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APR 21 2021

ATTN: Document Control Desk  
U. S. Nuclear Regulatory Commission  
Washington, DC 20555-0001

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**DOMINION ENERGY KEWAUNEE, INC.**  
**KEWAUNEE POWER STATION**  
**2020 ANNUAL RADIOACTIVE EFFLUENT RELEASE REPORT**

Enclosed is the Kewaunee Power Station (KPS) 2020 Annual Radioactive Effluent Release Report for January through December 2020. This report is submitted to meet the requirements of KPS Technical Requirements Manual (TRM) Section 10.3. Also included is Revision 19 of the Offsite Dose Calculation Manual, submitted to meet the requirements of KPS TRM Section 10.1.1.

If you have questions or require additional information, please feel free to contact Mr. William Zipp at 920-304-9729.

Sincerely,

A handwritten signature in black ink that reads "Bradley J. McMahon".

Bradly J. McMahon  
Director Kewaunee Site

Commitments made by this letter: NONE

IE48  
A009  
NRR



**Dominion  
Energy®**

**2020  
Annual  
Radioactive  
Effluent  
Release  
Report**  
*Kewaunee Power Station*

Dominion Energy Kewaunee, Inc.

DOCKET 50-305

**KEWAUNEE POWER STATION**

**ANNUAL RADIOACTIVE  
EFFLUENT RELEASE REPORT**

January 1 - December 31, 2020

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Appendix A Kewaunee Power Station Offsite Dose Calculation Manual (ODCM) Rev. 19

## 0.0 SUMMARY

On October 22, 2012, Dominion made known the decision to permanently shut down the Kewaunee Power Station (KPS). On February 25, 2013, Dominion Energy Kewaunee (DEK) submitted a certification of permanent cessation of power operations pursuant to 10 CFR 50.82(a)(1)(i), stating that DEK has decided to permanently cease power operation of KPS on May 7, 2013. On May 15, 2013 the NRC docketed the certification for permanent removal of fuel from the reactor vessel pursuant to 10 CFR 50.82(a)(1)(ii). Therefore the 10 CFR Part 50 license no longer authorizes KPS to operate the reactor or emplace or retain fuel in the reactor vessel, as specified in 10 CFR 50.82(a)(2).

On June 15, 2017, the transfer of all spent fuel from the KPS Spent Fuel Pool (SFP) to the Independent Spent Fuel Storage Installation (ISFSI) was completed. All remaining irradiated materials were removed from the SFP in October 2017.

All radioactive liquid was drained from systems in the Auxiliary Building by the end of the first week of August 2018.

The remaining effluent release paths are continuous gaseous radioactive releases from the Auxiliary Building Vent and batch liquid radioactive waste releases to Lake Michigan. Batch gaseous radioactive releases and continuous liquid radioactive releases are no longer performed.

In 2020 there were no identified gaseous radionuclides released from the Auxiliary Building Vent, and no batch liquid radioactive waste releases to Lake Michigan.

In 2020 there was one combined solid and oil waste shipment off site totaling  $1.23\text{E}+01 \text{ m}^3$  ( $4.34\text{E}+2 \text{ ft}^3$ ) containing  $1.26\text{E}-02$  Curies.

## **1.0 INTRODUCTION**

This report is being submitted in accordance with the requirements of Kewaunee Technical Requirements Manual, Section 10.3.2 and the Offsite Dose Calculation Manual, Section 15.2. It includes data from all effluent releases made from January 1 - December 31, 2020. The report contains summaries of the gaseous and liquid releases made to the environment including the quantity, characterization, time duration and calculated radiation dose at the site boundary resulting from these releases. The report also includes a summation of solid radioactive waste disposal and the revision to the Offsite Dose Calculation Manual. Values indicated as 0 (zero) in this report refer to actual values less than the detection limits. A table of these less than detectable (LLD) values is identified in sections 2.1 and 3.1.

### **1.1 Effluent Dose Limits**

Specifications are set to ensure that offsite doses are maintained as low as reasonably achievable while still allowing for practical and dependable evolutions at the Kewaunee Power Station.

The Kewaunee Offsite Dose Calculation Manual (ODCM) describes the methodology and parameters used in:

1. The calculation of radioactive liquid effluent monitoring instrumentation alarm/trip set points.
2. The calculation of radioactive liquid and gaseous concentrations, dose rates and cumulative quarterly and annual doses. The ODCM methodology is acceptable for use in demonstrating compliance with 10 CFR 20.1301/1302; 10 CFR 50, Appendix I; and 40 CFR 190.

## 2.0 GASEOUS EFFLUENTS

### 2.1 Lower Limits of Detection (LLD) for Gaseous Effluents

Gaseous radioactive effluents are released in the continuous mode. Batch gaseous radioactive releases are no longer performed. The Auxiliary Building ventilation stack was sampled continuously for Particulates, Gross Alpha, and Strontium 90, by an "off-line" sample train. This stack was also grab-sampled monthly for Tritium.

The LLD's for gaseous radio-analyses, as listed in Table 13.2.1-1 of the Kewaunee ODCM are:

Analysis	LLD ( $\mu\text{Ci/ml}$ )
Particulate Gamma Emitters	1.00E-11
Particulate Gross Alpha	1.00E-11
Strontium 90	1.00E-11
Tritium (H-3)	1.00E-06

The nominal "a priori" LLD values are shown below.

Isotope                      a priori LLD ( $\mu\text{Ci/ml}$ )

a. Particulate emissions:

Mn-54	1.11E-13
Co-60	3.57E-13
Zn-65	1.68E-13
Cs-134	4.69E-13
Cs-137	1.68E-13
Ce-144	1.24E-12

b. Composite particulate samples:

Sr-90	1.00E-14
Gross Alpha	1.00E-14

These "a priori" LLDs represent the capabilities of the counting systems in use, not an after the fact "a posteriori" limit for a particular measurement.

## 2.2 Gaseous Effluent Data

Table 2.1 presents a quarterly summation of the total activity released and average release rates of gaseous effluents (continuous mode). Table 2.2 presents the dose limits for gaseous effluents, and the calculated doses this year from gaseous effluents.



**Table 2.1  
Gaseous Effluents - Summation of all Releases (Continuous Mode)**

	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Total
<u>Particulates</u>					
Total Activity Released (Ci)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Average Release Rate ( $\mu$ Ci/sec)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
<u>Tritium</u>					
Total Activity Released (Ci)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Average Release Rate ( $\mu$ Ci/sec)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
<u>Gross Alpha Released (Ci)</u>	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

**Table 2.2**  
**Dose from Gaseous Effluents**

The offsite dose limits from radioactive materials in gaseous effluents are specified in Section 13.2.3 of the Kewaunee ODCM and can be summarized as follows:

	<u>Organ</u>
Quarterly Limit	7.5 mrem
Annual Limit	15.0 mrem

The following offsite doses were calculated using equation 2.2 from the Kewaunee ODCM. Calculated offsite doses versus quarterly and annual limits are shown below.

In 2020 there were no identified gaseous radionuclides released from the Auxiliary Building Vent.

	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr	Annual
<u>1. Organ Dose</u>					
Specification (mrem)	7.50E+00	7.50E+00	7.50E+00	7.50E+00	1.50E+01
<u>Total Body</u>					
Actual Dose (mrem)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
% of Specification	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
<u>Bone</u>					
Actual Dose (mrem)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
% of Specification	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
<u>Liver</u>					
Actual Dose (mrem)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
% of Specification	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

**Table 2.2 (continued)  
Dose from Gaseous Effluents**

	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr	Annual
<u>Thyroid</u>					
Actual Dose (mrem)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
% of Specification	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
<u>Kidney</u>					
Actual Dose (mrem)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
% of Specification	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
<u>Lung</u>					
Actual Dose (mrem)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
% of Specification	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
<u>GI-LLI</u>					
Actual Dose (mrem)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
% of Specification	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

### 3.0 LIQUID EFFLUENTS

#### 3.1 Lower Limits of Detection (LLD) for Liquid Effluents

Liquid radioactive effluents are released as batch releases. Continuous liquid radioactive releases are no longer performed. Each batch is sampled prior to release and analyzed for gamma emitters and tritium. A fraction of each sample is retained for a proportional composite which is then analyzed for Gross Alpha, Strontium 90, Iron 55 and Nickel 63.

The LLD's for liquid batch release radio-analyses, as listed in Table 13.1.1-1 of the Kewaunee ODCM are:

<u>Analysis</u>	<u>LLD (µCi/ml)</u>
Principal Gamma Emitters	1.00 E-06
Tritium (H-3)	1.00 E-05
Gross Alpha	5.00 E-07
Strontium 90	5.00 E-08
Iron 55	1.00 E-06
Nickel 63	1.00 E-04

There were no batch liquid radioactive waste releases to Lake Michigan in 2020, therefore there are no "a priori" LLD values shown below.

#### 3.2 Liquid Batch Release Statistics

The following is a summation of all liquid batch releases during 2020.

Number of batch releases.....	0
Total time for all batch releases (min).....	0
Maximum time for a batch release (min).....	0
Minimum time for a batch release (min).....	0
Average time for a batch release (min).....	0

#### 3.3 Liquid Effluent Data

The following Table 3.1 presents a quarterly summation of the total activity released (batch mode) and average concentration for all liquid effluents. It also presents the gross alpha activity released, volume of waste released, and volume of dilution water used. Table 3.2 presents the doses from liquid effluents for each quarter and the calculated doses this year from liquid effluents.

