-12	2.00 E-11	4.05 E-12	1.72 E-11
Nd-144	0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00
Nd-147+D	2.30 E-04	1.94 E-04	1.54 E-04	1.29 E-04
Pm-143	3.28 E-03	3.86 E-03	2.24 E-03	2.60 E-03
Pm-144+D	2.20 E-02	2.61 E-02	1.50 E-02	1.76 E-02
Pm-145	4.56 E-03	5.44 E-03	3.11 E-03	3.66 E-03
Pm-146+D	5.17 E-02	6.20 E-02	3.53 E-02	4.18 E-02
Pm-147+D	3.50 E-04	3.02 E-04	2.32 E-04	1.97 E-04
Pm-148	2.82 E-04	2.86 E-04	1.89 E-04	1.90 E-04
Pm-148m+D	3.84 E-03	4.21 E-03	2.62 E-03	2.83 E-03
Pm-149	3.35 E-05	3.99 E-05	2.20 E-05	2.59 E-05
Pm-150	2.20 E-05	2.84 E-05	1.47 E-05	1.87 E-05
Pm-151+D	3.76 E-05	4.56 E-05	2.50 E-05	3.00 E-05
Sm-145+D	1.12 E-03	1.25 E-03	7.61 E-04	8.44 E-04
Sm-146	6.03 E-01	7.02 E-01	3.95 E-01	4.52 E-01
Sm-147	5.45 E-01	6.33 E-01	3.56 E-01	4.07 E-01
Sm-148+D	0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00
Sm-151	2.59 E-04	2.63 E-04	1.70 E-04	1.70 E-04
Sm-153	3.19 E-05	3.84 E-05	2.10 E-05	2.49 E-05
Sm-155+D	1.15 E-07	1.93 E-07	8.28 E-08	1.37 E-07
Sm-156+D	3.09 E-05	3.68 E-05	2.07 E-05	2.45 E-05
Sm-156	1.13 E-05	1.39 E-05	7.44 E-06	9.04 E-06
Sm-157+D	2.01 E-07	2.48 E-07	1.34 E-07	1.63 E-07
Sm-157	8.93 E-10	3.45 E-09	7.76 E-10	2.90 E-09
Eu-150	3.34 E-01	4.03 E-01	2.28 E-01	2.71 E-01
Eu-150m+D	9.64 E-06	1.18 E-05	6.36 E-06	7.68 E-06
Eu-152+D	1.54 E-01	1.86 E-01	1.05 E-01	1.25 E-01
Eu-152m+D	1.71 E-05	2.11 E-05	1.14 E-05	1.38 E-05
Eu-152n+D	2.54 E-06	3.12 E-06	1.73 E-06	2.10 E-06
Eu-152n	4.75 E-07	6.41 E-07	3.21 E-07	4.26 E-07
Eu-154	1.21 E-01	1.45 E-01	8.29 E-02	9.81 E-02
Eu-154m+D	1.38 E-06	1.70 E-06	9.44 E-07	1.15 E-06
Eu-154m	1.53 E-07	2.32 E-07	1.06 E-07	1.58 E-07
Eu-155	3.81 E-03	4.44 E-03	2.59 E-03	2.99 E-03
Eu-156	1.11 E-03	1.09 E-03	7.53 E-04	7.31 E-04
Eu-157	2.25 E-05	2.75 E-05	1.50 E-05	1.80 E-05
Gd-148	6.38 E-01	7.43 E-01	4.17 E-01	4.79 E-01
Gd-149+D	2.69 E-04	2.97 E-04	1.83 E-04	1.99 E-04
Gd-150+D	8.54 E-13	8.63 E-13	5.40 E-13	5.39 E-13
Gd-150	0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00
Gd-151+D	4.11 E-04	4.23 E-04	2.80 E-04	2.85 E-04
Gd-152	4.51 E-01	5.24 E-01	2.95 E-01	3.38 E-01
Gd-153	1.08 E-03	1.19 E-03	7.33 E-04	7.96 E-04
Gd-159	1.39 E-05	1.70 E-05	9.15 E-06	1.10 E-05

Table 4.4. (contd)

Nuclide[a,b]	Effective Release Height <40 m mrem/yr per Ci/yr[c]		Effective Release Height ≥40 m mrem/yr per Ci/yr[c]	
	200-E Offsite MEI	200-E Onsite MEI[d]	200-E Offsite MEI	200-E Onsite MEI[d]
Tb-157	1.15 E-03	1.37 E-03	7.83 E-04	9.21 E-04
Tb-158	2.27 E-01	2.73 E-01	1.55 E-01	1.84 E-01
Tb-160	3.85 E-03	4.15 E-03	2.62 E-03	2.79 E-03
Tb-161	8.43 E-05	7.62 E-05	5.60 E-05	4.99 E-05
Dy-159	2.79 E-04	2.97 E-04	1.90 E-04	2.00 E-04
Dy-165	1.94 E-06	2.53 E-06	1.30 E-06	1.66 E-06
Ho-163	0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00
Ho-164	4.86 E-08	8.38 E-08	3.49 E-08	5.87 E-08
Ho-164m+D	2.97 E-07	4.45 E-07	2.06 E-07	3.01 E-07
Ho-164m	1.22 E-07	1.94 E-07	8.57 E-08	1.33 E-07
Ho-166	3.33 E-05	4.05 E-05	2.19 E-05	2.63 E-05
Ho-166m	4.94 E-01	5.95 E-01	3.38 E-01	4.01 E-01
Er-169	6.29 E-05	5.30 E-05	4.17 E-05	3.46 E-05
Er-171+D	1.65 E-05	2.04 E-05	1.10 E-05	1.34 E-05
Tm-168	4.37 E-03	5.27 E-03	2.99 E-03	3.56 E-03
Tm-170	8.96 E-04	5.93 E-04	6.02 E-04	3.95 E-04
Tm-171	1.25 E-04	1.03 E-04	8.35 E-05	6.75 E-05
Yb-164+D	5.33 E-06	7.40 E-06	3.63 E-06	4.95 E-06
Yb-164	2.34 E-07	3.24 E-07	1.59 E-07	2.17 E-07
Yb-165+D	1.94 E-07	2.42 E-07	1.32 E-07	1.63 E-07
Yb-166+D	2.16 E-04	2.59 E-04	1.47 E-04	1.73 E-04
Yb-166	4.02 E-05	4.77 E-05	2.65 E-05	3.10 E-05
Yb-167+D	2.19 E-07	2.69 E-07	1.52 E-07	1.87 E-07
Yb-169	6.25 E-04	6.04 E-04	4.24 E-04	4.06 E-04
Yb-175	3.78 E-05	4.14 E-05	2.50 E-05	2.70 E-05
Yb-177+D	3.82 E-06	4.88 E-06	2.56 E-06	3.22 E-06
Lu-177	6.91 E-05	6.62 E-05	4.59 E-05	4.32 E-05
Lu-177m+D	7.16 E-03	7.98 E-03	4.88 E-03	5.37 E-03
Hf-175	1.08 E-03	1.20 E-03	7.37 E-04	8.06 E-04
Hf-177m	9.06 E-06	1.34 E-05	6.26 E-06	9.09 E-06
Hf-178	n/a	n/a	n/a	n/a
Hf-178m	4.54 E-01	5.47 E-01	3.10 E-01	3.68 E-01
Hf-179m	1.23 E-03	1.27 E-03	8.33 E-04	8.55 E-04
Hf-180m	2.26 E-05	2.82 E-05	1.51 E-05	1.86 E-05
Hf-181	1.30 E-03	1.32 E-03	8.82 E-04	8.86 E-04
Hf-182+D	4.58 E-01	5.51 E-01	3.12 E-01	3.71 E-01
Hf-182	7.98 E-02	9.52 E-02	5.43 E-02	6.40 E-02
Ta-179	5.70 E-04	6.66 E-04	3.89 E-04	4.49 E-04
Ta-180	2.64 E-04	3.27 E-04	1.74 E-04	2.11 E-04
Ta-182	6.19 E-03	7.04 E-03	4.22 E-03	4.74 E-03
Ta-182m+D	6.36 E-07	7.70 E-07	4.37 E-07	5.26 E-07
Ta-182m	4.18 E-08	9.47 E-08	3.24 E-08	7.10 E-08
Ta-183	1.60 E-04	1.71 E-04	1.07 E-04	1.13 E-04
W-181	3.15 E-04	2.16 E-04	2.15 E-04	1.48 E-04
W-185	7.12 E-04	1.88 E-04	4.83 E-04	1.30 E-04
W-185m+D	1.05 E-08	2.78 E-09	7.13 E-09	1.93 E-09
W-185m	8.01 E-21	1.77 E-19	7.77 E-21	1.30 E-19
W-187+D	4.12 E-05	5.02 E-05	2.75 E-05	3.30 E-05
W-188+D	3.56 E-03	1.31 E-03	2.41 E-03	9.00 E-04
W-188	3.14 E-03	8.09 E-04	2.13 E-03	5.62 E-04

Table 4.4. (contd)

Nuclide[a,b]	Effective Release Height <40 m mrem/yr per Ci/yr[c] 200-E Offsite MEI	Effective Release Height <40 m mrem/yr per Ci/yr[c] 200-E Onsite MEI[d]	Effective Release Height ≥40 m mrem/yr per Ci/yr[c] 200-E Offsite MEI	Effective Release Height ≥40 m mrem/yr per Ci/yr[c] 200-E Onsite MEI[d]
Re-186	6.90 E-05	6.77 E-05	4.57 E-05	4.41 E-05
Re-186m+D	2.77 E-02	2.33 E-02	1.89 E-02	1.58 E-02
Re-186m	1.37 E-02	6.35 E-03	9.32 E-03	4.41 E-03
Re-187	2.06 E-05	1.66 E-06	1.41 E-05	1.45 E-06
Re-188	2.78 E-05	3.38 E-05	1.83 E-05	2.19 E-05
Os-185	2.68 E-03	3.06 E-03	1.83 E-03	2.06 E-03
Os-191	1.71 E-04	1.40 E-04	1.15 E-04	9.34 E-05
Ir-189+D	8.09 E-05	7.28 E-05	5.46 E-05	4.86 E-05
Ir-190	8.68 E-04	9.43 E-04	5.90 E-04	6.33 E-04
Ir-192	2.93 E-03	3.10 E-03	1.99 E-03	2.08 E-03
Ir-194	2.94 E-05	3.58 E-05	1.94 E-05	2.33 E-05
Pt-191	4.70 E-05	5.62 E-05	3.17 E-05	3.73 E-05
Pt-193	6.03 E-05	4.01 E-05	4.11 E-05	2.74 E-05
Pt-193m+D	4.18 E-05	4.55 E-05	2.75 E-05	2.95 E-05
Pt-195m	5.81 E-05	6.48 E-05	3.84 E-05	4.21 E-05
Pt-197	1.35 E-05	1.65 E-05	8.89 E-06	1.07 E-05
Pt-197m+D	2.59 E-06	3.34 E-06	1.72 E-06	2.20 E-06
Pt-199+D	6.58 E-07	9.62 E-07	4.54 E-07	6.57 E-07
Au-193+D	1.05 E-05	1.28 E-05	6.98 E-06	8.40 E-06
Au-193m+D	6.43 E-10	7.85 E-10	4.29 E-10	5.16 E-10
Au-193m	4.11 E-22	3.82 E-22	3.29 E-22	2.09 E-22
Au-194	8.43 E-05	1.02 E-04	5.69 E-05	6.80 E-05
Au-195	6.91 E-04	6.89 E-04	4.71 E-04	4.65 E-04
Au-195m+D	1.31 E-09	1.31 E-09	8.93 E-10	8.81 E-10
Au-195m	8.13 E-21	1.23 E-20	5.56 E-21	8.39 E-21
Au-196	1.16 E-04	1.40 E-04	7.91 E-05	9.43 E-05
Au-196m+D	1.31 E-05	1.59 E-05	8.85 E-06	1.06 E-05
Au-196m	5.87 E-06	7.23 E-06	3.95 E-06	4.79 E-06
Au-198	8.47 E-05	1.00 E-04	5.67 E-05	6.64 E-05
Au-198m+D	1.62 E-04	1.95 E-04	1.08 E-04	1.28 E-04
Au-198m	1.24 E-04	1.49 E-04	8.23 E-05	9.77 E-05
Au-199	4.23 E-05	4.95 E-05	2.80 E-05	3.23 E-05
Hg-203	7.20 E-04	6.43 E-04	4.89 E-04	4.33 E-04
Hg-205	3.54 E-13	2.41 E-12	3.25 E-13	2.17 E-12
Hg-206+D	3.41 E-10	1.30 E-09	2.96 E-10	1.09 E-09
Tl-200	7.78 E-05	9.44 E-05	5.24 E-05	6.28 E-05
Tl-201	1.84 E-05	2.15 E-05	1.23 E-05	1.42 E-05
Tl-202	2.97 E-04	2.92 E-04	2.02 E-04	1.97 E-04
Tl-204	3.26 E-03	1.17 E-03	2.22 E-03	8.14 E-04
Tl-206	1.10 E-13	2.24 E-13	7.60 E-14	1.79 E-13
Tl-206m	4.97 E-13	6.38 E-12	4.64 E-13	5.90 E-12
Tl-207+D	1.13 E-13	7.26 E-13	9.89 E-14	6.51 E-13
Tl-208	1.18 E-10	1.40 E-10	7.89 E-11	9.21 E-11
Tl-209+D	1.82 E-08	2.33 E-08	1.21 E-08	1.52 E-08
Tl-210+D	3.61 E-08	1.04 E-08	2.45 E-08	7.37 E-09
Pb-203	3.76 E-05	4.53 E-05	2.53 E-05	3.01 E-05
Pb-204m	1.13 E-05	1.60 E-05	7.74 E-06	1.07 E-05
Pb-205	1.85 E-04	9.76 E-05	1.26 E-04	6.75 E-05
Pb-209	1.63 E-06	2.08 E-06	1.08 E-06	1.35 E-06
Pb-210+D	3.24 E-01	9.39 E-02	2.20 E-01	6.62 E-02

Table 4.4. (contd)

Nuclide[a,b]	Effective Release Height <40 m mrem/yr per Ci/yr[c] 200-E Offsite MEI	Effective Release Height <40 m mrem/yr per Ci/yr[c] 200-E Onsite MEI[d]	Effective Release Height ≥40 m mrem/yr per Ci/yr[c] 200-E Offsite MEI	Effective Release Height ≥40 m mrem/yr per Ci/yr[c] 200-E Onsite MEI[d]
Pb-210	3.18 E-01	8.61 E-02	2.16 E-01	6.09 E-02
Pb-211+D	6.39 E-05	1.03 E-04	4.50 E-05	7.08 E-05
Pb-212+D	6.85 E-03	8.34 E-03	4.47 E-03	5.38 E-03
Pb-214+D	1.21 E-04	2.01 E-04	8.63 E-05	1.39 E-04
Pb-214	3.26 E-05	5.77 E-05	2.36 E-05	4.07 E-05
Bi-207	3.15 E-01	3.79 E-01	2.15 E-01	2.55 E-01
Bi-208	7.12 E-01	8.59 E-01	4.86 E-01	5.79 E-01
Bi-210+D	3.99 E-03	4.76 E-03	2.61 E-03	3.07 E-03
Bi-210	3.90 E-03	4.69 E-03	2.55 E-03	3.02 E-03
Bi-210m+D	2.66 E-01	2.97 E-01	1.78 E-01	1.95 E-01
Bi-211+D	7.04 E-14	5.54 E-13	6.51 E-14	5.04 E-13
Bi-211	4.57 E-20	2.37 E-18	4.32 E-20	2.23 E-18
Bi-212+D	3.56 E-04	5.10 E-04	2.43 E-04	3.42 E-04
Bi-212n+D	6.72 E-11	3.03 E-10	5.97 E-11	2.62 E-10
Bi-212n	5.80 E-12	2.61 E-11	5.15 E-12	2.25 E-11
Bi-213+D	2.28 E-04	3.46 E-04	1.57 E-04	2.34 E-04
Bi-214+D	1.50 E-05	2.91 E-05	1.12 E-05	2.11 E-05
Po-208+D	7.86 E-07	9.49 E-07	5.38 E-07	6.40 E-07
Po-209+D	1.62 E-03	1.95 E-03	1.11 E-03	1.32 E-03
Po-210	2.46 E-01	1.73 E-01	1.64 E-01	1.14 E-01
Po-211	0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00
Po-212	0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00
Po-212m	9.84 E-20	1.87 E-20	5.60 E-20	1.25 E-20
Po-213+D	0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00
Po-214+D	7.58 E-14	2.15 E-14	5.14 E-14	1.52 E-14
Po-215+D	5.25 E-11	8.46 E-11	3.70 E-11	5.82 E-11
Po-215	2.21 E-27	2.68 E-27	1.50 E-27	1.80 E-27
Po-216+D	2.58 E-08	3.14 E-08	1.69 E-08	2.02 E-08
Po-216	0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00
Po-218+D	1.55 E-05	2.33 E+00	1.10 E-05	1.50 E+00
Po-218	7.68 E-22	7.85 E-21	6.17 E-22	7.19 E-21
At-217+D	2.69 E-09	4.08 E-09	1.86 E-09	2.77 E-09
At-217	0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00
At-218+D	1.82 E-08	3.65 E-08	1.36 E-08	2.65 E-08
At-218	6.83 E-31	9.14 E-32	2.70 E-31	8.31 E-32
Rn-218+D	1.62 E-11	4.68 E-12	1.10 E-11	3.31 E-12
Rn-218	5.57 E-30	4.69 E-28	5.08 E-30	4.23 E-28
Rn-219+D	1.17 E-07	1.88 E-07	8.24 E-08	1.30 E-07
Rn-219	7.90 E-18	2.20 E-17	1.25 E-17	1.48 E-17
Rn-220+D	9.95 E-06	1.21 E-05	6.51 E-06	7.81 E-06
Rn-220	1.01 E-22	3.06 E-22	9.13 E-23	2.78 E-22
Rn-222+D	9.92 E-04	1.13 E-03	6.39 E-04	7.13 E-04
Rn-222	7.17 E-09	8.50 E-09	4.11 E-09	4.83 E-09
Rn-224+D	2.42 E-03	2.91 E-03	1.58 E-03	1.88 E-03
Fr-221+D	2.74 E-05	4.16 E-05	1.89 E-05	2.82 E-05
Fr-221	3.23 E-13	2.43 E-12	2.98 E-13	2.20 E-12
Fr-222+D	6.34 E-06	1.45 E-05	4.95 E-06	1.11 E-05
Fr-223+D	4.12 E-04	4.87 E-04	2.69 E-04	3.14 E-04
Fr-223	1.42 E-05	2.72 E-05	1.05 E-05	1.95 E-05
Ra-223+D	3.08 E-01	3.63 E-01	2.01 E-01	2.34 E-01

Table 4.4. (contd)

Nuclide[a,b]	Effective Release Height <40 m mrem/yr per Ci/yr[c]		Effective Release Height ≥40 m mrem/yr per Ci/yr[c]	
	200-E Offsite MEI	200-E Onsite MEI[d]	200-E Offsite MEI	200-E Onsite MEI[d]
Ra-224+D	1.19 E-01	1.43 E-01	7.76 E-02	9.24 E-02
Ra-225+D	2.69 E-01	3.14 E-01	1.76 E-01	2.02 E-01
Ra-226+D	9.20 E-01	8.46 E-01	6.25 E-01	5.70 E-01
Ra-227+D	1.53 E-05	1.83 E-05	1.00 E-05	1.18 E-05
Ra-228+D	6.62 E-01	3.80 E-01	4.48 E-01	2.58 E-01
Ac-225+D	3.01 E-01	3.62 E-01	1.97 E-01	2.33 E-01
Ac-226+D	4.59 E-02	5.58 E-02	3.01 E-02	3.59 E-02
Ac-227+D	4.05 E+00	4.79 E+00	2.65 E+00	3.09 E+00
Ac-228+D	6.11 E-04	7.35 E-04	4.00 E-04	4.74 E-04
Th-227+D	4.28 E-01	5.16 E-01	2.79 E-01	3.32 E-01
Th-228+D	1.92 E+00	2.30 E+00	1.26 E+00	1.48 E+00
Th-229+D	4.06 E+00	4.73 E+00	2.66 E+00	3.06 E+00
Th-230+D	8.08 E-01	9.02 E-01	5.29 E-01	5.82 E-01
Th-231+D	1.38 E-05	1.68 E-05	9.02 E-06	1.08 E-05
Th-232+D	1.96 E+00	2.28 E+00	1.30 E+00	1.49 E+00
Th-233+D	3.03 E-07	2.96 E-07	2.06 E-07	2.00 E-07
Th-233	2.24 E-08	4.27 E-08	1.66 E-08	3.08 E-08
Th-234+D	9.75 E-04	6.34 E-04	6.55 E-04	4.23 E-04
Th-234	8.64 E-04	5.00 E-04	5.79 E-04	3.33 E-04
Pa-231+D	5.34 E+00	6.25 E+00	3.49 E+00	4.03 E+00
Pa-232m+D	1.17 E-04	1.41 E-04	7.81 E-05	9.33 E-05
Pa-232	9.82 E-05	1.19 E-04	6.56 E-05	7.86 E-05
Pa-233+D	4.99 E-04	4.52 E-04	3.37 E-04	3.02 E-04
Pa-234+D	4.50 E-05	5.59 E-05	3.00 E-05	3.67 E-05
Pa-234m+D	2.13 E-10	2.64 E-10	1.42 E-10	1.73 E-10
U-232+D	8.37 E-01	8.66 E-01	5.61 E-01	5.73 E-01
U-233+D	1.74 E-01	1.88 E-01	1.14 E-01	1.21 E-01
U-234+D	1.70 E-01	1.84 E-01	1.12 E-01	1.19 E-01
U-235+D	2.05 E-01	2.27 E-01	1.36 E-01	1.48 E-01
U-235m+D	1.37 E-14	1.50 E-14	9.11 E-15	9.76 E-15
U-235m	0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00
U-236+D	1.57 E-01	1.69 E-01	1.03 E-01	1.09 E-01
U-237+D	1.26 E-04	1.27 E-04	8.42 E-05	8.31 E-05
U-238+D	1.81 E-01	2.00 E-01	1.20 E-01	1.30 E-01
U-239+D	4.51 E-07	5.79 E-07	3.03 E-07	3.85 E-07
U-239	7.09 E-08	1.32 E-07	5.21 E-08	9.45 E-08
U-240+D	3.48 E-05	4.26 E-05	2.31 E-05	2.79 E-05
U-240	2.20 E-05	2.69 E-05	1.44 E-05	1.74 E-05
Np-235	7.36 E-05	6.85 E-05	4.97 E-05	4.58 E-05
Np-236+D	2.32 E-01	2.70 E-01	1.53 E-01	1.76 E-01
Np-236m+D	2.81 E-04	3.37 E-04	1.83 E-04	2.17 E-04
Np-237+D	1.33 E+00	1.54 E+00	8.73 E-01	1.00 E+00
Np-238+D	1.65 E-04	1.98 E-04	1.09 E-04	1.30 E-04
Np-239+D	5.66 E-05	6.77 E-05	3.75 E-05	4.42 E-05
Np-240+D	6.22 E-06	8.90 E-06	4.25 E-06	5.97 E-06
Np-240m+D	6.98 E-09	9.32 E-09	4.66 E-09	6.29 E-09
Pu-234+D	8.16 E-04	9.91 E-04	5.34 E-04	6.39 E-04
Pu-235+D	2.00 E-01	2.21 E-01	1.33 E-01	1.44 E-01
Pu-236+D	1.05 E+00	1.25 E+00	6.89 E-01	8.03 E-01
Pu-237+D	1.15 E-04	1.15 E-04	7.78 E-05	7.77 E-05

Table 4.4. (contd)

Nuclide[a,b]	Effective Release Height <40 m mrem/yr per Ci/yr[c]		Effective Release Height ≥40 m mrem/yr per Ci/yr[c]	
	200-E Offsite MEI	200-E Onsite MEI[d]	200-E Offsite MEI	200-E Onsite MEI[d]
Pu-238+D	2.55 E+00	3.01 E+00	1.67 E+00	1.93 E+00
Pu-239+D	2.78 E+00	3.28 E+00	1.82 E+00	2.11 E+00
Pu-240+D	2.78 E+00	3.28 E+00	1.82 E+00	2.11 E+00
Pu-241+D	5.19 E-02	6.00 E-02	3.40 E-02	3.86 E-02
Pu-242+D	2.64 E+00	3.11 E+00	1.72 E+00	2.00 E+00
Pu-243+D	3.14 E-06	3.94 E-06	2.08 E-06	2.56 E-06
Pu-244+D	2.72 E+00	3.21 E+00	1.78 E+00	2.07 E+00
Am-240+D	1.15 E-04	1.39 E-04	7.73 E-05	9.23 E-05
Am-241+D	2.30 E+00	2.71 E+00	1.51 E+00	1.74 E+00
Am-242+D	7.65 E-04	9.26 E-04	5.00 E-04	5.96 E-04
Am-242m+D	2.09 E+00	2.45 E+00	1.36 E+00	1.58 E+00
Am-243+D	2.33 E+00	2.76 E+00	1.53 E+00	1.78 E+00
Am-244+D	1.23 E-04	1.49 E-04	8.09 E-05	9.67 E-05
Am-244m+D	3.96 E-06	4.72 E-06	2.59 E-06	3.04 E-06
Am-244m	2.61 E-07	4.68 E-07	1.90 E-07	3.31 E-07
Am-245+D	1.58 E-06	2.07 E-06	1.06 E-06	1.36 E-06
Am-246+D	2.11 E-06	3.39 E-06	1.48 E-06	2.28 E-06
Cm-241+D	2.42 E-03	2.75 E-03	1.60 E-03	1.79 E-03
Cm-242+D	2.32 E-01	2.76 E-01	1.51 E-01	1.78 E-01
Cm-243+D	1.74 E+00	2.05 E+00	1.14 E+00	1.32 E+00
Cm-244+D	1.44 E+00	1.69 E+00	9.39 E-01	1.09 E+00
Cm-245+D	2.36 E+00	2.78 E+00	1.55 E+00	1.79 E+00
Cm-246+D	2.33 E+00	2.74 E+00	1.52 E+00	1.76 E+00
Cm-247+D	2.23 E+00	2.63 E+00	1.47 E+00	1.70 E+00
Cm-248+D	8.71 E+00	1.02 E+01	5.71 E+00	6.63 E+00
Cm-249+D	1.48 E-06	1.81 E-06	9.73 E-07	1.17 E-06
Cm-250+D	5.14 E+01	6.06 E+01	3.37 E+01	3.92 E+01
Bk-247+D	3.89 E+00	4.58 E+00	2.54 E+00	2.95 E+00
Bk-248m+D	4.92 E-05	5.12 E-05	3.12 E-05	3.21 E-05
Bk-248m	2.89 E-06	3.51 E-06	1.95 E-06	2.34 E-06
Bk-249+D	9.32 E-03	1.10 E-02	6.10 E-03	7.07 E-03
Bk-250+D	6.53 E-05	7.95 E-05	4.29 E-05	5.14 E-05
Cf-249+D	3.97 E+00	4.68 E+00	2.60 E+00	3.02 E+00
Cf-250+D	1.85 E+00	2.17 E+00	1.21 E+00	1.40 E+00
Cf-251+D	3.98 E+00	4.69 E+00	2.60 E+00	3.02 E+00
Cf-252+D	1.05 E+00	1.24 E+00	6.89 E-01	8.02 E-01
Es-254+D	4.21 E-01	5.01 E-01	2.75 E-01	3.23 E-01

MEI = Maximally exposed individual
Bold nuclides are newly available in CAP88-PC version 4.
n/a = nuclide or indicated solubility class is not available in CAP88-PC version 4.
(a) +D indicates that the listed radionuclide dose includes the contribution from the parent radionuclide plus decay products grown in during transit and the build-up period.
(b) If the *nuclide+D* is followed by the nuclide without the +D, the decay chain members contribute greater than 10% of the *nuclide+D* dose. V = vapor; E = elemental; O = organic compounds; F = particulate, fast clearance rate; M = particulate, moderate clearance rate; S = particulate, slow clearance rate. Carbon isotopes are modeled as particulate (M), carbon monoxide (CO), or carbon dioxide (CO2).
(c) If a radionuclide is indicated rather than a dose factor value, the nuclide is used as a surrogate. See Table 3.4 for additional details.
(d) Onsite MEI assumed to occupy the onsite location for the maximum possible 8,766 hr in a year.

Table 4.5. **200 West Area**: Offsite and Onsite MEIs CAP88-PC Dose-per-Unit-Release Factors (mrem/Ci) by Effective Release Height

	Effective Release Height <40 m		**Effective Release Height ≥40 m**	
	mrem/yr per Ci/yr[c]		**mrem/yr per Ci/yr[c]**	
Nuclide[a,b]	**200-W Offsite MEI**	**200-W Onsite MEI[d]**	**200-W Offsite MEI**	**200-W Onsite MEI[d]**
H-3 (V)	1.27 E-05	4.11 E-06	6.56 E-06	2.21 E-06
H-3 (E)	1.13 E-05	2.22 E-06	5.86 E-06	1.24 E-06
H-3 (O)	2.77 E-05	6.78 E-06	1.44 E-05	3.57 E-06
H-3 (F)	6.89 E-06	1.26 E-06	4.94 E-06	1.05 E-06
H-3 (M)	8.61 E-06	3.94 E-06	6.17 E-06	2.84 E-06
H-3 (S)	1.82 E-05	1.90 E-05	1.31 E-05	1.29 E-05
Be-7	8.78 E-05	1.27 E-04	6.60 E-05	8.86 E-05
Be-10	1.85 E-03	1.99 E-03	1.38 E-03	1.39 E-03
C-11	3.09 E-08	7.84 E-08	3.03 E-08	7.09 E-08
C-11 (CO)	3.35 E-08	9.15 E-08	3.11 E-08	7.46 E-08
C-11 (CO2)	3.36 E-08	9.19 E-08	3.12 E-08	7.49 E-08
C-14	8.77 E-04	1.93 E-04	6.28 E-04	1.51 E-04
C-14 (CO)	1.37 E-03	2.17 E-04	7.08 E-04	1.21 E-04
C-14 (CO2)	1.37 E-03	2.17 E-04	7.08 E-04	1.22 E-04
C-15	C-11	C-11	C-11	C-11
N-13	4.02 E-10	6.80 E-10	3.96 E-10	6.15 E-10
O-15	3.23 E-18	4.77 E-18	2.94 E-18	2.86 E-18
O-19	4.73 E-19	8.21 E-19	4.32 E-19	7.12 E-19
F-18	3.92 E-06	7.80 E-06	3.18 E-06	5.66 E-06
Na-22	7.32 E-02	9.00 E-02	5.50 E-02	6.33 E-02
Na-24	1.19 E-04	1.91 E-04	8.88 E-05	1.31 E-04
Mg-27	2.36 E-10	3.27 E-10	2.36 E-10	3.12 E-10
Mg-28+D	1.46 E-04	2.31 E-04	1.08 E-04	1.58 E-04
Mg-28	8.45 E-05	1.33 E-04	6.23 E-05	9.06 E-05
Al-26	6.22 E-01	9.58 E-01	4.67 E-01	6.69 E-01
Al-28	1.27 E-18	4.58 E-18	1.26 E-18	3.93 E-18
Si-31	1.09 E-06	2.04 E-06	8.56 E-07	1.44 E-06
Si-32+D	2.01 E-02	3.07 E-02	1.50 E-02	2.14 E-02
Si-32	8.88 E-04	1.10 E-03	6.44 E-04	7.41 E-04
P-32	7.50 E-04	3.24 E-04	5.60 E-04	2.39 E-04
P-33	1.69 E-04	8.92 E-05	1.25 E-04	6.36 E-05
S-35	7.04 E-04	1.34 E-04	5.27 E-04	1.08 E-04
Cl-36	5.96 E-01	6.78 E-02	4.48 E-01	6.51 E-02
Ar-37	0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00
Ar-39	5.06 E-08	7.11 E-08	2.62 E-08	3.64 E-08
Ar-41	6.17 E-06	1.17 E-05	3.89 E-06	6.72 E-06
Ar-42+D	4.45 E-06	5.69 E-06	2.96 E-06	3.58 E-06
Ar-42	5.54 E-08	7.79 E-08	2.87 E-08	3.99 E-08
K-40	1.15 E-01	8.65 E-02	8.68 E-02	6.23 E-02
K-42	1.85 E-05	3.00 E-05	1.37 E-05	2.05 E-05
Ca-41	1.05 E-03	1.38 E-04	7.88 E-04	1.34 E-04
Ca-45	3.84 E-04	1.81 E-04	2.85 E-04	1.32 E-04
Ca-47+D	2.49 E-04	3.59 E-04	1.85 E-04	2.47 E-04
Sc-44	2.21 E-05	3.90 E-05	1.70 E-05	2.73 E-05
Sc-44m+D	2.38 E-04	3.65 E-04	1.77 E-04	2.52 E-04
Sc-44m	6.84 E-05	1.04 E-04	5.00 E-05	7.08 E-05
Sc-46	5.49 E-03	8.00 E-03	4.12 E-03	5.59 E-03
Sc-47	3.40 E-05	5.08 E-05	2.49 E-05	3.45 E-05
Ti-44+D	4.51 E-01	6.83 E-01	3.39 E-01	4.77 E-01
Ti-44	3.60 E-02	4.17 E-02	2.70 E-02	2.93 E-02

Table 4.5. (contd)