**Table 3.1**  
**Liquid Effluents - Summation of all Releases (Batch Mode)**

	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr	Total
<u>Fission and Activation Products</u>					
Total Release (Ci)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Average Concentration ( $\mu\text{Ci/ml}$ )	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
<u>Tritium</u>					
Total Release (Ci)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Average Concentration ( $\mu\text{Ci/ml}$ )	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
% of Specification Limit( $3.0\text{E-}3 \mu\text{Ci/ml}$ )	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
<u>Gross Alpha Activity</u>					
Total Release (Ci)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
<u>Volume of Waste Released</u>					
Total (liters)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
<u>Volume of Dilution Water</u>					
Total (liters)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

There were no batch liquid radioactive waste releases to Lake Michigan in 2020.

**Table 3.2  
Dose from Liquid Effluents**

There were no batch liquid radioactive releases to Lake Michigan in 2020.

	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr	Annual
<u>Total Body</u>					
Specification (mrem)	1.50E+00	1.50E+00	1.50E+00	1.50E+00	3.00E+00
Actual Dose (mrem)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
% of Specification	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
<u>Organs</u>					
Specification (mrem)	5.00E+00	5.00E+00	5.00E+00	5.00E+00	1.00E+01
<u>Bone</u>					
Actual Dose (mrem)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
% of Specification	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
<u>Liver</u>					
Actual Dose (mrem)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
% of Specification	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
<u>Thyroid</u>					
Actual Dose (mrem)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
% of Specification	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
<u>Kidney</u>					
Actual Dose (mrem)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
% of Specification	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
<u>Lung</u>					
Actual Dose (mrem)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
% of Specification	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
<u>GI-LLI</u>					
Actual Dose (mrem)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
% of Specification	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

### 3.4 Ground Water Monitoring

The Kewaunee Power Station has 14 wells used to sample for groundwater contamination. Eight of the wells are located to monitor for leakage from the Auxiliary Building (AB). The other six wells are designated as Monitoring Wells (MW) and sample areas outside the industrial security area to identify any spread of contamination. As the data below indicates there was no gamma activity identified and the tritium in all the AB and MW wells was below Minimum Detectable Concentrations (MDC). The tritium levels have decreased to below MDC in the AB and MW wells since the plant was permanently shut down in 2013. There were no voluntary ground water communications, no spills, and no leaks in 2020.

Sample Point Sample Date	Tritium pCi/L	Total Gamma Activity μCi/ml
<b>AB-707</b>		
5/27/2020	<261	None Detected
<b>AB-708</b>		
5/27/2020	<261	None Detected
<b>AB-709</b>		
5/27/2020	<261	None Detected
<b>AB-710</b>		
5/27/2020	<261	None Detected
<b>AB-711</b>		
6/17/2020	<350	None Detected
<b>AB-712</b>		
6/18/2020	<270	None Detected

Sample Point Sample Date	Tritium pCi/L	Total Gamma Activity μCi/ml
<b>AB-715</b>		
7/29/2020	<304	None Detected
<b>AB-717</b>		
7/29/2020	<304	None Detected
<b>MW-701</b>		
8/26/2020	<417	None Detected
<b>MW-702</b>		
8/26/2020	<417	None Detected
<b>MW-703</b>		
9/23/2020	<283	None Detected
<b>MW-704</b>		
9/23/2020	<283	None Detected
<b>MW-705</b>		
10/8/2020	<269	None Detected
<b>MW-706</b>		
10/8/2020	<269	None Detected



#### **4.0 METEOROLOGICAL DATA**

Meteorological data is no longer required to be reported in accordance with the Kewaunee ODCM Rev. 19, Section 15.2.

#### **5.0 SOLID WASTE DISPOSAL**

Table 5.1 is a summation of solid and oil radioactive waste shipped during 2020. Presented are the types of waste streams, waste classification, and major nuclides.

**Table 5.1  
Solid Waste and Irradiated Fuel Shipments**

A. Solid Radioactive Waste Shipped Off-Site for Burial or Disposal

1. Type of Waste with Estimate of Major Nuclide Composition

Resins, Filters, and Evaporator Bottoms	Volume		Curies Shipped
Waste Class	ft <sup>3</sup>	m <sup>3</sup>	Curies
A	0.00E+00	0.00E+00	0.00E+00
B	0.00E+00	0.00E+00	0.00E+00
C	0.00E+00	0.00E+00	0.00E+00
Unclassified	0.00E+00	0.00E+00	0.00E+00
All	0.00E+00	0.00E+00	0.00E+00

Major nuclides for the above table: NA

Dry Active Waste	Volume		Curies Shipped
Waste Class	ft <sup>3</sup>	m <sup>3</sup>	Curies
A	4.25E+02	1.20E+01	1.26E-02
B	0.00E+00	0.00E+00	0.00E+00
C	0.00E+00	0.00E+00	0.00E+00
Unclassified	0.00E+00	0.00E+00	0.00E+00
All	4.25E+02	1.20E+01	1.26E-02

Major nuclides for the above table: H-3, C-14, Fe-55, Co-60, Ni-59, Ni-63, Nb-94, Tc-99, I-129, Cs-137, Pu-238, Pu-239, Pu-240, Pu-241, Am-241, Cm-243, Cm-244

**Table 5.1 (continued)**  
**Solid Waste and Irradiated Fuel Shipments**

Irradiated Components	Volume		Curies Shipped
	ft <sup>3</sup>	m <sup>3</sup>	
Waste Class			Curies
A	0.00E+00	0.00E+00	0.00E+00
B	0.00E+00	0.00E+00	0.00E+00
C	0.00E+00	0.00E+00	0.00E+00
Unclassified	0.00E+00	0.00E+00	0.00E+00
All	0.00E+00	0.00E+00	0.00E+00

Major nuclides for the above table: NA

Other Waste –Oil	Volume		Curies Shipped
	ft <sup>3</sup>	m <sup>3</sup>	
Waste Class			Curies
A	9.43E+00	2.67E-01	1.53E-05
B	0.00E+00	0.00E+00	0.00E+00
C	0.00E+00	0.00E+00	0.00E+00
Unclassified	0.00E+00	0.00E+00	0.00E+00
All	9.43E+00	2.67E-01	1.53E-05

Major nuclides for the above table: H-3, C-14, Fe-55, Co-60, Ni-59, Ni-63, Nb-94, Tc-99, I-129, Sb-125, Cs-137, Ce-141, Ce-144, Cm-243, Cm-244

Sum of All Low-Level Waste	Volume		Curies Shipped
	ft <sup>3</sup>	m <sup>3</sup>	
Waste Class			Curies
A	4.34E+02	1.23E+01	1.26E-02
B	0.00E+00	0.00E+00	0.00E+00
C	0.00E+00	0.00E+00	0.00E+00
Unclassified	0.00E+00	0.00E+00	0.00E+00
All	4.34E+02	1.23E+01	1.26E-02

Major nuclides for the above table: H-3, C-14, Fe-55, Co-60, Ni-59, Ni-63, Nb-94, Tc-99, I-129, Cs-137, Pu-238, Pu-239, Pu-240, Pu-241, Am-241, Cm-243, Cm-244

**Table 5.1 (continued)**  
**Solid Waste and Irradiated Fuel Shipments**

B. Irradiated Fuel Shipments

<u>Number of Shipments</u>	<u>Mode of Transportation</u>	<u>Destination</u>
None	NA	NA

No irradiated fuel shipments were made from the Kewaunee Power Station during 2020.

## **6.0 SUPPLEMENTAL INFORMATION**

### **6.1 Abnormal Releases or Abnormal Discharges**

No abnormal releases or abnormal discharges were made from the Kewaunee Power Station during the report period.

### **6.2 Non-routine Planned Discharges**

No non-routine planned discharges were made from the Kewaunee Power Station during the reporting period.

### **6.3 Program Revisions**

In accordance with Technical Requirements Manual Section 10.1.1.c.3 and the Offsite Dose Calculation Manual Section 15.2.f, revisions to the Process Control Program, Offsite Dose Calculation Manual, or the Radiological Environmental Monitoring Program for the report period are listed below.

#### **6.3.1 Process Control Program**

There were no revisions to the Process Control Program during the report period.

#### **6.3.2 Offsite Dose Calculation Manual**

Revision 19 of the Offsite Dose Calculation Manual (ODCM) was issued July 28, 2020. See Appendix A.

#### **6.3.3 Radiological Environmental Monitoring Manual**

There were no revisions to the Kewaunee Power Station Radiological Environmental Monitoring Manual (REMM) during this report period.

### **6.4 Major Changes to the Radioactive Liquid, Gaseous and Solid Waste Systems**

There were no changes to the radioactive liquid, gaseous, or solid waste systems during the reporting period.

### **6.5 Effluent Monitoring System Inoperability**

Missed ODCM channel functional test September 2020 for R-14 sample flow rate monitor. This event resulted in R-14 being declared non-functional for a period of 4 days without the required contingency actions taken since R-13 was also non-functional during this time (CR2094).

## 6.6 Corrections to Previous Reports

None.

## 6.7 Other

6.7.1 Condition Report CR2064 was submitted on July 14, 2020.

Condition Report CR2064 documented the shutdown of R-13 due to loss of the detector link following an electrical bus outage in July 2020. Since R-14 was operating, no contingency actions were required.

6.7.2 Condition Report CR2066 was submitted on July 14, 2020.

Condition Report CR2066 documented R-18 increased count rate following shutdown and startup to support an electrical bus outage in July 2020. Since no discharges were in progress, no contingency actions were required.

6.7.3 Condition Report CR2073 was submitted on July 22, 2020.

Condition Report CR2073 documented the contingency actions taken in July 2020 for the shutdown of R-13 and R-14 due to planned breaker maintenance. Contingency actions were taken as required by the ODCM and applicable implementing procedures.

6.7.4 Condition Report CR2094 was submitted on September 1, 2020.

Condition Report CR2094 documented a missed ODCM channel functional test in September 2020 for the R-14 sample flow rate monitor. This event resulted in R-14 being declared non-functional for a period of 4 days without the required contingency actions taken since R-13 was also non-functional during this time. The monthly particulate air sample collected during this time period was analyzed and the results were less than required detection limits in Table 13.2.1-1 of the ODCM.

This event was a result of a scheduling process weakness. Corrective Action CA790 was created and completed to improve tracking and performance of scheduled activities.

6.7.5 Condition Report CR2119 was submitted on September 9, 2020.

Condition Report CR2119 documented the contingency actions taken for radiological effluent monitoring during the TAT-TST planned maintenance outage from August 24 through September 16, 2020. During this period power was secured to the ABV supply and exhaust fans, and to RMS channels R-13, R-14, and R-18. Contingency actions were taken as required by the ODCM and applicable implementing procedures.



Appendix A

Kewaunee Power Station

Offsite Dose Calculation  
Manual (ODCM)

Revision 19  
July 28, 2020

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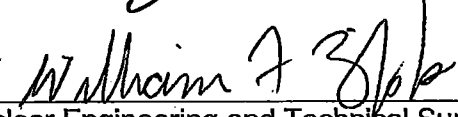

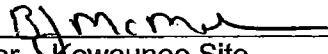
# Dominion Energy Kewaunee, Inc.

## Kewaunee Power Station

### OFFSITE DOSE CALCULATION MANUAL (ODCM)

Revision 19

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**Kewaunee Power Station**

**Offsite Dose Calculation Manual**

**PART I - RADIOACTIVE EFFLUENT CONTROLS**

## 11.0 INTRODUCTION

The Kewaunee OFFSITE DOSE CALCULATION MANUAL (ODCM) is established and maintained pursuant to Technical Requirements Manual Section 10.1.1. The ODCM consists of two parts: Radiological Effluent Controls, Part I, and Calculational Methodologies, Part II.

Part I, Radiological Effluent Controls, includes: (1) The Radioactive Effluent Control Specifications (RECS) and Radiological Environmental Monitoring Programs (REMP) required by Technical Requirements Manual 10.1 and (2) descriptions of the information that should be included in the Annual Radiological Environmental Operating and Radioactive Effluent Release Reports required by Technical Requirements Manual 10.3.1 and 10.3.2, respectively.

Part II, Calculational Methodologies: provides the methodology to manually calculate radiation dose rates and doses to individual persons in UNRESTRICTED AREAS due to the routine release of gaseous and liquid effluents. Computer programs are utilized to routinely estimate the doses due to radioactivity in gaseous and liquid effluents. Manual dose calculations are performed when computerized calculations are not available.

The methodology stated in this manual is acceptable for use in demonstrating compliance with 10CFR20.1302; 10CFR50, Appendix I; and 40CFR190.

More conservative calculational methods and/or conditions (e.g., location and/or exposure pathways) expected to yield higher computed doses than appropriate for the maximally exposed person may be assumed in the dose evaluations.

The ODCM will be maintained at the station for use as a reference guide and training document of accepted methodologies and calculations. Changes will be made to the ODCM calculational methodologies and parameters as is deemed necessary to assure reasonable conservatism in keeping with the principles of 10CFR50.36a and Appendix I for demonstrating radioactive effluents are ALARA.

### 11.1 Change Process

Instructions for defining the responsibilities and requirements for revision and control of both the ODCM and the RADIOLOGICAL ENVIRONMENTAL MONITORING MANUAL (REMM) are located in approved station procedure for Revision and Control of the REMM and ODCM.



## 13.0 USE AND APPLICATION

### 13.0.1 Definitions

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-----NOTE-----

Terms defined in the OFFSITE DOSE CALCULATION MANUAL appear in capitalized type and are applicable throughout the Radiological Effluent Controls Normal Conditions and Bases and the Calculational Methodologies.

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<u>Term</u>	<u>Definition</u>
ACTIONS	ACTIONS shall be that part of a Specification that prescribes CONTINGENCY MEASURES to be taken under designated Nonconformances within specified Restoration Times.
CHANNEL CHECK	A CHANNEL CHECK shall be the qualitative assessment, by observation, of channel behavior during operation. This determination shall include, where possible, comparison of the channel indication and status to other indications or status derived from independent instrument channels measuring the same parameter.
CHANNEL FUNCTIONAL TEST	A CHANNEL FUNCTIONAL TEST consists of injecting a simulated signal into the channel as close to the primary sensor as practicable to verify that it is FUNCTIONAL, including alarm and/or trip initiating action.
CHANNEL CALIBRATION	A CHANNEL CALIBRATION shall be the adjustment, as necessary, of the channel output such that it responds within the necessary range and accuracy to known values of the parameter that the channel monitors. The CHANNEL CALIBRATION shall encompass all devices in the channel required for channel FUNCTIONALITY. Calibration of instrument channels with resistance temperature detector (RTD) or thermocouple sensors may consist of an in-place qualitative assessment of sensor behavior and normal calibration of the remaining adjustable devices in the channel. The CHANNEL CALIBRATION may be performed by means of any series of sequential, overlapping, or total channel steps.
FUNCTIONAL - FUNCTIONALITY	A structure, system or component (SSC), shall be FUNCTIONAL or have FUNCTIONALITY when it is capable of performing its specified function(s) as set forth in the Current License Basis. FUNCTIONALITY does not apply to specified safety functions, but does apply to the ability of non-TS SSCs to perform other specified functions that have a necessary support function.

MAJOR DECOMMISSIONING ACTIVITY	MAJOR DECOMMISSIONING ACTIVITY means, for a nuclear power reactor facility, any activity that results in permanent removal of major radioactive components, permanently modifies the structure of the containment, or results in dismantling components for shipment containing greater than Class C waste in accordance with 10CFR61.55.
MEMBER(S) OF THE PUBLIC	MEMBER(S) OF THE PUBLIC means any individual except when that individual is receiving an OCCUPATIONAL DOSE.
OCCUPATIONAL DOSE	OCCUPATIONAL DOSE means the dose received by an individual in the course of employment in which the individual's assigned duties involve exposure to radiation or to radioactive material from licensed and unlicensed sources of radiation, whether in the possession of the licensee or other person. OCCUPATIONAL DOSE does not include doses received from background radiation, from any medical administration the individual has received, from exposure to individuals administered radioactive material and released under 10 CFR 35.75, from voluntary participation in medical research programs, or as a MEMBER OF THE PUBLIC.
OFFSITE DOSE CALCULATION MANUAL	The OFFSITE DOSE CALCULATION MANUAL shall contain the current methodology and parameters used in the calculation of offsite doses due to radioactive liquid effluents, in the calculation of liquid effluent monitoring alarm/trip setpoints, in the conduct of the Radiological Environmental Monitoring Program. Shall also contain the Radioactive Effluent Controls and Radiological Environmental Operating and Radioactive Effluent Release Reports required by Technical Requirements Manual 10.3.1 and 10.3.2.
ODCM NORMAL CONDITIONS (DNC)	Specify minimum requirements for ensuring safe plant decommissioning activities. The Contingency Measures associated with a DNC state Nonconformances that typically describe the ways in which the requirements of the DNC can fail to be met. Specified with each stated Nonconformance are Contingency Measures and Restoration Time(s).
ODCM VERIFICATION REQUIREMENTS (DVR)	Verification requirements are requirements relating to test, calibration, or inspection to assure that the necessary FUNCTIONALITY of systems and components are maintained, that plant decommissioning activities will be maintained within the current licensing basis, and that the ODCM Normal Condition (DNC) will be met.