Nuclide[a,b]	Effective Release Height <40 m mrem/yr per Ci/yr[c] 200-W Offsite MEI	Effective Release Height <40 m mrem/yr per Ci/yr[c] 200-W Onsite MEI[d]	Effective Release Height ≥40 m mrem/yr per Ci/yr[c] 200-W Offsite MEI	Effective Release Height ≥40 m mrem/yr per Ci/yr[c] 200-W Onsite MEI[d]
Ti-45	7.21 E-06	1.31 E-05	5.62 E-06	9.26 E-06
Ti-51	1.15 E-12	3.86 E-13	1.16 E-12	3.75 E-13
V-48	1.68 E-03	2.31 E-03	1.26 E-03	1.61 E-03
V-49	1.26 E-05	3.43 E-06	9.45 E-06	2.66 E-06
Cr-49+D	5.29 E-07	1.29 E-06	4.83 E-07	1.04 E-06
Cr-51	3.92 E-05	4.38 E-05	2.94 E-05	3.08 E-05
Cr-55	9.60 E-17	6.10 E-18	9.62 E-17	6.09 E-18
Mn-52	6.70 E-04	1.00 E-03	5.02 E-04	6.96 E-04
Mn-52m+D	1.20 E-07	2.72 E-07	1.10 E-07	2.35 E-07
Mn-53	1.02 E-04	1.57 E-05	7.68 E-05	1.43 E-05
Mn-54	7.88 E-03	1.18 E-02	5.92 E-03	8.23 E-03
Mn-56	1.15 E-05	2.14 E-05	9.04 E-06	1.52 E-05
Fe-55	5.32 E-04	7.38 E-05	4.00 E-04	6.46 E-05
Fe-59	2.54 E-03	2.68 E-03	1.90 E-03	1.89 E-03
Co-56	1.02 E-02	1.27 E-02	7.64 E-03	8.94 E-03
Co-57	1.25 E-03	1.47 E-03	9.39 E-04	1.03 E-03
Co-58	2.68 E-03	3.32 E-03	2.01 E-03	2.33 E-03
Co-58m+D	1.21 E-05	1.77 E-05	9.02 E-06	1.24 E-05
Co-58m	3.79 E-07	6.28 E-07	2.79 E-07	4.25 E-07
Co-60	1.31 E-01	1.88 E-01	9.85 E-02	1.31 E-01
Co-60m+D	4.93 E-07	7.07 E-07	3.71 E-07	4.95 E-07
Co-60m	4.03 E-12	6.63 E-12	4.03 E-12	6.32 E-12
Ni-56+D	1.02 E-03	1.51 E-03	7.69 E-04	1.06 E-03
Ni-56	4.02 E-04	5.58 E-04	3.01 E-04	3.89 E-04
Ni-57+D	1.25 E-04	1.90 E-04	9.35 E-05	1.31 E-04
Ni-59	2.03 E-04	3.85 E-05	1.52 E-04	3.34 E-05
Ni-63	4.44 E-04	8.11 E-05	3.33 E-04	7.08 E-05
Ni-65	4.30 E-06	8.08 E-06	3.40 E-06	5.75 E-06
Cu-64	7.14 E-06	1.16 E-05	5.30 E-06	7.92 E-06
Cu-66	1.02 E-13	2.21 E-14	1.02 E-13	2.16 E-14
Cu-67	2.72 E-05	4.16 E-05	1.99 E-05	2.82 E-05
Zn-65	2.07 E-02	7.90 E-03	1.56 E-02	5.94 E-03
Zn-69	7.32 E-08	1.70 E-07	6.43 E-08	1.31 E-07
Zn-69m+D	1.86 E-05	2.99 E-05	1.38 E-05	2.04 E-05
Ga-67	2.38 E-05	3.65 E-05	1.76 E-05	2.51 E-05
Ga-68	1.64 E-06	3.63 E-06	1.41 E-06	2.75 E-06
Ga-70	2.27 E-09	5.76 E-09	2.21 E-09	5.18 E-09
Ga-72	8.16 E-05	1.32 E-04	6.08 E-05	9.05 E-05
Ge-68+D	2.15 E-02	1.48 E-02	1.61 E-02	1.07 E-02
Ge-68	1.32 E-02	2.05 E-03	9.87 E-03	1.72 E-03
Ge-69	6.41 E-05	9.95 E-05	4.77 E-05	6.87 E-05
Ge-71	4.83 E-06	1.13 E-06	3.62 E-06	8.86 E-07
Ge-75	3.02 E-07	6.39 E-07	2.52 E-07	4.74 E-07
Ge-77+D	3.41 E-05	5.51 E-05	2.54 E-05	3.78 E-05
As-73	1.98 E-04	8.92 E-05	1.48 E-04	6.50 E-05
As-74	6.88 E-04	7.96 E-04	5.14 E-04	5.58 E-04
As-76	4.48 E-05	7.12 E-05	3.30 E-05	4.85 E-05
As-77	1.30 E-05	2.06 E-05	9.43 E-06	1.38 E-05
Se-75	9.24 E-03	2.85 E-03	6.95 E-03	2.19 E-03
Se-77m	3.04 E-22	8.64 E-22	2.92 E-22	6.77 E-22
Se-79	3.17 E-02	3.03 E-03	2.38 E-02	2.96 E-03
Se-79m+D	8.00 E-13	7.69 E-14	6.01 E-13	7.49 E-14
Se-79m	1.97 E-16	1.75 E-17	1.97 E-16	1.74 E-17
Br-82	1.59 E-04	2.46 E-04	1.19 E-04	1.70 E-04
Br-82m+D	4.50 E-07	6.97 E-07	3.36 E-07	4.81 E-07
Br-82m	2.07 E-14	8.60 E-15	2.07 E-14	8.34 E-15
Br-83+D	6.35 E-07	1.20 E-06	5.00 E-07	8.55 E-07
Br-84	3.80 E-07	9.73 E-07	3.59 E-07	8.20 E-07

Table 4.5. (contd)

Nuclide[a,b]	Effective Release Height <40 m mrem/yr per Ci/yr[c] 200-W Offsite MEI	Effective Release Height <40 m mrem/yr per Ci/yr[c] 200-W Onsite MEI[d]	Effective Release Height ≥40 m mrem/yr per Ci/yr[c] 200-W Offsite MEI	Effective Release Height ≥40 m mrem/yr per Ci/yr[c] 200-W Onsite MEI[d]
Br-84m	1.34 E-11	5.21 E-12	1.35 E-11	5.05 E-12
Br-85+D	1.76 E-08	2.84 E-08	9.93 E-09	1.52 E-08
Br-85	1.22 E-17	6.21 E-19	1.22 E-17	6.03 E-19
Kr-81	1.68 E-08	2.36 E-08	8.69 E-09	1.21 E-08
Kr-81m+D	3.04 E-20	4.28 E-20	1.58 E-20	2.19 E-20
Kr-83m	1.11 E-10	2.10 E-10	6.97 E-11	1.20 E-10
Kr-85	1.06 E-07	1.49 E-07	5.48 E-08	7.63 E-08
Kr-85m+D	1.62 E-06	2.61 E-06	9.13 E-07	1.40 E-06
Kr-87+D	2.18 E-06	4.59 E-06	1.48 E-06	2.76 E-06
Kr-88+D	2.07 E-05	3.63 E-05	1.31 E-05	2.12 E-05
Kr-88	1.62 E-05	2.80 E-05	9.57 E-06	1.54 E-05
Kr-89+D	5.50 E-08	3.65 E-08	4.20 E-08	2.83 E-08
Kr-89	1.42 E-15	6.89 E-17	1.42 E-15	6.85 E-17
Kr-90	5.32 E-09	1.56 E-09	4.01 E-09	1.22 E-09
Rb-81+D	8.07 E-06	1.38 E-05	5.92 E-06	9.32 E-06
Rb-81	6.41 E-06	1.11 E-05	4.90 E-06	7.75 E-06
Rb-81m+D	9.80 E-07	1.67 E-06	7.16 E-07	1.13 E-06
Rb-81m	1.07 E-08	2.75 E-08	1.02 E-08	2.34 E-08
Rb-82	3.28 E-19	1.55 E-19	2.67 E-19	8.95 E-20
Rb-82m	4.21 E-05	7.07 E-05	3.18 E-05	4.90 E-05
Rb-83+D	3.19 E-03	2.20 E-03	2.40 E-03	1.58 E-03
Rb-84	2.18 E-03	1.65 E-03	1.63 E-03	1.19 E-03
Rb-84m+D	9.45 E-07	7.36 E-07	7.11 E-07	5.34 E-07
Rb-84m	1.05 E-08	2.67 E-08	1.03 E-08	2.42 E-08
Rb-86	8.88 E-04	4.62 E-04	6.62 E-04	3.36 E-04
Rb-86m+D	3.36 E-08	1.76 E-08	2.51 E-08	1.27 E-08
Rb-86m	1.15 E-19	7.20 E-19	1.14 E-19	6.81 E-19
Rb-87	1.52 E-02	1.82 E-03	1.14 E-02	1.69 E-03
Rb-88	1.21 E-08	2.99 E-08	1.20 E-08	2.74 E-08
Rb-89+D	2.61 E-07	1.67 E-07	1.98 E-07	1.28 E-07
Rb-90+D	2.61 E-08	7.60 E-09	1.96 E-08	5.98 E-09
Rb-90	4.69 E-17	1.29 E-17	4.69 E-17	1.22 E-17
Rb-90m+D	4.26 E-08	1.24 E-08	3.21 E-08	9.77 E-09
Rb-90m	3.31 E-13	3.94 E-14	3.32 E-13	3.90 E-14
Sr-82+D	2.44 E-03	2.20 E-03	1.82 E-03	1.56 E-03
Sr-82	1.47 E-03	6.99 E-04	1.09 E-03	5.07 E-04
Sr-83+D	7.18 E-05	1.09 E-04	5.34 E-05	7.56 E-05
Sr-83	4.99 E-05	7.83 E-05	3.71 E-05	5.39 E-05
Sr-85	1.20 E-03	1.54 E-03	9.04 E-04	1.08 E-03
Sr-85m+D	1.07 E-06	1.70 E-06	8.34 E-07	1.23 E-06
Sr-85m	3.29 E-07	7.29 E-07	2.83 E-07	5.53 E-07
Sr-87m+D	2.19 E-06	4.04 E-06	1.72 E-06	2.86 E-06
Sr-89	1.18 E-03	6.35 E-04	8.80 E-04	4.59 E-04
Sr-90+D	1.50 E-01	4.37 E-02	1.13 E-01	3.44 E-02
Sr-91+D	3.16 E-05	5.05 E-05	2.35 E-05	3.47 E-05
Sr-92+D	1.47 E-05	2.62 E-05	1.13 E-05	1.83 E-05
Y-88	8.51 E-03	1.27 E-02	6.39 E-03	8.87 E-03
Y-89m	0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00
Y-90	6.18 E-05	9.21 E-05	4.49 E-05	6.20 E-05
Y-90m+D	7.83 E-06	1.33 E-05	5.93 E-06	9.23 E-06
Y-91	8.82 E-04	7.05 E-04	6.53 E-04	4.95 E-04
Y-91m+D	8.98 E-07	1.35 E-06	7.22 E-07	1.03 E-06
Y-92	5.40 E-06	9.67 E-06	4.16 E-06	6.76 E-06
Y-93+D	1.44 E-05	2.37 E-05	1.07 E-05	1.61 E-05
Zr-88+D	7.36 E-03	1.13 E-02	5.53 E-03	7.86 E-03
Zr-88	1.15 E-03	1.66 E-03	8.60 E-04	1.16 E-03
Zr-89	1.43 E-04	2.19 E-04	1.07 E-04	1.52 E-04
Zr-89m+D	1.19 E-07	1.82 E-07	8.84 E-08	1.26 E-07

Table 4.5. (contd)

Nuclide[a,b]	Effective Release Height <40 m mrem/yr per Ci/yr[c] 200-W Offsite MEI	Effective Release Height <40 m mrem/yr per Ci/yr[c] 200-W Onsite MEI[d]	Effective Release Height ≥40 m mrem/yr per Ci/yr[c] 200-W Offsite MEI	Effective Release Height ≥40 m mrem/yr per Ci/yr[c] 200-W Onsite MEI[d]
Zr-93+D	7.80 E-04	8.44 E-04	5.71 E-04	5.77 E-04
Zr-95+D	3.19 E-03	4.68 E-03	2.39 E-03	3.27 E-03
Zr-97+D	7.49 E-05	1.19 E-04	5.54 E-05	8.15 E-05
Zr-97	5.40 E-05	8.68 E-05	3.99 E-05	5.92 E-05
Nb-91	1.16 E-03	1.80 E-03	8.76 E-04	1.26 E-03
Nb-91m+D	5.03 E-05	7.76 E-05	3.78 E-05	5.42 E-05
Nb-92	3.56 E-01	5.50 E-01	2.68 E-01	3.84 E-01
Nb-92m	2.96 E-04	4.58 E-04	2.22 E-04	3.19 E-04
Nb-93m	1.34 E-04	1.61 E-04	9.98 E-05	1.13 E-04
Nb-94	3.72 E-01	5.74 E-01	2.80 E-01	4.01 E-01
Nb-94m+D	2.17 E-10	3.35 E-10	1.63 E-10	2.34 E-10
Nb-95	9.34 E-04	1.33 E-03	7.00 E-04	9.30 E-04
Nb-95m+D	1.13 E-04	1.73 E-04	8.43 E-05	1.19 E-04
Nb-95m	3.56 E-05	5.25 E-05	2.59 E-05	3.55 E-05
Nb-96	1.09 E-04	1.74 E-04	8.14 E-05	1.20 E-04
Nb-97	1.35 E-06	2.93 E-06	1.15 E-06	2.21 E-06
Mo-93+D	4.35 E-03	2.07 E-03	3.27 E-03	1.57 E-03
Mo-93m+D	3.62 E-05	6.07 E-05	2.73 E-05	4.20 E-05
Mo-99+D	5.72 E-05	8.69 E-05	4.19 E-05	5.92 E-05
Mo-99	4.80 E-05	7.29 E-05	3.51 E-05	4.94 E-05
Tc-95	2.87 E-05	4.57 E-05	2.14 E-05	3.15 E-05
Tc-95m+D	1.55 E-03	2.08 E-03	1.16 E-03	1.45 E-03
Tc-96	3.74 E-04	5.67 E-04	2.80 E-04	3.93 E-04
Tc-96m+D	3.11 E-06	4.72 E-06	2.33 E-06	3.29 E-06
Tc-96m	5.14 E-08	1.21 E-07	4.57 E-08	9.50 E-08
Tc-97	3.48 E-03	2.09 E-03	2.62 E-03	1.55 E-03
Tc-97m+D	4.10 E-04	2.23 E-04	3.05 E-04	1.62 E-04
Tc-98	4.04 E-01	5.29 E-01	3.04 E-01	3.72 E-01
Tc-99	2.21 E-02	3.21 E-03	1.66 E-02	3.08 E-03
Tc-99m+D	1.88 E-06	3.19 E-06	1.42 E-06	2.21 E-06
Tc-101	1.53 E-09	3.41 E-09	1.52 E-09	3.20 E-09
Ru-97+D	2.54 E-05	3.92 E-05	1.89 E-05	2.71 E-05
Ru-103+D	7.90 E-04	1.06 E-03	5.91 E-04	7.34 E-04
Ru-105+D	1.15 E-05	1.97 E-05	8.72 E-06	1.37 E-05
Ru-106+D	7.26 E-03	8.20 E-03	5.41 E-03	5.74 E-03
Ru-106	3.32 E-03	2.11 E-03	2.45 E-03	1.49 E-03
Rh-101	9.16 E-03	1.38 E-02	6.88 E-03	9.68 E-03
Rh-101m+D	4.89 E-05	7.34 E-05	3.64 E-05	5.08 E-05
Rh-102	4.21 E-03	5.43 E-03	3.15 E-03	3.81 E-03
Rh-102m+D	7.94 E-02	1.22 E-01	5.97 E-02	8.51 E-02
Rh-103m	6.06 E-09	1.40 E-08	5.32 E-09	1.09 E-08
Rh-104	8.44 E-21	1.89 E-20	8.20 E-21	1.75 E-20
Rh-104m+D	6.15 E-15	7.52 E-16	6.16 E-15	7.44 E-16
Rh-104m	2.13 E-15	2.61 E-16	2.13 E-15	2.58 E-16
Rh-105	1.38 E-05	2.18 E-05	1.01 E-05	1.47 E-05
Rh-105m	Rh-105	Rh-105	Rh-105	Rh-105
Rh-106	5.35 E-22	0.00 E+00	5.36 E-22	0.00 E+00
Pd-103+D	3.31 E-05	2.88 E-05	2.45 E-05	2.01 E-05
Pd-107	3.61 E-05	9.96 E-06	2.70 E-05	8.01 E-06
Pd-109	9.98 E-06	1.62 E-05	7.30 E-06	1.09 E-05
Pd-109m+D	5.73 E-08	9.30 E-08	4.19 E-08	6.28 E-08
Pd-111+D	2.57 E-07	2.48 E-07	1.90 E-07	1.73 E-07
Pd-111	3.74 E-09	9.56 E-09	3.63 E-09	8.47 E-09
Pd-112+D	2.81 E-05	4.26 E-05	2.06 E-05	2.91 E-05
Pd-112	6.00 E-08	9.51 E-08	4.54 E-08	6.65 E-08
Ag-108	5.72 E-20	1.19 E-19	4.95 E-20	9.09 E-20
Ag-108m+D	3.77 E-01	5.80 E-01	2.83 E-01	4.05 E-01
Ag-109m	8.20 E-22	1.50 E-21	7.94 E-22	1.39 E-21

Table 4.5. (contd)

Nuclide[a,b]	Effective Release Height <40 m mrem/yr per Ci/yr[c] 200-W Offsite MEI	Effective Release Height <40 m mrem/yr per Ci/yr[c] 200-W Onsite MEI[d]	Effective Release Height ≥40 m mrem/yr per Ci/yr[c] 200-W Offsite MEI	Effective Release Height ≥40 m mrem/yr per Ci/yr[c] 200-W Onsite MEI[d]
Ag-110	2.44 E-20	3.76 E-20	2.36 E-20	3.50 E-20
Ag-110m+D	2.15 E-02	3.15 E-02	1.62 E-02	2.20 E-02
Ag-111	1.17 E-04	1.10 E-04	8.62 E-05	7.61 E-05
Ag-111m+D	1.17 E-08	1.10 E-08	8.62 E-09	7.61 E-09
Ag-111m	1.29 E-21	6.35 E-21	1.30 E-21	6.05 E-21
Ag-112	7.83 E-06	1.42 E-05	6.09 E-06	1.00 E-05
Cd-107	1.98 E-06	3.35 E-06	1.48 E-06	2.29 E-06
Cd-109	1.46 E-03	8.72 E-04	1.09 E-03	6.32 E-04
Cd-111m	1.83 E-07	4.35 E-07	1.64 E-07	3.44 E-07
Cd-113	9.29 E-02	1.57 E-02	6.98 E-02	1.43 E-02
Cd-113m	4.39 E-02	9.21 E-03	3.29 E-02	7.91 E-03
Cd-115+D	6.22 E-05	9.42 E-05	4.56 E-05	6.41 E-05
Cd-115	5.01 E-05	7.58 E-05	3.66 E-05	5.14 E-05
Cd-115m+D	1.03 E-03	6.81 E-04	7.63 E-04	4.88 E-04
Cd-117+D	1.20 E-05	2.14 E-05	9.22 E-06	1.50 E-05
Cd-117m+D	2.52 E-05	4.51 E-05	1.95 E-05	3.16 E-05
In-106	2.33 E-11	1.01 E-11	2.34 E-11	9.82 E-12
In-111	4.37 E-05	6.76 E-05	3.26 E-05	4.67 E-05
In-111m+D	8.35 E-08	1.29 E-07	6.22 E-08	8.91 E-08
In-112	1.61 E-09	3.70 E-09	1.60 E-09	3.45 E-09
In-112m+D	2.67 E-08	6.91 E-08	2.60 E-08	6.18 E-08
In-112m	6.74 E-10	1.71 E-09	6.60 E-10	1.54 E-09
In-113m	9.09 E-07	1.84 E-06	7.45 E-07	1.35 E-06
In-114	2.13 E-20	5.53 E-20	2.09 E-20	5.27 E-20
In-114m+D	1.40 E-03	9.55 E-04	1.05 E-03	6.81 E-04
In-115	2.25 E-02	1.26 E-02	1.67 E-02	8.96 E-03
In-115m+D	2.60 E-06	4.54 E-06	1.98 E-06	3.15 E-06
In-116m	2.48 E-06	5.78 E-06	2.19 E-06	4.50 E-06
In-117+D	3.78 E-07	9.20 E-07	3.43 E-07	7.39 E-07
In-117m+D	2.90 E-06	5.57 E-06	2.32 E-06	3.97 E-06
In-117m	1.03 E-06	2.02 E-06	8.27 E-07	1.46 E-06
Sn-113+D	1.41 E-03	1.66 E-03	1.06 E-03	1.16 E-03
Sn-113	5.32 E-04	2.95 E-04	3.96 E-04	2.13 E-04
Sn-113m+D	1.66 E-07	1.95 E-07	1.24 E-07	1.37 E-07
Sn-113m	9.49 E-11	2.38 E-10	9.28 E-11	2.14 E-10
Sn-117m	2.05 E-04	2.27 E-04	1.51 E-04	1.57 E-04
Sn-119m	4.01 E-04	2.77 E-04	2.99 E-04	1.98 E-04
Sn-121	6.69 E-06	1.06 E-05	4.84 E-06	7.12 E-06
Sn-121m+D	1.93 E-03	1.44 E-03	1.45 E-03	1.03 E-03
Sn-123	1.68 E-03	1.03 E-03	1.26 E-03	7.36 E-04
Sn-123m	8.41 E-08	2.08 E-07	7.74 E-08	1.69 E-07
Sn-125+D	5.27 E-04	5.77 E-04	3.93 E-04	4.03 E-04
Sn-125m+D	8.41 E-08	1.27 E-07	6.32 E-08	8.87 E-08
Sn-126+D	5.12 E-01	7.68 E-01	3.85 E-01	5.35 E-01
Sn-126	3.05 E-02	2.25 E-02	2.29 E-02	1.62 E-02
Sb-122	8.34 E-05	1.27 E-04	6.15 E-05	8.69 E-05
Sb-122m+D	8.92 E-08	1.36 E-07	6.58 E-08	9.30 E-08
Sb-122m	2.55 E-15	2.80 E-16	2.56 E-15	2.77 E-16
Sb-124	3.99 E-03	5.50 E-03	2.99 E-03	3.84 E-03
Sb-124m+D	5.35 E-08	7.37 E-08	4.01 E-08	5.15 E-08
Sb-124n+D	7.11 E-07	9.96 E-07	5.35 E-07	7.03 E-07
Sb-124n	4.38 E-10	1.11 E-09	4.29 E-10	1.01 E-09
Sb-125+D	1.28 E-02	1.93 E-02	9.62 E-03	1.35 E-02
Sb-126	1.30 E-03	1.81 E-03	9.74 E-04	1.26 E-03
Sb-126m+D	2.31 E-07	3.60 E-07	1.81 E-07	2.69 E-07
Sb-127+D	1.55 E-04	2.29 E-04	1.15 E-04	1.58 E-04
Sb-128	6.42 E-05	1.06 E-04	4.81 E-05	7.29 E-05
Sb-128m+D	4.63 E-08	7.63 E-08	3.50 E-08	5.30 E-08

Table 4.5. (contd)

Nuclide[a,b]	Effective Release Height <40 m mrem/yr per Ci/yr[c] 200-W Offsite MEI	Effective Release Height <40 m mrem/yr per Ci/yr[c] 200-W Onsite MEI[d]	Effective Release Height ≥40 m mrem/yr per Ci/yr[c] 200-W Offsite MEI	Effective Release Height ≥40 m mrem/yr per Ci/yr[c] 200-W Onsite MEI[d]
Te-121	3.99 E-04	5.44 E-04	3.00 E-04	3.81 E-04
Te-121m+D	4.44 E-03	5.38 E-03	3.33 E-03	3.78 E-03
Te-121m	2.13 E-03	1.81 E-03	1.59 E-03	1.29 E-03
Te-123	9.39 E-03	1.14 E-03	7.06 E-03	1.08 E-03
Te-123m+D	1.18 E-03	1.03 E-03	8.82 E-04	7.30 E-04
Te-125m	4.03 E-04	2.77 E-04	2.99 E-04	1.96 E-04
Te-127	3.29 E-06	5.43 E-06	2.42 E-06	3.68 E-06
Te-127m+D	1.24 E-03	6.09 E-04	9.17 E-04	4.40 E-04
Te-129+D	2.67 E-07	5.87 E-07	2.28 E-07	4.43 E-07
Te-129m+D	9.53 E-04	6.60 E-04	7.08 E-04	4.69 E-04
Te-129m	8.75 E-04	5.40 E-04	6.50 E-04	3.85 E-04
Te-131+D	1.68 E-06	3.48 E-07	4.39 E-06	7.64 E-07
Te-131	3.71 E-08	9.57 E-08	3.58 E-08	8.39 E-08
Te-131m+D	1.23 E-04	1.86 E-04	1.08 E-04	1.31 E-04
Te-131m	9.89 E-05	1.56 E-04	7.32 E-05	1.07 E-04
Te-132+D	3.19 E-04	4.79 E-04	2.42 E-04	3.39 E-04
Te-132	1.06 E-04	1.48 E-04	7.72 E-05	1.00 E-04
Te-133+D	1.04 E-07	1.09 E-07	2.59 E-07	4.11 E-07
Te-133	2.42 E-09	4.91 E-09	2.41 E-09	4.64 E-09
Te-133m+D	2.75 E-06	5.94 E-06	3.11 E-06	5.90 E-06
Te-134+D	1.05 E-06	1.93 E-06	1.41 E-06	2.90 E-06
Te-134	4.67 E-07	1.15 E-06	4.27 E-07	9.28 E-07
I-122	6.27 E-15	3.78 E-16	6.56 E-15	4.06 E-16
I-122(V)	n/a	n/a	n/a	n/a
I-123+D	1.13 E-06	1.33 E-06	2.80 E-06	5.16 E-06
I-123(V)+D	1.50 E-05	2.22 E-05	8.01 E-06	1.15 E-05
I-124	1.85 E-04	8.50 E-05	4.80 E-04	3.13 E-04
I-124(V)	8.67 E-04	1.24 E-03	4.50 E-04	6.47 E-04
I-125	5.84 E-03	4.61 E-04	1.53 E-02	8.24 E-04
I-125(V)	1.02 E-03	1.87 E-03	5.30 E-04	1.42 E-03
I-126	2.07 E-03	2.58 E-04	5.40 E-03	6.47 E-04
I-126(V)	1.93 E-03	2.88 E-03	1.00 E-03	1.65 E-03
I-128	2.66 E-09	2.23 E-09	3.62 E-09	5.05 E-09
I-128(V)	2.68 E-08	7.40 E-08	2.41 E-08	5.73 E-08
I-129	1.35 E-01	1.19 E-02	3.52 E-01	2.53 E-02
I-129(V)	7.05 E-03	1.92 E-02	3.65 E-03	2.00 E-02
I-130	1.36 E-05	1.62 E-05	3.37 E-05	6.27 E-05
I-130(V)	1.43 E-04	2.12 E-04	7.64 E-05	1.10 E-04
I-130m+D	1.38 E-07	1.64 E-07	3.42 E-07	6.36 E-07
I-130m	1.15 E-11	3.38 E-12	1.26 E-11	5.11 E-12
I-130m(V)	n/a	n/a	n/a	n/a
I-131+D	7.88 E-04	1.16 E-04	2.05 E-03	3.16 E-04
I-131(V)+D	1.44 E-03	1.16 E-04	7.48 E-04	1.04 E-03
I-132	1.85 E-06	2.03 E-03	3.78 E-06	7.33 E-06
I-132(V)	2.09 E-05	2.15 E-06	1.27 E-05	2.10 E-05
I-132m+D	1.46 E-06	3.75 E-05	3.18 E-06	6.22 E-06
I-132m	1.42 E-07	1.73 E-06	2.59 E-07	4.99 E-07
I-132m(V)+D	4.29 E-06	1.60 E-07	4.31 E-06	8.17 E-06
I-132m(V)	3.49 E-06	8.15 E-06	2.33 E-06	4.25 E-06
I-133+D	1.00 E-05	7.16 E-06	2.53 E-05	4.01 E-05
I-133(V)+D	2.66 E-04	1.03 E-05	1.40 E-04	2.00 E-04
I-133m	I-133+D	3.86 E-04	I-133+D	I-133+D
I-134	3.95 E-07	I-133+D	6.43 E-07	1.17 E-06
I-134(V)	3.44 E-06	4.18 E-07	2.57 E-06	5.24 E-06
I-134m+D	2.84 E-08	8.15 E-06	4.62 E-08	8.42 E-08
I-134m	1.48 E-15	3.01 E-08	1.55 E-15	9.40 E-17
I-134m(V)	n/a	8.76 E-17	n/a	n/a
I-135+D	7.74 E-06	n/a	1.47 E-05	2.74 E-05

Table 4.5. (contd)

Nuclide[a,b]	Effective Release Height <40 m mrem/yr per Ci/yr[c] 200-W Offsite MEI	Effective Release Height <40 m mrem/yr per Ci/yr[c] 200-W Onsite MEI[d]	Effective Release Height ≥40 m mrem/yr per Ci/yr[c] 200-W Offsite MEI	Effective Release Height ≥40 m mrem/yr per Ci/yr[c] 200-W Onsite MEI[d]
I-135(V)+D	6.80 E-05	9.54 E-06	3.72 E-05	5.52 E-05
Xe-122+D	1.11 E-06	1.55 E-06	1.14 E-06	1.95 E-06
Xe-122	8.37 E-07	1.21 E-06	4.42 E-07	6.28 E-07
Xe-123+D	3.49 E-06	6.36 E-06	2.38 E-06	4.05 E-06
Xe-123	3.40 E-06	6.25 E-06	2.09 E-06	3.54 E-06
Xe-125+D	9.74 E-06	6.78 E-06	2.37 E-05	4.84 E-06
Xe-125	4.02 E-06	5.86 E-06	2.13 E-06	3.04 E-06
Xe-127	4.95 E-06	6.97 E-06	2.56 E-06	3.57 E-06
Xe-127m+D	1.09 E-10	1.53 E-10	5.64 E-11	7.85 E-11
Xe-127m	3.61 E-20	1.35 E-18	3.60 E-20	1.31 E-18
Xe-129m	3.98 E-07	5.62 E-07	2.07 E-07	2.88 E-07
Xe-131m	1.55 E-07	2.19 E-07	8.05 E-08	1.12 E-07
Xe-133	5.89 E-07	8.32 E-07	3.06 E-07	4.27 E-07
Xe-133m+D	5.51 E-07	7.79 E-07	2.86 E-07	4.00 E-07
Xe-135+D	3.56 E-06	5.35 E-06	1.92 E-06	2.81 E-06
Xe-135m+D	1.04 E-07	1.60 E-07	5.75 E-08	8.63 E-08
Xe-137+D	4.50 E-08	3.56 E-08	3.39 E-08	2.56 E-08
Xe-137	3.89 E-15	3.31 E-16	3.88 E-15	3.25 E-16
Xe-138+D	4.14 E-07	1.05 E-06	3.89 E-07	8.83 E-07
Xe-138	5.15 E-09	1.25 E-08	4.97 E-09	1.09 E-08
Cs-131	1.34 E-05	1.08 E-05	1.00 E-05	7.72 E-06
Cs-132	1.82 E-04	2.38 E-04	1.36 E-04	1.67 E-04
Cs-134	9.39 E-02	5.73 E-02	7.06 E-02	4.17 E-02
Cs-134m+D	1.13 E-05	9.60 E-06	8.28 E-06	6.92 E-06
Cs-134m	3.23 E-07	5.95 E-07	2.52 E-07	4.19 E-07
Cs-135	1.91 E-02	1.96 E-03	1.44 E-02	1.91 E-03
Cs-135m+D	1.41 E-06	3.31 E-06	1.25 E-06	2.58 E-06
Cs-136	1.45 E-03	1.43 E-03	1.09 E-03	1.01 E-03
Cs-137+D	1.87 E-01	1.48 E-01	1.41 E-01	1.06 E-01
Cs-137	9.82 E-02	1.07 E-02	7.38 E-02	1.02 E-02
Cs-138	5.73 E-07	1.46 E-06	5.39 E-07	1.22 E-06
Cs-138m+D	4.43 E-08	1.13 E-07	4.16 E-08	9.42 E-08
Cs-138m	6.26 E-17	3.93 E-18	6.28 E-17	3.77 E-18
Cs-139+D	6.11 E-08	1.29 E-07	5.11 E-08	9.58 E-08
Cs-139	8.09 E-11	1.08 E-10	8.10 E-11	1.03 E-10
Cs-140+D	7.45 E-08	1.02 E-07	5.56 E-08	7.10 E-08
Ba-131+D	2.22 E-04	3.08 E-04	1.66 E-04	2.14 E-04
Ba-131	2.15 E-04	2.98 E-04	1.61 E-04	2.07 E-04
Ba-131m+D	1.96 E-07	2.73 E-07	1.47 E-07	1.90 E-07
Ba-131m	3.82 E-10	8.67 E-10	3.79 E-10	8.12 E-10
Ba-133	3.46 E-02	5.28 E-02	2.60 E-02	3.69 E-02
Ba-133m+D	3.12 E-05	4.85 E-05	2.30 E-05	3.33 E-05
Ba-135m	1.24 E-05	1.97 E-05	9.06 E-06	1.33 E-05
Ba-137m	6.44 E-18	2.09 E-18	5.97 E-18	2.00 E-18
Ba-139	4.86 E-07	1.03 E-06	4.06 E-07	7.62 E-07
Ba-140+D	1.29 E-03	1.76 E-03	9.63 E-04	1.23 E-03
Ba-140	4.26 E-04	4.33 E-04	3.14 E-04	2.99 E-04
Ba-141+D	3.59 E-07	6.08 E-07	2.75 E-07	4.31 E-07
Ba-142+D	9.73 E-07	2.01 E-06	8.06 E-07	1.48 E-06
Ba-142	6.73 E-10	1.13 E-09	6.73 E-10	1.07 E-09
La-137	5.23 E-03	8.03 E-03	3.92 E-03	5.60 E-03
La-138	2.84 E-01	4.38 E-01	2.14 E-01	3.06 E-01
La-140	1.69 E-04	2.66 E-04	1.26 E-04	1.83 E-04
La-141+D	4.17 E-06	6.82 E-06	3.13 E-06	4.73 E-06
La-142	7.39 E-06	1.53 E-05	6.11 E-06	1.13 E-05
Ce-139	7.28 E-04	1.05 E-03	5.45 E-04	7.32 E-04
Ce-141	2.73 E-04	2.93 E-04	2.02 E-04	2.02 E-04
Ce-142	Ce-144+D	Ce-144+D	Ce-144+D	Ce-144+D

Table 4.5. (contd)