PROCESS CONTROL PROGRAM	<p>The PROCESS CONTROL PROGRAM shall contain the current formulae, sampling, analyses, tests, and determinations to be made to ensure that the processing and packaging of solid radioactive wastes, based on demonstrated processing of actual or simulated wet solid wastes, will be accomplished in such a way as to ensure compliance with 10 CFR Part 20, 10 CFR Part 61, 10 CFR Part 71, Federal and State regulations, burial ground requirements, and other requirements governing the disposal of the radioactive waste.</p> <p>Licensee initiated changes to the PCP, which was approved by the Commission prior to implementation:</p> <ol style="list-style-type: none"><li>1. Shall be documented and records of reviews performed shall be retained as required by the quality assurance program. The documentation shall contain:<ol style="list-style-type: none"><li>a. Sufficient information to support the change together with the appropriate analyses or evaluations justifying the change(s).</li><li>b. A determination that the change will maintain the overall conformance of the solidified waste product to existing requirements of Federal, State, or other applicable regulations.</li></ol></li><li>2. Shall become effective upon review and acceptance by the FSRG.</li></ol>
PUBLIC DOSE	<p>PUBLIC DOSE means the dose received by a MEMBER OF THE PUBLIC from exposure to radiation or to radioactive material released by a licensee, or to any other source of radiation under the control of a licensee. PUBLIC DOSE does not include OCCUPATIONAL DOSE or doses received from background radiation, from any medical administration the individual has received, from exposure to individuals administered radioactive material and released under 10 CFR 35.75, or from voluntary participation in medical research programs.</p>
PURGE - PURGING	<p>PURGE or PURGING is the controlled process of discharging air or gas from a confinement to maintain temperature, pressure, humidity, concentration or other operating condition, in such a manner that replacement air or gas is required to purify the confinement.</p>
RADIOLOGICAL ENVIRONMENTAL MONITORING MANUAL (REMM)	<p>The REMM shall contain the current methodology and parameters used in the conduct of the radiological environmental monitoring program.</p>
SITE BOUNDARY	<p>The SITE BOUNDARY shall be that line beyond which the land is neither owned, leased, nor otherwise controlled by the licensee. (See Plant Drawing A-408)</p>
SOURCE CHECK	<p>A SOURCE CHECK shall be the qualitative assessment of channel response when the channel sensor is exposed to a source of increased radioactivity.</p>

**UNRESTRICTED  
AREA**

An UNRESTRICTED AREA shall be any area at or beyond the SITE BOUNDARY; access to which is not controlled by the licensee for purposes of protection of individuals from exposure to radiation and radioactive materials, or any area within the SITE BOUNDARY used for residential quarters or for industrial, commercial, institutional, and/or recreational purposes.

**VENTILATION  
EXHAUST  
TREATMENT  
SYSTEM**

A VENTILATION EXHAUST TREATMENT SYSTEM is any system designed and installed to reduce gaseous radioactive material in particulate form in effluents by passing ventilation or vent exhaust gases through HEPA filters for the purpose of removing particulates from the gaseous exhaust stream prior to the release to the environment. Such a system is not considered to have any effect on tritium or other non-particulate effluents.

**VENTING**

VENTING is the controlled process of discharging air or gas from a confinement to maintain temperature, pressure, humidity, concentration or other operating condition, in such a manner that replacement air or gas is not provided or required during venting. Vent, used in system names, does not imply a VENTING process.

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## 13.0 USE AND APPLICATION

### 13.0.2 Logical Connectors

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Logical Connectors are discussed in Section 7.2 of the Technical Requirements Manual and are applicable throughout the OFFSITE DOSE CALCULATION MANUAL and Bases.

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## 13.0 USE AND APPLICATION

### 13.0.3 Restoration Times

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Restoration Times are discussed in Section 7.3 of the Technical Requirements Manual and are applicable throughout the OFFSITE DOSE CALCULATION MANUAL and Bases.

When "Immediately" is used as a Restoration Time, the Contingency Measure should be pursued without delay in a controlled manner.

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## 13.0 USE AND APPLICATION

### 13.0.4 Frequency

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Frequency is discussed in Section 7.4 of the Technical Requirements Manual and is applicable throughout the OFFSITE DOSE CALCULATION MANUAL and Bases

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## 13.0 USE AND APPLICATION

### 13.0.5 ODCM Normal Condition (DNC) Applicability

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DNC 13.0.5.1 DNCs shall be met during the specified conditions in the Applicability.

DNC 13.0.5.2 Upon discovery of a failure to meet the DNC, the Contingency Measures of the associated Nonconformance shall be met, except as provided in DNC 13.0.5.4.

DNC 13.0.5.3 When it is discovered that a DNC has not been met and the associated contingency measures are not satisfied within the specified restoration time (or an associated contingency measure is not provided), the equipment subject to the DNC is in a nonconforming condition. In this situation, appropriate actions shall be taken as necessary to provide assurance of continued safe plant decommissioning activities. In addition a Condition Report shall be initiated and assessment of reasonable assurance of safety shall be conducted. Items to be considered for this assessment include the following:

- Availability of redundant or backup equipment;
- Compensatory measures, including limited administrative controls;
- Safety function and events protected against;
- Probability of needing the safety function; and
- Conservatism and margins.

If this assessment concludes that safety is sufficiently assured, then plant decommissioning activities may continue while prompt corrective action is taken.

DNC 13.0.5.4 Equipment removed from service or declared nonfunctional to comply with Contingency Measures may be returned to service under administrative control solely to perform testing required to demonstrate its FUNCTIONALITY or the FUNCTIONALITY of other equipment. This is an exception to DNC 13.0.5.2 for the system returned to service under administrative control to perform the testing required to demonstrate FUNCTIONALITY.

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## 13.0 USE AND APPLICATION

### 13.0.6 ODCM VERIFICATION REQUIREMENTS (DVR) Applicability

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DVR 13.0.6.1 DVRs shall be met during the specified conditions in the Applicability for individual DNCs, unless otherwise stated in the DVR. Failure to meet a DVR, whether such failure is experienced during the performance of the DVR or between performances of the DVR, shall be failure to meet the DNC. Failure to perform a DVR within the specified Frequency shall be failure to meet the DNC except as provided in DVR 13.0.6.3. DVR's do not have to be performed on nonfunctional equipment or variables outside specified limits.

DVR 13.0.6.2 Each Verification Requirement shall be performed within the specified time interval with a maximum allowable extension not to exceed 25% of the specified DVR frequency.

DVR 13.0.6.3 When it is discovered that a DVR frequency (including the 1.25 times extension) has not been met, the equipment subject to the DVR is in a nonconforming condition. In this situation, a Condition Report shall be initiated and, if indicated, determination to evaluate the impact on plant safety shall be performed in a timely fashion and in accordance with plant procedures.

Actions should be taken to restore conformance with the DNCs / DVRs in a timely fashion.

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13.1 RADIOACTIVE LIQUID EFFLUENTS

13.1.1 Liquid Effluents Concentration

DNC 13.1.1 The concentration of radioactive material released in liquid effluents to UNRESTRICTED AREAS shall be limited to:

- a. 10 times the concentrations specified in 10 CFR Part 20, Appendix B, Table 2, Column 2 for radionuclides other than dissolved or entrained noble gases.

APPLICABILITY: During release via the monitored pathway.

ACTIONS

NON-CONFORMANCE	CONTINGENCY MEASURES	RESTORATION TIME
A. Concentration of radioactive material released in liquid effluents to UNRESTRICTED AREAS exceeds limits.	A.1 Initiate ACTION to restore concentration to within limits.	Immediately
B. CONTINGENCY MEASURES <u>OR</u> RESTORATION TIME not met.	B.1 Initiate a CR  <u>AND</u>  B.2 Explain in the next Radioactive Effluent Release Report why the CONTINGENCY MEASURE was not met in a timely manner.	In accordance with Corrective Action Program   In accordance with Radioactive Effluent Release Report

VERIFICATION REQUIREMENTS

VERIFICATION		FREQUENCY
DVR 13.1.1.1	Perform radioactive liquid waste sampling and activity analysis.	In accordance with Table 13.1.1-1
<p style="text-align: center;">-----NOTE-----</p> <p style="text-align: center;">In this DVR the results of DVR 13.1.1.1 shall be used in accordance with the methodology and parameters of the ODCM.</p> <p style="text-align: center;">-----</p>		In accordance with Table 13.1.1-1
DVR 13.1.1.2	Verify the results of the DVR 13.1.1.1 analyses to assure that the concentrations at the point of release are maintained within the limits of DNC 13.1.1.	

Table 13.1.1-1 (Page 1 of 2)  
Radioactive Liquid Waste Sampling and Analysis

LIQUID RELEASE TYPE	TYPE OF ACTIVITY ANALYSIS	SAMPLE TYPE	SAMPLE FREQUENCY	MINIMUM ANALYSIS FREQUENCY	LOWER LIMIT OF DETECTION (LLD) (a)
1. Batch Waste Release Tanks (b)					
a.	Principal Gamma Emitters(c)	Grab Sample	Each Batch (f)	Each Batch (g)	$1 \times 10^{-6}$ $\mu\text{Ci/ml}$
b.	H-3	Grab Sample	Each Batch (f)	Each Batch (g)	$1 \times 10^{-5}$ $\mu\text{Ci/ml}$
c.	Gross Alpha	Composite (d)	Each Batch (f)	184 days (e)	$5 \times 10^{-7}$ $\mu\text{Ci/ml}$
d.	Sr-90	Composite (d)	Each Batch (f)	184 days (e)	$5 \times 10^{-8}$ $\mu\text{Ci/ml}$
e.	Fe-55	Composite (d)	Each Batch (f)	184 days (e)	$1 \times 10^{-8}$ $\mu\text{Ci/ml}$
f.	Ni-63	Composite (d)	Each Batch (f)	184 days (e)	$1 \times 10^{-4}$ $\mu\text{Ci/ml}$

Table 13.1.1-1 (Page 2 of 2)  
Radioactive Liquid Waste Sampling and Analysis

- (a) The LLD is defined, for purposes of these DNC's, as the smallest concentration of radioactive material in a sample that will yield a net count, above system background, that will be detected with 95% probability with only 5% probability of falsely concluding that a blank observation represents a "real" signal.

For a particular measurement system, which may include radiochemical separation:

$$LLD = \frac{4.66 * S_b}{E * V * 2.22 \times 10^6 * Y * \exp(-\lambda \Delta t)}$$

Where:

- LLD is the a priori lower limit of detection as defined above, as  $\mu\text{Ci}$  per unit mass or volume,
- $S_b$  is the standard deviation of the background counting rate or of the counting rate of a blank sample as appropriate, as counts per minute,
- E is the counting efficiency, as counts per disintegration,
- V is the sample size in units of mass or volume,
- $2.22 \times 10^6$  is the number of disintegrations per minute per microcurie,
- Y is the fractional radiochemical yield, when applicable,
- $\lambda$  is the radioactive decay constant for the particular radionuclide, and
- $\Delta t$  for plant effluents is the elapsed time between the midpoint of sample collection and time of counting.
- Typical values of E, V, Y and  $\Delta t$  should be used in the calculation.

It should be recognized that the LLD is defined as an a priori (before the fact) limit representing the capability of a measurement system and not as an a posteriori (after the fact) limit for a particular measurement..

- (b) A batch release is the discharge of liquid wastes of a discrete volume. Prior to sampling for analyses, each batch shall be isolated, and then thoroughly mixed to assure representative sampling.
- (c) The principal gamma emitters for which the LLD requirement applies, includes the following radionuclides: Mn-54, Fe-59, Co-60, Cs-134, Cs-137, and Ce-144. This list does not mean that only these nuclides are to be considered. Other gamma peaks that are identified, together with those of the above nuclides, shall also be analyzed and reported in the Radioactive Effluent Release Report pursuant to Section 15.2.
- (d) A composite sample is one in which the quantity of liquid sampled is proportional to the quantity of liquid waste discharged and in which the method of sampling employed results in a specimen that is representative of the liquids released.
- (e) At a minimum, analyze semi-annually if batch releases were made within the six (6) month period. A grab sample of the batch volume can substitute for the composite.
- (f) Draw sample for each batch volume.
- (g) Complete prior to each release.

## BASES

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This DNC is provided to ensure that the concentration of radioactive materials released in liquid waste effluents to UNRESTRICTED AREAS will be less than ten times the concentration levels specified in 10 CFR Part 20, Appendix B, Table 2, Column 2. This limitation provides additional assurance that the levels of radioactive materials in bodies of water in UNRESTRICTED AREAS will result in exposures within (1) the Section II.A design objectives of Appendix I, 10 CFR Part 50, to a MEMBER OF THE PUBLIC and (2) the limits of 10 CFR Part 20.1301 to the population.

The required detection capabilities for radioactive materials in liquid waste samples are tabulated in terms of the lower limits of detection (LLDs). Detailed discussion of the LLD, and other detection limits can be found in HASL Procedures Manual, HASL-300 (revised annually), Currie, L.A., "Limits for Qualitative Detection and Quantitative Determination - Application to Radiochemistry," Anal. Chem. 40, 586-93 (1968), and Hartwell, J.K., "Detection Limits for Radioanalytical Counting Techniques," Atlantic Richfield Hanford Company Report ARH-SA-215 (June 1975).

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13.1 RADIOACTIVE LIQUID EFFLUENTS

13.1.2 Liquid Effluents Dose

DNC 13.1.2 The dose or dose commitment to a MEMBER OF THE PUBLIC from radioactive materials released in liquid effluents released to UNRESTRICTED AREAS shall be limited to:

- a.  $\leq 1.5$  mrem to the total body and  $\leq 5$  mrem to any organ during any calendar quarter; and
- b.  $\leq 3$  mrem to the total body and  $\leq 10$  mrem to any organ during any calendar year.

APPLICABILITY: At all times.

ACTIONS

NON-CONFORMANCE	CONTINGENCY MEASURES	RESTORATION TIME
<p>A. Calculated dose to a MEMBER OF THE PUBLIC from the release of radioactive materials in liquid effluents to UNRESTRICTED AREAS exceeds limits.</p>	<p>A.1 Prepare and submit to the NRC, pursuant to Section 15.3, a Special Report that</p> <ul style="list-style-type: none"> <li>(1) Identifies the cause(s) for exceeding the limit(s) and;</li> <li>(2) Defines the corrective actions that have been taken to reduce the releases and the proposed corrective actions to be taken to assure that subsequent releases will be in compliance with DNC 13.1.2.</li> </ul>	<p>30 days</p>

ACTIONS (continued)

NON-CONFORMANCE	CONTINGENCY MEASURES	RESTORATION TIME
<p>B. Calculated dose to a MEMBER OF THE PUBLIC from the release of radioactive materials in liquid effluents exceeds 2 times the limits.</p>	<p>B.1 Calculate the annual dose to a MEMBER OF THE PUBLIC which includes contributions from direct radiation from the facility (including outside storage tanks, etc.).</p>	<p>Immediately</p>
	<p><u>AND</u></p> <p>B.2 Verify that the limits of DNC 13.4.1 have not been exceeded.</p>	<p>Immediately</p>
<p>C. CONTINGENCY MEASURE B.2 and Associated RESTORATION TIME not met.</p>	<p>C.1 Prepare and submit to the NRC, pursuant to Section 15.3, a Special Report, as defined in 10 CFR 20.2203 (a)(4), of CONTINGENCY MEASURE A.1 shall also include the following:</p> <ul style="list-style-type: none"> <li>(1) The corrective action(s) to be taken to prevent recurrence of exceeding the limits of DNC 13.4.1 and the schedule for achieving conformance,</li> <li>(2) An analysis that estimates the dose to a MEMBER OF THE PUBLIC from uranium fuel cycle sources, including all effluent pathways and direct radiation, for the calendar year that includes the release(s), and</li> <li>(3) Describes the levels of radiation and concentrations of radioactive material involved and the cause of the exposure levels or concentrations.</li> </ul>	<p>30 days</p>



VERIFICATION REQUIREMENTS

VERIFICATION		FREQUENCY
DVR 13.1.2.1	Determine cumulative dose contributions from liquid effluents for the current calendar quarter and the current calendar year in accordance with the methodology and parameters in the ODCM.	31 days

## BASES

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This DNC is provided to implement the requirements of Sections II.A, III.A and IV.A of Appendix I, 10 CFR 50. The DNC implements the guides set forth in Section II.A of Appendix I. The ACTION statements provide the required operating flexibility and at the same time implement the guides set forth in Section IV.A of Appendix I to assure that the releases of radioactive material in liquid effluents to UNRESTRICTED AREAS will be kept "as low as is reasonably achievable." The dose calculation methodology and parameters in the ODCM implement the requirements in Section III.A of Appendix I that conformance with the guides of Appendix I be shown by calculational procedures based on models and data, such that the actual exposure of a MEMBER OF THE PUBLIC through appropriate pathways is unlikely to be substantially underestimated.

The equations specified in the ODCM for calculating the doses due to the actual release rates of radioactive materials in liquid effluents are consistent with the methodology provided in Regulatory Guide 1.109, "Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR Part 50, Appendix I," Revision 1, October 1977 and Regulatory Guide 1.113, "Estimating Aquatic Dispersion of Effluents from Accidental and Routine Reactor Releases for the Purpose of Implementing Appendix I," April 1977.

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13.1 RADIOACTIVE LIQUID EFFLUENTS

13.1.3 Liquid Radwaste Treatment System

DNC 13.1.3 The Liquid Radwaste Treatment System, as described in the ODCM, shall be used to reduce the radioactive material in liquid wastes prior to their discharge when the projected dose, due to the liquid effluent, to UNRESTRICTED AREAS would exceed in a 31 day period:

- a. > 0.06 mrem to the total body; or
- b. > 0.2 mrem to any organ.

APPLICABILITY: At all times, except for the parts of the system taken permanently out of service.

ACTIONS

NON-CONFORMANCE	CONTINGENCY MEASURES	RESTORATION TIME
<p>A. Radioactive liquid waste being discharged without treatment and in excess of the above limits.</p>	<p>A.1 Prepare and submit to the NRC, pursuant to Section 15.3, a Special Report that includes:                      (1) An explanation of why liquid radwaste was being discharged without treatment, identification of any non-functional / inoperable equipment or subsystems, and the reason for the non-functional / inoperability,                      (2) ACTION(s) taken to restore the non-functional / inoperable equipment to FUNCTIONAL / OPERABLE status, and                      (3) Summary description of ACTION(s) taken to prevent a recurrence.</p>	<p>30 days</p>

VERIFICATION REQUIREMENTS

VERIFICATION	FREQUENCY
DVR 13.1.3.1 Project the doses due to liquid effluents from the facility to UNRESTRICTED AREAS in accordance with the methodology and parameters specified in the ODCM.	31 days

## BASES

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The requirement that the appropriate portions of this system be used, when specified, provides assurance that the releases of radioactive materials in liquid effluents will be kept "as low as is reasonably achievable."

This DNC implements the requirements of 10 CFR Part 50.36a, July 1967 Atomic Energy Commission (AEC) General Design Criteria 70 and the design objective given in Section II.D of Appendix I to 10 CFR Part 50.