Nuclide[a,b]	Effective Release Height <40 m mrem/yr per Ci/yr[c] 200-W Offsite MEI	Effective Release Height <40 m mrem/yr per Ci/yr[c] 200-W Onsite MEI[d]	Effective Release Height ≥40 m mrem/yr per Ci/yr[c] 200-W Offsite MEI	Effective Release Height ≥40 m mrem/yr per Ci/yr[c] 200-W Onsite MEI[d]
Ce-143+D	4.12 E-05	6.42 E-05	3.02 E-05	4.36 E-05
Ce-144+D	4.18 E-03	4.89 E-03	3.09 E-03	3.39 E-03
Pr-142	2.00 E-05	3.22 E-05	1.47 E-05	2.17 E-05
Pr-142m+D	2.58 E-07	4.14 E-07	1.89 E-07	2.80 E-07
Pr-142m	9.44 E-11	2.16 E-10	9.37 E-11	2.02 E-10
Pr-143	1.65 E-04	1.42 E-04	1.21 E-04	9.84 E-05
Pr-144	1.39 E-09	3.39 E-09	1.38 E-09	3.12 E-09
Pr-144m+D	9.94 E-10	2.42 E-09	9.81 E-10	2.23 E-09
Pr-144m	1.52 E-13	1.07 E-13	1.52 E-13	1.03 E-13
Nd-144	0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00
Nd-147+D	1.78 E-04	1.97 E-04	1.31 E-04	1.35 E-04
Pm-143	2.55 E-03	3.85 E-03	1.92 E-03	2.69 E-03
Pm-144+D	1.71 E-02	2.60 E-02	1.29 E-02	1.82 E-02
Pm-145	3.55 E-03	5.44 E-03	2.67 E-03	3.79 E-03
Pm-146+D	4.03 E-02	6.18 E-02	3.03 E-02	4.31 E-02
Pm-147+D	2.72 E-04	3.07 E-04	1.98 E-04	2.07 E-04
Pm-148	2.17 E-04	2.86 E-04	1.61 E-04	1.98 E-04
Pm-148m+D	2.99 E-03	4.21 E-03	2.25 E-03	2.93 E-03
Pm-149	2.54 E-05	3.93 E-05	1.84 E-05	2.64 E-05
Pm-150	1.06 E-05	1.96 E-05	8.31 E-06	1.39 E-05
Pm-151+D	2.78 E-05	4.41 E-05	2.05 E-05	3.01 E-05
Sm-145+D	8.70 E-04	1.25 E-03	6.52 E-04	8.75 E-04
Sm-146	4.69 E-01	7.05 E-01	3.36 E-01	4.70 E-01
Sm-147	4.23 E-01	6.36 E-01	3.04 E-01	4.24 E-01
Sm-148+D	0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00
Sm-151	2.01 E-04	2.65 E-04	1.45 E-04	1.78 E-04
Sm-153	2.41 E-05	3.77 E-05	1.75 E-05	2.54 E-05
Sm-155+D	3.30 E-08	5.63 E-08	2.62 E-08	4.25 E-08
Sm-156+D	2.38 E-05	3.59 E-05	1.76 E-05	2.49 E-05
Sm-156	7.59 E-06	1.25 E-05	5.61 E-06	8.52 E-06
Sm-157+D	1.42 E-07	2.30 E-07	1.05 E-07	1.57 E-07
Sm-157	2.92 E-11	2.81 E-11	2.92 E-11	2.70 E-11
Eu-150	2.60 E-01	4.01 E-01	1.96 E-01	2.80 E-01
Eu-150m+D	6.74 E-06	1.10 E-05	4.95 E-06	7.43 E-06
Eu-152+D	1.20 E-01	1.85 E-01	9.04 E-02	1.29 E-01
Eu-152m+D	1.15 E-05	1.90 E-05	8.58 E-06	1.30 E-05
Eu-152n+D	1.79 E-06	2.84 E-06	1.35 E-06	1.99 E-06
Eu-152n	1.71 E-07	3.49 E-07	1.41 E-07	2.56 E-07
Eu-154	9.46 E-02	1.45 E-01	7.10 E-02	1.01 E-01
Eu-154m+D	9.90 E-07	1.54 E-06	7.48 E-07	1.09 E-06
Eu-154m	2.88 E-08	6.95 E-08	2.61 E-08	5.54 E-08
Eu-155	2.97 E-03	4.43 E-03	2.22 E-03	3.08 E-03
Eu-156	8.61 E-04	1.09 E-03	6.43 E-04	7.60 E-04
Eu-157	1.60 E-05	2.58 E-05	1.18 E-05	1.76 E-05
Gd-148	4.96 E-01	7.47 E-01	3.56 E-01	4.98 E-01
Gd-149+D	2.08 E-04	2.97 E-04	1.56 E-04	2.06 E-04
Gd-150+D	1.38 E-12	1.68 E-12	8.98 E-13	1.04 E-12
Gd-150	0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00
Gd-151+D	3.20 E-04	4.24 E-04	2.40 E-04	2.96 E-04
Gd-152	3.51 E-01	5.28 E-01	2.52 E-01	3.52 E-01
Gd-153	8.38 E-04	1.18 E-03	6.28 E-04	8.26 E-04
Gd-159	1.00 E-05	1.61 E-05	7.33 E-06	1.09 E-05

Table 4.5. (contd)

Nuclide[a,b]	Effective Release Height <40 m mrem/yr per Ci/yr[c] 200-W Offsite MEI	Effective Release Height <40 m mrem/yr per Ci/yr[c] 200-W Onsite MEI[d]	Effective Release Height ≥40 m mrem/yr per Ci/yr[c] 200-W Offsite MEI	Effective Release Height ≥40 m mrem/yr per Ci/yr[c] 200-W Onsite MEI[d]
Tb-157	8.95 E-04	1.37 E-03	6.71 E-04	9.51 E-04
Tb-158	1.77 E-01	2.73 E-01	1.33 E-01	1.90 E-01
Tb-160	3.00 E-03	4.15 E-03	2.25 E-03	2.89 E-03
Tb-161	6.50 E-05	7.67 E-05	4.75 E-05	5.22 E-05
Dy-159	2.17 E-04	2.97 E-04	1.63 E-04	2.08 E-04
Dy-165	8.72 E-07	1.66 E-06	6.90 E-07	1.18 E-06
Ho-163	0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00
Ho-164	5.41 E-09	1.39 E-08	5.16 E-09	1.19 E-08
Ho-164m+D	5.39 E-08	1.33 E-07	4.92 E-08	1.07 E-07
Ho-164m	1.86 E-08	4.65 E-08	1.72 E-08	3.81 E-08
Ho-166	2.46 E-05	3.91 E-05	1.79 E-05	2.64 E-05
Ho-166m	3.85 E-01	5.94 E-01	2.89 E-01	4.14 E-01
Er-169	4.86 E-05	5.37 E-05	3.54 E-05	3.64 E-05
Er-171+D	1.07 E-05	1.79 E-05	8.05 E-06	1.23 E-05
Tm-168	3.40 E-03	5.26 E-03	2.56 E-03	3.67 E-03
Tm-170	6.97 E-04	6.07 E-04	5.15 E-04	4.22 E-04
Tm-171	9.74 E-05	1.04 E-04	7.13 E-05	7.12 E-05
Yb-164+D	1.61 E-06	3.46 E-06	1.36 E-06	2.59 E-06
Yb-164	7.05 E-08	1.52 E-07	5.98 E-08	1.14 E-07
Yb-165+D	1.43 E-07	2.25 E-07	1.07 E-07	1.56 E-07
Yb-166+D	1.71 E-04	2.62 E-04	1.27 E-04	1.81 E-04
Yb-166	3.05 E-05	4.70 E-05	2.21 E-05	3.17 E-05
Yb-167+D	1.34 E-07	1.69 E-07	1.00 E-07	1.18 E-07
Yb-169	4.86 E-04	6.07 E-04	3.62 E-04	4.23 E-04
Yb-175	2.90 E-05	4.12 E-05	2.11 E-05	2.79 E-05
Yb-177+D	1.84 E-06	3.25 E-06	1.44 E-06	2.31 E-06
Lu-177	5.33 E-05	6.65 E-05	3.89 E-05	4.51 E-05
Lu-177m+D	5.57 E-03	7.98 E-03	4.18 E-03	5.56 E-03
Hf-175	8.42 E-04	1.19 E-03	6.31 E-04	8.34 E-04
Hf-177m	1.92 E-06	4.51 E-06	1.71 E-06	3.54 E-06
Hf-178	n/a	n/a	n/a	n/a
Hf-178m	3.54 E-01	5.45 E-01	2.66 E-01	3.80 E-01
Hf-179m	9.53 E-04	1.27 E-03	7.12 E-04	8.88 E-04
Hf-180m	1.38 E-05	2.36 E-05	1.05 E-05	1.63 E-05
Hf-181	1.01 E-03	1.32 E-03	7.54 E-04	9.23 E-04
Hf-182+D	3.56 E-01	5.50 E-01	2.68 E-01	3.83 E-01
Hf-182	6.22 E-02	9.50 E-02	4.66 E-02	6.60 E-02
Ta-179	4.44 E-04	6.65 E-04	3.34 E-04	4.64 E-04
Ta-180	1.74 E-04	2.90 E-04	1.28 E-04	1.97 E-04
Ta-182	4.82 E-03	7.03 E-03	3.61 E-03	4.90 E-03
Ta-182m+D	4.65 E-07	6.81 E-07	3.49 E-07	4.76 E-07
Ta-182m	2.25 E-09	5.31 E-09	2.22 E-09	4.93 E-09
Ta-183	1.23 E-04	1.71 E-04	9.07 E-05	1.17 E-04
W-181	2.45 E-04	2.20 E-04	1.84 E-04	1.55 E-04
W-185	5.54 E-04	2.02 E-04	4.13 E-04	1.49 E-04
W-185m+D	8.19 E-09	2.99 E-09	6.10 E-09	2.19 E-09
W-185m	4.72 E-22	1.83 E-21	4.18 E-22	1.45 E-21
W-187+D	3.03 E-05	4.81 E-05	2.23 E-05	3.29 E-05
W-188+D	2.77 E-03	1.37 E-03	2.06 E-03	9.93 E-04
W-188	2.44 E-03	8.72 E-04	1.82 E-03	6.43 E-04

Table 4.5. (contd)

Nuclide[a,b]	Effective Release Height <40 m mrem/yr per Ci/yr[c] 200-W Offsite MEI	Effective Release Height <40 m mrem/yr per Ci/yr[c] 200-W Onsite MEI[d]	Effective Release Height ≥40 m mrem/yr per Ci/yr[c] 200-W Offsite MEI	Effective Release Height ≥40 m mrem/yr per Ci/yr[c] 200-W Onsite MEI[d]
Re-186	5.28 E-05	6.76 E-05	3.85 E-05	4.57 E-05
Re-186m+D	2.15 E-02	2.34 E-02	1.62 E-02	1.65 E-02
Re-186m	1.06 E-02	6.58 E-03	7.98 E-03	4.79 E-03
Re-187	1.61 E-05	2.21 E-06	1.21 E-05	2.04 E-06
Re-188	1.99 E-05	3.19 E-05	1.46 E-05	2.16 E-05
Os-185	2.09 E-03	3.06 E-03	1.57 E-03	2.14 E-03
Os-191	1.33 E-04	1.42 E-04	9.81 E-05	9.83 E-05
Ir-189+D	6.27 E-05	7.32 E-05	4.65 E-05	5.08 E-05
Ir-190	6.73 E-04	9.41 E-04	5.03 E-04	6.54 E-04
Ir-192	2.28 E-03	3.11 E-03	1.71 E-03	2.17 E-03
Ir-194	2.13 E-05	3.41 E-05	1.56 E-05	2.31 E-05
Pt-191	3.59 E-05	5.53 E-05	2.66 E-05	3.81 E-05
Pt-193	4.70 E-05	4.10 E-05	3.52 E-05	2.93 E-05
Pt-193m+D	3.20 E-05	4.55 E-05	2.32 E-05	3.04 E-05
Pt-195m	4.45 E-05	6.44 E-05	3.24 E-05	4.35 E-05
Pt-197	9.82 E-06	1.58 E-05	7.14 E-06	1.06 E-05
Pt-197m+D	1.34 E-06	2.39 E-06	1.03 E-06	1.66 E-06
Pt-199+D	2.65 E-07	4.50 E-07	2.03 E-07	3.24 E-07
Au-193+D	7.55 E-06	1.21 E-05	5.59 E-06	8.27 E-06
Au-193m+D	4.63 E-10	7.42 E-10	3.43 E-10	5.08 E-10
Au-193m	2.73 E-22	7.03 E-22	2.63 E-22	5.44 E-22
Au-194	6.33 E-05	9.95 E-05	4.72 E-05	6.87 E-05
Au-195	5.38 E-04	6.90 E-04	4.03 E-04	4.83 E-04
Au-195m+D	1.02 E-09	1.31 E-09	7.65 E-10	9.16 E-10
Au-195m	9.27 E-22	2.10 E-21	9.08 E-22	1.99 E-21
Au-196	8.95 E-05	1.39 E-04	6.72 E-05	9.67 E-05
Au-196m+D	9.60 E-06	1.52 E-05	7.21 E-06	1.06 E-05
Au-196m	3.98 E-06	6.51 E-06	2.99 E-06	4.51 E-06
Au-198	6.45 E-05	9.91 E-05	4.76 E-05	6.78 E-05
Au-198m+D	1.24 E-04	1.93 E-04	9.13 E-05	1.32 E-04
Au-198m	9.40 E-05	1.47 E-04	6.88 E-05	9.96 E-05
Au-199	3.23 E-05	4.90 E-05	2.35 E-05	3.31 E-05
Hg-203	5.60 E-04	6.47 E-04	4.18 E-04	4.53 E-04
Hg-205	1.44 E-14	3.27 E-15	1.44 E-14	3.21 E-15
Hg-206+D	1.12 E-11	1.12 E-11	1.13 E-11	1.07 E-11
Tl-200	5.75 E-05	9.08 E-05	4.29 E-05	6.27 E-05
Tl-201	1.41 E-05	2.13 E-05	1.04 E-05	1.46 E-05
Tl-202	2.30 E-04	2.91 E-04	1.73 E-04	2.04 E-04
Tl-204	2.54 E-03	1.23 E-03	1.90 E-03	9.01 E-04
Tl-206	1.56 E-13	1.94 E-13	1.07 E-13	1.26 E-13
Tl-206m	2.92 E-14	2.25 E-15	2.92 E-14	2.24 E-15
Tl-207+D	7.70 E-15	1.01 E-14	7.47 E-15	8.54 E-15
Tl-208	9.31 E-11	1.47 E-10	6.90 E-11	1.01 E-10
Tl-209+D	9.45 E-09	1.72 E-08	7.27 E-09	1.20 E-08
Tl-210+D	2.82 E-08	1.14 E-08	2.10 E-08	8.53 E-09
Pb-203	2.85 E-05	4.44 E-05	2.12 E-05	3.06 E-05
Pb-204m	3.09 E-06	6.84 E-06	2.65 E-06	5.19 E-06
Pb-205	1.44 E-04	1.01 E-04	1.08 E-04	7.30 E-05
Pb-209	8.44 E-07	1.53 E-06	6.50 E-07	1.07 E-06
Pb-210+D	2.53 E-01	1.02 E-01	1.89 E-01	7.66 E-02

Table 4.5. (contd)

Nuclide[a,b]	Effective Release Height <40 m mrem/yr per Ci/yr[c] 200-W Offsite MEI	Effective Release Height <40 m mrem/yr per Ci/yr[c] 200-W Onsite MEI[d]	Effective Release Height ≥40 m mrem/yr per Ci/yr[c] 200-W Offsite MEI	Effective Release Height ≥40 m mrem/yr per Ci/yr[c] 200-W Onsite MEI[d]
Pb-210	2.48 E-01	9.42 E-02	1.85 E-01	7.11 E-02
Pb-211+D	9.16 E-06	2.31 E-05	8.52 E-06	1.91 E-05
Pb-212+D	4.85 E-03	7.91 E-03	3.55 E-03	5.32 E-03
Pb-214+D	1.44 E-05	3.64 E-05	1.37 E-05	3.11 E-05
Pb-214	3.28 E-06	8.51 E-06	3.15 E-06	7.37 E-06
Bi-207	2.46 E-01	3.78 E-01	1.85 E-01	2.64 E-01
Bi-208	5.54 E-01	8.56 E-01	4.17 E-01	5.98 E-01
Bi-210+D	3.14 E-03	4.81 E-03	2.25 E-03	3.21 E-03
Bi-210	2.99 E-03	4.68 E-03	2.15 E-03	3.12 E-03
Bi-210m+D	2.06 E-01	2.99 E-01	1.52 E-01	2.04 E-01
Bi-211+D	3.12 E-15	5.22 E-16	3.13 E-15	5.14 E-16
Bi-211	5.61 E-21	3.14 E-23	5.62 E-21	3.15 E-23
Bi-212+D	8.75 E-05	2.00 E-04	7.60 E-05	1.53 E-04
Bi-212n+D	2.23 E-12	1.45 E-12	2.23 E-12	1.39 E-12
Bi-212n	2.00 E-13	1.26 E-13	2.01 E-13	1.22 E-13
Bi-213+D	4.24 E-05	1.02 E-04	3.82 E-05	8.17 E-05
Bi-214+D	1.44 E-06	2.58 E-06	1.31 E-06	2.34 E-06
Po-208+D	6.13 E-07	9.47 E-07	4.61 E-07	6.61 E-07
Po-209+D	1.26 E-03	1.95 E-03	9.49 E-04	1.36 E-03
Po-210	1.92 E-01	1.76 E-01	1.40 E-01	1.21 E-01
Po-211	0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00
Po-212	0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00
Po-212m	3.36 E-20	6.77 E-20	3.25 E-20	6.24 E-20
Po-213+D	0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00
Po-214+D	5.90 E-14	2.35 E-14	4.40 E-14	1.76 E-14
Po-215+D	7.52 E-12	1.90 E-11	7.00 E-12	1.57 E-11
Po-215	1.72 E-27	2.66 E-27	1.29 E-27	1.86 E-27
Po-216+D	1.83 E-08	2.98 E-08	1.34 E-08	2.00 E-08
Po-216	0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00
Po-218+D	1.85 E-06	2.34 E+00	1.76 E-06	1.56 E+00
Po-218	3.49 E-22	4.97 E-22	2.69 E-22	3.48 E-22
At-217+D	5.00 E-10	1.22 E-09	4.51 E-10	9.65 E-10
At-217	0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00
At-218+D	1.27 E-09	3.24 E-09	1.25 E-09	2.93 E-09
At-218	3.73 E-33	6.06 E-29	3.75 E-33	4.82 E-29
Rn-218+D	1.27 E-11	5.11 E-12	9.43 E-12	3.82 E-12
Rn-218	8.66 E-32	0.00 E+00	8.66 E-32	0.00 E+00
Rn-219+D	1.67 E-08	4.24 E-08	1.56 E-08	3.50 E-08
Rn-219	6.15 E-18	2.20 E-17	4.63 E-18	1.53 E-17
Rn-220+D	7.05 E-06	1.15 E-05	5.15 E-06	7.73 E-06
Rn-220	9.37 E-24	6.63 E-25	8.72 E-24	6.49 E-25
Rn-222+D	8.60 E-04	1.33 E-03	6.13 E-04	8.81 E-04
Rn-222	7.38 E-09	1.04 E-08	3.83 E-09	5.36 E-09
Rn-224+D	1.86 E-03	2.90 E-03	1.33 E-03	1.94 E-03
Fr-221+D	5.10 E-06	1.24 E-05	4.60 E-06	9.85 E-06
Fr-221	1.36 E-14	2.53 E-15	1.36 E-14	2.48 E-15
Fr-222+D	5.82 E-07	7.46 E-07	5.04 E-07	6.79 E-07
Fr-223+D	3.18 E-04	4.87 E-04	2.29 E-04	3.24 E-04
Fr-223	1.12 E-06	2.89 E-06	1.09 E-06	2.58 E-06
Ra-223+D	2.37 E-01	3.63 E-01	1.70 E-01	2.42 E-01

Table 4.5. (contd)

Nuclide[a,b]	Effective Release Height <40 m mrem/yr per Ci/yr[c]		Effective Release Height ≥40 m mrem/yr per Ci/yr[c]	
	200-W Offsite MEI	200-W Onsite MEI[d]	200-W Offsite MEI	200-W Onsite MEI[d]
Ra-224+D	9.15 E-02	1.43 E-01	6.57 E-02	9.54 E-02
Ra-225+D	2.10 E-01	3.15 E-01	1.50 E-01	2.10 E-01
Ra-226+D	7.17 E-01	8.52 E-01	5.35 E-01	5.94 E-01
Ra-227+D	1.16 E-05	1.79 E-05	8.38 E-06	1.20 E-05
Ra-228+D	5.16 E-01	3.92 E-01	3.85 E-01	2.78 E-01
Ac-225+D	2.33 E-01	3.63 E-01	1.67 E-01	2.41 E-01
Ac-226+D	3.41 E-02	5.44 E-02	2.46 E-02	3.64 E-02
Ac-227+D	3.15 E+00	4.82 E+00	2.26 E+00	3.22 E+00
Ac-228+D	4.90 E-04	7.55 E-04	3.49 E-04	5.03 E-04
Th-227+D	3.33 E-01	5.19 E-01	2.39 E-01	3.45 E-01
Th-228+D	1.49 E+00	2.31 E+00	1.07 E+00	1.54 E+00
Th-229+D	3.16 E+00	4.76 E+00	2.27 E+00	3.18 E+00
Th-230+D	6.28 E-01	9.08 E-01	4.52 E-01	6.07 E-01
Th-231+D	1.01 E-05	1.62 E-05	7.35 E-06	1.09 E-05
Th-232+D	1.52 E+00	2.29 E+00	1.11 E+00	1.55 E+00
Th-233+D	2.2382 E-07	2.66 E-07	1.67 E-07	1.85 E-07
Th-233	1.82 E-09	4.66 E-09	1.78 E-09	4.16 E-09
Th-234+D	7.57 E-04	6.50 E-04	5.59 E-04	4.53 E-04
Th-234	6.71 E-04	5.16 E-04	4.94 E-04	3.60 E-04
Pa-231+D	4.14 E+00	6.28 E+00	2.98 E+00	4.20 E+00
Pa-232m+D	8.83 E-05	1.38 E-04	6.52 E-05	9.47 E-05
Pa-232	7.32 E-05	1.16 E-04	5.40 E-05	7.91 E-05
Pa-233+D	3.88 E-04	4.56 E-04	2.88 E-04	3.17 E-04
Pa-234+D	2.87 E-05	4.82 E-05	2.16 E-05	3.32 E-05
Pa-234m+D	1.38 E-10	2.29 E-10	1.03 E-10	1.58 E-10
U-232+D	6.51 E-01	8.70 E-01	4.80 E-01	5.97 E-01
U-233+D	1.35 E-01	1.89 E-01	9.75 E-02	1.27 E-01
U-234+D	1.32 E-01	1.85 E-01	9.52 E-02	1.24 E-01
U-235+D	1.59 E-01	2.29 E-01	1.16 E-01	1.55 E-01
U-235m+D	1.12 E-14	1.59 E-14	8.09 E-15	1.07 E-14
U-235m	0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00
U-236+D	1.22 E-01	1.71 E-01	8.81 E-02	1.15 E-01
U-237+D	9.74 E-05	1.26 E-04	7.15 E-05	8.64 E-05
U-238+D	1.41 E-01	2.01 E-01	1.03 E-01	1.36 E-01
U-239+D	3.02 E-07	4.75 E-07	2.22 E-07	3.25 E-07
U-239	6.09 E-09	1.57 E-08	5.91 E-09	1.39 E-08
U-240+D	2.46 E-05	3.99 E-05	1.82 E-05	2.71 E-05
U-240	1.55 E-05	2.52 E-05	1.13 E-05	1.69 E-05
Np-235	5.73 E-05	6.91 E-05	4.25 E-05	4.79 E-05
Np-236+D	1.80 E-01	2.72 E-01	1.31 E-01	1.82 E-01
Np-236m+D	2.26 E-04	3.47 E-04	1.60 E-04	2.31 E-04
Np-237+D	1.03 E+00	1.55 E+00	7.45 E-01	1.04 E+00
Np-238+D	1.29 E-04	1.99 E-04	9.32 E-05	1.34 E-04
Np-239+D	4.30 E-05	6.68 E-05	3.14 E-05	4.51 E-05
Np-240+D	1.60 E-06	3.58 E-06	1.38 E-06	2.73 E-06
Np-240m+D	4.75 E-09	7.40 E-09	3.45 E-09	4.99 E-09
Pu-234+D	6.11 E-04	9.67 E-04	4.41 E-04	6.47 E-04
Pu-235+D	1.55 E-01	2.23 E-01	1.13 E-01	1.51 E-01
Pu-236+D	8.19 E-01	1.25 E+00	5.87 E-01	8.34 E-01
Pu-237+D	8.92 E-05	1.16 E-04	6.66 E-05	8.09 E-05

Table 4.5. (contd)

Nuclide[a,b]	Effective Release Height <40 m mrem/yr per Ci/yr[c] 200-W Offsite MEI	Effective Release Height <40 m mrem/yr per Ci/yr[c] 200-W Onsite MEI[d]	Effective Release Height ≥40 m mrem/yr per Ci/yr[c] 200-W Offsite MEI	Effective Release Height ≥40 m mrem/yr per Ci/yr[c] 200-W Onsite MEI[d]
Pu-238+D	1.98 E+00	3.02 E+00	1.42 E+00	2.01 E+00
Pu-239+D	2.16 E+00	3.29 E+00	1.55 E+00	2.19 E+00
Pu-240+D	2.16 E+00	3.29 E+00	1.55 E+00	2.19 E+00
Pu-241+D	4.03 E-02	6.03 E-02	2.90 E-02	4.02 E-02
Pu-242+D	2.05 E+00	3.13 E+00	1.47 E+00	2.08 E+00
Pu-243+D	1.90 E-06	3.26 E-06	1.43 E-06	2.24 E-06
Pu-244+D	2.12 E+00	3.23 E+00	1.52 E+00	2.16 E+00
Am-240+D	8.70 E-05	1.36 E-04	6.48 E-05	9.37 E-05
Am-241+D	1.79 E+00	2.73 E+00	1.28 E+00	1.82 E+00
Am-242+D	5.96 E-04	9.31 E-04	4.27 E-04	6.19 E-04
Am-242m+D	1.61 E+00	2.46 E+00	1.16 E+00	1.64 E+00
Am-243+D	1.81 E+00	2.77 E+00	1.30 E+00	1.63 E+00
Am-244+D	9.26 E-05	1.46 E-04	6.69 E-05	9.79 E-05
Am-244m+D	3.05 E-06	4.67 E-06	2.18 E-06	3.11 E-06
Am-244m	2.54 E-08	6.59 E-08	2.45 E-08	5.73 E-08
Am-245+D	6.83 E-07	1.31 E-06	5.43 E-07	9.39 E-07
Am-246+D	3.55 E-07	8.57 E-07	3.22 E-07	6.93 E-07
Cm-241+D	1.88 E-03	2.76 E-03	1.37 E-03	1.87 E-03
Cm-242+D	1.80 E-01	2.78 E-01	1.29 E-01	1.85 E-01
Cm-243+D	1.35 E+00	2.07 E+00	9.68 E-01	1.37 E+00
Cm-244+D	1.12 E+00	1.70 E+00	8.00 E-01	1.13 E+00
Cm-245+D	1.84 E+00	2.81 E+00	1.32 E+00	1.87 E+00
Cm-246+D	1.81 E+00	2.76 E+00	1.30 E+00	1.84 E+00
Cm-247+D	1.74 E+00	2.65 E+00	1.24 E+00	1.76 E+00
Cm-248+D	6.76 E+00	1.03 E+01	4.87 E+00	6.89 E+00
Cm-249+D	1.03 E-06	1.62 E-06	7.51 E-07	1.09 E-06
Cm-250+D	3.99 E+01	6.08 E+01	2.87 E+01	4.07 E+01
Bk-247+D	3.02 E+00	4.60 E+00	2.17 E+00	3.07 E+00
Bk-248m+D	7.44 E-05	9.40 E-05	4.89 E-05	5.85 E-05
Bk-248m	2.12 E-06	3.36 E-06	1.59 E-06	2.33 E-06
Bk-249+D	7.24 E-03	1.10 E-02	5.20 E-03	7.35 E-03
Bk-250+D	4.72 E-05	7.49 E-05	3.43 E-05	5.04 E-05
Cf-249+D	3.09 E+00	4.71 E+00	2.22 E+00	3.14 E+00
Cf-250+D	1.43 E+00	2.19 E+00	1.03 E+00	1.46 E+00
Cf-251+D	3.09 E+00	4.71 E+00	2.22 E+00	3.14 E+00
Cf-252+D	8.18 E-01	1.25 E+00	5.87 E-01	8.34 E-01
Es-254+D	3.27 E-01	5.03 E-01	2.34 E-01	3.36 E-01

MEI = Maximally exposed individual
Bold nuclides are newly available in CAP88-PC version 4.
n/a = nuclide or indicated solubility class is not available in CAP88-PC version 4.
(a) +D indicates that the listed radionuclide dose includes the contribution from the parent radionuclide plus decay products grown in during transit and the build-up period.
(b) If the *nuclide+D* is followed by the nuclide without the +D, the decay chain members contribute greater than 10% of the *nuclide+D* dose. V = vapor; E = elemental; O = organic compounds; F = particulate, fast clearance rate; M = particulate, moderate clearance rate; S = particulate, slow clearance rate. Carbon isotopes are modeled as particulate (M), carbon monoxide (CO), or carbon dioxide (CO2).
(c) If a radionuclide is indicated rather than a dose factor value, the nuclide is used as a surrogate. See Table 3.4 for additional details.
(d) Onsite MEI assumed to occupy the onsite location for the maximum possible 8,766 hr in a year.

This page intentionally left blank.