The specified limits governing the use of appropriate portions of the liquid radwaste treatment system were specified as a suitable fraction of the dose design objectives set forth in Section II.A of Appendix I, 10 CFR Part 50, for liquid effluents.

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13.1 LIQUID EFFLUENTS

13.1.4 Liquid Holdup Tanks

DNC 13.1.4 The quantity of radioactivity contained in unprotected outdoor liquid storage tanks shall be limited to less than the amount that would result in concentrations less than the limits in 10 CFR20, Appendix B, Table II, Column 2, at the nearest potable water supply and surface water supply in an UNRESTRICTED AREA, excluding tritium.

APPLICABILITY: At all times.

ACTIONS

NON-CONFORMANCE	CONTINGENCY MEASURES	RESTORATION TIME
A. Level of radioactivity exceeds the limits in any listed tank.	A.1 Suspend addition of radioactive material.	Immediately
	<u>AND</u>	
	A.2 Initiate measures to reduce content to within the limits.	48 hours
	<u>AND</u>	
	A.3 Describe the events leading to the condition in the Radioactive Effluent Release Report.	Prior to submittal of next Radioactive Effluent Release Report

VERIFICATION REQUIREMENTS

VERIFICATION	FREQUENCY
DVR 13.1.4.1 Sample and analyze radioactive liquid located in unprotected outdoor liquid storage tanks for level of radioactivity.	31 days during addition of radioactive liquid to the tanks

#### 13.1.4 Liquid Holdup Tanks

##### BASES

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The tanks listed in this Normal Condition include outdoor tanks that are not surrounded by liners, dikes or walls capable of holding the tank contents and do not have tank overflows and surrounding area drains connected to the radwaste treatment system.

Technical Requirements Manual 10.1.3 requires a program to ensure that the quantity of radioactive material contained in the specified tanks provides assurance that, in the event of an uncontrolled release of any such tank's contents, the resulting concentration would be less than the limits of 10 CFR 20, Appendix B Table II, Column 2 at the nearest potable water supply and the nearest surface water supply in an UNRESTRICTED AREA. Tank quantities shall be determined in accordance with Standard Review Plan, Section 15.7.3, "Postulated Radioactive Release due to Tank Failures."

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13.2 RADIOACTIVE GASEOUS EFFLUENTS

13.2.1 Gaseous Effluents Dose Rate

DNC 13.2.1 The dose rate due to radioactive materials released in gaseous effluents from the site to areas at and beyond the SITE BOUNDARY shall be limited to the following:

- a. For tritium and for all radionuclides in particulate form with half-lives > 8 days, ≤ 1500 mrem/yr to any organ.

APPLICABILITY: At all times.

ACTIONS

NON-CONFORMANCE	CONTINGENCY MEASURES	RESTORATION TIME
A. The dose rate(s) at or beyond the SITE BOUNDARY due to radioactive gaseous effluents exceeds limits.	A.1 Restore the release rate to within the limit.	Immediately
B. CONTINGENCY MEASURES <u>OR</u> RESTORATION TIME not met.	B.1 Initiate a CR  <u>AND</u>  B.2 Explain in the next Radioactive Effluent Release Report why the CONTINGENCY MEASURE was not met in a timely manner.	In accordance with Corrective Action Program    In accordance with Radioactive Effluent Release Report



VERIFICATION REQUIREMENTS

VERIFICATION	FREQUENCY
DVR 13.2.1.1    The dose rate due to tritium and all radionuclides in particulate form with half-lives > 8 days in gaseous effluents shall be determined to be within the above limits in accordance with the methodology and parameters in the ODCM by obtaining representative samples and performing analyses in accordance with the sampling and analysis program specified in Table 13.2.1-1	In accordance with Table 13.2.1-1

Table 13.2.1-1 (Page 1 of 2)  
Radioactive Gaseous Waste Sampling and Analysis

GASEOUS RELEASE TYPE	TYPE OF ACTIVITY ANALYSIS	SAMPLE TYPE	SAMPLE FREQUENCY	MINIMUM ANALYSIS FREQUENCY	LOWER LIMIT OF DETECTION (LLD) (a)
1. Auxiliary Building Vent	a. Principal Gamma Emitters (b)	Particulate Sample	Continuous (c)	31 days (SAFSTOR)	$1 \times 10^{-11}$ $\mu\text{Ci/ml}$
				7 days (Major Decommissioning Activities*)	
	b. Gross Alpha	Particulate Sample	Continuous (c)	31 days (SAFSTOR)	$1 \times 10^{-11}$ $\mu\text{Ci/ml}$
				7 days (Major Decommissioning Activities*)	
c. H-3	Grab Sample	31 days	31 days	$1 \times 10^{-6}$ $\mu\text{Ci/ml}$	
d. Sr-90	Composite Particulate Sample	Continuous (c)	184 days (d)	$1 \times 10^{-11}$ $\mu\text{Ci/ml}$	

\* Reference 10 CFR 50.2

Table 13.2.1-1 (Page 2 of 2)  
Radioactive Gaseous Waste Sampling and Analysis

- (a) The LLD is defined, for purposes of these DNC's, as the smallest concentration of radioactive material in a sample that will yield a net count, above system background, that will be detected with 95% probability with only 5% probability of falsely concluding that a blank observation represents a "real" signal.

For a particular measurement system, which may include radiochemical separation:

$$LLD = \frac{4.66 * S_b}{E * V * 2.22 * 10^6 * Y * \exp(-\lambda \Delta t)}$$

Where:

- LLD is the a priori lower limit of detection as defined above, as  $\mu\text{Ci}$  per unit mass or volume,
- $S_b$  is the standard deviation of the background counting rate or of the counting rate of a blank sample as appropriate, as counts per minute,
- E is the counting efficiency, as counts per disintegration,
- V is the sample size in units of mass or volume,
- $2.22 \times 10^6$  is the number of disintegrations per minute per microcurie,
- Y is the fractional radiochemical yield, when applicable,
- $\lambda$  is the radioactive decay constant for the particular radionuclide, and
- $\Delta t$  for plant effluents is the elapsed time between the midpoint of sample collection and time of counting.
- Typical values of E, V, Y, and  $\Delta t$  should be used in the calculation.

It should be recognized that the LLD is defined as an a priori (before the fact) limit representing the capability of a measurement system and not as an a posteriori (after the fact) limit for a particular measurement.

- (b) The principal gamma emitters for which the LLD requirement applies exclusively are the following radionuclides: Mn-54, Co-60, Cs-134, Cs-137, and Ce-144 for particulate emissions. This list does not mean that only these nuclides are to be considered. Other gamma peaks that are identifiable, together with those of the above nuclides, shall also be analyzed and reported in the Radioactive Effluent Release Report pursuant to Section 15.2.
- (c) The ratio of the sample flow rate to the sampled flow stream flow rate shall be known (based on sampler and ventilation system flow measuring devices or periodic flow estimates) for the time period covered by each dose or dose rate calculation made in accordance with ODCM DNC 13.2.1 and 13.2.3.
- (d) At a minimum, analyze semi-annually.

## BASES

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This DNC is provided to ensure that the dose rates at any time to a MEMBER OF THE PUBLIC at or beyond the SITE BOUNDARY are less than or equal to 1500 mrem/yr to any organ. This dose rate limit provides additional assurance that radioactive material discharged in gaseous effluents will be maintained ALARA, and ensure that the exposures of MEMBERS OF THE PUBLIC in an UNRESTRICTED AREA, either within or outside the SITE BOUNDARY, will not exceed the annual average concentrations specified in Appendix B, Table 2, Column 1 of 10 CFR 20. For MEMBERS OF THE PUBLIC who may at times be within the SITE BOUNDARY, the occupancy of that MEMBER OF THE PUBLIC will usually be sufficiently low to compensate for any increase in the atmospheric diffusion factor above that for the SITE BOUNDARY.

The required detection capabilities for radioactive materials in gaseous waste samples are tabulated in terms of the lower limits of detection (LLDs). Detailed discussion of the LLD, and other detection limits can be found in HASL Procedures Manual, HASL-300 (revised annually), Currie, L.A., "Limits for Qualitative Detection and Quantitative Determination - Application to Radiochemistry," Anal. Chem. 40, 586-93 (1968), and Hartwell, J.K., "Detection Limits for Radioanalytical Counting Techniques," Atlantic Richfield Hanford Company Report ARH-SA-215 (June 1975).

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## 13.2 RADIOACTIVE GASEOUS EFFLUENTS

### 13.2.2 Gaseous Effluent Dose - Noble Gas

Content deleted. No longer applicable.

13.2 RADIOACTIVE GASEOUS EFFLUENTS

13.2.3 Gaseous Effluent Dose – Tritium and Particulate

DNC 13.2.3 The dose to a MEMBER OF THE PUBLIC from tritium, and all radionuclides in particulate form with half-lives > 8 days, in gaseous effluents, released to areas at or beyond the SITE BOUNDARY (Plant Drawing A-408) shall be limited to the following:

- a.  $\leq 7.5$  mrem to any organ during any calendar quarter, and
- b.  $\leq 15$  mrem to any organ during any calendar year.

APPLICABILITY: At all times.

ACTIONS

NON-CONFORMANCE	CONTINGENCY MEASURES	RESTORATION TIME
<p>A. The calculated dose from the release of tritium, and radionuclides in particulate form with half-lives &gt; 8 days released in gaseous effluents at or beyond the SITE BOUNDARY exceeds limits.</p>	<p>A.1 Prepare and submit to the NRC, pursuant to Section 15.3, a Special Report that</p> <ul style="list-style-type: none"> <li>(1) Identifies the cause(s) for exceeding the limit(s) and;</li> <li>(2) Defines the corrective actions that have been taken to reduce the releases and the proposed corrective actions to be taken to assure that subsequent releases will be in compliance with DNC 13.2.3.</li> </ul>	<p>30 days</p>



VERIFICATION REQUIREMENTS

VERIFICATION	FREQUENCY
DVR 13.2.3.1 Determine cumulative dose contributions for the current calendar quarter and current calendar year for tritium, and radionuclides in particulate form with half-lives > 8 days in accordance with the methodology and parameters in the ODCM.	31 days



## BASES

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This DNC is provided to implement the requirements of Sections II.C, III.A and IV.A of Appendix I, 10 CFR Part 50. The DNC's are the guides set forth in Section II.C of Appendix I. The contingency measures provide the required operating flexibility and at the same time implement the guides set forth in Section IV.A of Appendix I to assure that the releases of radioactive materials in gaseous effluents to UNRESTRICTED AREAS will be kept "as low as is reasonably achievable."

The ODCM calculational methods specified in the DVR's implement the requirements in Section III.A of Appendix I that conformance with the guides of Appendix I be shown by calculational procedures based on models and data, such that the actual exposure of a MEMBER OF THE PUBLIC through appropriate pathways is unlikely to be substantially underestimated. The ODCM calculational methodology and parameters for calculating the doses due to the actual release rates of the subject materials are consistent with the methodology provided in Regulatory Guide 1.109, "Calculation of Annual Doses to man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR Part 50, Appendix I," Revision 1, October 1977 and Regulatory Guide 1.111, "Methods for Estimating Atmospheric Transport and Dispersion of Gaseous Effluents in Routine Releases from Light-Water-Cooled Reactors," Revision 1, July 1977.

These equations also provide for determining the actual doses based upon the historical average atmospheric conditions. The release rate limitations for tritium, and radionuclides in particulate form with half-lives greater than 8 days are dependent upon the existing radionuclide pathways to man, in areas at and beyond the SITE BOUNDARY. The pathways that were examined in the development of these calculations were: 1) individual inhalation of airborne radionuclides, 2) deposition of radionuclides onto broad leaf vegetation with subsequent consumption by man, 3) deposition onto grassy areas where milk animals and meat producing animals graze with consumption of the milk and meat by man, and 4) deposition on the ground with subsequent exposure of man.

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13.2 RADIOACTIVE GASEOUS EFFLUENTS

13.2.4 GASEOUS RADWASTE TREATMENT SYSTEM

DNC 13.2.4 The VENTILATION EXHAUST TREATMENT SYSTEM shall be used to reduce radioactive materials in gaseous waste prior to their discharge when the projected gaseous effluent air doses due to gaseous effluent releases to areas at and beyond the SITE BOUNDARY (Plant Drawing A-408) would be:

- a. > 0.3 mrem to any organ in 31 day period.

APPLICABILITY: At all times, except for the parts of the system taken permanently out of service.

ACTIONS

NON-CONFORMANCE	CONTINGENCY MEASURES	RESTORATION TIME
<p>A. Radioactive gaseous waste is being discharged without treatment.</p> <p><u>AND</u></p> <p>Projected doses due to the gaseous effluent, from the facility, at and beyond the SITE BOUNDARY would exceed limits.</p>	<p>A.1 Prepare and submit to the NRC, pursuant to Section 15.3, a Special Report that includes the following:</p> <ul style="list-style-type: none"> <li>(1) Explanation of why gaseous radwaste was being discharged without treatment,</li> <li>(2) Identification of any non-functional / inoperable equipment or subsystems and the reason for the non-functional / inoperability,</li> <li>(3) ACTION(s) taken to restore the non-functional / inoperable equipment to FUNCTIONAL / OPERABLE status, and</li> <li>(4) Summary description of ACTION(s) taken to prevent a recurrence.</li> </ul>	<p>30 days</p>

VERIFICATION REQUIREMENTS

VERIFICATION	FREQUENCY
DVR 13.2.4.1      Project the doses due to gaseous effluents from each facility at and beyond the SITE BOUNDARY in accordance with the methodology and parameters in the ODCM.	31 days

## BASES

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The requirement that the appropriate portions of these systems be used, when specified, provides reasonable assurance that the releases of radioactive materials in gaseous effluents will be kept "as low as is reasonably achievable."

This DNC implements the requirements of 10 CFR 50.36a, July 1967 AEC General Design Criteria 70 and the design objectives given in section II.D of Appendix I to 10 CFR Part 50.

The specified limits governing the use of appropriate portions of the systems were specified as a suitable fraction of the dose design objectives set forth in Sections II.B and II.C of Appendix I, 10 CFR Part 50, for gaseous effluents.

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13.2 GASEOUS EFFLUENTS

13.2.5 Gas Storage Tanks

Content deleted. No longer applicable.

13.3 INSTRUMENTATION

13.3.1 Radioactive Liquid Effluent Monitoring Instrumentation

DNC 13.3.1 The radioactive liquid effluent monitoring instrumentation channels shown in Table 13.3.1-1 shall be FUNCTIONAL with:

- a. The minimum FUNCTIONAL channel(s) in service.
- b. The alarm/trip setpoints set to ensure that the limits of DNC 13.1.1 are not exceeded.

APPLICABILITY: During release via the monitored pathway.

ACTIONS

NON-CONFORMANCE	CONTINGENCY MEASURES	RESTORATION TIME
A. Liquid effluent monitoring instrumentation channel alarm/trip setpoint less conservative than required.	A.1 Suspend the release of radioactive liquid effluents monitored by the affected channel.	Immediately
	<u>OR</u>	
	A.2 Declare the channel non-functional.	Immediately
	<u>OR</u>	
	A.3 Change the setpoint so it is acceptably conservative.	Immediately

ACTIONS (continued)

NON-CONFORMANCE	CONTINGENCY MEASURES	RESTORATION TIME
<p>B. Liquid Radwaste Effluent Line (R-18) non-functional prior to or during effluent releases.</p>	<p>-----NOTE-----            Prior to initiating an effluent release, complete sections B.1.1 and B.1.2            -----</p> <p>B.1.1 Analyze at least 2 independent samples in accordance with Table 13.1.1-1.</p> <p><u>AND</u></p> <p>B.1.2 -----NOTE-----            Verification ACTION will be performed by at least 2 separate technically qualified members of the facility staff.            -----</p> <p>Independently verify the release rate calculations and discharge line valving.</p> <p><u>OR</u></p> <p>B.2 Suspend release of radioactive effluents via this pathway</p>	<p>Prior to initiating a release</p> <p>Prior to initiating a release</p> <p>Immediately</p>

ACTIONS (continued)

NON-CONFORMANCE	CONTINGENCY MEASURES	RESTORATION TIME
C. CONTINGENCY MEASURES OR RESTORATION TIME of A or B not met.	C.1 Initiate a CR  <u>AND</u>  C.2 Explain in the next Radioactive Effluent Release Report why the CONTINGENCY MEASURE was not met in a timely manner.	In accordance with Corrective Action Program          In accordance with Radioactive Effluent Release Report



VERIFICATION REQUIREMENTS

----- NOTE -----  
Refer to Table 13.3.1-1 to determine which DVRs apply for each function.  
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VERIFICATION	FREQUENCY
DVR 13.3.1.1    Perform CHANNEL CHECK.	24 hours
DVR 13.3.1.2    Perform SOURCE CHECK.	Prior to release
DVR 13.3.1.3    Perform CHANNEL FUNCTIONAL TEST	92 days
DVR 13.3.1.4    Perform CHANNEL CALIBRATION.	18 months

Table 13.3.1-1  
 Radioactive Liquid Effluent Monitoring Instrumentation

INSTRUMENT	REQUIRED CHANNELS PER INSTRUMENT	VERIFICATION REQUIREMENTS
1. Gross Radioactivity Monitors Providing Alarm and Automatic Termination of Release  a. Liquid Radwaste Effluent Line (R-18)	1	DVR 13.3.1.1 DVR 13.3.1.2 DVR 13.3.1.3 DVR 13.3.1.4

## BASES

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The radioactive liquid effluent instrumentation, required FUNCTIONAL by this DNC, is provided to monitor and control, as applicable, the releases of radioactive materials in liquid effluents during actual or potential releases of liquid effluent. The alarm/trip setpoints for these instruments shall be calculated and adjusted in accordance with methodology and parameters in the ODCM to ensure that the alarm/trip will occur prior to exceeding ten (10) times the values 10 CFR Part 20, Appendix B, Table 2, Column 2. The FUNCTIONALITY and use of this instrumentation is consistent with the appropriate requirements of July 1967 AEC General Design Criteria 17, 18, and 70.