Table 4.6. **Eastern and Western 300 Area**: Offsite MEI CAP88-PC Dose-per-Unit-Release Factors (mrem/Ci) by Effective Release Height

Nuclide[a,b]	Effective Release Height <40 m		Effective Release Height ≥40 m	
	mrem/yr per Ci/yr[c]		mrem/yr per Ci/yr[c]	
	Eastern 300 Area Offsite MEI[d]	Western 300 Area Offsite MEI[d]	Eastern 300 Area Offsite MEI[e]	Western 300 Area Offsite MEI[e]
H-3 (V)	2.10 E-04	4.57 E-04	5.59 E-05	5.64 E-05
H-3 (E)	1.88 E-04	4.08 E-04	5.00 E-05	5.04 E-05
H-3 (O)	4.60 E-04	1.00 E-03	1.22 E-04	1.23 E-04
H-3 (F)	1.87 E-04	4.16 E-04	5.16 E-05	5.15 E-05
H-3 (M)	2.33 E-04	5.19 E-04	6.44 E-05	6.44 E-05
H-3 (S)	4.93 E-04	1.10 E-03	1.36 E-04	1.36 E-04
Be-7	2.28 E-03	5.07 E-03	6.90 E-04	6.89 E-04
Be-10	4.82 E-02	1.07 E-01	1.44 E-02	1.43 E-02
C-11	2.30 E-04	6.50 E-04	8.01 E-05	5.80 E-05
C-11 (CO)	2.20 E-04	6.10 E-04	7.40 E-05	5.40 E-05
C-11 (CO2)	2.21 E-04	6.12 E-04	7.42 E-05	5.42 E-05
C-14	2.37 E-02	5.29 E-02	6.56 E-03	6.56 E-03
C-14 (CO)	2.27 E-02	4.93 E-02	6.04 E-03	6.08 E-03
C-14 (CO2)	2.27 E-02	4.93 E-02	6.04 E-03	6.09 E-03
C-15	C-11	C-11	C-11	C-11
N-13	1.44 E-04	5.08 E-04	6.10 E-05	3.18 E-05
O-15	7.58 E-06	1.29 E-04	1.47 E-05	6.00 E-07
O-19	1.73 E-10	3.11 E-07	3.53 E-08	1.26 E-13
F-18	3.87 E-04	9.03 E-04	1.13 E-04	1.07 E-04
Na-22	1.89 E+00	4.21 E+00	5.74 E-01	5.74 E-01
Na-24	3.72 E-03	8.33 E-03	1.08 E-03	1.07 E-03
Mg-27	1.23 E-04	4.54 E-04	5.53 E-05	2.76 E-05
Mg-28+D	4.33 E-03	9.44 E-03	1.23 E-03	1.26 E-03
Mg-28	2.53 E-03	5.66 E-03	7.28 E-04	7.23 E-04
Al-26	1.61 E+01	3.58 E+01	4.88 E+00	4.87 E+00
Al-28	1.95 E-05	2.88 E-04	3.34 E-05	1.81 E-06
Si-31	7.42 E-05	1.70 E-04	2.13 E-05	2.04 E-05
Si-32+D	5.20 E-01	1.15 E+00	1.58 E-01	1.57 E-01
Si-32	2.38 E-02	5.30 E-02	6.72 E-03	6.71 E-03
P-32	1.97 E-02	4.39 E-02	5.88 E-03	5.88 E-03
P-33	4.45 E-03	9.91 E-03	1.32 E-03	1.31 E-03
S-35	1.83 E-02	4.07 E-02	5.51 E-03	5.51 E-03
Cl-36	1.54 E+01	3.43 E+01	4.68 E+00	4.67 E+00
Ar-37	0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00
Ar-39	8.38 E-07	1.82 E-06	2.23 E-07	2.25 E-07
Ar-41	4.14 E-04	9.44 E-04	1.15 E-04	1.09 E-04
Ar-42+D	7.91 E-06	8.50 E-06	1.13 E-06	2.65 E-06
Ar-42	9.18 E-07	2.00 E-06	2.45 E-07	2.46 E-07
K-40	2.99 E+00	6.65 E+00	9.06 E-01	9.05 E-01
K-42	6.06 E-04	1.36 E-03	1.73 E-04	1.71 E-04
Ca-41	2.72 E-02	6.04 E-02	8.23 E-03	8.22 E-03
Ca-45	1.01 E-02	2.24 E-02	2.98 E-03	2.98 E-03
Ca-47+D	6.67 E-03	1.48 E-02	1.96 E-03	1.96 E-03
Sc-44	1.10 E-03	2.50 E-03	3.17 E-04	3.08 E-04
Sc-44m+D	6.01 E-03	1.33 E-02	1.78 E-03	1.78 E-03
Sc-44m	1.91 E-03	4.25 E-03	5.43 E-04	5.41 E-04
Sc-46	1.42 E-01	3.17 E-01	4.30 E-02	4.30 E-02
Sc-47	9.36 E-04	2.09 E-03	2.68 E-04	2.67 E-04
Ti-44+D	1.17 E+01	2.60 E+01	3.54 E+00	3.54 E+00
Ti-44	9.33 E-01	2.08 E+00	2.82 E-01	2.81 E-01

Table 4.6. (contd)

Nuclide[a,b]	Effective Release Height <40 m mrem/yr per Ci/yr[c]		Effective Release Height ≥40 m mrem/yr per Ci/yr[c]	
	Eastern 300 Area Offsite MEI[d]	Western 300 Area Offsite MEI[d]	Eastern 300 Area Offsite MEI[e]	Western 300 Area Offsite MEI[e]
Ti-45	4.26 E-04	9.74 E-04	1.23 E-04	1.19 E-04
Ti-51	2.92 E-05	1.46 E-04	1.76 E-05	5.61 E-06
V-48	4.38 E-02	9.75 E-02	1.32 E-02	1.32 E-02
V-49	3.29 E-04	7.32 E-04	9.87 E-05	9.86 E-05
Cr-49+D	3.15 E-04	7.88 E-04	9.79 E-05	8.37 E-05
Cr-51	1.02 E-03	2.27 E-03	3.08 E-04	3.08 E-04
Cr-55	7.33 E-07	5.89 E-06	6.98 E-07	1.07 E-07
Mn-52	1.78 E-02	3.96 E-02	5.33 E-03	5.32 E-03
Mn-52m+D	5.69 E-04	1.60 E-03	1.97 E-04	1.44 E-04
Mn-53	2.65 E-03	5.89 E-03	8.01 E-04	8.01 E-04
Mn-54	2.04 E-01	4.54 E-01	6.18 E-02	6.18 E-02
Mn-56	7.86 E-04	1.81 E-03	2.28 E-04	2.18 E-04
Fe-55	1.38 E-02	3.07 E-02	4.17 E-03	4.17 E-03
Fe-59	6.60 E-02	1.47 E-01	1.99 E-02	1.99 E-02
Co-56	2.64 E-01	5.87 E-01	7.98 E-02	7.98 E-02
Co-57	3.24 E-02	7.21 E-02	9.81 E-03	9.80 E-03
Co-58	6.96 E-02	1.55 E-01	2.10 E-02	2.10 E-02
Co-58m+D	2.96 E-04	6.55 E-04	8.90 E-05	8.92 E-05
Co-58m	1.35 E-05	3.04 E-05	3.77 E-06	3.72 E-06
Co-60	3.39 E+00	7.54 E+00	1.03 E+00	1.03 E+00
Co-60m+D	1.34 E-05	3.06 E-05	4.12 E-06	4.00 E-06
Co-60m	1.08 E-06	3.81 E-06	4.64 E-07	2.47 E-07
Ni-56+D	2.66 E-02	5.93 E-02	8.05 E-03	8.04 E-03
Ni-56	1.06 E-02	2.37 E-02	3.19 E-03	3.18 E-03
Ni-57+D	3.52 E-03	7.85 E-03	1.04 E-03	1.04 E-03
Ni-59	5.25 E-03	1.17 E-02	1.59 E-03	1.59 E-03
Ni-63	1.15 E-02	2.56 E-02	3.48 E-03	3.47 E-03
Ni-65	3.02 E-04	6.95 E-04	8.74 E-05	8.36 E-05
Cu-64	2.31 E-04	5.19 E-04	6.64 E-05	6.58 E-05
Cu-66	7.93 E-06	4.37 E-05	5.24 E-06	1.45 E-06
Cu-67	7.57 E-04	1.69 E-03	2.16 E-04	2.15 E-04
Zn-65	5.36 E-01	1.19 E+00	1.63 E-01	1.62 E-01
Zn-69	2.20 E-05	5.36 E-05	6.64 E-06	5.90 E-06
Zn-69m+D	5.73 E-04	1.29 E-03	1.64 E-04	1.63 E-04
Ga-67	6.48 E-04	1.44 E-03	1.90 E-04	1.89 E-04
Ga-68	3.40 E-04	8.14 E-04	1.02 E-04	9.22 E-05
Ga-70	1.44 E-05	4.03 E-05	4.97 E-06	3.64 E-06
Ga-72	2.58 E-03	5.78 E-03	7.49 E-04	7.42 E-04
Ge-68+D	5.56 E-01	1.24 E+00	1.68 E-01	1.68 E-01
Ge-68	3.41 E-01	7.59 E-01	1.03 E-01	1.03 E-01
Ge-69	1.79 E-03	4.00 E-03	5.29 E-04	5.27 E-04
Ge-71	1.27 E-04	2.82 E-04	3.81 E-05	3.80 E-05
Ge-75	4.45 E-05	1.05 E-04	1.31 E-05	1.21 E-05
Ge-77+D	1.11 E-03	2.47 E-03	3.18 E-04	3.15 E-04
As-73	5.18 E-03	1.15 E-02	1.55 E-03	1.54 E-03
As-74	1.80 E-02	4.01 E-02	5.40 E-03	5.39 E-03
As-76	1.32 E-03	2.94 E-03	3.77 E-04	3.75 E-04
As-77	3.76 E-04	8.40 E-04	1.05 E-04	1.04 E-04
Se-75	2.39 E-01	5.33 E-01	7.26 E-02	7.25 E-02
Se-77m	5.19 E-14	6.34 E-10	7.09 E-11	7.49 E-18
Se-79	8.20 E-01	1.82 E+00	2.49 E-01	2.48 E-01
Se-79m+D	3.24 E-07	2.30 E-06	2.73 E-07	5.10 E-08
Se-79m	3.24 E-07	2.30 E-06	2.73 E-07	5.10 E-08
Br-82	4.48 E-03	9.99 E-03	1.32 E-03	1.32 E-03
Br-82m+D	1.18 E-05	2.42 E-05	3.25 E-06	3.56 E-06
Br-82m	2.97 E-07	1.42 E-06	1.71 E-07	5.86 E-08
Br-83+D	4.69 E-05	1.08 E-04	1.34 E-05	1.28 E-05

Table 4.6. (contd)

Nuclide[a,b]	Effective Release Height <40 m mrem/yr per Ci/yr[c]		Effective Release Height ≥40 m mrem/yr per Ci/yr[c]	
	Eastern 300 Area Offsite MEI[d]	Western 300 Area Offsite MEI[d]	Eastern 300 Area Offsite MEI[e]	Western 300 Area Offsite MEI[e]
Br-84	5.26 E-04	1.37 E-03	1.69 E-04	1.38 E-04
Br-84m	2.35 E-04	1.15 E-03	1.38 E-04	4.60 E-05
Br-85+D	2.34 E-06	1.96 E-05	2.30 E-06	3.65 E-07
Br-85	1.83 E-06	1.86 E-05	2.18 E-06	2.27 E-07
Kr-81	2.78 E-07	6.06 E-07	7.41 E-08	7.47 E-08
Kr-81m+D	8.44 E-16	4.14 E-11	3.87 E-12	1.10 E-17
Kr-83m	7.41 E-09	1.69 E-08	2.06 E-09	1.96 E-09
Kr-85	1.76 E-06	3.82 E-06	4.68 E-07	4.71 E-07
Kr-85m+D	4.83 E-05	1.07 E-04	1.31 E-05	1.29 E-05
Kr-87+D	2.59 E-04	6.01 E-04	7.34 E-05	6.78 E-05
Kr-88+D	7.72 E-04	1.62 E-03	1.98 E-04	2.11 E-04
Kr-88	6.73 E-04	1.51 E-03	1.84 E-04	1.79 E-04
Kr-89+D	1.60 E-04	7.12 E-04	8.50 E-05	3.46 E-05
Kr-89	5.53 E-05	4.94 E-04	5.74 E-05	7.20 E-06
Kr-90	1.38 E-07	3.07 E-07	4.19 E-08	4.19 E-08
Rb-81+D	3.49 E-04	7.88 E-04	9.99 E-05	9.76 E-05
Rb-81	2.94 E-04	6.66 E-04	8.45 E-05	8.25 E-05
Rb-81m+D	3.40 E-05	7.41 E-05	9.48 E-06	9.72 E-06
Rb-81m	1.71 E-05	4.47 E-05	5.51 E-06	4.44 E-06
Rb-82	1.11 E-06	5.04 E-05	5.68 E-06	3.60 E-08
Rb-82m	1.64 E-03	3.70 E-03	4.75 E-04	4.66 E-04
Rb-83+D	8.27 E-02	1.84 E-01	2.51 E-02	2.50 E-02
Rb-84	5.67 E-02	1.26 E-01	1.71 E-02	1.71 E-02
Rb-84m+D	9.51 E-05	2.55 E-04	3.19 E-05	2.50 E-05
Rb-84m	8.03 E-05	2.28 E-04	2.81 E-05	2.03 E-05
Rb-86	2.33 E-02	5.18 E-02	6.95 E-03	6.94 E-03
Rb-86m+D	1.03 E-06	1.41 E-05	1.62 E-06	2.66 E-07
Rb-86m	1.49 E-07	1.22 E-05	1.36 E-06	2.64 E-09
Rb-87	3.94 E-01	8.75 E-01	1.19 E-01	1.19 E-01
Rb-88	1.68 E-04	4.92 E-04	6.05 E-05	4.17 E-05
Rb-89+D	4.64 E-04	1.41 E-03	1.74 E-04	1.13 E-04
Rb-90+D	3.88 E-05	4.44 E-04	5.19 E-05	4.49 E-06
Rb-90	3.82 E-05	4.43 E-04	5.17 E-05	4.29 E-06
Rb-90m+D	1.80 E-04	1.15 E-03	1.37 E-04	3.04 E-05
Rb-90m	1.74 E-04	1.13 E-03	1.34 E-04	2.91 E-05
Sr-82+D	6.38 E-02	1.42 E-01	1.90 E-02	1.90 E-02
Sr-82	3.86 E-02	8.58 E-02	1.14 E-02	1.14 E-02
Sr-83+D	1.93 E-03	4.29 E-03	5.70 E-04	5.68 E-04
Sr-83	1.42 E-03	3.16 E-03	4.16 E-04	4.14 E-04
Sr-85	3.13 E-02	6.95 E-02	9.45 E-03	9.45 E-03
Sr-85m+D	8.44 E-05	1.99 E-04	2.53 E-05	2.35 E-05
Sr-85m	6.84 E-05	1.64 E-04	2.05 E-05	1.86 E-05
Sr-87m+D	1.39 E-04	3.19 E-04	4.03 E-05	3.87 E-05
Sr-89	3.09 E-02	6.88 E-02	9.20 E-03	9.20 E-03
Sr-90+D	3.89 E+00	8.64 E+00	1.18 E+00	1.18 E+00
Sr-91+D	9.53 E-04	2.11 E-03	2.73 E-04	2.73 E-04
Sr-92+D	7.65 E-04	1.75 E-03	2.20 E-04	2.14 E-04
Y-88	2.21 E-01	4.91 E-01	6.68 E-02	6.67 E-02
Y-89m	1.18 E-13	2.42 E-09	2.59 E-10	4.09 E-17
Y-90	1.72 E-03	3.84 E-03	4.86 E-04	4.85 E-04
Y-90m+D	3.54 E-04	8.05 E-04	1.02 E-04	9.92 E-05
Y-91	2.32 E-02	5.16 E-02	6.83 E-03	6.83 E-03
Y-91m+D	1.64 E-04	4.00 E-04	4.99 E-05	4.42 E-05
Y-92	2.90 E-04	6.60 E-04	8.30 E-05	8.04 E-05
Y-93+D	4.95 E-04	1.11 E-03	1.40 E-04	1.38 E-04
Zr-88+D	1.91 E-01	4.25 E-01	5.78 E-02	5.77 E-02
Zr-88	2.99 E-02	6.66 E-02	8.99 E-03	8.98 E-03

Table 4.6. (contd)

Nuclide[a,b]	Effective Release Height <40 m mrem/yr per Ci/yr[c]		Effective Release Height ≥40 m mrem/yr per Ci/yr[c]	
	Eastern 300 Area Offsite MEI[d]	Western 300 Area Offsite MEI[d]	Eastern 300 Area Offsite MEI[e]	Western 300 Area Offsite MEI[e]
Zr-89	3.85 E-03	8.58 E-03	1.15 E-03	1.14 E-03
Zr-89m+D	3.21 E-05	2.00 E-04	2.39 E-05	5.68 E-06
Zr-93+D	2.08 E-02	4.61 E-02	5.96 E-03	5.96 E-03
Zr-95+D	8.26 E-02	1.84 E-01	2.49 E-02	2.49 E-02
Zr-97+D	2.08 E-03	4.63 E-03	5.99 E-04	6.01 E-04
Zr-97	1.67 E-03	3.74 E-03	4.78 E-04	4.75 E-04
Nb-91	3.01 E-02	6.70 E-02	9.14 E-03	9.13 E-03
Nb-91m+D	1.31 E-03	2.90 E-03	3.95 E-04	3.95 E-04
Nb-92	9.22 E+00	2.05 E+01	2.80 E+00	2.79 E+00
Nb-92m	7.74 E-03	1.72 E-02	2.34 E-03	2.34 E-03
Nb-93m	3.48 E-03	7.75 E-03	1.04 E-03	1.04 E-03
Nb-94	9.63 E+00	2.14 E+01	2.92 E+00	2.92 E+00
Nb-94m+D	4.17 E-07	1.95 E-06	2.36 E-07	8.35 E-08
Nb-95	2.43 E-02	5.41 E-02	7.33 E-03	7.32 E-03
Nb-95m+D	2.98 E-03	6.64 E-03	8.85 E-04	8.84 E-04
Nb-95m	9.80 E-04	2.19 E-03	2.78 E-04	2.77 E-04
Nb-96	3.21 E-03	7.17 E-03	9.39 E-04	9.34 E-04
Nb-97	2.49 E-04	5.94 E-04	7.42 E-05	6.77 E-05
Mo-93+D	1.13 E-01	2.50 E-01	3.41 E-02	3.41 E-02
Mo-93m+D	1.38 E-03	3.12 E-03	4.00 E-04	3.93 E-04
Mo-99+D	1.55 E-03	3.46 E-03	4.48 E-04	4.47 E-04
Mo-99	1.33 E-03	2.96 E-03	3.80 E-04	3.79 E-04
Tc-95	8.57 E-04	1.92 E-03	2.51 E-04	2.50 E-04
Tc-95m+D	4.00 E-02	8.91 E-02	1.21 E-02	1.21 E-02
Tc-96	1.00 E-02	2.23 E-02	2.99 E-03	2.99 E-03
Tc-96m+D	8.83 E-05	1.98 E-04	2.64 E-05	2.62 E-05
Tc-96m	1.89 E-05	4.63 E-05	5.74 E-06	5.05 E-06
Tc-97	9.01 E-02	2.00 E-01	2.73 E-02	2.73 E-02
Tc-97m+D	1.08 E-02	2.39 E-02	3.19 E-03	3.18 E-03
Tc-98	1.05 E+01	2.33 E+01	3.17 E+00	3.17 E+00
Tc-99	5.73 E-01	1.27 E+00	1.74 E-01	1.74 E-01
Tc-99m+D	7.57 E-05	1.71 E-04	2.18 E-05	2.14 E-05
Tc-101	6.67 E-05	2.09 E-04	2.56 E-05	1.61 E-05
Ru-97+D	6.88 E-04	1.53 E-03	2.04 E-04	2.04 E-04
Ru-103+D	2.06 E-02	4.59 E-02	6.19 E-03	6.18 E-03
Ru-105+D	5.00 E-04	1.14 E-03	1.44 E-04	1.41 E-04
Ru-106+D	1.89 E-01	4.21 E-01	5.65 E-02	5.65 E-02
Ru-106	8.73 E-02	1.94 E-01	2.56 E-02	2.56 E-02
Rh-101	2.37 E-01	5.28 E-01	7.19 E-02	7.18 E-02
Rh-101m+D	1.30 E-03	2.91 E-03	3.89 E-04	3.88 E-04
Rh-102	1.09 E-01	2.43 E-01	3.29 E-02	3.29 E-02
Rh-102m+D	2.06 E+00	4.57 E+00	6.23 E-01	6.23 E-01
Rh-103m	1.84 E-06	4.49 E-06	5.55 E-07	4.93 E-07
Rh-104	5.93 E-10	1.58 E-07	1.76 E-08	3.18 E-12
Rh-104m+D	2.86 E-06	1.81 E-05	2.16 E-06	4.81 E-07
Rh-104m	1.00 E-06	6.40 E-06	7.63 E-07	1.68 E-07
Rh-105	3.98 E-04	8.89 E-04	1.13 E-04	1.12 E-04
Rh-105m	Rh-105	Rh-105	Rh-105	Rh-105
Rh-106	1.52 E-10	1.64 E-07	1.86 E-08	2.03 E-13
Pd-103+D	8.76 E-04	1.95 E-03	2.56 E-04	2.57 E-04
Pd-107	9.39 E-04	2.09 E-03	2.82 E-04	2.82 E-04
Pd-109	3.24 E-04	7.25 E-04	9.04 E-05	8.96 E-05
Pd-109m+D	7.25 E-06	3.63 E-05	4.36 E-06	1.46 E-06
Pd-111+D	1.87 E-05	4.78 E-05	5.96 E-06	4.99 E-06
Pd-111	1.55 E-05	4.25 E-05	5.26 E-06	3.97 E-06
Pd-112+D	5.69 E-04	1.24 E-03	1.70 E-04	1.73 E-04

Table 4.6. (contd)

Nuclide[a,b]	Effective Release Height <40 m mrem/yr per Ci/yr[c]		Effective Release Height ≥40 m mrem/yr per Ci/yr[c]	
	Eastern 300 Area Offsite MEI[d]	Western 300 Area Offsite MEI[d]	Eastern 300 Area Offsite MEI[e]	Western 300 Area Offsite MEI[e]
Pd-112	1.76 E-06	3.92 E-06	5.29 E-07	5.26 E-07
Ag-108	3.35 E-07	4.53 E-06	5.27 E-07	3.33 E-08
Ag-108m+D	9.76 E+00	2.17 E+01	2.95 E+00	2.95 E+00
Ag-109m	3.76 E-11	1.28 E-08	1.43 E-09	1.59 E-13
Ag-110	3.80 E-12	9.49 E-09	1.09 E-09	1.87 E-15
Ag-110m+D	5.58 E-01	1.24 E+00	1.69 E-01	1.69 E-01
Ag-111	3.14 E-03	6.99 E-03	9.12 E-04	9.11 E-04
Ag-111m+D	3.14 E-07	7.76 E-07	9.98 E-08	9.10 E-08
Ag-111m	1.48 E-09	1.02 E-07	1.15 E-08	3.12 E-11
Ag-112	4.58 E-04	1.05 E-03	1.32 E-04	1.27 E-04
Cd-107	7.84 E-05	1.77 E-04	2.21 E-05	2.17 E-05
Cd-109	3.81 E-02	8.48 E-02	1.14 E-02	1.14 E-02
Cd-111m	7.66 E-05	1.89 E-04	2.35 E-05	2.05 E-05
Cd-113	2.41 E+00	5.35 E+00	7.28 E-01	7.28 E-01
Cd-113m	1.14 E+00	2.53 E+00	3.44 E-01	3.43 E-01
Cd-115+D	1.68 E-03	3.74 E-03	4.84 E-04	4.83 E-04
Cd-115	1.40 E-03	3.13 E-03	4.00 E-04	3.99 E-04
Cd-115m+D	2.69 E-02	5.98 E-02	7.98 E-03	7.97 E-03
Cd-117+D	6.10 E-04	1.39 E-03	1.75 E-04	1.70 E-04
Cd-117m+D	1.16 E-03	2.58 E-03	3.27 E-04	3.25 E-04
In-106	3.06 E-04	1.45 E-03	1.75 E-04	6.06 E-05
In-111	1.19 E-03	2.65 E-03	3.52 E-04	3.51 E-04
In-111m+D	5.28 E-05	2.14 E-04	2.60 E-05	1.14 E-05
In-112	5.28 E-05	1.63 E-04	2.00 E-05	1.28 E-05
In-112m+D	3.85 E-05	5.92 E-05	7.61 E-06	1.15 E-05
In-112m	4.80 E-06	1.36 E-05	1.67 E-06	1.21 E-06
In-113m	1.02 E-04	2.39 E-04	2.99 E-05	2.80 E-05
In-114	1.17 E-08	6.14 E-07	6.91 E-08	3.25 E-10
In-114m+D	3.67 E-02	8.18 E-02	1.09 E-02	1.09 E-02
In-115	5.91 E-01	1.31 E+00	1.74 E-01	1.74 E-01
In-115m+D	1.21 E-04	2.74 E-04	3.46 E-05	3.37 E-05
In-116m	8.03 E-04	1.96 E-03	2.44 E-04	2.16 E-04
In-117+D	2.12 E-04	5.30 E-04	6.58 E-05	5.64 E-05
In-117m+D	1.35 E-04	2.86 E-04	3.64 E-05	3.86 E-05
In-117m	9.52 E-05	2.21 E-04	2.76 E-05	2.61 E-05
Sn-113+D	3.67 E-02	8.16 E-02	1.11 E-02	1.10 E-02
Sn-113	1.39 E-02	3.09 E-02	4.14 E-03	4.14 E-03
Sn-113m+D	3.89 E-06	8.42 E-06	1.13 E-06	1.18 E-06
Sn-113m	5.58 E-07	1.56 E-06	1.94 E-07	1.43 E-07
Sn-117m	5.43 E-03	1.21 E-02	1.59 E-03	1.59 E-03
Sn-119m	1.05 E-02	2.33 E-02	3.12 E-03	3.12 E-03
Sn-121	1.99 E-04	4.44 E-04	5.51 E-05	5.48 E-05
Sn-121m+D	5.03 E-02	1.12 E-01	1.51 E-02	1.51 E-02
Sn-123	4.40 E-02	9.79 E-02	1.31 E-02	1.31 E-02
Sn-123m	5.82 E-05	1.47 E-04	1.82 E-05	1.54 E-05
Sn-125+D	1.38 E-02	3.09 E-02	4.12 E-03	4.12 E-03
Sn-125m+D	4.98 E-05	1.81 E-04	2.20 E-05	1.13 E-05
Sn-126+D	1.33 E+01	2.95 E+01	4.02 E+00	4.02 E+00
Sn-126	7.92 E-01	1.76 E+00	2.39 E-01	2.39 E-01
Sb-122	2.29 E-03	5.11 E-03	6.65 E-04	6.63 E-04
Sb-122m+D	4.08 E-06	1.62 E-05	1.99 E-06	9.77 E-07
Sb-122m	1.82 E-06	1.20 E-05	1.43 E-06	2.98 E-07
Sb-124	1.04 E-01	2.31 E-01	3.13 E-02	3.12 E-02
Sb-124m+D	2.49 E-06	3.50 E-05	4.05 E-06	4.74 E-07
Sb-124n+D	1.20 E-04	2.99 E-04	3.77 E-05	3.15 E-05
Sb-124n	3.41 E-06	9.67 E-06	1.19 E-06	8.57 E-07

Table 4.6. (contd)

Nuclide[a,b]	Effective Release Height <40 m mrem/yr per Ci/yr[c]		Effective Release Height ≥40 m mrem/yr per Ci/yr[c]	
	Eastern 300 Area Offsite MEI[d]	Western 300 Area Offsite MEI[d]	Eastern 300 Area Offsite MEI[e]	Western 300 Area Offsite MEI[e]
Sb-125+D	3.32 E-01	7.37 E-01	1.00 E-01	1.00 E-01
Sb-126	3.41 E-02	7.59 E-02	1.03 E-02	1.02 E-02
Sb-126m+D	3.43 E-04	9.83 E-04	1.21 E-04	8.64 E-05
Sb-127+D	4.19 E-03	9.32 E-03	1.22 E-03	1.22 E-03
Sb-128	2.24 E-03	5.04 E-03	6.50 E-04	6.42 E-04
Sb-128m+D	2.86 E-04	1.01 E-03	1.23 E-04	6.57 E-05
Te-121	1.04 E-02	2.32 E-02	3.14 E-03	3.14 E-03
Te-121m+D	1.15 E-01	2.56 E-01	3.47 E-02	3.47 E-02
Te-121m	5.53 E-02	1.23 E-01	1.66 E-02	1.66 E-02
Te-123	2.43 E-01	5.41 E-01	7.37 E-02	7.36 E-02
Te-123m+D	3.07 E-02	6.83 E-02	9.22 E-03	9.21 E-03
Te-125m	1.06 E-02	2.36 E-02	3.13 E-03	3.13 E-03
Te-127	1.16 E-04	2.61 E-04	3.24 E-05	3.20 E-05
Te-127m+D	3.22 E-02	7.16 E-02	9.57 E-03	9.56 E-03
Te-129+D	5.27 E-05	1.26 E-04	1.57 E-05	1.43 E-05
Te-129m+D	2.50 E-02	5.56 E-02	7.40 E-03	7.40 E-03
Te-129m	2.30 E-02	5.12 E-02	6.80 E-03	6.80 E-03
Te-131+D	4.09 E-04	7.74 E-04	1.14 E-04	1.88 E-04
Te-131	1.20 E-04	3.24 E-04	4.01 E-05	3.08 E-05
Te-131m+D	3.61 E-03	7.80 E-03	1.03 E-03	1.12 E-03
Te-131m	2.85 E-03	6.35 E-03	8.26 E-04	8.22 E-04
Te-132+D	8.70 E-03	1.93 E-02	2.58 E-03	2.61 E-03
Te-132	2.92 E-03	6.50 E-03	8.31 E-04	8.29 E-04
Te-133+D	2.50 E-04	7.71 E-04	9.66 E-05	6.83 E-05
Te-133	2.17 E-04	7.12 E-04	8.71 E-05	5.14 E-05
Te-133m+D	7.30 E-04	1.71 E-03	2.15 E-04	2.08 E-04
Te-134+D	4.90 E-04	1.08 E-03	1.46 E-04	1.74 E-04
Te-134	2.88 E-04	7.22 E-04	8.96 E-05	7.65 E-05
I-122	2.03 E-05	2.23 E-04	3.29 E-05	4.79 E-06
I-122(V)	n/a	n/a	n/a	n/a
I-123+D	7.34 E-04	2.44 E-03	3.82 E-04	3.34 E-04
I-123(V)+D	3.05 E-04	6.67 E-04	8.17 E-05	8.16 E-05
I-124	1.11 E-01	3.66 E-01	5.72 E-02	5.05 E-02
I-124(V)	1.48 E-02	3.21 E-02	3.93 E-03	3.96 E-03
I-125	3.45 E+00	1.14 E+01	1.78 E+00	1.57 E+00
I-125(V)	1.70 E-02	3.70 E-02	4.53 E-03	4.56 E-03
I-126	1.23 E+00	4.06 E+00	6.35 E-01	5.60 E-01
I-126(V)	3.23 E-02	7.02 E-02	8.60 E-03	8.66 E-03
I-128	2.87 E-05	1.15 E-04	1.78 E-05	1.21 E-05
I-128(V)	7.45 E-05	1.97 E-04	2.40 E-05	1.86 E-05
I-129	7.93 E+01	2.62 E+02	4.10 E+01	3.62 E+01
I-129(V)	1.17 E-01	2.54 E-01	3.11 E-02	3.14 E-02
I-130	8.95 E-03	2.98 E-02	4.66 E-03	4.08 E-03
I-130(V)	2.94 E-03	6.45 E-03	7.89 E-04	7.88 E-04
I-130m+D	9.63 E-05	3.34 E-04	5.20 E-05	4.33 E-05
I-130m	9.24 E-06	5.16 E-05	7.85 E-06	3.30 E-06
I-130m(V)	n/a	n/a	n/a	n/a
I-131+D	4.67 E-01	1.55 E+00	2.42 E-01	2.13 E-01
I-131(V)+D	2.42 E-02	5.28 E-02	6.46 E-03	6.51 E-03
I-132	1.93 E-03	6.61 E-03	1.03 E-03	8.69 E-04
I-132(V)	1.07 E-03	2.40 E-03	2.94 E-04	2.82 E-04
I-132m+D	1.08 E-03	3.58 E-03	5.59 E-04	4.92 E-04
I-132m	2.13 E-04	7.47 E-04	1.16 E-04	9.49 E-05
I-132m(V)+D	4.55 E-04	9.66 E-04	1.24 E-04	1.48 E-04
I-132m(V)	3.56 E-04	8.22 E-04	1.00 E-04	9.34 E-05
I-133+D	6.31 E-03	2.09 E-02	3.28 E-03	2.88 E-03

Table 4.6. (contd)

Nuclide[a,b]	Effective Release Height <40 m mrem/yr per Ci/yr[c]		Effective Release Height ≥40 m mrem/yr per Ci/yr[c]	
	Eastern 300 Area Offsite MEI[d]	**Western 300 Area Offsite MEI[d]**	**Eastern 300 Area Offsite MEI[e]**	**Western 300 Area Offsite MEI[e]**
I-133(V)+D	5.02 E-03	1.10 E-02	1.34 E-03	1.35 E-03
I-133m	I-133+D	I-133+D	I-133+D	I-133+D
I-134	9.95 E-04	3.61 E-03	5.61 E-04	4.37 E-04
I-134(V)	9.02 E-04	2.16 E-03	2.63 E-04	2.34 E-04
I-134m+D	7.29 E-05	2.74 E-04	4.25 E-05	3.18 E-05
I-134m	5.39 E-06	5.96 E-05	8.79 E-06	1.26 E-06
I-134m(V)	n/a	n/a	n/a	n/a
I-135+D	4.19 E-03	1.40 E-02	2.19 E-03	1.91 E-03
I-135(V)+D	1.65 E-03	3.62 E-03	4.43 E-04	4.41 E-04
Xe-122+D	1.73 E-04	3.99 E-04	6.27 E-05	7.98 E-05
Xe-122	1.58 E-05	3.46 E-05	4.24 E-06	4.25 E-06
Xe-123+D	2.01 E-04	4.50 E-04	5.55 E-05	5.55 E-05
Xe-123	1.94 E-04	4.39 E-04	5.37 E-05	5.13 E-05
Xe-125+D	4.14 E-04	6.40 E-04	9.91 E-05	2.10 E-04
Xe-125	7.80 E-05	1.71 E-04	2.09 E-05	2.09 E-05
Xe-127	8.23 E-05	1.79 E-04	2.19 E-05	2.21 E-05
Xe-127m+D	8.88 E-08	4.97 E-06	5.51 E-07	2.63 E-09
Xe-127m	8.70 E-08	4.97 E-06	5.51 E-07	2.14 E-09
Xe-129m	6.68 E-06	1.45 E-05	1.78 E-06	1.79 E-06
Xe-131m	2.60 E-06	5.66 E-06	6.93 E-07	6.98 E-07
Xe-133	9.97 E-06	2.17 E-05	2.66 E-06	2.68 E-06
Xe-133m+D	9.38 E-06	2.04 E-05	2.50 E-06	2.51 E-06
Xe-135+D	7.89 E-05	1.73 E-04	2.12 E-05	2.11 E-05
Xe-135m+D	8.03 E-05	2.39 E-04	2.88 E-05	1.91 E-05
Xe-137+D	1.02 E-05	6.69 E-05	7.87 E-06	1.71 E-06
Xe-137	9.15 E-06	6.53 E-05	7.65 E-06	1.38 E-06
Xe-138+D	3.62 E-04	8.46 E-04	1.04 E-04	9.61 E-05
Xe-138	2.19 E-04	6.74 E-04	8.14 E-05	5.14 E-05
Cs-131	3.52 E-04	7.82 E-04	1.06 E-04	1.06 E-04
Cs-132	4.80 E-03	1.07 E-02	1.44 E-03	1.44 E-03
Cs-134	2.43 E+00	5.41 E+00	7.37 E-01	7.37 E-01
Cs-134m+D	1.69 E-04	3.62 E-04	4.90 E-05	5.16 E-05
Cs-134m	2.01 E-05	4.61 E-05	5.77 E-06	5.56 E-06
Cs-135	4.96 E-01	1.10 E+00	1.50 E-01	1.50 E-01
Cs-135m+D	4.85 E-04	1.19 E-03	1.48 E-04	1.30 E-04
Cs-136	3.80 E-02	8.45 E-02	1.15 E-02	1.15 E-02
Cs-137+D	4.84 E+00	1.08 E+01	1.47 E+00	1.47 E+00
Cs-137	2.54 E+00	5.65 E+00	7.71 E-01	7.70 E-01
Cs-138	6.77 E-04	1.75 E-03	2.16 E-04	1.78 E-04
Cs-138m+D	5.70 E-05	1.82 E-04	2.22 E-05	1.43 E-05
Cs-138m	8.87 E-06	8.95 E-05	1.05 E-05	1.10 E-06
Cs-139+D	5.35 E-05	1.87 E-04	2.28 E-05	1.24 E-05
Cs-139	4.83 E-05	1.80 E-04	2.19 E-05	1.08 E-05
Cs-140+D	2.65 E-06	5.55 E-05	6.31 E-06	5.95 E-07
Ba-131+D	5.82 E-03	1.30 E-02	1.74 E-03	1.74 E-03
Ba-131	5.65 E-03	1.26 E-02	1.69 E-03	1.69 E-03
Ba-131m+D	1.87 E-05	5.36 E-05	6.70 E-06	4.82 E-06
Ba-131m	1.43 E-05	4.45 E-05	5.46 E-06	3.48 E-06
Ba-133	8.95 E-01	1.99 E+00	2.71 E-01	2.71 E-01
Ba-133m+D	8.53 E-04	1.91 E-03	2.49 E-04	2.47 E-04
Ba-135m	3.65 E-04	8.16 E-04	1.03 E-04	1.02 E-04
Ba-137m	8.72 E-06	1.06 E-04	1.23 E-05	9.46 E-07
Ba-139	7.11 E-05	1.68 E-04	2.10 E-05	1.94 E-05
Ba-140+D	3.35 E-02	7.47 E-02	1.00 E-02	1.00 E-02
Ba-140	1.13 E-02	2.52 E-02	3.30 E-03	3.30 E-03
Ba-141+D	2.24 E-04	6.39 E-04	7.88 E-05	5.61 E-05

Table 4.6. (contd)

Nuclide[a,b]	Effective Release Height <40 m mrem/yr per Ci/yr[c]		Effective Release Height ≥40 m mrem/yr per Ci/yr[c]	
	Eastern 300 Area Offsite MEI[d]	Western 300 Area Offsite MEI[d]	Eastern 300 Area Offsite MEI[e]	Western 300 Area Offsite MEI[e]
Ba-142+D	2.34 E-04	6.77 E-04	8.35 E-05	5.92 E-05
Ba-142	1.66 E-04	5.82 E-04	7.10 E-05	3.82 E-05
La-137	1.36 E-01	3.01 E-01	4.10 E-02	4.09 E-02
La-138	7.36 E+00	1.64 E+01	2.23 E+00	2.23 E+00
La-140	4.74 E-03	1.06 E-02	1.39 E-03	1.39 E-03
La-141+D	1.77 E-04	4.01 E-04	5.05 E-05	4.93 E-05
La-142	9.39 E-04	2.21 E-03	2.76 E-04	2.57 E-04
Ce-139	1.89 E-02	4.21 E-02	5.69 E-03	5.69 E-03
Ce-141	7.22 E-03	1.61 E-02	2.11 E-03	2.11 E-03
Ce-142	Ce-144+D	Ce-144+D	Ce-144+D	Ce-144+D
Ce-143+D	1.16 E-03	2.57 E-03	3.28 E-04	3.28 E-04
Ce-144+D	1.10 E-01	2.45 E-01	3.22 E-02	3.22 E-02
Pr-142	6.14 E-04	1.37 E-03	1.73 E-04	1.72 E-04
Pr-142m+D	7.68 E-06	1.70 E-05	2.14 E-06	2.16 E-06
Pr-142m	3.57 E-06	1.11 E-05	1.36 E-06	8.65 E-07
Pr-143	4.39 E-03	9.77 E-03	1.28 E-03	1.27 E-03
Pr-144	2.20 E-05	6.50 E-05	8.01 E-06	5.47 E-06
Pr-144m+D	8.38 E-06	1.49 E-05	1.90 E-06	2.37 E-06
Pr-144m	5.74 E-07	2.47 E-06	2.99 E-07	1.20 E-07
Nd-144	0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00
Nd-147+D	4.74 E-03	1.06 E-02	1.38 E-03	1.38 E-03
Pm-143	6.62 E-02	1.47 E-01	2.00 E-02	2.00 E-02
Pm-144+D	4.44 E-01	9.89 E-01	1.35 E-01	1.34 E-01
Pm-145	9.22 E-02	2.05 E-01	2.78 E-02	2.78 E-02
Pm-146+D	1.04 E+00	2.32 E+00	3.16 E-01	3.16 E-01
Pm-147+D	7.27 E-03	1.62 E-02	2.07 E-03	2.06 E-03
Pm-148	5.82 E-03	1.30 E-02	1.71 E-03	1.70 E-03
Pm-148m+D	7.79 E-02	1.73 E-01	2.35 E-02	2.35 E-02
Pm-149	7.16 E-04	1.60 E-03	2.01 E-04	2.00 E-04
Pm-150	7.00 E-04	1.61 E-03	2.03 E-04	1.94 E-04
Pm-151+D	8.09 E-04	1.81 E-03	2.32 E-04	2.31 E-04
Sm-145+D	2.26 E-02	5.03 E-02	6.80 E-03	6.80 E-03
Sm-146	1.27 E+01	2.82 E+01	3.51 E+00	3.51 E+00
Sm-147	1.14 E+01	2.55 E+01	3.17 E+00	3.17 E+00
Sm-148+D	0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00
Sm-151	5.41 E-03	1.20 E-02	1.52 E-03	1.52 E-03
Sm-153	6.83 E-04	1.52 E-03	1.92 E-04	1.91 E-04
Sm-155+D	3.38 E-05	9.37 E-05	1.16 E-05	8.66 E-06
Sm-156+D	6.38 E-04	1.42 E-03	1.87 E-04	1.87 E-04
Sm-156	2.66 E-04	5.98 E-04	7.51 E-05	7.41 E-05
Sm-157+D	5.18 E-05	2.01 E-04	2.44 E-05	1.14 E-05
Sm-157	4.84 E-05	1.95 E-04	2.37 E-05	1.04 E-05
Eu-150	6.74 E+00	1.50 E+01	2.04 E+00	2.04 E+00
Eu-150m+D	2.20 E-04	4.94 E-04	6.20 E-05	6.15 E-05
Eu-152+D	3.12 E+00	6.93 E+00	9.44 E-01	9.43 E-01
Eu-152m+D	4.02 E-04	9.04 E-04	1.15 E-04	1.13 E-04
Eu-152n+D	6.14 E-05	1.39 E-04	1.84 E-05	1.80 E-05
Eu-152n	2.01 E-05	4.71 E-05	5.92 E-06	5.52 E-06
Eu-154	2.45 E+00	5.45 E+00	7.42 E-01	7.41 E-01
Eu-154m+D	3.81 E-05	8.81 E-05	1.16 E-05	1.11 E-05
Eu-154m	1.38 E-05	3.43 E-05	4.27 E-06	3.70 E-06
Eu-155	7.71 E-02	1.72 E-01	2.32 E-02	2.32 E-02
Eu-156	2.26 E-02	5.03 E-02	6.75 E-03	6.75 E-03
Eu-157	5.03 E-04	1.13 E-03	1.44 E-04	1.43 E-04
Gd-148	1.34 E+01	2.98 E+01	3.72 E+00	3.71 E+00
Gd-149+D	5.48 E-03	1.22 E-02	1.64 E-03	1.64 E-03

Table 4.6. (contd)

Nuclide[a,b]	Effective Release Height <40 m mrem/yr per Ci/yr[c]		Effective Release Height ≥40 m mrem/yr per Ci/yr[c]	
	Eastern 300 Area Offsite MEI[d]	Western 300 Area Offsite MEI[d]	Eastern 300 Area Offsite MEI[e]	Western 300 Area Offsite MEI[e]
Gd-150+D	1.99 E-12	1.84 E-12	2.43 E-13	6.69 E-13
Gd-150	0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00
Gd-151+D	8.33 E-03	1.85 E-02	2.50 E-03	2.50 E-03
Gd-152	9.47 E+00	2.11 E+01	2.63 E+00	2.63 E+00
Gd-153	2.18 E-02	4.85 E-02	6.55 E-03	6.55 E-03
Gd-159	3.09 E-04	6.91 E-04	8.68 E-05	8.63 E-05
Tb-157	2.32 E-02	5.17 E-02	7.01 E-03	7.00 E-03
Tb-158	4.58 E+00	1.02 E+01	1.39 E+00	1.39 E+00
Tb-160	7.81 E-02	1.74 E-01	2.35 E-02	2.35 E-02
Tb-161	1.76 E-03	3.91 E-03	5.03 E-04	5.02 E-04
Dy-159	5.65 E-03	1.26 E-02	1.70 E-03	1.70 E-03
Dy-165	6.61 E-05	1.53 E-04	1.90 E-05	1.82 E-05
Ho-163	0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00
Ho-164	1.02 E-05	2.69 E-05	3.33 E-06	2.65 E-06
Ho-164m+D	1.86 E-05	4.27 E-05	5.33 E-06	5.10 E-06
Ho-164m	1.50 E-05	3.79 E-05	4.70 E-06	3.95 E-06
Ho-166	7.26 E-04	1.62 E-03	2.04 E-04	2.03 E-04
Ho-166m	9.98 E+00	2.22 E+01	3.02 E+00	3.02 E+00
Er-169	1.31 E-03	2.92 E-03	3.74 E-04	3.73 E-04
Er-171+D	4.00 E-04	9.01 E-04	1.14 E-04	1.12 E-04
Tm-168	8.82 E-02	1.96 E-01	2.67 E-02	2.67 E-02
Tm-170	1.84 E-02	4.09 E-02	5.38 E-03	5.37 E-03
Tm-171	2.58 E-03	5.75 E-03	7.45 E-04	7.44 E-04
Yb-164+D	2.67 E-04	5.49 E-04	6.97 E-05	7.39 E-05
Yb-164	1.19 E-05	2.83 E-05	3.55 E-06	3.26 E-06
Yb-165+D	4.57 E-05	1.60 E-04	1.96 E-05	1.06 E-05
Yb-166+D	4.31 E-03	9.56 E-03	1.28 E-03	1.28 E-03
Yb-166	8.55 E-04	1.91 E-03	2.41 E-04	2.40 E-04
Yb-167+D	4.85 E-05	1.40 E-04	1.73 E-05	1.22 E-05
Yb-169	1.27 E-02	2.83 E-02	3.79 E-03	3.79 E-03
Yb-175	7.96 E-04	1.77 E-03	2.26 E-04	2.25 E-04
Yb-177+D	1.30 E-04	3.02 E-04	3.78 E-05	3.59 E-05
Lu-177	1.44 E-03	3.22 E-03	4.12 E-04	4.11 E-04
Lu-177m+D	1.45 E-01	3.23 E-01	4.37 E-02	4.36 E-02
Hf-175	2.19 E-02	4.87 E-02	6.60 E-03	6.59 E-03
Hf-177m	7.04 E-04	1.73 E-03	2.15 E-04	1.89 E-04
Hf-178	n/a	n/a	n/a	n/a
Hf-178m	9.17 E+00	2.04 E+01	2.78 E+00	2.78 E+00
Hf-179m	2.49 E-02	5.55 E-02	7.46 E-03	7.45 E-03
Hf-180m	5.77 E-04	1.30 E-03	1.66 E-04	1.63 E-04
Hf-181	2.65 E-02	5.89 E-02	7.89 E-03	7.89 E-03
Hf-182+D	9.24 E+00	2.05 E+01	2.80 E+00	2.80 E+00
Hf-182	1.62 E+00	3.59 E+00	4.86 E-01	4.86 E-01
Ta-179	1.15 E-02	2.56 E-02	3.48 E-03	3.48 E-03
Ta-180	6.39 E-03	1.44 E-02	1.78 E-03	1.76 E-03
Ta-182	1.25 E-01	2.79 E-01	3.78 E-02	3.77 E-02
Ta-182m+D	6.63 E-05	1.91 E-04	2.38 E-05	1.69 E-05
Ta-182m	5.51 E-05	1.67 E-04	2.05 E-05	1.35 E-05
Ta-183	3.34 E-03	7.44 E-03	9.65 E-04	9.63 E-04
W-181	6.36 E-03	1.42 E-02	1.92 E-03	1.92 E-03
W-185	1.45 E-02	3.22 E-02	4.32 E-03	4.32 E-03
W-185m+D	2.71 E-07	2.03 E-06	2.41 E-07	6.67 E-08
W-185m	5.87 E-08	1.61 E-06	1.84 E-07	3.13 E-09
W-187+D	8.94 E-04	2.00 E-03	2.57 E-04	2.56 E-04
W-188+D	7.21 E-02	1.61 E-01	2.15 E-02	2.15 E-02
W-188	6.38 E-02	1.42 E-01	1.90 E-02	1.90 E-02

Table 4.6. (contd)

Nuclide[a,b]	Effective Release Height <40 m mrem/yr per Ci/yr[c]		Effective Release Height ≥40 m mrem/yr per Ci/yr[c]	
	Eastern 300 Area Offsite MEI[d]	Western 300 Area Offsite MEI[d]	Eastern 300 Area Offsite MEI[e]	Western 300 Area Offsite MEI[e]
Re-186	1.45 E-03	3.24 E-03	4.13 E-04	4.12 E-04
Re-186m+D	5.58 E-01	1.24 E+00	1.69 E-01	1.69 E-01
Re-186m	2.76 E-01	6.14 E-01	8.34 E-02	8.33 E-02
Re-187	4.17 E-04	9.27 E-04	1.26 E-04	1.26 E-04
Re-188	6.21 E-04	1.39 E-03	1.75 E-04	1.74 E-04
Os-185	5.42 E-02	1.20 E-01	1.64 E-02	1.64 E-02
Os-191	3.53 E-03	7.85 E-03	1.03 E-03	1.03 E-03
Ir-189+D	1.66 E-03	3.69 E-03	4.89 E-04	4.89 E-04
Ir-190	1.77 E-02	3.93 E-02	5.30 E-03	5.29 E-03
Ir-192	5.93 E-02	1.32 E-01	1.78 E-02	1.78 E-02
Ir-194	6.50 E-04	1.45 E-03	1.84 E-04	1.82 E-04
Pt-191	9.79 E-04	2.18 E-03	2.88 E-04	2.87 E-04
Pt-193	1.22 E-03	2.72 E-03	3.67 E-04	3.67 E-04
Pt-193m+D	8.82 E-04	1.97 E-03	2.47 E-04	2.47 E-04
Pt-195m	1.22 E-03	2.73 E-03	3.47 E-04	3.46 E-04
Pt-197	3.01 E-04	6.73 E-04	8.39 E-05	8.34 E-05
Pt-197m+D	8.70 E-05	2.02 E-04	2.51 E-05	2.38 E-05
Pt-199+D	7.37 E-05	1.90 E-04	2.36 E-05	1.94 E-05
Au-193+D	2.31 E-04	5.17 E-04	6.65 E-05	6.61 E-05
Au-193m+D	1.42 E-08	3.17 E-08	4.08 E-09	4.06 E-09
Au-193m	6.45 E-17	4.79 E-16	6.26 E-17	3.14 E-17
Au-194	1.77 E-03	3.96 E-03	5.24 E-04	5.22 E-04
Au-195	1.40 E-02	3.11 E-02	4.21 E-03	4.21 E-03
Au-195m+D	2.67 E-08	2.11 E-07	2.52 E-08	7.98 E-09
Au-195m	1.55 E-10	1.52 E-07	1.72 E-08	2.32 E-13
Au-196	2.36 E-03	5.26 E-03	7.13 E-04	7.12 E-04
Au-196m+D	2.80 E-04	6.26 E-04	8.34 E-05	8.29 E-05
Au-196m	1.36 E-04	3.06 E-04	3.98 E-05	3.93 E-05
Au-198	1.77 E-03	3.95 E-03	5.15 E-04	5.14 E-04
Au-198m+D	3.37 E-03	7.51 E-03	9.76 E-04	9.75 E-04
Au-198m	2.62 E-03	5.85 E-03	7.50 E-04	7.48 E-04
Au-199	8.92 E-04	1.99 E-03	2.53 E-04	2.53 E-04
Hg-203	1.46 E-02	3.25 E-02	4.37 E-03	4.37 E-03
Hg-205	9.40 E-07	5.11 E-06	6.15 E-07	1.74 E-07
Hg-206+D	1.57 E-05	6.05 E-05	7.36 E-06	3.45 E-06
Tl-200	1.66 E-03	3.71 E-03	4.90 E-04	4.87 E-04
Tl-201	3.85 E-04	8.57 E-04	1.12 E-04	1.12 E-04
Tl-202	6.03 E-03	1.34 E-02	1.82 E-03	1.81 E-03
Tl-204	6.60 E-02	1.47 E-01	1.98 E-02	1.98 E-02
Tl-206	4.25 E-07	2.81 E-06	3.36 E-07	7.03 E-08
Tl-206m	8.93 E-05	6.66 E-04	7.89 E-05	1.36 E-05
Tl-207+D	6.13 E-07	3.59 E-06	4.30 E-07	1.09 E-07
Tl-208	8.74 E-05	8.28 E-04	9.74 E-05	1.14 E-05
Tl-209+D	2.04 E-05	3.13 E-04	3.62 E-05	1.91 E-06
Tl-210+D	3.94 E-06	1.40 E-04	1.58 E-05	3.29 E-07
Pb-203	7.86 E-04	1.75 E-03	2.31 E-04	2.30 E-04
Pb-204m	6.49 E-04	1.56 E-03	1.94 E-04	1.76 E-04
Pb-205	3.74 E-03	8.32 E-03	1.13 E-03	1.13 E-03
Pb-209	4.84 E-05	1.11 E-04	1.37 E-05	1.33 E-05
Pb-210+D	6.60 E+00	1.47 E+01	1.97 E+00	1.97 E+00
Pb-210	6.47 E+00	1.44 E+01	1.93 E+00	1.93 E+00
Pb-211+D	8.61 E-03	2.19 E-02	2.71 E-03	2.25 E-03
Pb-212+D	1.44 E-01	3.19 E-01	3.97 E-02	3.98 E-02
Pb-214+D	1.20 E-02	2.64 E-02	3.28 E-03	3.30 E-03
Pb-214	8.24 E-03	2.20 E-02	2.71 E-03	2.12 E-03
Bi-207	6.36 E+00	1.41 E+01	1.93 E+00	1.93 E+00
Bi-208	1.44 E+01	3.19 E+01	4.35 E+00	4.35 E+00

Table 4.6. (contd)

Nuclide[a,b]	Effective Release Height <40 m mrem/yr per Ci/yr[c]		Effective Release Height ≥40 m mrem/yr per Ci/yr[c]	
	Eastern 300 Area Offsite MEI[d]	Western 300 Area Offsite MEI[d]	Eastern 300 Area Offsite MEI[e]	Western 300 Area Offsite MEI[e]
Bi-210+D	8.29 E-02	1.84 E-01	2.29 E-02	2.29 E-02
Bi-210	8.27 E-02	1.84 E-01	2.29 E-02	2.28 E-02
Bi-210m+D	5.49 E+00	1.22 E+01	1.58 E+00	1.58 E+00
Bi-211+D	8.16 E-07	8.00 E-06	9.37 E-07	1.16 E-07
Bi-211	3.91 E-07	6.24 E-06	7.21 E-07	3.40 E-08
Bi-212+D	2.27 E-02	5.47 E-02	6.77 E-03	6.09 E-03
Bi-212n+D	1.06 E-05	4.58 E-05	5.54 E-06	2.20 E-06
Bi-212n	9.10 E-07	3.98 E-06	4.84 E-07	1.89 E-07
Bi-213+D	2.09 E-02	5.18 E-02	6.40 E-03	5.54 E-03
Bi-214+D	8.43 E-03	2.40 E-02	2.95 E-03	2.12 E-03
Po-208+D	1.59 E-05	3.53 E-05	4.81 E-06	4.81 E-06
Po-209+D	3.27 E-02	7.26 E-02	9.90 E-03	9.90 E-03
Po-210	5.09 E+00	1.13 E+01	1.47 E+00	1.46 E+00
Po-211	0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00
Po-212	0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00
Po-212m	2.86 E-09	6.04 E-07	6.73 E-08	1.91 E-11
Po-213+D	0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00
Po-214+D	1.55 E-12	3.44 E-12	4.61 E-13	4.60 E-13
Po-215+D	7.07 E-09	1.80 E-08	2.22 E-09	1.85 E-09
Po-215	4.49 E-26	9.98 E-26	1.36 E-26	1.36 E-26
Po-216+D	5.44 E-07	1.20 E-06	1.50 E-07	1.50 E-07
Po-216	4.08 E-25	0.00 E+00	3.45 E-24	3.13 E-27
Po-218+D	1.28 E-03	2.05 E-03	2.61 E-04	3.68 E-04
Po-218	1.41 E-12	1.31 E-11	1.54 E-12	1.85 E-13
At-217+D	2.47 E-07	6.12 E-07	7.56 E-08	6.55 E-08
At-217	7.22 E-27	2.56 E-27	0.00 E+00	2.29 E-28
At-218+D	1.06 E-05	3.02 E-05	3.71 E-06	2.66 E-06
At-218	4.60 E-22	8.08 E-22	5.61 E-22	1.22 E-22
Rn-218+D	3.29 E-10	7.33 E-10	9.84 E-11	9.83 E-11
Rn-218	5.77 E-31	3.53 E-28	2.54 E-29	0.00 E+00
Rn-219+D	1.57 E-05	4.03 E-05	4.97 E-06	4.14 E-06
Rn-219	3.10 E-16	4.38 E-16	5.47 E-17	4.85 E-17
Rn-220+D	2.09 E-04	4.53 E-04	5.63 E-05	5.79 E-05
Rn-220	9.68 E-11	1.02 E-08	1.13 E-09	1.26 E-12
Rn-222+D	2.49 E-03	1.38 E-03	1.90 E-04	8.95 E-04
Rn-222	1.26 E-07	2.74 E-07	3.36 E-08	3.38 E-08
Rn-224+D	5.11 E-02	1.14 E-01	1.41 E-02	1.41 E-02
Fr-221+D	1.94 E-03	2.97 E-03	3.80 E-04	5.65 E-04
Fr-221	1.67 E-06	9.56 E-06	1.14 E-06	2.99 E-07
Fr-222+D	1.24 E-02	3.88 E-02	4.75 E-03	2.98 E-03
Fr-223+D	8.82 E-03	1.98 E-02	2.46 E-03	2.44 E-03
Fr-223	6.07 E-03	1.69 E-02	2.08 E-03	1.54 E-03
Ra-223+D	6.47 E+00	1.44 E+01	1.79 E+00	1.79 E+00
Ra-224+D	2.52 E+00	5.61 E+00	6.96 E-01	6.95 E-01
Ra-225+D	5.64 E+00	1.25 E+01	1.56 E+00	1.56 E+00
Ra-226+D	1.87 E+01	4.15 E+01	5.58 E+00	5.58 E+00
Ra-227+D	3.49 E-04	7.86 E-04	9.78 E-05	9.61 E-05
Ra-228+D	1.35 E+01	3.00 E+01	4.01 E+00	4.00 E+00
Ac-225+D	6.34 E+00	1.41 E+01	1.75 E+00	1.75 E+00
Ac-226+D	9.75 E-01	2.17 E+00	2.68 E-01	2.69 E-01
Ac-227+D	8.51 E+01	1.89 E+02	2.36 E+01	2.36 E+01
Ac-228+D	1.25 E-02	2.77 E-02	3.44 E-03	3.45 E-03
Th-227+D	8.99 E+00	2.00 E+01	2.48 E+00	2.48 E+00
Th-228+D	4.02 E+01	8.97 E+01	1.11 E+01	1.11 E+01
Th-229+D	8.51 E+01	1.90 E+02	2.36 E+01	2.36 E+01
Th-230+D	1.69 E+01	3.77 E+01	4.72 E+00	4.71 E+00

Table 4.6. (contd)

Nuclide[a,b]	Effective Release Height <40 m mrem/yr per Ci/yr[c]		Effective Release Height ≥40 m mrem/yr per Ci/yr[c]	
	Eastern 300 Area Offsite MEI[d]	Western 300 Area Offsite MEI[d]	Eastern 300 Area Offsite MEI[e]	Western 300 Area Offsite MEI[e]
Th-231+D	3.02 E-04	6.75 E-04	8.41 E-05	8.36 E-05
Th-232+D	4.06 E+01	9.04 E+01	1.15 E+01	1.15 E+01
Th-233+D	1.277 E-05	3.22 E-05	4.07 E-06	3.47 E-06
Th-233	9.19 E-06	2.55 E-05	3.15 E-06	2.35 E-06
Th-234+D	2.00 E-02	4.46 E-02	5.86 E-03	5.86 E-03
Th-234	1.78 E-02	3.96 E-02	5.18 E-03	5.18 E-03
Pa-231+D	1.12 E+02	2.49 E+02	3.11 E+01	3.10 E+01
Pa-232m+D	2.45 E-03	5.47 E-03	7.13 E-04	7.11 E-04
Pa-232	2.10 E-03	4.69 E-03	6.07 E-04	6.05 E-04
Pa-233+D	1.02 E-02	2.27 E-02	3.01 E-03	3.01 E-03
Pa-234+D	1.11 E-03	2.50 E-03	3.18 E-04	3.13 E-04
Pa-234m+D	2.51 E-08	1.12 E-06	1.26 E-07	1.99 E-09
U-232+D	1.72 E+01	3.83 E+01	4.99 E+00	4.99 E+00
U-233+D	3.64 E+00	8.12 E+00	1.02 E+00	1.02 E+00
U-234+D	3.56 E+00	7.93 E+00	9.94 E-01	9.93 E-01
U-235+D	4.25 E+00	9.46 E+00	1.21 E+00	1.21 E+00
U-235m+D	1.37 E-13	2.29 E-13	3.11 E-14	4.31 E-14
U-235m	0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00
U-236+D	3.29 E+00	7.33 E+00	9.20 E-01	9.19 E-01
U-237+D	2.63 E-03	5.85 E-03	7.57 E-04	7.56 E-04
U-238+D	3.76 E+00	8.38 E+00	1.07 E+00	1.07 E+00
U-239+D	2.93 E-05	7.60 E-05	9.45 E-06	7.70 E-06
U-239	2.53 E-05	6.93 E-05	8.55 E-06	6.45 E-06
U-240+D	7.52 E-04	1.61 E-03	2.05 E-04	2.14 E-04
U-240	5.02 E-04	1.12 E-03	1.39 E-04	1.38 E-04
Np-235	1.50 E-03	3.35 E-03	4.44 E-04	4.43 E-04
Np-236+D	4.83 E+00	1.08 E+01	1.37 E+00	1.37 E+00
Np-236m+D	5.72 E-03	1.27 E-02	1.58 E-03	1.58 E-03
Np-237+D	2.79 E+01	6.21 E+01	7.78 E+00	7.77 E+00
Np-238+D	3.42 E-03	7.62 E-03	9.72 E-04	9.71 E-04
Np-239+D	1.20 E-03	2.67 E-03	3.40 E-04	3.39 E-04
Np-240+D	3.86 E-04	9.31 E-04	1.16 E-04	1.04 E-04
Np-240m+D	3.38 E-05	1.45 E-04	1.75 E-05	7.07 E-06
Pu-234+D	1.78 E-02	3.97 E-02	4.93 E-03	4.90 E-03
Pu-235+D	4.15 E+00	9.24 E+00	1.18 E+00	1.18 E+00
Pu-236+D	2.21 E+01	4.92 E+01	6.13 E+00	6.12 E+00
Pu-237+D	2.33 E-03	5.18 E-03	6.97 E-04	6.96 E-04
Pu-238+D	5.35 E+01	1.19 E+02	1.48 E+01	1.48 E+01
Pu-239+D	5.83 E+01	1.30 E+02	1.62 E+01	1.62 E+01
Pu-240+D	5.83 E+01	1.30 E+02	1.62 E+01	1.62 E+01
Pu-241+D	1.09 E+00	2.43 E+00	3.03 E-01	3.02 E-01
Pu-242+D	5.54 E+01	1.23 E+02	1.53 E+01	1.53 E+01
Pu-243+D	8.20 E-05	1.85 E-04	2.31 E-05	2.27 E-05
Pu-244+D	5.72 E+01	1.28 E+02	1.60 E+01	1.59 E+01
Am-240+D	2.39 E-03	5.34 E-03	7.07 E-04	7.05 E-04
Am-241+D	4.83 E+01	1.08 E+02	1.34 E+01	1.34 E+01
Am-242+D	1.60 E-02	3.58 E-02	4.44 E-03	4.44 E-03
Am-242m+D	4.37 E+01	9.75 E+01	1.21 E+01	1.21 E+01
Am-243+D	4.91 E+01	1.09 E+02	1.36 E+01	1.36 E+01
Am-244+D	2.66 E-03	5.94 E-03	7.42 E-04	7.40 E-04
Am-244m+D	9.40 E-05	2.14 E-04	2.67 E-05	2.58 E-05
Am-244m	7.12 E-05	1.91 E-04	2.36 E-05	1.83 E-05
Am-245+D	5.65 E-05	1.31 E-04	1.63 E-05	1.54 E-05
Am-246+D	2.45 E-04	6.18 E-04	7.67 E-05	6.47 E-05
Cm-241+D	5.02 E-02	1.12 E-01	1.43 E-02	1.43 E-02
Cm-242+D	4.87 E+00	1.09 E+01	1.35 E+00	1.35 E+00
Cm-243+D	3.65 E+01	8.12 E+01	1.01 E+01	1.01 E+01

Table 4.6. (contd)

Nuclide[a,b]	Effective Release Height <40 m mrem/yr per Ci/yr[c]		Effective Release Height ≥40 m mrem/yr per Ci/yr[c]	
	Eastern 300 Area Offsite MEI[d]	Western 300 Area Offsite MEI[d]	Eastern 300 Area Offsite MEI[e]	Western 300 Area Offsite MEI[e]
Cm-244+D	3.02 E+01	6.72 E+01	8.35 E+00	8.35 E+00
Cm-245+D	4.96 E+01	1.11 E+02	1.38 E+01	1.38 E+01
Cm-246+D	4.89 E+01	1.09 E+02	1.35 E+01	1.35 E+01
Cm-247+D	4.67 E+01	1.04 E+02	1.30 E+01	1.29 E+01
Cm-248+D	1.83 E+02	4.07 E+02	5.08 E+01	5.08 E+01
Cm-249+D	3.95 E-05	9.04 E-05	1.13 E-05	1.09 E-05
Cm-250+D	1.07 E+03	2.39 E+03	3.01 E+02	3.00 E+02
Bk-247+D	8.16 E+01	1.82 E+02	2.26 E+01	2.26 E+01
Bk-248m+D	1.73 E-04	2.42 E-04	3.20 E-05	5.55 E-05
Bk-248m	6.17 E-05	1.38 E-04	1.83 E-05	1.82 E-05
Bk-249+D	1.96 E-01	4.36 E-01	5.42 E-02	5.42 E-02
Bk-250+D	1.49 E-03	3.35 E-03	4.17 E-04	4.13 E-04
Cf-249+D	8.34 E+01	1.86 E+02	2.31 E+01	2.31 E+01
Cf-250+D	3.88 E+01	8.64 E+01	1.07 E+01	1.07 E+01
Cf-251+D	8.35 E+01	1.86 E+02	2.32 E+01	2.31 E+01
Cf-252+D	2.21 E+01	4.93 E+01	6.13 E+00	6.13 E+00
Es-254+D	8.85 E+00	1.97 E+01	2.46 E+00	2.45 E+00

MEI = Maximally exposed individual
Bold nuclides are newly available in CAP88-PC version 4.
n/a = nuclide or indicated solubility class is not available in CAP88-PC version 4.
(a) +D indicates that the listed radionuclide dose includes the contribution from the parent radionuclide plus decay products grown in during transit and the build-up period.
(b) If the *nuclide+D* is followed by the nuclide without the +D, the decay chain members contribute greater than 10% of the *nuclide+D* dose. V = vapor; E = elemental; O = organic compounds; F = particulate, fast clearance rate; M = particulate, moderate clearance rate; S = particulate, slow clearance rate. Carbon isotopes are modeled as particulate (M), carbon monoxide (CO), or carbon dioxide (CO2).
(c) If a radionuclide is indicated rather than a dose factor value, the nuclide is used as a surrogate. See Table 3.4 for additional details.
(d) See Figure 4.2 for areas applicable to <40-m Effective Release Height.
(e) See Figure 4.3 for areas applicable to ≥40-m Effective Release Height.

This page intentionally left blank.

Table 4.7. **400 Area**: Offsite and Onsite MEIs CAP88-PC Dose-per-Unit-Release Factors (mrem/Ci) by Effective Release Height

Nuclide[a,b]	Effective Release Height <40 m		Effective Release Height ≥40 m	
	mrem/yr per Ci/yr[c]		mrem/yr per Ci/yr[c]	
	400 Area Offsite MEI	400 Area Onsite MEI[d]	400 Area Offsite MEI	400 Area Onsite MEI[d]
H-3 (V)	2.70 E-05	8.61 E-06	1.13 E-05	4.03 E-06
H-3 (E)	2.42 E-05	2.85 E-06	1.01 E-05	1.51 E-06
H-3 (O)	5.92 E-05	1.67 E-05	2.47 E-05	7.57 E-06
H-3 (F)	2.19 E-05	3.64 E-06	1.00 E-05	1.99 E-06
H-3 (M)	2.74 E-05	1.53 E-05	1.25 E-05	7.35 E-06
H-3 (S)	5.79 E-05	8.08 E-05	2.65 E-05	3.74 E-05
Be-7	2.71 E-04	5.41 E-04	1.31 E-04	2.63 E-04
Be-10	5.72 E-03	8.37 E-03	2.75 E-03	4.04 E-03
C-11	1.01 E-05	4.53 E-05	4.81 E-06	2.16 E-05
C-11 (CO)	1.06 E-05	4.45 E-05	4.60 E-06	2.02 E-05
C-11 (CO2)	1.06 E-05	4.47 E-05	4.62 E-06	2.03 E-05
C-14	2.79 E-03	6.48 E-04	1.28 E-03	3.37 E-04
C-14 (CO)	2.92 E-03	2.49 E-04	1.22 E-03	1.39 E-04
C-14 (CO2)	2.92 E-03	2.50 E-04	1.22 E-03	1.40 E-04
C-15	C-11	C-11	C-11	C-11
N-13	2.49 E-06	2.25 E-05	1.14 E-06	1.06 E-05
O-15	8.80 E-11	1.57 E-07	6.53 E-11	9.94 E-08
O-19	7.52 E-19	1.58 E-15	3.79 E-19	1.30 E-15
F-18	3.79 E-05	9.33 E-05	1.76 E-05	4.35 E-05
Na-22	2.25 E-01	3.81 E-01	1.09 E-01	1.86 E-01
Na-24	4.30 E-04	9.33 E-04	2.03 E-04	4.42 E-04
Mg-27	1.75 E-06	1.82 E-05	8.81 E-07	9.06 E-06
Mg-28+D	5.06 E-04	1.09 E-03	2.39 E-04	5.15 E-04
Mg-28	2.94 E-04	6.27 E-04	1.38 E-04	2.95 E-04
Al-26	1.91 E+00	4.10 E+00	9.30 E-01	2.00 E+00
Al-28	4.73 E-10	5.02 E-07	3.53 E-10	3.19 E-07
Si-31	7.67 E-06	1.81 E-05	3.55 E-06	8.39 E-06
Si-32+D	6.18 E-02	1.32 E-01	3.00 E-02	6.39 E-02
Si-32	2.80 E-03	4.71 E-03	1.30 E-03	2.18 E-03
P-32	2.34 E-03	1.25 E-03	1.12 E-03	6.12 E-04
P-33	5.27 E-04	3.55 E-04	2.52 E-04	1.70 E-04
S-35	2.17 E-03	4.43 E-04	1.05 E-03	2.37 E-04
Cl-36	1.83 E+00	1.38 E-01	8.91 E-01	9.61 E-02
Ar-37	0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00
Ar-39	1.08 E-07	2.16 E-07	4.50 E-08	9.43 E-08
Ar-41	4.44 E-05	1.02 E-04	1.86 E-05	4.49 E-05
Ar-42+D	2.85 E-06	3.01 E-06	1.29 E-06	1.34 E-06
Ar-42	1.18 E-07	2.36 E-07	4.93 E-08	1.03 E-07
K-40	3.55 E-01	3.54 E-01	1.73 E-01	1.75 E-01
K-42	6.94 E-05	1.52 E-04	3.24 E-05	7.09 E-05
Ca-41	3.23 E-03	2.47 E-04	1.57 E-03	1.74 E-04
Ca-45	1.19 E-03	6.89 E-04	5.71 E-04	3.33 E-04
Ca-47+D	7.87 E-04	1.56 E-03	3.76 E-04	7.47 E-04
Sc-44	1.19 E-04	2.71 E-04	5.54 E-05	1.27 E-04
Sc-44m+D	7.18 E-04	1.52 E-03	3.44 E-04	7.29 E-04
Sc-44m	2.23 E-04	4.66 E-04	1.04 E-04	2.18 E-04
Sc-46	1.69 E-02	3.42 E-02	8.20 E-03	1.67 E-02
Sc-47	1.10 E-04	2.24 E-04	5.14 E-05	1.05 E-04
Ti-44+D	1.39 E+00	2.92 E+00	6.75 E-01	1.43 E+00
Ti-44	1.11 E-01	1.77 E-01	5.37 E-02	8.61 E-02

Table 4.7. (contd)

Nuclide[a,b]	Effective Release Height <40 m		Effective Release Height ≥40 m	
	mrem/yr per Ci/yr[c]		mrem/yr per Ci/yr[c]	
	400 Area Offsite MEI	400 Area Onsite MEI[d]	400 Area Offsite MEI	400 Area Onsite MEI[d]
Ti-45	4.49 E-05	1.04 E-04	2.09 E-05	4.88 E-05
Ti-51	1.10 E-07	3.06 E-06	5.98 E-08	1.60 E-06
V-48	5.20 E-03	9.84 E-03	2.52 E-03	4.78 E-03
V-49	3.91 E-05	1.20 E-05	1.89 E-05	6.13 E-06
Cr-49+D	2.30 E-05	7.05 E-05	1.08 E-05	3.31 E-05
Cr-51	1.21 E-04	1.85 E-04	5.88 E-05	9.03 E-05
Cr-55	3.25 E-10	4.32 E-08	2.04 E-10	2.46 E-08
Mn-52	2.11 E-03	4.35 E-03	1.02 E-03	2.10 E-03
Mn-52m+D	2.59 E-05	1.13 E-04	1.23 E-05	5.39 E-05
Mn-53	3.15 E-04	3.65 E-05	1.53 E-04	2.25 E-05
Mn-54	2.43 E-02	5.04 E-02	1.18 E-02	2.45 E-02
Mn-56	8.12 E-05	1.92 E-04	3.78 E-05	8.95 E-05
Fe-55	1.64 E-03	2.06 E-04	7.95 E-04	1.22 E-04
Fe-59	7.84 E-03	1.13 E-02	3.80 E-03	5.50 E-03
Co-56	3.14 E-02	5.41 E-02	1.52 E-02	2.64 E-02
Co-57	3.85 E-03	6.23 E-03	1.87 E-03	3.04 E-03
Co-58	8.27 E-03	1.41 E-02	4.01 E-03	6.87 E-03
Co-58m+D	3.54 E-05	7.51 E-05	1.72 E-05	3.65 E-05
Co-58m	1.53 E-06	3.36 E-06	7.01 E-07	1.55 E-06
Co-60	4.03 E-01	8.01 E-01	1.96 E-01	3.90 E-01
Co-60m+D	1.53 E-06	3.19 E-06	7.43 E-07	1.55 E-06
Co-60m	1.88 E-08	1.69 E-07	9.37 E-09	8.31 E-08
Ni-56+D	3.17 E-03	6.50 E-03	1.54 E-03	3.16 E-03
Ni-56	1.26 E-03	2.41 E-03	6.08 E-04	1.17 E-03
Ni-57+D	4.12 E-04	8.58 E-04	1.97 E-04	4.11 E-04
Ni-59	6.24 E-04	1.03 E-04	3.03 E-04	5.91 E-05
Ni-63	1.37 E-03	2.12 E-04	6.63 E-04	1.22 E-04
Ni-65	3.11 E-05	7.36 E-05	1.44 E-05	3.43 E-05
Cu-64	2.66 E-05	5.81 E-05	1.24 E-05	2.72 E-05
Cu-66	1.97 E-08	7.46 E-07	1.10 E-08	3.96 E-07
Cu-67	8.87 E-05	1.85 E-04	4.14 E-05	8.67 E-05
Zn-65	6.37 E-02	3.04 E-02	3.10 E-02	1.55 E-02
Zn-69	1.81 E-06	5.08 E-06	8.42 E-07	2.37 E-06
Zn-69m+D	6.68 E-05	1.44 E-04	3.13 E-05	6.75 E-05
Ga-67	7.63 E-05	1.60 E-04	3.63 E-05	7.65 E-05
Ga-68	2.97 E-05	7.95 E-05	1.38 E-05	3.72 E-05
Ga-70	6.53 E-07	2.86 E-06	3.11 E-07	1.36 E-06
Ga-72	2.97 E-04	6.49 E-04	1.40 E-04	3.07 E-04
Ge-68+D	6.61 E-02	6.11 E-02	3.21 E-02	3.02 E-02
Ge-68	4.06 E-02	6.31 E-03	1.97 E-02	3.55 E-03
Ge-69	2.10 E-04	4.49 E-04	1.00 E-04	2.15 E-04
Ge-71	1.50 E-05	3.93 E-06	7.26 E-06	2.04 E-06
Ge-75	4.10 E-06	1.05 E-05	1.90 E-06	4.91 E-06
Ge-77+D	1.27 E-04	2.77 E-04	5.94 E-05	1.30 E-04
As-73	6.14 E-04	3.50 E-04	2.95 E-04	1.71 E-04
As-74	2.14 E-03	3.38 E-03	1.03 E-03	1.64 E-03
As-76	1.53 E-04	3.31 E-04	7.17 E-05	1.56 E-04
As-77	4.38 E-05	9.41 E-05	2.01 E-05	4.34 E-05
Se-75	2.85 E-02	1.05 E-02	1.38 E-02	5.50 E-03
Se-77m	1.34 E-21	3.66 E-18	1.34 E-21	1.63 E-18
Se-79	9.75 E-02	6.33 E-03	4.74 E-02	4.56 E-03
Se-79m+D	2.59 E-10	2.24 E-08	1.56 E-10	1.24 E-08
Se-79m	2.57 E-10	2.24 E-08	1.55 E-10	1.24 E-08
Br-82	5.25 E-04	1.11 E-03	2.51 E-04	5.34 E-04

Table 4.7. (contd)

Nuclide[a,b]	Effective Release Height <40 m		Effective Release Height ≥40 m	
	mrem/yr per Ci/yr[c]		mrem/yr per Ci/yr[c]	
	400 Area Offsite MEI	400 Area Onsite MEI[d]	400 Area Offsite MEI	400 Area Onsite MEI[d]
Br-82m+D	1.48 E-06	3.07 E-06	7.08 E-07	1.47 E-06
Br-82m	1.37 E-09	3.29 E-08	7.38 E-10	1.71 E-08
Br-83+D	4.79 E-06	1.14 E-05	2.21 E-06	5.28 E-06
Br-84	3.29 E-05	1.13 E-04	1.55 E-05	5.34 E-05
Br-84m	1.02 E-06	2.56 E-05	5.48 E-07	1.33 E-05
Br-85+D	6.32 E-08	2.12 E-07	2.65 E-08	1.05 E-07
Br-85	2.74 E-10	7.96 E-08	1.84 E-10	4.72 E-08
Kr-81	3.59 E-08	7.17 E-08	1.49 E-08	3.13 E-08
Kr-81m+D	3.64 E-19	9.03 E-19	2.09 E-19	7.74 E-19
Kr-83m	7.95 E-10	1.83 E-09	3.34 E-10	8.04 E-10
Kr-85	2.26 E-07	4.52 E-07	9.42 E-08	1.98 E-07
Kr-85m+D	5.78 E-06	1.22 E-05	2.41 E-06	5.36 E-06
Kr-87+D	2.56 E-05	6.24 E-05	1.08 E-05	2.76 E-05
Kr-88+D	9.97 E-05	2.02 E-04	4.25 E-05	8.91 E-05
Kr-88	7.70 E-05	1.68 E-04	3.22 E-05	7.39 E-05
Kr-89+D	3.94 E-06	2.40 E-05	1.90 E-06	1.17 E-05
Kr-89	1.46 E-08	2.82 E-06	8.88 E-09	1.57 E-06
Kr-90	1.64 E-08	5.46 E-09	7.99 E-09	2.89 E-09
Rb-81+D	3.85 E-05	8.65 E-05	1.78 E-05	4.03 E-05
Rb-81	3.21 E-05	7.27 E-05	1.50 E-05	3.40 E-05
Rb-81m+D	4.17 E-06	8.72 E-06	1.92 E-06	4.07 E-06
Rb-81m	1.04 E-06	3.65 E-06	4.88 E-07	1.72 E-06
Rb-82	1.03 E-13	5.23 E-09	9.40 E-14	3.99 E-09
Rb-82m	1.84 E-04	4.09 E-04	8.61 E-05	1.92 E-04
Rb-83+D	9.83 E-03	8.96 E-03	4.77 E-03	4.45 E-03
Rb-84	6.73 E-03	6.77 E-03	3.26 E-03	3.34 E-03
Rb-84m+D	5.98 E-06	1.86 E-05	2.86 E-06	8.92 E-06
Rb-84m	3.51 E-06	1.58 E-05	1.67 E-06	7.55 E-06
Rb-86	2.76 E-03	1.82 E-03	1.33 E-03	8.90 E-04
Rb-86m+D	1.05 E-07	6.92 E-08	5.03 E-08	3.40 E-08
Rb-86m	7.93 E-16	2.76 E-10	7.52 E-16	2.25 E-10
Rb-87	4.68 E-02	4.19 E-03	2.27 E-02	2.74 E-03
Rb-88	6.39 E-06	3.19 E-05	3.06 E-06	1.53 E-05
Rb-89+D	1.51 E-05	8.38 E-05	7.29 E-06	4.05 E-05
Rb-90+D	8.34 E-08	1.42 E-06	4.11 E-08	8.56 E-07
Rb-90	3.02 E-09	1.39 E-06	2.11 E-09	8.42 E-07
Rb-90m+D	3.53 E-07	1.41 E-05	1.93 E-07	7.67 E-06
Rb-90m	2.12 E-07	1.35 E-05	1.24 E-07	7.38 E-06
Sr-82+D	7.57 E-03	9.12 E-03	3.64 E-03	4.43 E-03
Sr-82	4.57 E-03	2.69 E-03	2.19 E-03	1.30 E-03
Sr-83+D	2.27 E-04	4.87 E-04	1.09 E-04	2.33 E-04
Sr-83	1.66 E-04	3.57 E-04	7.89 E-05	1.70 E-04
Sr-85	3.71 E-03	6.57 E-03	1.80 E-03	3.20 E-03
Sr-85m+D	7.99 E-06	2.00 E-05	3.76 E-06	9.44 E-06
Sr-85m	5.98 E-06	1.60 E-05	2.78 E-06	7.48 E-06
Sr-87m+D	1.45 E-05	3.41 E-05	6.77 E-06	1.59 E-05
Sr-89	3.67 E-03	2.50 E-03	1.76 E-03	1.22 E-03
Sr-90+D	4.62 E-01	1.54 E-01	2.24 E-01	8.11 E-02
Sr-91+D	1.13 E-04	2.41 E-04	5.27 E-05	1.13 E-04
Sr-92+D	8.22 E-05	1.89 E-04	3.82 E-05	8.79 E-05
Y-88	2.62 E-02	5.43 E-02	1.27 E-02	2.64 E-02
Y-89m	4.80 E-18	9.18 E-17	2.21 E-18	3.28 E-17
Y-90	2.02 E-04	4.11 E-04	9.35 E-05	1.91 E-04

Table 4.7. (contd)

Nuclide[a,b]	Effective Release Height <40 m		Effective Release Height ≥40 m	
	mrem/yr per Ci/yr[c]		mrem/yr per Ci/yr[c]	
	400 Area Offsite MEI	400 Area Onsite MEI[d]	400 Area Offsite MEI	400 Area Onsite MEI[d]
Y-90m+D	3.86 E-05	8.76 E-05	1.79 E-05	4.09 E-05
Y-91	2.75 E-03	2.90 E-03	1.31 E-03	1.38 E-03
Y-91m+D	1.34 E-05	3.73 E-05	6.26 E-06	1.75 E-05
Y-92	3.10 E-05	7.13 E-05	1.44 E-05	3.32 E-05
Y-93+D	5.63 E-05	1.24 E-04	2.61 E-05	5.74 E-05
Zr-88+D	2.27 E-02	4.81 E-02	1.10 E-02	2.34 E-02
Zr-88	3.55 E-03	7.10 E-03	1.72 E-03	3.44 E-03
Zr-89	4.55 E-04	9.64 E-04	2.18 E-04	4.63 E-04
Zr-89m+D	4.08 E-07	2.95 E-06	1.99 E-07	1.57 E-06
Zr-93+D	2.45 E-03	3.57 E-03	1.15 E-03	1.67 E-03
Zr-95+D	9.82 E-03	2.00 E-02	4.75 E-03	9.73 E-03
Zr-97+D	2.48 E-04	5.29 E-04	1.17 E-04	2.50 E-04
Zr-97	1.93 E-04	4.20 E-04	9.02 E-05	1.97 E-04
Nb-91	3.58 E-03	7.69 E-03	1.74 E-03	3.75 E-03
Nb-91m+D	1.55 E-04	3.33 E-04	7.53 E-05	1.62 E-04
Nb-92	1.10 E+00	2.35 E+00	5.33 E-01	1.15 E+00
Nb-92m	9.19 E-04	1.97 E-03	4.46 E-04	9.59 E-04
Nb-93m	4.13 E-04	6.82 E-04	1.99 E-04	3.30 E-04
Nb-94	1.14 E+00	2.45 E+00	5.56 E-01	1.20 E+00
Nb-94m+D	2.71 E-09	4.78 E-08	1.42 E-09	2.47 E-08
Nb-95	2.89 E-03	5.69 E-03	1.40 E-03	2.76 E-03
Nb-95m+D	3.53 E-04	7.43 E-04	1.70 E-04	3.57 E-04
Nb-95m	1.15 E-04	2.31 E-04	5.35 E-05	1.08 E-04
Nb-96	3.74 E-04	8.11 E-04	1.77 E-04	3.86 E-04
Nb-97	2.22 E-05	5.85 E-05	1.03 E-05	2.73 E-05
Mo-93+D	1.34 E-02	7.72 E-03	6.51 E-03	3.93 E-03
Mo-93m+D	1.55 E-04	3.45 E-04	7.28 E-05	1.62 E-04
Mo-99+D	1.83 E-04	3.82 E-04	8.60 E-05	1.79 E-04
Mo-99	1.56 E-04	3.24 E-04	7.29 E-05	1.51 E-04
Tc-95	9.96 E-05	2.16 E-04	4.73 E-05	1.03 E-04
Tc-95m+D	4.76 E-03	8.80 E-03	2.31 E-03	4.29 E-03
Tc-96	1.18 E-03	2.47 E-03	5.70 E-04	1.19 E-03
Tc-96m+D	1.02 E-05	2.21 E-05	4.91 E-06	1.07 E-05
Tc-96m	1.50 E-06	4.31 E-06	6.99 E-07	2.02 E-06
Tc-97	1.07 E-02	8.12 E-03	5.20 E-03	4.08 E-03
Tc-97m+D	1.27 E-03	8.63 E-04	6.10 E-04	4.16 E-04
Tc-98	1.24 E+00	2.23 E+00	6.04 E-01	1.09 E+00
Tc-99	6.81 E-02	5.85 E-03	3.31 E-02	3.99 E-03
Tc-99m+D	8.44 E-06	1.89 E-05	3.94 E-06	8.84 E-06
Tc-101	1.91 E-06	1.18 E-05	9.29 E-07	5.72 E-06
Ru-97+D	8.12 E-05	1.73 E-04	3.89 E-05	8.30 E-05
Ru-103+D	2.44 E-03	4.48 E-03	1.18 E-03	2.17 E-03
Ru-105+D	5.50 E-05	1.24 E-04	2.56 E-05	5.80 E-05
Ru-106+D	2.24 E-02	3.45 E-02	1.08 E-02	1.67 E-02
Ru-106	1.03 E-02	8.49 E-03	4.91 E-03	4.03 E-03
Rh-101	2.82 E-02	5.92 E-02	1.37 E-02	2.88 E-02
Rh-101m+D	1.54 E-04	3.20 E-04	7.41 E-05	1.54 E-04
Rh-102	1.30 E-02	2.31 E-02	6.28 E-03	1.12 E-02
Rh-102m+D	2.44 E-01	5.21 E-01	1.19 E-01	2.54 E-01
Rh-103m	1.51 E-07	4.25 E-07	7.03 E-08	1.98 E-07
Rh-104	1.06 E-18	1.55 E-13	6.95 E-19	1.38 E-13
Rh-104m+D	3.63 E-09	2.25 E-07	2.12 E-09	1.23 E-07
Rh-104m	1.27 E-09	7.85 E-08	7.39 E-10	4.28 E-08

Table 4.7. (contd)

Nuclide[a,b]	Effective Release Height <40 m		Effective Release Height ≥40 m	
	mrem/yr per Ci/yr[c]		mrem/yr per Ci/yr[c]	
	400 Area Offsite MEI	400 Area Onsite MEI[d]	400 Area Offsite MEI	400 Area Onsite MEI[d]
Rh-105	4.64 E-05	9.97 E-05	2.16 E-05	4.65 E-05
Rh-105m	Rh-105	Rh-105	Rh-105	Rh-105
Rh-106	1.97 E-19	3.05 E-15	1.76 E-19	2.87 E-15
Pd-103+D	1.03 E-04	1.19 E-04	4.92 E-05	5.65 E-05
Pd-107	1.11 E-04	3.13 E-05	5.38 E-05	1.64 E-05
Pd-109	3.71 E-05	8.09 E-05	1.71 E-05	3.73 E-05
Pd-109m+D	2.22 E-07	9.27 E-07	1.03 E-07	4.64 E-07
Pd-111+D	1.40 E-06	3.87 E-06	6.60 E-07	1.84 E-06
Pd-111	7.71 E-07	3.15 E-06	3.67 E-07	1.50 E-06
Pd-112+D	7.19 E-05	1.47 E-04	3.47 E-05	7.14 E-05
Pd-112	2.05 E-07	4.46 E-07	9.91 E-08	2.16 E-07
Ag-108	1.25 E-11	9.76 E-09	9.10 E-12	6.11 E-09
Ag-108m+D	1.16 E+00	2.48 E+00	5.64 E-01	1.21 E+00
Ag-109m	8.73 E-20	6.45 E-15	4.35 E-20	5.80 E-15
Ag-110	1.33 E-18	2.90 E-17	7.26 E-19	2.19 E-17
Ag-110m+D	6.64 E-02	1.34 E-01	3.22 E-02	6.54 E-02
Ag-111	3.70 E-04	4.64 E-04	1.75 E-04	2.19 E-04
Ag-111m+D	3.70 E-08	4.64 E-08	1.75 E-08	2.19 E-08
Ag-111m	1.81 E-17	3.58 E-12	1.68 E-17	2.87 E-12
Ag-112	4.84 E-05	1.12 E-04	2.25 E-05	5.24 E-05
Cd-107	8.75 E-06	1.95 E-05	4.03 E-06	9.01 E-06
Cd-109	4.52 E-03	3.42 E-03	2.18 E-03	1.68 E-03
Cd-111m	5.95 E-06	1.74 E-05	2.78 E-06	8.16 E-06
Cd-113	2.86 E-01	3.53 E-02	1.39 E-01	2.16 E-02
Cd-113m	1.35 E-01	2.49 E-02	6.55 E-02	1.40 E-02
Cd-115+D	1.98 E-04	4.10 E-04	9.31 E-05	1.93 E-04
Cd-115	1.64 E-04	3.38 E-04	7.67 E-05	1.58 E-04
Cd-115m+D	3.19 E-03	2.72 E-03	1.53 E-03	1.31 E-03
Cd-117+D	6.60 E-05	1.51 E-04	3.07 E-05	7.02 E-05
Cd-117m+D	1.31 E-04	2.90 E-04	6.13 E-05	1.35 E-04
In-106	1.47 E-06	3.42 E-05	7.85 E-07	1.77 E-05
In-111	1.40 E-04	2.98 E-04	6.70 E-05	1.43 E-04
In-111m+D	7.17 E-07	7.21 E-06	3.60 E-07	3.63 E-06
In-112	1.63 E-06	9.52 E-06	7.88 E-07	4.60 E-06
In-112m+D	4.32 E-06	1.09 E-05	2.01 E-06	5.01 E-06
In-112m	2.13 E-07	9.49 E-07	1.01 E-07	4.53 E-07
In-113m	9.80 E-06	2.45 E-05	4.56 E-06	1.14 E-05
In-114	5.19 E-16	4.35 E-11	4.82 E-16	3.37 E-11
In-114m+D	4.35 E-03	3.84 E-03	2.10 E-03	1.87 E-03
In-115	6.99 E-02	5.03 E-02	3.34 E-02	2.40 E-02
In-115m+D	1.32 E-05	2.99 E-05	6.13 E-06	1.39 E-05
In-116m	6.52 E-05	1.85 E-04	3.04 E-05	8.63 E-05
In-117+D	1.57 E-05	4.76 E-05	7.32 E-06	2.23 E-05
In-117m+D	1.74 E-05	3.53 E-05	8.02 E-06	1.64 E-05
In-117m	9.41 E-06	2.30 E-05	4.36 E-06	1.07 E-05
Sn-113+D	4.36 E-03	6.99 E-03	2.11 E-03	3.40 E-03
Sn-113	1.65 E-03	1.17 E-03	7.92 E-04	5.73 E-04
Sn-113m+D	4.93 E-07	8.89 E-07	2.38 E-07	4.33 E-07
Sn-113m	2.57 E-08	1.11 E-07	1.23 E-08	5.34 E-08
Sn-117m	6.42 E-04	9.64 E-04	3.05 E-04	4.58 E-04
Sn-119m	1.24 E-03	1.13 E-03	5.97 E-04	5.49 E-04
Sn-121	2.30 E-05	4.95 E-05	1.06 E-05	2.28 E-05
Sn-121m+D	5.98 E-03	5.86 E-03	2.89 E-03	2.88 E-03
Sn-123	5.22 E-03	4.14 E-03	2.51 E-03	2.01 E-03

Table 4.7. (contd)

Nuclide[a,b]	Effective Release Height <40 m		Effective Release Height ≥40 m	
	mrem/yr per Ci/yr[c]		mrem/yr per Ci/yr[c]	
	400 Area Offsite MEI	400 Area Onsite MEI[d]	400 Area Offsite MEI	400 Area Onsite MEI[d]
Sn-123m	4.14 E-06	1.29 E-05	1.94 E-06	6.07 E-06
Sn-125+D	1.64 E-03	2.44 E-03	7.89 E-04	1.17 E-03
Sn-125m+D	9.47 E-07	7.64 E-06	4.72 E-07	3.78 E-06
Sn-126+D	1.58 E+00	3.28 E+00	7.67 E-01	1.59 E+00
Sn-126	9.41 E-02	9.12 E-02	4.56 E-02	4.51 E-02
Sb-122	2.69 E-04	5.64 E-04	1.27 E-04	2.66 E-04
Sb-122m+D	2.90 E-07	7.27 E-07	1.37 E-07	3.53 E-07
Sb-122m	1.97 E-09	1.37 E-07	1.16 E-09	7.50 E-08
Sb-124	1.23 E-02	2.34 E-02	5.96 E-03	1.14 E-02
Sb-124m+D	1.65 E-07	3.25 E-07	8.00 E-08	1.60 E-07
Sb-124n+D	6.66 E-06	2.48 E-05	3.19 E-06	1.18 E-05
Sb-124n	1.48 E-07	6.70 E-07	7.06 E-08	3.19 E-07
Sb-125+D	3.95 E-02	8.26 E-02	1.92 E-02	4.02 E-02
Sb-126	4.05 E-03	7.74 E-03	1.95 E-03	3.75 E-03
Sb-126m+D	1.46 E-05	6.69 E-05	6.96 E-06	3.20 E-05
Sb-127+D	4.93 E-04	1.00 E-03	2.34 E-04	4.76 E-04
Sb-128	2.55 E-04	5.63 E-04	1.20 E-04	2.65 E-04
Sb-128m+D	5.08 E-06	4.47 E-05	2.53 E-06	2.21 E-05
Te-121	1.24 E-03	2.32 E-03	5.99 E-04	1.13 E-03
Te-121m+D	1.37 E-02	2.28 E-02	6.64 E-03	1.11 E-02
Te-121m	6.56 E-03	7.51 E-03	3.18 E-03	3.68 E-03
Te-123	2.89 E-02	2.44 E-03	1.40 E-02	1.63 E-03
Te-123m+D	3.65 E-03	4.27 E-03	1.76 E-03	2.08 E-03
Te-125m	1.25 E-03	1.13 E-03	6.00 E-04	5.41 E-04
Te-127	1.31 E-05	2.89 E-05	6.04 E-06	1.33 E-05
Te-127m+D	3.82 E-03	2.37 E-03	1.83 E-03	1.15 E-03
Te-129+D	4.64 E-06	1.23 E-05	2.16 E-06	5.76 E-06
Te-129m+D	2.96 E-03	2.67 E-03	1.42 E-03	1.29 E-03
Te-129m	2.72 E-03	2.16 E-03	1.30 E-03	1.04 E-03
Te-131+D	2.42 E-05	2.96 E-05	4.22 E-05	1.72 E-05
Te-131	6.30 E-06	2.47 E-05	2.98 E-06	1.17 E-05
Te-131m+D	4.16 E-04	8.47 E-04	2.42 E-04	4.08 E-04
Te-131m	3.32 E-04	7.17 E-04	1.57 E-04	3.39 E-04
Te-132+D	1.02 E-03	2.12 E-03	5.07 E-04	1.04 E-03
Te-132	3.42 E-04	6.53 E-04	1.60 E-04	3.05 E-04
Te-133+D	6.68 E-06	4.27 E-05	5.76 E-06	2.44 E-05
Te-133	5.15 E-06	3.66 E-05	2.52 E-06	1.79 E-05
Te-133m+D	6.24 E-05	1.70 E-04	3.38 E-05	8.43 E-05
Te-134+D	3.33 E-05	1.11 E-04	3.11 E-05	7.51 E-05
Te-134	2.09 E-05	6.44 E-05	9.79 E-06	3.02 E-05
I-122	4.18 E-09	9.17 E-07	7.01 E-09	1.06 E-06
I-122(V)	n/a	n/a	n/a	n/a
I-123+D	1.92 E-05	1.19 E-04	4.13 E-05	1.32 E-04
I-123(V)+D	3.83 E-05	7.80 E-05	1.60 E-05	3.41 E-05
I-124	2.94 E-03	6.11 E-03	6.36 E-03	6.82 E-03
I-124(V)	1.89 E-03	3.82 E-03	7.90 E-04	1.73 E-03
I-125	9.21 E-02	3.85 E-03	1.99 E-01	6.44 E-03
I-125(V)	2.19 E-03	5.33 E-03	9.12 E-04	5.14 E-03
I-126	3.27 E-02	8.28 E-03	7.07 E-02	9.95 E-03
I-126(V)	4.15 E-03	8.64 E-03	1.73 E-03	4.78 E-03
I-128	3.67 E-07	3.96 E-06	7.60 E-07	4.42 E-06
I-128(V)	4.29 E-06	1.57 E-05	1.85 E-06	7.08 E-06
I-129	2.12 E+00	2.31 E-01	4.58 E+00	3.06 E-01

Table 4.7. (contd)

Nuclide[a,b]	Effective Release Height <40 m		Effective Release Height ≥40 m	
	mrem/yr per Ci/yr[c]		mrem/yr per Ci/yr[c]	
	400 Area Offsite MEI	400 Area Onsite MEI[d]	400 Area Offsite MEI	400 Area Onsite MEI[d]
I-129(V)	1.51 E-02	5.14 E-02	6.27 E-03	8.57 E-02
I-130	2.33 E-04	1.46 E-03	5.03 E-04	1.62 E-03
I-130(V)	3.69 E-04	7.53 E-04	1.54 E-04	3.30 E-04
I-130m+D	2.38 E-06	1.54 E-05	5.13 E-06	1.71 E-05
I-130m	3.15 E-08	9.02 E-07	6.06 E-08	1.02 E-06
I-130m(V)	n/a	n/a	n/a	n/a
I-131+D	1.25 E-02	4.57 E-03	2.69 E-02	5.35 E-03
I-131(V)+D	3.12 E-03	6.24 E-03	1.30 E-03	2.73 E-03
I-132	4.51 E-05	3.10 E-04	9.66 E-05	3.44 E-04
I-132(V)	1.19 E-04	2.65 E-04	4.97 E-05	1.16 E-04
I-132m+D	2.81 E-05	1.79 E-04	6.04 E-05	1.97 E-04
I-132m	4.56 E-06	3.35 E-05	9.71 E-06	3.71 E-05
I-132m(V)+D	4.31 E-05	1.11 E-04	3.08 E-05	6.47 E-05
I-132m(V)	3.60 E-05	8.63 E-05	1.51 E-05	3.81 E-05
I-133+D	1.66 E-04	8.80 E-04	3.58 E-04	9.75 E-04
I-133(V)+D	6.36 E-04	1.29 E-03	2.65 E-04	5.63 E-04
I-133m	I-133+D	I-133+D	I-133+D	I-133+D
I-134	1.87 E-05	1.51 E-04	3.95 E-05	1.68 E-04
I-134(V)	7.92 E-05	2.11 E-04	3.35 E-05	9.37 E-05
I-134m+D	1.34 E-06	1.09 E-05	2.84 E-06	1.22 E-05
I-134m	1.07 E-09	2.40 E-07	1.78 E-09	2.78 E-07
I-134m(V)	n/a	n/a	n/a	n/a
I-135+D	1.09 E-04	6.89 E-04	2.31 E-04	7.61 E-04
I-135(V)+D	2.04 E-04	4.21 E-04	8.49 E-05	1.85 E-04
Xe-122+D	6.65 E-06	3.24 E-05	1.08 E-05	3.31 E-05
Xe-122	2.01 E-06	4.06 E-06	8.37 E-07	1.78 E-06
Xe-123+D	2.19 E-05	4.99 E-05	1.02 E-05	2.31 E-05
Xe-123	2.13 E-05	4.80 E-05	8.91 E-06	2.11 E-05
Xe-125+D	3.85 E-05	2.15 E-05	6.82 E-05	1.29 E-05
Xe-125	9.85 E-06	2.00 E-05	4.11 E-06	8.75 E-06
Xe-127	1.06 E-05	2.12 E-05	4.42 E-06	9.27 E-06
Xe-127m+D	2.33 E-10	7.45 E-10	9.72 E-11	4.18 E-10
Xe-127m	2.36 E-15	2.79 E-10	2.19 E-15	2.14 E-10
Xe-129m	8.60 E-07	1.72 E-06	3.58 E-07	7.52 E-07
Xe-131m	3.35 E-07	6.69 E-07	1.39 E-07	2.93 E-07
Xe-133	1.28 E-06	2.57 E-06	5.34 E-07	1.12 E-06
Xe-133m+D	1.20 E-06	2.41 E-06	5.02 E-07	1.05 E-06
Xe-135+D	9.80 E-06	2.01 E-05	4.09 E-06	8.82 E-06
Xe-135m+D	2.98 E-06	1.51 E-05	1.31 E-06	6.92 E-06
Xe-137+D	1.45 E-07	7.66 E-07	7.12 E-08	4.03 E-07
Xe-137	6.86 E-09	6.23 E-07	3.87 E-09	3.33 E-07
Xe-138+D	2.86 E-05	8.48 E-05	1.31 E-05	3.86 E-05
Xe-138	6.80 E-06	3.97 E-05	3.02 E-06	1.83 E-05
Cs-131	4.17 E-05	4.48 E-05	2.02 E-05	2.19 E-05
Cs-132	5.68 E-04	1.03 E-03	2.75 E-04	4.99 E-04
Cs-134	2.89 E-01	2.32 E-01	1.40 E-01	1.16 E-01
Cs-134m+D	2.29 E-05	4.09 E-05	1.11 E-05	2.01 E-05
Cs-134m	2.11 E-06	4.93 E-06	9.76 E-07	2.29 E-06
Cs-135	5.89 E-02	3.95 E-03	2.86 E-02	2.85 E-03
Cs-135m+D	3.90 E-05	0.000111	1.82 E-05	5.2 E-05
Cs-136	4.51 E-03	6.01 E-03	2.18 E-03	2.94 E-03
Cs-137+D	5.76 E-01	6.10 E-01	2.80 E-01	3.02 E-01
Cs-137	3.02 E-01	2.34 E-02	1.47 E-01	1.60 E-02

Table 4.7. (contd)

Nuclide[a,b]	Effective Release Height <40 m		Effective Release Height ≥40 m	
	mrem/yr per Ci/yr[c]		mrem/yr per Ci/yr[c]	
	400 Area Offsite MEI	400 Area Onsite MEI[d]	400 Area Offsite MEI	400 Area Onsite MEI[d]
Cs-138	*4.36 E-05	1.47 E-04	2.05 E-05	6.91 E-05
Cs-138m+D	3.37 E-06	1.16 E-05	1.58 E-06	5.46 E-06
Cs-138m	1.35 E-09	3.87 E-07	9.06 E-10	2.29 E-07
Cs-139+D	1.43 E-06	8.66 E-06	6.90 E-07	4.25 E-06
Cs-139	6.60 E-07	7.09 E-06	3.33 E-07	3.53 E-06
Cs-140+D	2.30 E-07	4.36 E-07	1.11 E-07	2.11 E-07
Ba-131+D	6.90 E-04	1.32 E-03	3.33 E-04	6.39 E-04
Ba-131	6.70 E-04	1.28 E-03	3.23 E-04	6.18 E-04
Ba-131m+D	1.01 E-06	3.65 E-06	4.90 E-07	1.77 E-06
Ba-131m	4.28 E-07	2.56 E-06	2.07 E-07	1.24 E-06
Ba-133	1.06 E-01	2.26 E-01	5.17 E-02	1.10 E-01
Ba-133m+D	1.00 E-04	2.15 E-04	4.74 E-05	1.02 E-04
Ba-135m	4.25 E-05	9.15 E-05	1.96 E-05	4.24 E-05
Ba-137m	5.54 E-10	2.97 E-07	3.92 E-10	1.82 E-07
Ba-139	6.56 E-06	1.69 E-05	3.05 E-06	7.86 E-06
Ba-140+D	3.99 E-03	7.51 E-03	1.92 E-03	3.63 E-03
Ba-140	1.34 E-03	1.83 E-03	6.34 E-04	8.64 E-04
Ba-141+D	9.78 E-06	4.36 E-05	4.66 E-06	2.08 E-05
Ba-142+D	1.37 E-05	4.68 E-05	6.39 E-06	2.23 E-05
Ba-142	2.96 E-06	2.61 E-05	1.47 E-06	1.29 E-05
La-137	1.61 E-02	3.44 E-02	7.81 E-03	1.67 E-02
La-138	8.75 E-01	1.88 E+00	4.25 E-01	9.13 E-01
La-140	5.56 E-04	1.20 E-03	2.64 E-04	5.71 E-04
La-141+D	1.95 E-05	4.38 E-05	9.03 E-06	2.04 E-05
La-142	8.85 E-05	2.24 E-04	4.11 E-05	1.04 E-04
Ce-139	2.25 E-03	4.48 E-03	1.09 E-03	2.18 E-03
Ce-141	8.54 E-04	1.23 E-03	4.05 E-04	5.85 E-04
Ce-142	Ce-144+D	Ce-144+D	Ce-144+D	Ce-144+D
Ce-143+D	1.35 E-04	2.90 E-04	6.31 E-05	1.36 E-04
Ce-144+D	1.30 E-02	2.08 E-02	6.20 E-03	9.86 E-03
Pr-142	7.10 E-05	1.54 E-04	3.28 E-05	7.15 E-05
Pr-142m+D	9.08 E-07	1.94 E-06	4.20 E-07	9.02 E-07
Pr-142m	1.07 E-07	6.39 E-07	5.16 E-08	3.09 E-07
Pr-143	5.18 E-04	5.91 E-04	2.45 E-04	2.78 E-04
Pr-144	8.12 E-07	4.16 E-06	3.90 E-07	2.00 E-06
Pr-144m+D	5.25 E-07	2.05 E-06	2.50 E-07	9.58 E-07
Pr-144m	4.26 E-09	7.20 E-08	2.23 E-09	3.67 E-08
Nd-144	0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00
Nd-147+D	5.60 E-04	8.34 E-04	2.66 E-04	3.96 E-04
Pm-143	7.86 E-03	1.64 E-02	3.81 E-03	8.00 E-03
Pm-144+D	5.28 E-02	1.11 E-01	2.56 E-02	5.42 E-02
Pm-145	1.09 E-02	2.32 E-02	5.31 E-03	1.13 E-02
Pm-146+D	1.24 E-01	2.65 E-01	6.03 E-02	1.29 E-01
Pm-147+D	8.56 E-04	1.31 E-03	3.99 E-04	6.06 E-04
Pm-148	6.87 E-04	1.24 E-03	3.27 E-04	5.90 E-04
Pm-148m+D	9.24 E-03	1.80 E-02	4.47 E-03	8.71 E-03
Pm-149	8.37 E-05	1.76 E-04	3.86 E-05	8.17 E-05
Pm-150	7.27 E-05	1.71 E-04	3.38 E-05	7.98 E-05
Pm-151+D	9.42 E-05	2.04 E-04	4.42 E-05	9.59 E-05
Sm-145+D	2.69 E-03	5.35 E-03	1.30 E-03	2.60 E-03
Sm-146	1.49 E+00	3.06 E+00	6.83 E-01	1.41 E+00
Sm-147	1.34 E+00	2.76 E+00	6.16 E-01	1.27 E+00
Sm-148+D	0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00

Table 4.7. (contd)

Nuclide[a,b]	Effective Release Height <40 m		Effective Release Height ≥40 m	
	mrem/yr per Ci/yr[c]		mrem/yr per Ci/yr[c]	
	400 Area Offsite MEI	400 Area Onsite MEI[d]	400 Area Offsite MEI	400 Area Onsite MEI[d]
Sm-151	6.36 E-04	1.14 E-03	2.94 E-04	5.27 E-04
Sm-153	7.98 E-05	1.70 E-04	3.69 E-05	7.91 E-05
Sm-155+D	1.67 E-06	6.86 E-06	7.93 E-07	3.27 E-06
Sm-156+D	7.53 E-05	1.61 E-04	3.59 E-05	7.71 E-05
Sm-156	3.02 E-05	6.64 E-05	1.40 E-05	3.08 E-05
Sm-157+D	9.81 E-07	7.50 E-06	4.79 E-07	3.74 E-06
Sm-157	4.76 E-07	6.53 E-06	2.44 E-07	3.29 E-06
Eu-150	8.01 E-01	1.72 E+00	3.89 E-01	8.36 E-01
Eu-150m+D	2.52 E-05	5.51 E-05	1.17 E-05	2.56 E-05
Eu-152+D	3.70 E-01	7.92 E-01	1.80 E-01	3.86 E-01
Eu-152m+D	4.57 E-05	1.01 E-04	2.13 E-05	4.70 E-05
Eu-152n+D	6.84 E-06	1.53 E-05	3.28 E-06	7.38 E-06
Eu-152n	1.92 E-06	4.81 E-06	8.93 E-07	2.25 E-06
Eu-154	2.91 E-01	6.21 E-01	1.41 E-01	3.02 E-01
Eu-154m+D	3.96 E-06	9.32 E-06	1.91 E-06	4.49 E-06
Eu-154m	1.05 E-06	3.12 E-06	4.91 E-07	1.47 E-06
Eu-155	9.16 E-03	1.90 E-02	4.43 E-03	9.20 E-03
Eu-156	2.68 E-03	4.65 E-03	1.29 E-03	2.25 E-03
Eu-157	5.80 E-05	1.26 E-04	2.71 E-05	5.93 E-05
Gd-148	1.57 E+00	3.24 E+00	7.22 E-01	1.49 E+00
Gd-149+D	6.49 E-04	1.28 E-03	3.13 E-04	6.15 E-04
Gd-150+D	7.85 E-13	7.69 E-13	3.52 E-13	3.38 E-13
Gd-150	0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00
Gd-151+D	9.89 E-04	1.80 E-03	4.78 E-04	8.76 E-04
Gd-152	1.11 E+00	2.29 E+00	5.11 E-01	1.05 E+00
Gd-153	2.59 E-03	5.06 E-03	1.25 E-03	2.45 E-03
Gd-159	3.56 E-05	7.74 E-05	1.65 E-05	3.59 E-05
Tb-157	2.76 E-03	5.85 E-03	1.34 E-03	2.84 E-03
Tb-158	5.45 E-01	1.17 E+00	2.65 E-01	5.68 E-01
Tb-160	9.27 E-03	1.77 E-02	4.48 E-03	8.58 E-03
Tb-161	2.07 E-04	3.31 E-04	9.68 E-05	1.54 E-04
Dy-159	6.71 E-04	1.27 E-03	3.25 E-04	6.15 E-04
Dy-165	6.73 E-06	1.61 E-05	3.11 E-06	7.45 E-06
Ho-163	0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00
Ho-164	6.00 E-07	2.16 E-06	2.83 E-07	1.02 E-06
Ho-164m+D	1.74 E-06	4.48 E-06	8.07 E-07	2.08 E-06
Ho-164m	1.04 E-06	3.30 E-06	4.85 E-07	1.55 E-06
Ho-166	8.43 E-05	1.82 E-04	3.89 E-05	8.44 E-05
Ho-166m	1.19 E+00	2.54 E+00	5.76 E-01	1.24 E+00
Er-169	1.54 E-04	2.29 E-04	7.21 E-05	1.06 E-04
Er-171+D	4.50 E-05	9.98 E-05	2.10 E-05	4.66 E-05
Tm-168	1.05 E-02	2.25 E-02	5.09 E-03	1.10 E-02
Tm-170	2.17 E-03	2.52 E-03	1.03 E-03	1.19 E-03
Tm-171	3.05 E-04	4.41 E-04	1.44 E-04	2.07 E-04
Yb-164+D	2.46 E-05	6.41 E-05	1.14 E-05	2.99 E-05
Yb-164	1.07 E-06	2.81 E-06	5.01 E-07	1.32 E-06
Yb-165+D	1.12 E-06	7.36 E-06	5.54 E-07	3.63 E-06
Yb-166+D	5.14 E-04	1.09 E-03	2.47 E-04	5.27 E-04
Yb-166	1.00 E-04	2.10 E-04	4.64 E-05	9.78 E-05
Yb-167+D	2.09 E-06	9.31 E-06	1.00 E-06	4.46 E-06
Yb-169	1.51 E-03	2.58 E-03	7.25 E-04	1.25 E-03
Yb-175	9.34 E-05	1.81 E-04	4.35 E-05	8.43 E-05
Yb-177+D	1.31 E-05	3.16 E-05	6.12 E-06	1.47 E-05

Table 4.7. (contd)

Nuclide[a,b]	Effective Release Height <40 m		Effective Release Height ≥40 m	
	mrem/yr per Ci/yr[c]		mrem/yr per Ci/yr[c]	
	400 Area Offsite MEI	400 Area Onsite MEI[d]	400 Area Offsite MEI	400 Area Onsite MEI[d]
Lu-177	1.70 E-04	2.88 E-04	7.94 E-05	1.34 E-04
Lu-177m+D	1.72 E-02	3.40 E-02	8.33 E-03	1.65 E-02
Hf-175	2.60 E-03	5.10 E-03	1.26 E-03	2.47 E-03
Hf-177m	5.60 E-05	1.61 E-04	2.61 E-05	7.54 E-05
Hf-178	n/a	n/a	n/a	n/a
Hf-178m	1.09 E+00	2.33 E+00	5.29 E-01	1.14 E+00
Hf-179m	2.96 E-03	5.43 E-03	1.42 E-03	2.62 E-03
Hf-180m	6.40 E-05	1.44 E-04	2.99 E-05	6.73 E-05
Hf-181	3.14 E-03	5.64 E-03	1.51 E-03	2.72 E-03
Hf-182+D	1.10 E+00	2.35 E+00	5.33 E-01	1.14 E+00
Hf-182	1.92 E-01	4.06 E-01	9.28 E-02	1.97 E-01
Ta-179	1.37 E-03	2.84 E-03	6.64 E-04	1.38 E-03
Ta-180	7.20 E-04	1.59 E-03	3.30 E-04	7.32 E-04
Ta-182	1.49 E-02	3.00 E-02	7.20 E-03	1.45 E-02
Ta-182m+D	3.23 E-06	1.29 E-05	1.56 E-06	6.24 E-06
Ta-182m	1.83 E-06	1.01 E-05	8.82 E-07	4.88 E-06
Ta-183	3.93 E-04	7.46 E-04	1.85 E-04	3.51 E-04
W-181	7.56 E-04	9.15 E-04	3.67 E-04	4.50 E-04
W-185	1.72 E-03	7.74 E-04	8.26 E-04	3.80 E-04
W-185m+D	2.54 E-08	1.20 E-08	1.22 E-08	6.04 E-09
W-185m	6.68 E-14	6.04 E-10	5.70 E-14	4.28 E-10
W-187+D	1.04 E-04	2.25 E-04	4.88 E-05	1.06 E-04
W-188+D	8.56 E-03	5.45 E-03	4.12 E-03	2.68 E-03
W-188	7.57 E-03	3.32 E-03	3.64 E-03	1.64 E-03
Re-186	1.70 E-04	2.96 E-04	7.94 E-05	1.38 E-04
Re-186m+D	6.63 E-02	9.82 E-02	3.22 E-02	4.80 E-02
Re-186m	3.28 E-02	2.63 E-02	1.59 E-02	1.30 E-02
Re-187	4.95 E-05	5.04 E-06	2.41 E-05	3.19 E-06
Re-188	7.16 E-05	1.55 E-04	3.31 E-05	7.18 E-05
Os-185	6.44 E-03	1.30 E-02	3.12 E-03	6.34 E-03
Os-191	4.17 E-04	6.02 E-04	1.98 E-04	2.85 E-04
Ir-189+D	1.96 E-04	3.11 E-04	9.37 E-05	1.49 E-04
Ir-190	2.09 E-03	4.04 E-03	1.01 E-03	1.95 E-03
Ir-192	7.04 E-03	1.33 E-02	3.40 E-03	6.42 E-03
Ir-194	7.52 E-05	1.63 E-04	3.48 E-05	7.59 E-05
Pt-191	1.15 E-04	2.44 E-04	5.49 E-05	1.17 E-04
Pt-193	1.45 E-04	1.68 E-04	7.01 E-05	8.21 E-05
Pt-193m+D	1.03 E-04	2.00 E-04	4.78 E-05	9.23 E-05
Pt-195m	1.44 E-04	2.84 E-04	6.68 E-05	1.32 E-04
Pt-197	3.47 E-05	7.53 E-05	1.60 E-05	3.48 E-05
Pt-197m+D	8.79 E-06	2.11 E-05	4.06 E-06	9.77 E-06
Pt-199+D	4.85 E-06	1.60 E-05	2.28 E-06	7.54 E-06
Au-193+D	2.68 E-05	5.82 E-05	1.26 E-05	2.74 E-05
Au-193m+D	1.64 E-09	3.57 E-09	7.70 E-10	1.68 E-09
Au-193m	0.00 E+00	6.68 E-18	0.00 E+00	5.02 E-18
Au-194	2.08 E-04	4.49 E-04	9.94 E-05	2.15 E-04
Au-195	1.66 E-03	2.93 E-03	8.04 E-04	1.42 E-03
Au-195m+D	3.15 E-09	5.56 E-09	1.52 E-09	2.70 E-09
Au-195m	2.12 E-18	3.83 E-15	1.40 E-18	3.57 E-15
Au-196	2.80 E-04	6.02 E-04	1.36 E-04	2.92 E-04
Au-196m+D	3.26 E-05	7.10 E-05	1.57 E-05	3.41 E-05
Au-196m	1.55 E-05	3.42 E-05	7.34 E-06	1.62 E-05
Au-198	2.08 E-04	4.39 E-04	9.86 E-05	2.08 E-04
Au-198m+D	3.97 E-04	8.47 E-04	1.87 E-04	4.01 E-04

Table 4.7. (contd)

Nuclide[a,b]	Effective Release Height <40 m		Effective Release Height ≥40 m	
	mrem/yr per Ci/yr[c]		mrem/yr per Ci/yr[c]	
	400 Area Offsite MEI	400 Area Onsite MEI[d]	400 Area Offsite MEI	400 Area Onsite MEI[d]
Au-198m	3.07 E-04	6.56 E-04	1.44 E-04	3.08 E-04
Au-199	1.05 E-04	2.17 E-04	4.87 E-05	1.01 E-04
Hg-203	1.73 E-03	2.74 E-03	8.35 E-04	1.32 E-03
Hg-205	2.47 E-09	8.97 E-08	1.38 E-09	4.77 E-08
Hg-206+D	1.68 E-07	2.20 E-06	8.63 E-08	1.10 E-06
Tl-200	1.94 E-04	4.20 E-04	9.25 E-05	2.01 E-04
Tl-201	4.52 E-05	9.41 E-05	2.14 E-05	4.47 E-05
Tl-202	7.15 E-04	1.24 E-03	3.46 E-04	6.05 E-04
Tl-204	7.84 E-03	4.83 E-03	3.79 E-03	2.40 E-03
Tl-206	4.66 E-10	3.21 E-08	2.75 E-10	1.77 E-08
Tl-206m	5.61 E-08	5.79 E-06	3.43 E-08	3.24 E-06
Tl-207+D	1.16 E-09	5.35 E-08	6.58 E-10	2.88 E-08
Tl-208	1.82 E-08	4.15 E-06	1.19 E-08	2.43 E-06
Tl-209+D	5.78 E-08	6.04 E-07	2.67 E-08	3.64 E-07
Tl-210+D	8.71 E-08	5.78 E-08	4.19 E-08	3.29 E-08
Pb-203	9.24 E-05	1.98 E-04	4.40 E-05	9.46 E-05
Pb-204m	5.66 E-05	1.52 E-04	2.63 E-05	7.09 E-05
Pb-205	4.44 E-04	4.03 E-04	2.15 E-04	1.99 E-04
Pb-209	5.13 E-06	1.19 E-05	2.36 E-06	5.48 E-06
Pb-210+D	7.83 E-01	3.73 E-01	3.77 E-01	1.84 E-01
Pb-210	7.67 E-01	3.40 E-01	3.69 E-01	1.68 E-01
Pb-211+D	5.79 E-04	1.88 E-03	2.71 E-04	8.85 E-04
Pb-212+D	1.72 E-02	3.64 E-02	7.85 E-03	1.67 E-02
Pb-214+D	1.08 E-03	2.93 E-03	5.02 E-04	1.36 E-03
Pb-214	4.58 E-04	1.72 E-03	2.16 E-04	8.13 E-04
Bi-207	7.56 E-01	1.62 E+00	3.67 E-01	7.87 E-01
Bi-208	1.71 E+00	3.66 E+00	8.29 E-01	1.78 E+00
Bi-210+D	9.77 E-03	2.08 E-02	4.48 E-03	9.53 E-03
Bi-210	9.68 E-03	2.07 E-02	4.44 E-03	9.50 E-03
Bi-210m+D	6.48 E-01	1.28 E+00	3.05 E-01	6.05 E-01
Bi-211+D	9.43 E-10	5.08 E-08	5.37 E-10	2.81 E-08
Bi-211	6.54 E-12	9.03 E-09	4.99 E-12	5.82 E-09
Bi-212+D	1.92 E-03	5.28 E-03	8.89 E-04	2.45 E-03
Bi-212n+D	7.30 E-08	1.30 E-06	3.82 E-08	6.66 E-07
Bi-212n	6.26 E-09	1.12 E-07	3.30 E-09	5.74 E-08
Bi-213+D	1.58 E-03	4.71 E-03	7.35 E-04	2.20 E-03
Bi-214+D	3.63 E-04	1.65 E-03	1.72 E-04	7.87 E-04
Po-208+D	1.89 E-06	4.05 E-06	9.17 E-07	1.97 E-06
Po-209+D	3.88 E-03	8.34 E-03	1.89 E-03	4.06 E-03
Po-210	6.01 E-01	7.41 E-01	2.82 E-01	3.46 E-01
Po-211	0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00
Po-212	0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00
Po-212m	1.58 E-18	1.10 E-12	1.19 E-18	9.63 E-13
Po-213+D	0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00
Po-214+D	1.83 E-13	8.64 E-14	8.79 E-14	4.25 E-14
Po-215+D	4.77 E-10	1.55 E-09	2.22 E-10	7.27 E-10
Po-215	5.33 E-27	1.14 E-26	2.59 E-27	5.57 E-27
Po-216+D	6.46 E-08	1.37 E-07	2.96 E-08	6.31 E-08
Po-216	2.19 E-33	1.93 E-29	2.13 E-33	1.93 E-29
Po-218+D	1.33 E-04	1.02 E+01	6.15 E-05	4.67 E+00
Po-218	3.16 E-16	6.87 E-14	2.07 E-16	4.01 E-14
At-217+D	1.86 E-08	5.56 E-08	8.68 E-09	2.60 E-08
At-217	0.00 E+00	2.04 E-29	0.00 E+00	1.57 E-29
At-218+D	4.54 E-07	2.08 E-06	2.16 E-07	9.89 E-07

Table 4.7. (contd)

Nuclide[a,b]	Effective Release Height <40 m		Effective Release Height ≥40 m	
	mrem/yr per Ci/yr[c]		mrem/yr per Ci/yr[c]	
	400 Area Offsite MEI	400 Area Onsite MEI[d]	400 Area Offsite MEI	400 Area Onsite MEI[d]
At-218	5.84 E-27	8.52 E-24	3.91 E-27	6.10 E-24
Rn-218+D	3.91 E-11	1.86 E-11	1.88 E-11	9.19 E-12
Rn-218	3.47 E-29	1.23 E-28	1.38 E-29	1.66 E-29
Rn-219+D	1.06 E-06	3.46 E-06	4.96 E-07	1.62 E-06
Rn-219	1.89 E-17	9.39 E-17	9.21 E-18	4.57 E-17
Rn-220+D	2.49 E-05	5.28 E-05	1.14 E-05	2.42 E-05
Rn-220	1.52 E-19	1.15 E-13	1.24 E-19	9.42 E-14
Rn-222+D	1.26 E-03	1.15 E-03	5.64 E-04	4.95 E-04
Rn-222	1.62 E-08	3.24 E-08	6.73 E-09	1.42 E-08
Rn-224+D	5.99 E-03	1.28 E-02	2.75 E-03	5.88 E-03
Fr-221+D	1.89 E-04	5.17 E-04	8.78 E-05	2.37 E-04
Fr-221	3.50 E-09	1.50 E-07	1.98 E-09	8.03 E-08
Fr-222+D	3.56 E-04	2.19 E-03	1.72 E-04	1.06 E-03
Fr-223+D	1.02 E-03	2.19 E-03	4.69 E-04	1.01 E-03
Fr-223	2.86 E-04	1.22 E-03	1.36 E-04	5.78 E-04
Ra-223+D	7.59 E-01	1.59 E+00	3.48 E-01	7.31 E-01
Ra-224+D	2.95 E-01	6.30 E-01	1.36 E-01	2.90 E-01
Ra-225+D	6.62 E-01	1.36 E+00	3.04 E-01	6.28 E-01
Ra-226+D	2.22 E+00	3.59 E+00	1.07 E+00	1.74 E+00
Ra-227+D	3.94 E-05	8.62 E-05	1.81 E-05	3.98 E-05
Ra-228+D	1.60 E+00	1.59 E+00	7.68 E-01	7.71 E-01
Ac-225+D	7.44 E-01	1.58 E+00	3.41 E-01	7.28 E-01
Ac-226+D	1.15 E-01	2.46 E-01	5.26 E-02	1.13 E-01
Ac-227+D	9.99 E+00	2.09 E+01	4.59 E+00	9.63 E+00
Ac-228+D	1.48 E-03	3.14 E-03	6.77 E-04	1.45 E-03
Th-227+D	1.05 E+00	2.25 E+00	4.84 E-01	1.04 E+00
Th-228+D	4.73 E+00	1.00 E+01	2.17 E+00	4.61 E+00
Th-229+D	1.00 E+01	2.07 E+01	4.60 E+00	9.51 E+00
Th-230+D	1.99 E+00	3.93 E+00	9.16 E-01	1.81 E+00
Th-231+D	3.50 E-05	7.57 E-05	1.61 E-05	3.49 E-05
Th-232+D	4.78 E+00	9.90 E+00	2.23 E+00	4.63 E+00
Th-233+D	1.025 E-06	2.71 E-06	4.87 E-07	1.30 E-06
Th-233	4.40 E-07	1.85 E-06	2.09 E-07	8.83 E-07
Th-234+D	2.37 E-03	2.68 E-03	1.13 E-03	1.27 E-03
Th-234	2.10 E-03	2.11 E-03	9.96 E-04	9.96 E-04
Pa-231+D	1.32 E+01	2.73 E+01	6.04 E+00	1.26 E+01
Pa-232m+D	2.87 E-04	6.20 E-04	1.37 E-04	2.94 E-04
Pa-232	2.45 E-04	5.30 E-04	1.16 E-04	2.50 E-04
Pa-233+D	1.21 E-03	1.93 E-03	5.77 E-04	9.24 E-04
Pa-234+D	1.24 E-04	2.76 E-04	5.80 E-05	1.29 E-04
Pa-234m+D	5.86 E-10	1.37 E-09	2.74 E-10	6.62 E-10
U-232+D	2.04 E+00	3.71 E+00	9.62 E-01	1.76 E+00
U-233+D	4.29 E-01	8.19 E-01	1.97 E-01	3.77 E-01
U-234+D	4.18 E-01	8.00 E-01	1.93 E-01	3.69 E-01
U-235+D	5.01 E-01	9.83 E-01	2.34 E-01	4.61 E-01
U-235m+D	2.63 E-14	3.93 E-14	1.23 E-14	1.83 E-14
U-235m	0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00
U-236+D	3.87 E-01	7.39 E-01	1.78 E-01	3.40 E-01
U-237+D	3.09 E-04	5.48 E-04	1.46 E-04	2.58 E-04
U-238+D	4.43 E-01	8.64 E-01	2.07 E-01	4.04 E-01
U-239+D	2.02 E-06	6.34 E-06	9.49 E-07	3.00 E-06
U-239	1.26 E-06	5.14 E-06	5.98 E-07	2.44 E-06
U-240+D	9.00 E-05	1.92 E-04	4.19 E-05	8.96 E-05

Table 4.7. (contd)

Nuclide[a,b]	Effective Release Height <40 m		Effective Release Height ≥40 m	
	mrem/yr per Ci/yr[c]		mrem/yr per Ci/yr[c]	
	400 Area Offsite MEI	400 Area Onsite MEI[d]	400 Area Offsite MEI	400 Area Onsite MEI[d]
U-240	5.75 E-05	1.25 E-04	2.64 E-05	5.76 E-05
Np-235	1.78 E-04	2.93 E-04	8.51 E-05	1.40 E-04
Np-236+D	5.68 E-01	1.17 E+00	2.64 E-01	5.46 E-01
Np-236m+D	6.77 E-04	1.44 E-03	3.10 E-04	6.62 E-04
Np-237+D	3.28 E+00	6.74 E+00	1.51 E+00	3.11 E+00
Np-238+D	4.03 E-04	8.62 E-04	1.88 E-04	4.03 E-04
Np-239+D	1.40 E-04	2.98 E-04	6.55 E-05	1.39 E-04
Np-240+D	3.28 E-05	8.97 E-05	1.53 E-05	4.19 E-05
Np-240m+D	2.71 E-07	4.27 E-06	1.40 E-07	2.17 E-06
Pu-234+D	2.06 E-03	4.45 E-03	9.47 E-04	2.05 E-03
Pu-235+D	4.89 E-01	9.58 E-01	2.28 E-01	4.48 E-01
Pu-236+D	2.60 E+00	5.44 E+00	1.19 E+00	2.50 E+00
Pu-237+D	2.76 E-04	4.92 E-04	1.33 E-04	2.38 E-04
Pu-238+D	6.28 E+00	1.31 E+01	2.88 E+00	6.03 E+00
Pu-239+D	6.85 E+00	1.43 E+01	3.14 E+00	6.57 E+00
Pu-240+D	6.85 E+00	1.43 E+01	3.14 E+00	6.57 E+00
Pu-241+D	1.28 E-01	2.62 E-01	5.88 E-02	1.20 E-01
Pu-242+D	6.50 E+00	1.35 E+01	2.98 E+00	6.24 E+00
Pu-243+D	9.03 E-06	2.03 E-05	4.16 E-06	9.38 E-06
Pu-244+D	6.71 E+00	1.40 E+01	3.09 E+00	6.47 E+00
Am-240+D	2.82 E-04	6.06 E-04	1.34 E-04	2.90 E-04
Am-241+D	5.67 E+00	1.18 E+01	2.60 E+00	5.45 E+00
Am-242+D	1.89 E-03	4.04 E-03	8.65 E-04	1.86 E-03
Am-242m+D	5.13 E+00	1.07 E+01	2.36 E+00	4.92 E+00
Am-243+D	5.76 E+00	1.20 E+01	2.65 E+00	5.54 E+00
Am-244+D	3.09 E-04	6.67 E-04	1.43 E-04	3.09 E-04
Am-244m+D	1.03 E-05	2.29 E-05	4.73 E-06	1.06 E-05
Am-244m	3.86 E-06	1.48 E-05	1.82 E-06	6.99 E-06
Am-245+D	5.65 E-06	1.36 E-05	2.62 E-06	6.34 E-06
Am-246+D	1.72 E-05	5.43 E-05	8.06 E-06	2.55 E-05
Cm-241+D	5.93 E-03	1.19 E-02	2.76 E-03	5.58 E-03
Cm-242+D	5.72 E-01	1.21 E+00	2.62 E-01	5.55 E-01
Cm-243+D	4.28 E+00	8.95 E+00	1.97 E+00	4.12 E+00
Cm-244+D	3.54 E+00	7.40 E+00	1.62 E+00	3.40 E+00
Cm-245+D	5.83 E+00	1.22 E+01	2.68 E+00	5.60 E+00
Cm-246+D	5.74 E+00	1.20 E+01	2.63 E+00	5.51 E+00
Cm-247+D	5.49 E+00	1.14 E+01	2.53 E+00	5.30 E+00
Cm-248+D	2.14 E+01	4.47 E+01	9.87 E+00	2.06 E+01
Cm-249+D	4.24 E-06	9.68 E-06	1.95 E-06	4.47 E-06
Cm-250+D	1.26 E+02	2.64 E+02	5.82 E+01	1.22 E+02
Bk-247+D	9.58 E+00	2.00 E+01	4.40 E+00	9.20 E+00
Bk-248m+D	5.06 E-05	5.90 E-05	2.29 E-05	2.65 E-05
Bk-248m	7.21 E-06	1.56 E-05	3.45 E-06	7.51 E-06
Bk-249+D	2.30 E-02	4.78 E-02	1.06 E-02	2.20 E-02
Bk-250+D	1.71 E-04	3.72 E-04	7.83 E-05	1.72 E-04
Cf-249+D	9.79 E+00	2.04 E+01	4.50 E+00	9.41 E+00
Cf-250+D	4.55 E+00	9.51 E+00	2.09 E+00	4.38 E+00
Cf-251+D	9.81 E+00	2.04 E+01	4.50 E+00	9.41 E+00
Cf-252+D	2.60 E+00	5.42 E+00	1.19 E+00	2.50 E+00
Es-254+D	1.04 E+00	2.19 E+00	4.77 E-01	1.01 E+00

Table 4.7. (contd)

Nuclide[a,b]	Effective Release Height <40 m		Effective Release Height ≥40 m	
	mrem/yr per Ci/yr[c]		mrem/yr per Ci/yr[c]	
	400 Area Offsite MEI	400 Area Onsite MEI[d]	400 Area Offsite MEI	400 Area Onsite MEI[d]

MEI = Maximally exposed individual
Bold nuclides are newly available in CAP88-PC version 4.
n/a = nuclide or indicated solubility class is not available in CAP88-PC version 4.
(a) +D indicates that the listed radionuclide dose includes the contribution from the parent radionuclide plus decay products grown in during transit and the build-up period.
(b) If the *nuclide+D* is followed by the nuclide without the +D, the decay chain members contribute greater than 10% of the *nuclide+D* dose. V = vapor; E = elemental; O = organic compounds; F = particulate, fast clearance rate; M = particulate, moderate clearance rate; S = particulate, slow clearance rate. Carbon isotopes are modeled as particulate (M), carbon monoxide (CO), or carbon dioxide (CO2).
(c) If a radionuclide is indicated rather than a dose factor value, the nuclide is used as a surrogate. See Table 3.4 for additional details.
(d) Onsite MEI assumed to occupy the onsite location for the maximum possible 8,766 hr in a year.

5.0 IODIN E-SPECIFIC ASSESSMENTS

If iodine emissions are a significant source of dose to the Offsite MEI, the receptor location may require reevaluation. Particulate iodine deposition rates in the CAP88-PCv4 model are greater than those of other particulates. Therefore, site-specific meteorological evaluation of iodines indicates that the MEI iodine dose is greatest at a location closer to, and generally in a different direction from, the MEI location based on other particulates or gases. The following procedure is appropriate for emission units with significant iodine emissions from a 100-K ≥40-m emission unit; a 200 East ≥40-m emission unit; and a 200 West <40-m or ≥40-m emission unit. **No special procedure is required for:**

- Offsite MEI dose
  - <40-m emission unit in the 100-K, 200-E, 300, or 400 Areas
  - ≥40-m emission units in the 300 or 400 Areas
- Onsite MEI dose
  - Any emission unit in the 100-K, 200-E, 200-W, 300, or 400 Areas.

When determining the Offsite MEI PTE dose for an emission unit with radioiodine emissions for a <40-m emission unit in the 200-W Area or a ≥40-m emission unit in the 100-K, 200-E, or 200-W Area, calculate the iodine dose using the tables in this section (see Table 5.1 through Table 5.3). If the Offsite iodine MEI dose result is greater than 5% of the PTE dose based on tables in Section 4.0 for all nuclide emissions and the dose is within an order of magnitude of 0.1 mrem/yr, then the analyst has the option of adding the Section 5.0 Offsite iodine MEI doses to the Section 4.0 non-iodine dose results OR performing a CAP88-PCv4 evaluation at the iodine-specific offsite receptor location. If the PTE result is well below regulatory limits, dose results from Section 4.0 may be used. For ease of comparison, the Section 4.0 iodine dose factor results are repeated in Section 5.0 tables.

Iodine is modeled as solubility type F (fast) or V (vapor). Vapor iodine is an immediately soluble form, in accordance with ICRP Publication 66 class SR-2 (ICRP 1994). CAP88-PCv4 results indicate inhalation and external pathway doses for iodine type V, with zero deposition and therefore zero ingestion pathway doses.[2] Section 2.7.1 of Ramsdell et al. (1994) provides information on vapor iodine assumptions.

[2] In contrast to iodine vapor, tritium vapor (H-3 water vapor) is assumed for many conservative (overestimating) dose assumptions. The tritium vapor dose modeling uses a specific activity equivalence food model for the ingestion pathway. As a result, tritium vapor models include inhalation, external, and ingestion pathway doses; iodine vapor models do not include an ingestion pathway in CAP88-PC V4.0.1.17.

Table 5.1. **Iodines 100-K Area**: Offsite MEIs CAP88-PC Iodine Dose-per-Unit-Release Factors (mrem/Ci) by Effective Release Height with Iodine MEI

Nuclide	100-K <40-m Offsite MEI 20300m E	100-K <40-m Onsite MEI	100-K ≥40-m Offsite MEI (from Table 4.3) 20300m E	100-K ≥40-m Offsite Iodine MEI 8900m NNW	100-K <40-m Onsite MEI
			mrem/yr per Ci/yr	mrem/yr per Ci/yr	
I-122	See Table 4.3	<blank>	1.54 E-16	**3.44 E-14**	<blank>
I-123+D			5.26 E-06	**7.54 E-06**	
I-124			8.86 E-04	**1.21 E-03**	
I-125			2.81 E-02	**3.82 E-02**	
I-126			9.94 E-03	**1.36 E-02**	
I-128			7.20 E-09	**2.88 E-08**	
I-129			6.46 E-01	**8.80 E-01**	
I-130			6.36 E-05	**9.14 E-05**	
I-130m+D			6.44 E-07	**9.26 E-07**	
I-130m			8.79 E-12	**1.33 E-10**	
I-131+D			3.77 E-03	**5.16 E-03**	
I-132			7.73 E-06	**1.38 E-05**	
I-132m+D			6.38 E-06	**1.03 E-05**	
I-132m			5.50 E-07	**1.14 E-06**	
I-133+D			4.73 E-05	**6.66 E-05**	
I-133m			I-133+D	I-133+D	
I-134			1.39 E-06	**3.48 E-06**	
I-134m+D			9.98 E-08	**2.50 E-07**	
I-134m			3.48 E-17	**8.04 E-15**	
I-135+D			2.75 E-05	**4.06 E-05**	
I-135			2.22 E-05	**3.34 E-05**	
I-122(V)	See Table 4.3	<blank>	n/a	n/a	<blank>
I-123(V)+D			**9.77 E-06**	8.25 E-06	
I-124(V)			**5.31 E-04**	4.27 E-04	
I-125(V)			**6.22 E-04**	4.96 E-04	
I-126(V)			**1.17 E-03**	9.39 E-04	
I-128(V)			6.65 E-08	**1.99 E-07**	
I-129(V)			**4.28 E-03**	3.41 E-03	
I-130(V)			**9.35 E-05**	7.93 E-05	
I-130m(V)+D			n/a	n/a	
I-130m(V)			n/a	n/a	
I-131(V)+D			**8.80 E-04**	7.04 E-04	
I-132(V)			1.84 E-05	**2.01 E-05**	
I-132m(V)+D			7.70 E-06	**1.01 E-05**	
I-132m(V)			3.85 E-06	**5.05 E-06**	
I-133(V)+D			**1.69 E-04**	1.40 E-04	
I-133m			I-133(V)+D	I-133(V)+D	
I-134(V)			5.02 E-06	**8.41 E-06**	
I-134m(V)			n/a	n/a	
I-135(V)+D			**4.71 E-05**	4.19 E-05	
135(V)			n/a	n/a	

n/a = no vapor form (V) is available in the CAP88-PC V4 model.
A "-" means that the parent-only dose contributes more than 90% of the parent+progeny dose; therefore, there is no need to list the parent-only dose separately.
Bold font is the maximum dose factor for the nuclide form considering all receptors evaluated.

Table 5.2. **Iodines 200 East Area**: Offsite and Onsite MEIs CAP88-PC Iodine Dose-per-Unit-Release Factors (mrem/Ci) by Effective Release Height with Iodine MEI

Nuclide	200-E <40-m Offsite MEI 19350m ESE	200-E <40-m Onsite MEI EnergyNW 16650m ESE	200-E ≥40-m Offsite MEI (from Table 4.4) 19350m ESE	200-E ≥40-m Offsite Iodine MEI 14350m E	200-E ≥40-m Onsite MEI (from Table 4.4) 16650m ESE
			mrem/yr per Ci/yr	mrem/yr per Ci/yr	mrem/yr per Ci/yr
I-122			3.44 E-14	1.29 E-13	**5.37 E-13**
I-123+D			9.02 E-06	9.70 E-06	**1.31 E-05**
I-124	See	See	1.46 E-03	**1.56 E-03**	7.27 E-04
I-125			4.59 E-02	**4.89 E-02**	1.01 E-03
I-126	Table 4.4	Table 4.4	1.63 E-02	**1.74 E-02**	1.18 E-03
I-128			3.12 E-08	4.28 E-08	**6.68 E-08**
I-129			1.06 E+00	**1.13 E+00**	3.94 E-02
I-130			1.09 E-04	1.18 E-04	**1.61 E-04**
I-130m+D			1.11 E-06	1.19 E-06	**1.63 E-06**
I-130m			1.35 E-10	2.56 E-10	**5.44 E-10**
I-131+D			6.20 E-03	**6.61 E-03**	6.17 E-04
I-132			1.62 E-05	1.81 E-05	**2.54 E-05**
I-132m+D			1.22 E-05	1.33 E-05	**1.86 E-05**
I-132m			1.32 E-06	1.53 E-06	**2.17 E-06**
I-133+D			7.98 E-05	8.55 E-05	9.95 E-05
I-133m			I-133+D	I-133+D	I-133+D
I-134			3.96 E-06	4.80 E-06	**6.97 E-06**
I-134m+D			2.85 E-07	3.45 E-07	**5.01 E-07**
I-134m			8.03 E-15	3.06 E-14	**1.28 E-13**
I-135+D			4.83 E-05	5.23 E-05	**7.21 E-05**
I-135			3.98 E-05	4.32 E-05	**5.97 E-05**
I-122(V)			n/a	n/a	n/a
I-123(V)+D			9.27 E-06	8.68 E-06	**1.10 E-05**
I-124(V)	See	See	4.82 E-04	4.47 E-04	**5.84 E-04**
I-125(V)			5.61 E-04	5.20 E-04	**1.33 E-03**
I-126(V)	Table 4.4	Table 4.4	1.06 E-03	9.84 E-04	**1.50 E-03**
I-128(V)			1.90 E-07	2.35 E-07	**3.33 E-07**
I-129(V)			3.86 E-03	3.58 E-03	**1.92 E-02**
I-130(V)			8.90 E-05	8.34 E-05	**1.06 E-04**
I-130m(V)+D			n/a	n/a	n/a
I-130m(V)			n/a	n/a	n/a
I-131(V)+D			7.96 E-04	7.38 E-04	**9.36 E-04**
I-132(V)			2.19 E-05	2.15 E-05	**2.77 E-05**
I-132m(V)+D			1.15 E-05	1.18 E-05	**1.57 E-05**
I-132m(V)			5.37 E-06	5.47 E-06	**7.14 E-06**
I-133(V)+D			1.57 E-04	1.47 E-04	**1.86 E-04**
I-133m			I-133(V)+D	I-133(V)+D	I-133(V)+D
I-134(V)			8.67 E-06	4.80 E-06	**1.24 E-05**
I-134m(V)			n/a	n/a	n/a
I-135(V)+D			4.67 E-05	4.43 E-05	**5.64 E-05**
135(V)			-	-	-

n/a = no vapor form (V) is available in the CAP88-PC V4 model.
A "-" means that the parent-only dose contributes more than 90% of the parent+progeny dose; therefore, there is no need to list the parent-only dose separately.
Bold font is the maximum dose factor considering all receptors evaluated.

Table 5.3. **Iodines 200 West Area**: Offsite and Onsite MEIs CAP88-PC Iodine Dose-per-Unit-Release Factors (mrem/Ci) by Effective Release Height with Iodine MEI

Nuclide	200-W <40-m Offsite MEI (from Table 4.5) 22000m SE	200-W <40-m Offsite Iodine MEI 12650m S	200-W <40-m Onsite MEI (from Table 4.5) 18520m ESE	200-W ≥40-m Offsite MEI (from Table 4.5) 22000m SE	200-W ≥40-m Offsite Iodine MEI 12650m S	200-W ≥40-m Onsite MEI (from Table 4.5) 18520m ESE
	mrem/yr per Ci/yr	mrem/yr per Ci/yr	mrem/yr per Ci/yr	mrem/yr per Ci/yr	mrem/yr per Ci/yr	mrem/yr per Ci/yr
I-122	6.27 E-15	**9.45 E-15**	3.78 E-16	6.56 E-15	**1.03 E-14**	4.06 E-16
I-123+D	1.13 E-06	**1.57 E-06**	1.33 E-06	2.80 E-06	3.94 E-06	**5.16 E-06**
I-124	1.85 E-04	**2.55 E-04**	8.50 E-05	4.80 E-04	**6.55 E-04**	3.13 E-04
I-125	5.84 E-03	**8.05 E-03**	4.61 E-04	1.53 E-02	**2.07 E-02**	8.24 E-04
I-126	2.07 E-03	**2.86 E-03**	2.58 E-04	5.40 E-03	**7.34 E-03**	6.47 E-04
I-128	2.66 E-09	**5.08 E-09**	2.23 E-09	3.62 E-09	**7.62 E-09**	5.05 E-09
I-129	1.35 E-01	**1.85 E-01**	1.19 E-02	3.52 E-01	**4.77 E-01**	2.53 E-02
I-130	1.36 E-05	**1.91 E-05**	1.62 E-05	3.37 E-05	4.77 E-05	**6.27 E-05**
I-130m+D	1.38 E-07	**1.93 E-07**	1.64 E-07	3.42 E-07	4.83 E-07	**6.36 E-07**
I-130m	1.15 E-11	**2.42 E-11**	3.38 E-12	1.26 E-11	**2.82 E-11**	5.11 E-12
I-131+D	7.88 E-04	**1.09 E-03**	1.16 E-04	2.05 E-03	**2.79 E-03**	3.16 E-04
I-132	1.85 E-06	**2.76 E-06**	2.15 E-06	3.78 E-06	6.16 E-06	**7.33 E-06**
I-132m+D	1.46 E-06	**2.10 E-06**	1.73 E-06	3.18 E-06	4.97 E-06	**6.22 E-06**
I-132m	1.42 E-07	**2.22 E-07**	1.60 E-07	2.59 E-07	4.57 E-07	**4.99 E-07**
I-133+D	1.00 E-05	**1.39 E-05**	1.03 E-05	2.53 E-05	3.53 E-05	**4.01 E-05**
I-133m	I-133+D	I-133+D	I-133+D	I-133+D	I-133+D	I-133+D
I-134	3.95 E-07	**6.56 E-07**	4.18 E-07	6.43 E-07	**1.22 E-06**	1.17 E-06
I-134m+D	2.84 E-08	**4.72 E-08**	3.01 E-08	4.62 E-08	**8.76 E-08**	8.42 E-08
I-134m	1.48 E-15	**2.22 E-15**	8.76 E-17	1.55 E-15	**2.42 E-15**	9.40 E-17
I-135+D	7.74 E-06	9.48 E-06	**9.54 E-06**	1.47 E-05	2.08 E-05	**2.74 E-05**
I-135	4.87 E-06	**6.90 E-06**	5.80 E-06	1.15 E-05	1.69 E-05	**2.19 E-05**
I-122(V)	n/a	n/a	n/a	n/a	n/a	n/a
I-123(V)+D	1.50 E-05	1.10 E-05	**2.22 E-05**	8.01 E-06	6.15 E-06	**1.15 E-05**
I-124(V)	8.67 E-04	5.98 E-04	**1.24 E-03**	4.50 E-04	3.32 E-04	**6.47 E-04**
I-125(V)	1.02 E-03	7.01 E-04	**1.87 E-03**	5.30 E-04	3.88 E-04	**1.42 E-03**
I-126(V)	1.93 E-03	1.32 E-03	**2.88 E-03**	1.00 E-03	7.33 E-04	**1.65 E-03**
I-128(V)	2.68 E-08	5.43 E-08	**7.40 E-08**	2.41 E-08	4.31 E-08	**5.73 E-08**
I-129(V)	7.05 E-03	4.82 E-03	**1.92 E-02**	3.65 E-03	2.67 E-03	**2.00 E-02**
I-130(V)	1.43 E-04	1.05 E-04	**2.12 E-04**	7.64 E-05	5.89 E-05	**1.10 E-04**
I-130m(V)+D	n/a	n/a	n/a	n/a	n/a	n/a
I-130m(V)	n/a	n/a	n/a	n/a	n/a	n/a
I-131(V)+D	1.44 E-03	9.92 E-04	**2.03 E-03**	7.48 E-04	5.49 E-04	**1.04 E-03**
I-132(V)	2.09 E-05	2.01 E-05	**3.75 E-05**	1.27 E-05	1.20 E-05	**2.10 E-05**
I-132m(V)+D	4.29 E-06	5.14 E-06	**8.15 E-06**	4.31 E-06	5.39 E-06	**8.17 E-06**
I-132m(V)	3.49 E-06	4.06 E-06	**7.16 E-06**	2.33 E-06	2.54 E-06	**4.25 E-06**
I-133(V)+D	2.66 E-04	1.90 E-04	**3.86 E-04**	1.40 E-04	1.06 E-04	**2.00 E-04**
I-133m	I-133(V)+D	I-133(V)+D	I-133(V)+D	I-133(V)+D	I-133(V)+D	I-133(V)+D
I-134(V)	3.44 E-06	4.98 E-06	**8.15 E-06**	2.57 E-06	3.33 E-06	**5.24 E-06**
I-134m(V)	n/a	n/a	n/a	n/a	n/a	n/a
I-135(V)+D	6.80 E-05	5.26 E-05	**1.05 E-04**	3.72 E-05	2.99 E-05	**5.52 E-05**
135(V)	-	-	-	-	-	-

n/a = no vapor form (V) is available in the CAP88-PC V4 model.
A "-" means that the parent-only dose contributes more than 90% of the parent+progeny dose; therefore, there is no need to list the parent-only dose separately.
Bold font is the maximum dose factor considering all receptors evaluated.

6.0 QUALITY ASSURANCE: POTENTIAL-TO-EMIT DETERMINATION AND PEER REVIEW

This section discusses quality assurance (QA) aspects of determining PTEs, as well as providing an example format for documenting the recommended peer review of any PTE determination.

A PTE determination must be sufficiently detailed in its documentation to withstand not only peer review by a subject matter expert, but also an assessment by an outside inspector or auditor. Performing a PTE determination, which includes the peer review, should involve the equivalent of a facility design authority, a facility environmental compliance officer, and a regulatory subject matter expert.

Hanford Site prime contractors must follow the DOE QA criteria of 10 CFR Part 830.120, among which are general requirements pertinent to accurately determining PTE values. In addition to the foundational QA requirement that a DOE contractor is to have a QA program (see §830.121) and also a management program (see §830.122(a)) to implement QA requirements, several other criteria in 10 CFR 830.120 may apply to ensure the accuracy of PTE determinations (**Note:** Whereas the criteria wording may not specifically address PTEs, the principles inherent in them apply to the accurate determination of PTEs by organizational processes that assure, or safeguard, that accuracy.):

- **§830.122(b) Criterion 2 – Management/Personnel Training and Qualification**
  - (1) Train and qualify personnel to be capable of performing their assigned work.
- **§830.122(d) Criterion 4 – Management/Documents and Records**
  - (1) Prepare, review, approve, issue, use, and revise documents to prescribe processes, specify requirements, or establish design.
- **§830.122(f) Criterion 6 – Performance/Design**
  - (1) Design items and processes using sound engineering/scientific principles and appropriate standards.
  - (4) Verify and validate the adequacy of design products using individuals or groups other than those who performed the work.

Furthermore, as applicable, DOE contractors at the Hanford Site are subject to the regulations of WAC 246-247, "Radiation Protection — Air Emissions." With respect to contractor QA programs, the following applies from WAC 246-247-075(6):

> "Licensed facilities shall conduct and document a quality assurance program…[that]…shall be compatible with applicable national standards such as ANSI/ASME NQA-1-1988, ANSI/ASME NQA-2-1986, QA/R-2, and QA/R-5."

Each contractor is accountable for demonstrating compliance with the WAC regulation.

Peer-reviewing PTE determinations is an important part of the QA process to ensure that the PTE value has been calculated in a technically sound and defensible manner. An example of a format for documenting the peer review of a PTE determination follows. It may be modified to suit the user's

needs and preferences. Regardless of the contractor's choice of a peer-review style, keep in mind that 1) the individual(s) who perform the review need to be qualified and 2) that their documented reviews sufficiently address the essential components of the PTE determination (i.e., description of the approved method used to determine PTE, accuracy of calculations, radionuclide inventory assumptions and/or measurements, and, as applicable, facility pollution abatement equipment in use for the relevant emission source).

POTENTIAL-TO-EMIT PEER-REVIEW CHECKLIST

Source of PTE Factors: *Calculating Potential-to-Emit Radiological Releases and Doses* (DOE/RL-2006-29, Revision 2)

PTE Application: _____
Description of application (e.g., Notice of Construction or stack determination)

Yes	No	N/A	
[ ]	[ ]	[ ]	Assumptions and/or factors explicitly stated and supported, which include approved potential-to-emit method used, radionuclide inventory, and, as applicable, pollution abatement equipment in use.
[ ]	[ ]	[ ]	Decontamination factors, dose factors, release fractions, and/or similar emission reduction factors accurately used in calculations and technically sound.
[ ]	[ ]	[ ]	Applicable pollution abatement equipment accounted for in calculations.
[ ]	[ ]	[ ]	Sources of data used in calculations are identified.
[ ]	[ ]	[ ]	Mathematical formulas and calculations are accurate.
[ ]	[ ]	[ ]	Hand calculations (including spreadsheets) checked for errors.
[ ]	[ ]	[ ]	Sufficient documentation is available to support all essential aspects of the potential-to-emit determination.
[ ]	[ ]		**Document approved by**: _____ Name (printed)

Approval Signature: _____ Date: _____

7.0 DOSE FACTOR PEER REVIEW CHECKLISTS

This section provides the peer-review documentation for performing the dose-per-unit-release calculations whose results are presented in Tables 4.3 through 4.7 and Tables 5.1 through 5.3.

PEER-REVIEW CHECKLIST (Template)

Document Reviewed: *Calculating Potential-to-Emit Radiological Releases and Doses* (DOE/RL-2006-29, Revision 2)
Scope of Review: Use of CAP88-PC to Generate Dose-per-Unit-Release Factors

Yes	No	N/A	
[ ]	[ ]	[ ]	Necessary assumptions explicitly stated and supported.
[ ]	[ ]	[ ]	Computer codes and data files identified in document.
[ ]	[ ]	[ ]	Data used in calculations explicitly stated in document.
[ ]	[ ]	[ ]	Data checked for consistency with original source information as applicable.
[ ]	[ ]	[ ]	Mathematical derivations checked, including dimensional consistency of results.
[ ]	[ ]	[ ]	Models appropriate and used within range of validity or use outside range of established validity justified.
[ ]	[ ]	[ ]	Hand calculations (including spreadsheets) checked for errors.
[ ]	[ ]	[ ]	Software input correct and consistent with descriptions in the document.
[ ]	[ ]	[ ]	Software output consistent with input and with results reported in the document.
[ ]	[ ]	[ ]	Safety margins consistent with good engineering practices.
[ ]	[ ]		**Document approved by**: _____

Signature: _____ Date: _____

REVIEW CHECKLIST (Template)
for Radioactive and Nonradioactive Environmental Releases

Document Reviewed: *Calculating Potential-to-Emit Radiological Releases and Doses* (DOE/RL-2006-29, Revision 2)
Scope of Review: Use of CAP88-PC to Generate Dose-per-Unit-Release Factors

Yes	No*	N/A		
[ ]	[ ]	[ ]	1.	A detailed technical review and approval of the environmental transport and dose calculation portion of the analysis has been performed and documented.
[ ]	[ ]	[ ]	2.	Detailed technical reviews and approvals of scenario and release determinations have been performed and documented.
[ ]	[ ]	[ ]	3.	Approved codes were used.
[ ]	[ ]	[ ]	4.	Appropriate receptor locations were selected.
[ ]	[ ]	[ ]	5.	All applicable environmental pathways and code options were included and are appropriate for the calculations.
[ ]	[ ]	[ ]	6.	Hanford Site data were used where applicable.
[ ]	[ ]	[ ]	7.	Model adjustments external to the computer program were justified and performed correctly.
[ ]	[ ]	[ ]	8.	The analysis is consistent with Hanford Site recommendations.
[ ]	[ ]	[ ]	9.	Supporting notes, calculations, comments, comment resolutions, or other information is attached. (Use the "Page 1 of X" page numbering format and sign and date each added page.)
[ ]	[ ]	[ ]	10.	**Calculations are approved.**

* All "No" responses must be explained and the use of nonstandard methods justified.

_____
Reviewer Name

_____ _____
Reviewer Signature Date

COMMENTS (add additional signed and dated pages if necessary).

PEER-REVIEW CHECKLIST

Document Reviewed: *Calculating Potential-to-Emit Radiological Releases and Doses* (DOE/RL-2006-29, Revision 2

Scope of Review: Use of CAP88-PC to Generate Dose-per-Unit-Release Factors

Yes	No	N/A	
[x]	[ ]	[ ]	Necessary assumptions explicitly stated and supported.
[x]	[ ]	[ ]	Computer codes and data files identified in document.
[x]	[ ]	[ ]	Data used in calculations explicitly stated in document.
[x]	[ ]	[ ]	Data checked for consistency with original source information as applicable.
[x]	[ ]	[ ]	Mathematical derivations checked, including dimensional consistency of results.
[x]	[ ]	[ ]	Models appropriate and used within range of validity or use outside range of established validity justified.
[x]	[ ]	[ ]	Hand calculations (including spreadsheets) checked for errors.
[x]	[ ]	[ ]	Software input correct and consistent with descriptions in the document.
[x]	[ ]	[ ]	Software output consistent with input and with results reported in the document.
[x]	[ ]	[ ]	Safety margins consistent with good engineering practices.

[x] [ ] **Document approved by**: Ernest Antonio

Signature: Ernest Antonio Date: 12/9/2015

REVIEW CHECKLIST
for Radioactive and Nonradioactive Environmental Releases

Document Reviewed: *Calculating Potential-to-Emit Radiological Releases and Doses* (DOE/RL-2006-29, Revision 2)

Scope of Review: Use of CAP88-PC to Generate Dose-per-Unit-Release Factors

Yes	No*	N/A		
[x]	[ ]	[ ]	1.	A detailed technical review and approval of the environmental transport and dose calculation portion of the analysis has been performed and documented.
[x]	[ ]	[ ]	2.	Detailed technical reviews and approvals of scenario and release determinations have been performed and documented.
[x]	[ ]	[ ]	3.	Approved codes were used.
[x]	[ ]	[ ]	4.	Appropriate receptor locations were selected.
[x]	[ ]	[ ]	5.	All applicable environmental pathways and code options were included and are appropriate for the calculations.
[x]	[ ]	[ ]	6.	Hanford Site data were used where applicable.
[x]	[ ]	[ ]	7.	Model adjustments external to the computer program were justified and performed correctly.
[x]	[ ]	[ ]	8.	The analysis is consistent with Hanford Site recommendations.
[ ]	[ ]	[x]	9.	Supporting notes, calculations, comments, comment resolutions, or other information is attached. (Use the "Page 1 of X" page numbering format and sign and date each added page.)
[x]	[ ]	[ ]	10.	**Calculations are approved.**

* All "No" responses must be explained and the use of nonstandard methods justified.

Ernest Antonio
Reviewer Name

Ernest Antonio
Reviewer Signature

12/9/2015
Date

COMMENTS (add additional signed and dated pages if necessary).

8.0 REFERENCES

10 CFR Part 830. 2002. "Nuclear Safety Management." *Code of Federal Regulations*, U.S. Department of Energy, Washington, D.C. Accessed November 2015 at http://www.ecfr.gov/cgi-bin/text-idx?tpl=/ecfrbrowse/Title10/10cfr830_main_02.tpl.

40 CFR 61. 2009. "National Emission Standards for Hazardous Air Pollutants." *Code of Federal Regulations*, U.S. Environmental Protection Agency, Washington, D.C.

40 CFR 61, Subpart H. 2009. "National Emission Standards for Radionuclides Other Than Radon From Department of Energy Facilities." *Code of Federal Regulations*, U.S. Environmental Protection Agency, Washington, D.C.

40 CFR 61, Subpart I. 2009. "National Emission Standards for Radionuclide Emissions From Federal Facilities Other Than Nuclear Regulatory Commission Licensees and Not Covered by Subpart H." *Code of Federal Regulations*, U.S. Environmental Protection Agency, Washington, D.C.

40 CFR 61, Appendix D to Part 61. 2009. "Methods for Estimating Radionuclide Emissions." *Code of Federal Regulations*, U.S. Environmental Protection Agency.

80 FR 7461-7465, February 10, 2015. "National Emission Standards for Hazardous Air Pollutants (Radionuclides); Availability of Updated Compliance Model." *Federal Register*, U.S. Environmental Protection Agency, Washington, D.C.

ASME– American Society of Mechanical Engineers. 2002. *Technical Peer Review Report. Airborne Release Fractions*. ASME, New York, New York.

ASME/ANSI N510. 2007. *Testing of Nuclear Air Treatment Systems*. American Society of Mechanical Engineers, New York, New York.

ASTM E29-13. 2013. "Standard Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications." American Society for Testing and Materials (ASTM) International, West Conshohocken, Pennsylvania.

Barnett J M and WE Davis. 1996. "Six Methods to Assess Potential Radioactive Air Emissions from a Stack." *Health Physics* 71(5):773–778.

Diediker, LP, K Rhoads, and LH Staven. 2002. *Calculating Potential to Emit Releases and Doses for FEMPs and NOCs.* HNF-3602, Rev. 1, Fluor Hanford, Inc., Richland, Washington

Diediker, LP, DJ Rokkan, K Rhoads, and LH Staven. 2006. *Calculating Potential-to-Emit Radiological Releases and Doses*. DOE/RL-2006-29, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE–U.S. Department of Energy. 2003. *DOE Handbook. Nuclear Air Cleaning Handbook.* DOE-HDBK-1169-2003, U.S. Department of Energy, Washington, D.C.

DOE–U.S. Department of Energy. 2013. *DOE Handbook. Airborne Release Fractions/Rates and Respirable Fractions for Nonreactor Nuclear Facilities.* DOE-HDBK-3010-94 Volume 1 and 2, Reaffirmed 2013, U.S. Department of Energy, Washington, D.C.

DOE–U.S. Department of Energy. 2015. *Hanford Site Environmental Report for Calendar Year 2014.* DOE/RL-2014-52, Rev. 0. U.S. Department of Energy, Richland Operations Office, Richland, Washington.

Eckerman KF, RW Leggett, CB Nelson, JS Puskin, and ACB Richardson. 1999. *Cancer Risk Coefficients for Environmental Exposure to Radionuclides*. Federal Guidance Report No. 13. EPA 402-R-99-001, Office of Radiation and Indoor Air, U.S. Environmental Protection Agency, Washington, D.C.

Eckerman, KF and RW Leggett. 2008. User Guide to DCFPAK 2.2, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Eckerman KF and RW Leggett. 2013. *User Guide to DCFPAK 3.0*. Oak Ridge National Laboratory and Office of Radiation and Indoor Air, U.S. Environmental Protection Agency, Washington, D.C. Available at:
http://www2.epa.gov/radiation/tools-calculating-radiation-dose-and-risk ("DCAL" tab).

Eckerman KF and AL Sjoreen. 2013. *Radiological Toolbox User's Guide*. NUREG/CR-7166, Office of Nuclear Regulatory Research, U.S. Nuclear Regulatory Commission, Washington, D.C. Available at http://crpk.ornl.gov/software/.

Hamilton, EL and SF Snyder. 2011. *Hanford Site Regional Population – 2010 Census*. PNNL-20631, Pacific Northwest National Laboratory, Richland, Washington.

Hill, JS and PD Rittmann. 1999. *Calculating Potential to Emit Releases and Doses for FEMPs and NOCs*. HNF-3602, Rev. 0, Fluor Daniel Hanford, Richland, Washington.

Hoitink, DJ, KW Burk, JV Ramsdell, Jr., and WJ Shaw. 2005. *Hanford Site Climatological Data Summary 2004, with Historical Data*. PNNL-15160, Pacific Northwest National Laboratory, Richland, Washington.

ICRP–International Commission on Radiological Protection. 1994. "ICRP Publication 66, Human Respiratory Tract Model for Radiological Protection." *Annals of the ICRP 24:1-3*, Pergamon Press, Elmsford, New York.

ICRP–International Commission on Radiological Protection. 1996. "ICRP Publication 72, Age-Dependent Doses to Members of the Public from Intake of Radionuclides, Part 5, Compilation of Ingestion and Inhalation Dose Coefficients." *Annals of the ICRP 26:1*, Pergamon Press, Elmsford, New York.

ICRP–International Commission on Radiological Protection. 2008. "ICRP Publication 107, Nuclear Decay Data for Dosimetric Calculations." *Annals of the ICRP 38:3*, Elsevier, Exeter.

McCormack WD. 1982. *Hanford Dose Overview Program: Standardized Methods and Data for Hanford Environmental Dose Calculations*. PNL-3777, Rev. 0, Pacific Northwest Laboratory, Richland, Washington.

McCormack WD, JV Ramsdell, and BA Napier. 1984. *Hanford Dose Overview Program: Standardized Methods and Data for Hanford Environmental Dose Calculations*. PNL-3777, Rev. 1, Pacific Northwest Laboratory, Richland, Washington.

Napier BA. 1981. *Standardized Input for Hanford Environmental Impact Statements*. PNL-3509 PT1. *Part 1*, Pacific Northwest Laboratory, Richland, Washington.

Napier, BA. 2011. *GENII Version 2 Users' Guide*. PNNL-14583, Rev.3, Pacific Northwest Laboratory, Richland, Washington.

NCRP–National Council on Radiation Protection and Measurements. 1996. *Screening Models for Releases of Radionuclides to Atmosphere, Surface Water and Ground*. NCRP Report No. 123, Vol. 1, Bethesda, Maryland.

NEPA–*National Environmental Policy Act of 1969*. 1969. Public Law 91-190, as amended, 42 USC 4321 et seq.

Ramsdell, Jr., JV, CA Simonen, KW Burk. 1994. Regional Atmospheric Transport Code for Hanford Emission Tracking (RATCHET). PNWD-2224-HEDR, Battelle Pacific Northwest Division, Richland, WA.

Rhoads, K, LH Staven, SF Snyder, and DJ Rokkan. 2008. *Methods for Calculating Doses to Demonstrate Compliance with Air Pathway Radiation Dose Standards at the Hanford Site*. DOE/RL-2007-53, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

Rhoads, K, SF Snyder, RL Aaberg, and DJ Rokkan. 2010. Calculating Potential-to-Emit Radiological Releases and Doses. DOE/RL-2006-29, Rev. 1, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

Rokkan, DJ, SF Snyder, and CJ Perkins. 2015. *Radionuclide Air Emissions Report for the Hanford Site, Calendar Year 2014*. DOE/RL-2015-12, U.S. Department of Energy, Richland Operations Office, Richland, Washington

Rosnick R. 2007. *CAP88-PC Version 3.0 User Guide*. Office of Radiation and Indoor Air, U.S. Environmental Protection Agency, Washington, D.C.

Rosnick R. 2014. *CAP88-PC Version 4.0 User Guide*. Office of Radiation and Indoor Air, U.S. Environmental Protection Agency, Washington, D.C. Last accessed July 2014 at http://www.epa.gov/radiation/assessment/CAP88/index.html.

SAIC– Science Applications International Corporation. 1998. *Nuclear Fuel Cycle Facility Accident Analysis Handbook*. NUREG/CR-6410, U.S. Nuclear Regulatory Commission, Washington, D.C.

Schreckhise RG, K Rhoads, JS Davis, BA Napier, and JV Ramsdell. 1993. *Recommended Environmental Dose Calculation Methods and Hanford-Specific Parameters*. PNL-3777, Rev. 2, Pacific Northwest Laboratory, Richland, Washington.

WAC 173-480-070. 2007. "Emission Monitoring and Compliance Procedures." *Washington Administrative Code*, Olympia, Washington. Accessed on November 2015, at http://apps.leg.wa.gov/wac/default.aspx?cite=173-480-070.

WAC 246-247. 2014. "Radiation Protection — Air Emissions." *Washington Administrative Code*, Olympia, Washington. Accessed November 2015, at http://apps.leg.wa.gov/wac/default.aspx?cite=246-247.

WDOH–Washington Department of Health. 2014. *Hanford Site Radioactive Air Emissions License #FF-01*. Washington State Department of Health, Richland, Washington.

DISTRIBUTION

No. of Copies

OFFSITE

1 U.S. Environmental Protection Agency
Region 10
1200 Sixth Avenue
Seattle, WA 98101
ATTN: W. Wilson AWT-107

6 Washington State Department of Health
Division of Radiation Protection
Air Emissions and Defense Waste
309 Bradley Boulevard, Suite 201
Richland, WA 99352

ATTN: E. W. Fordham
T. P. Frazier
G. L. Laws
P. J. Martell
J. W. Schmidt
R. J. Utley

ONSITE

3 **DOE, Richland Operations Office**

E. T. Faust	A5-19
DOE-RL Public Reading Room (2)	H2-53

5 **Mission Support Alliance**

D. H. Butler	A3-01
S. J. Johnson	A3-01
R. A. Kaldor	A3-01
D. J. Rokkan	A3-01
A. F. Shattuck	A3-01

1 **Lockheed Martin Services, Inc.**

^Environmental Portal

No. of Copies

12 **CH2M HILL Plateau Remediation Company**

B. M. Barnes	X4-01
H. M. Bell	H8-43
W. G. Cox	T5-61
R. H. Engelmann	H8-45
R. E. Fox	T4-09
P. W. Martin	T4-52
P. T. Karschnia III	H8-45
J. W. McKibben	X4-01
L. C. Petersen	T4-04
R. W. Stevens	S2-42
D. R. Turlington	S2-42
D. J. Watson	S4-83

10 **Pacific Northwest National Laboratory**

B. G. Anderson	J2-25
E. J. Antonio	K9-89
M. Y. Ballinger	BSRC
J. M. Barnett (3)	J2-25
S. F. Snyder (2)	K7-68
Hanford Technical Library (2)	P8-55

2 **Washington Closure Hanford**

K. A. Hadley	H4-21
D. L. Johnson	L1-16

2 **Washington River Protection Solutions**

D. L. Dyekman	R1-51
N. A. Homan	H0-55

This page intentionally left blank.