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13.3 INSTRUMENTATION

13.3.2 Radioactive Gaseous Effluent Monitoring Instrumentation

DNC 13.3.2 The radioactive gaseous effluent monitoring instrumentation channels shown in Table 13.3.2-1 shall be FUNCTIONAL with:

- a. The minimum FUNCTIONAL channel(s) in service.

APPLICABILITY: During release via the monitored pathway.

ACTIONS

-----NOTE-----  
Separate NON-CONFORMANCE entry is allowed for each channel.  
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NON-CONFORMANCE	CONTINGENCY MEASURES	RESTORATION TIME
A. Less than the minimum number of channels FUNCTIONAL.	A.1 Restore non-functional channel(s) to FUNCTIONAL status.	30 days.
B. Sampler Flow rate Measuring Devices (for the Auxiliary Building Ventilation Sampler) non-functional prior to or during releases	B.1 Estimate the flow rate for the non-functional channel(s).	4 hours <u>AND</u> Once per 4 hours thereafter
C. Particulate Samplers (for the Auxiliary Building Ventilation system) non-functional prior to or during releases	C.1 Continuously collect samples using auxiliary sampling equipment as required in Table 13.2.1-1.	12 hours
D. <u>CONTINGENCY MEASURES OR</u> RESTORATION TIME A, B, or C not met.	D.1 Initiate a CR <u>AND</u> D.2 Explain in the next Radioactive Effluent Release Report why the <u>CONTINGENCY MEASURE</u> was not met in a timely manner.	In accordance with Corrective Action Program  In accordance with Radioactive Effluent Release Report

VERIFICATION REQUIREMENTS

VERIFICATION		FREQUENCY
DVR 13.3.2.1	Perform CHANNEL CHECK.	24 hours
DVR 13.3.2.2	Perform CHANNEL CHECK.	31 days
DVR 13.3.2.3	Perform CHANNEL FUNCTIONAL TEST.	92 days
DVR 13.3.2.4	Perform CHANNEL CALIBRATION.	18 months

Table 13.3.2-1  
Radioactive Gaseous Effluent Monitoring Instrumentation

INSTRUMENT	REQUIRED CHANNELS PER INSTRUMENT	NON-CONFORMANCE	VERIFICATION REQUIREMENTS
1. Auxiliary Building Vent			
a. Particulate Sampler (R-13 or R-14)	1	C	DVR 13.3.2.2
b. Sample Flow-Rate Monitor (R-13 or R-14)	1	B	DVR 13.3.2.1 DVR 13.3.2.3 DVR 13.3.2.4

**BASES**

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The radioactive gaseous effluent instrumentation, required FUNCTIONAL by this DNC, is provided to monitor and control, as applicable, the releases of radioactive materials in gaseous effluents during actual or potential releases of gaseous effluents. The FUNCTIONALITY and use of this instrumentation is consistent with the requirements of July 1967 AEC General Design Criteria 17, 18, and 70.

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13.4 RADIOACTIVE EFFLUENTS TOTAL DOSE

13.4.1 Radioactive Effluents Total Dose

DNC 13.4.1 The annual (calendar year) dose or dose commitment to any MEMBER OF THE PUBLIC due to releases of radioactivity and to radiation from uranium fuel cycle sources shall be limited to  $\leq 25$  mrem to the total body or any organ, except the thyroid, which shall be limited to  $\leq 75$  mrem.

APPLICABILITY: At all times.

ACTIONS

NON-CONFORMANCE	CONTINGENCY MEASURES	RESTORATION TIME
A. Estimated dose or dose commitment due to direct radiation and the release of radioactive materials in liquid or gaseous effluents exceeds the limits.	A.1 Verify the condition resulting in doses exceeding these limits has been corrected.	Immediately
B. CONTINGENCY MEASURES A.1 and RESTORATION TIME not met.	<p>B.1 -----NOTE-----            This is the Special Report required by DNC 13.1.2, or 13.2.3 supplemented with the following.</p> <p>-----</p> <p>Submit a Special Report, pursuant to Section 15.3, including a request for a variance in accordance with the provisions of 40 CFR 190. This submission is considered a timely request, and a variance is granted until staff ACTION on the request is complete.</p>	30 days



VERIFICATION REQUIREMENTS

VERIFICATION	FREQUENCY
DVR 13.4.1.1 Cumulative dose contributions from liquid and gaseous effluents shall be determined in accordance with VERIFICATION REQUIREMENTS 13.1.2.1, and 13.2.3.1 in accordance with the methodology and parameters in the ODCM.	12 months
DVR 13.4.1.2 Cumulative dose contributions from direct radiation from the facility shall be determined in accordance with the methodology and parameters in the ODCM. This requirement is applicable only under conditions set forth in ODCM DNC 13.4.1.A.	12 months

## BASES

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This normal condition is provided to meet the dose limitations of 40 CFR Part 190 that have been incorporated into 10 CFR Part 20 by 46 FR 18525. The DNC requires the preparation and submittal of a Special Report whenever the calculated doses from plant generated radioactive effluents and direct radiation exceed 25 mrem to the total body or any organ, except the thyroid, which shall be limited to less than or equal to 75 mrem. It is highly unlikely that the resultant dose to a MEMBER OF THE PUBLIC will exceed the dose limits of 40 CFR Part 190 if the facility remains within twice the dose design objectives of Appendix I, and if direct radiation doses from the facility are kept small.

The Special Report will describe a course of ACTION that should result in the limitation of the annual dose to a MEMBER OF THE PUBLIC to within the 40 CFR Part 190 limits. For the purposes of the Special Report, it may be assumed that the dose commitment to the MEMBER OF THE PUBLIC from other uranium fuel cycle sources is negligible. If the dose to any MEMBER OF THE PUBLIC is estimated to exceed the requirements of 40 CFR Part 190, the Special Report with a request for a variance (provided the release conditions resulting in violation of 40 CFR Part 190 have not already been corrected), in accordance with the provisions of 40 CFR 190.11 and 10 CFR 20.2203, is considered to be a timely request and fulfills the requirements of 40 CFR Part 190 until NRC staff ACTION is completed. The variance only relates to the limits of 40 CFR Part 190, and does not apply in any way to the other requirements for dose limitation of 10 CFR Part 20, as addressed in ODCM Normal Condition 13.3.1 and 13.4.1. An individual is not considered a MEMBER OF THE PUBLIC during any period in which he/she is engaged in carrying out any operation that is part of the nuclear fuel cycle.

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## 13.5 RADIOLOGICAL ENVIRONMENTAL MONITORING

### 13.5.1 Monitoring Program

This Kewaunee Program is established by the RADIOLOGICAL ENVIRONMENTAL MONITORING MANUAL (REMM) and implemented by approved station procedures. This program is required by Technical Requirements Manual 10.1.1 and ODCM.

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The radiological environmental monitoring program required by this DNC provides representative measurements of radiation and of radioactive materials in those exposure pathways and for those radionuclides that lead to the highest potential radiation exposures of MEMBERS OF THE PUBLIC resulting from the plant decommissioning activities. This monitoring program implements Section IV.B.2 of Appendix I to 10 CFR Part 50 and thereby supplements the radiological effluent monitoring program by verifying that the measurable concentrations of radioactive materials and levels of radiation are not higher than expected on the basis of the effluent measurements and the modeling of the environmental exposure pathways. Guidance for this monitoring program is provided by the Radiological Assessment Branch Technical Position on Environmental Monitoring.

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## 13.5 RADIOLOGICAL ENVIRONMENTAL MONITORING

### 13.5.2 Land Use Census Program

This Kewaunee Land Use Census Program is implemented by the RADIOLOGICAL ENVIRONMENTAL MONITORING MANUAL (REMM) and Land Use Census Program procedure.

#### BASES

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This DNC is provided to ensure that changes in the use of areas at and beyond the SITE BOUNDARY are identified and that modifications to the radiological environmental monitoring program are made if required by the results of this census. The best information from the door-to-door survey, from aerial survey or from consulting with local agricultural authorities shall be used. This census satisfies the requirements of Section IV.B.3 of Appendix I to 10 CFR Part 50. Restricting the census to gardens of greater than 50 m<sup>2</sup> provides assurance that significant exposure pathways via broad leaf vegetation will be identified and monitored since a garden of this size is the minimum required to produce the quantity (26 kg/year) of broad leaf vegetation assumed in Regulatory Guide 1.109 for consumption by a child. To determine this minimum garden size, the following assumptions were made: (1) 20% of the garden was used for growing broad leaf vegetation (i.e., similar to lettuce and cabbage), and (2) a broad leaf vegetation yield of 2 kg/m<sup>2</sup>.

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## 13.5 RADIOLOGICAL ENVIRONMENTAL MONITORING

### 13.5.3 Interlaboratory Comparison Program

This Kewaunee Interlaboratory Comparison Program is implemented by the RADIOLOGICAL ENVIRONMENTAL MONITORING MANUAL (REMM) and approved station procedures.

#### BASES

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The requirement for participation in an approved Interlaboratory Comparison Program is provided to ensure that independent checks on the precision and accuracy of the measurements of radioactive material in environmental sample matrices are performed as part of the quality assurance program for environmental monitoring (developed using the guidance in Regulatory Guide 1.21, Revision 1, April 1974 and Regulatory Guide 4.1, Revision 1, April 1975) in order to demonstrate that the results are valid for the purposes of Section IV.B.2 of Appendix I to 10 CFR Part 50.

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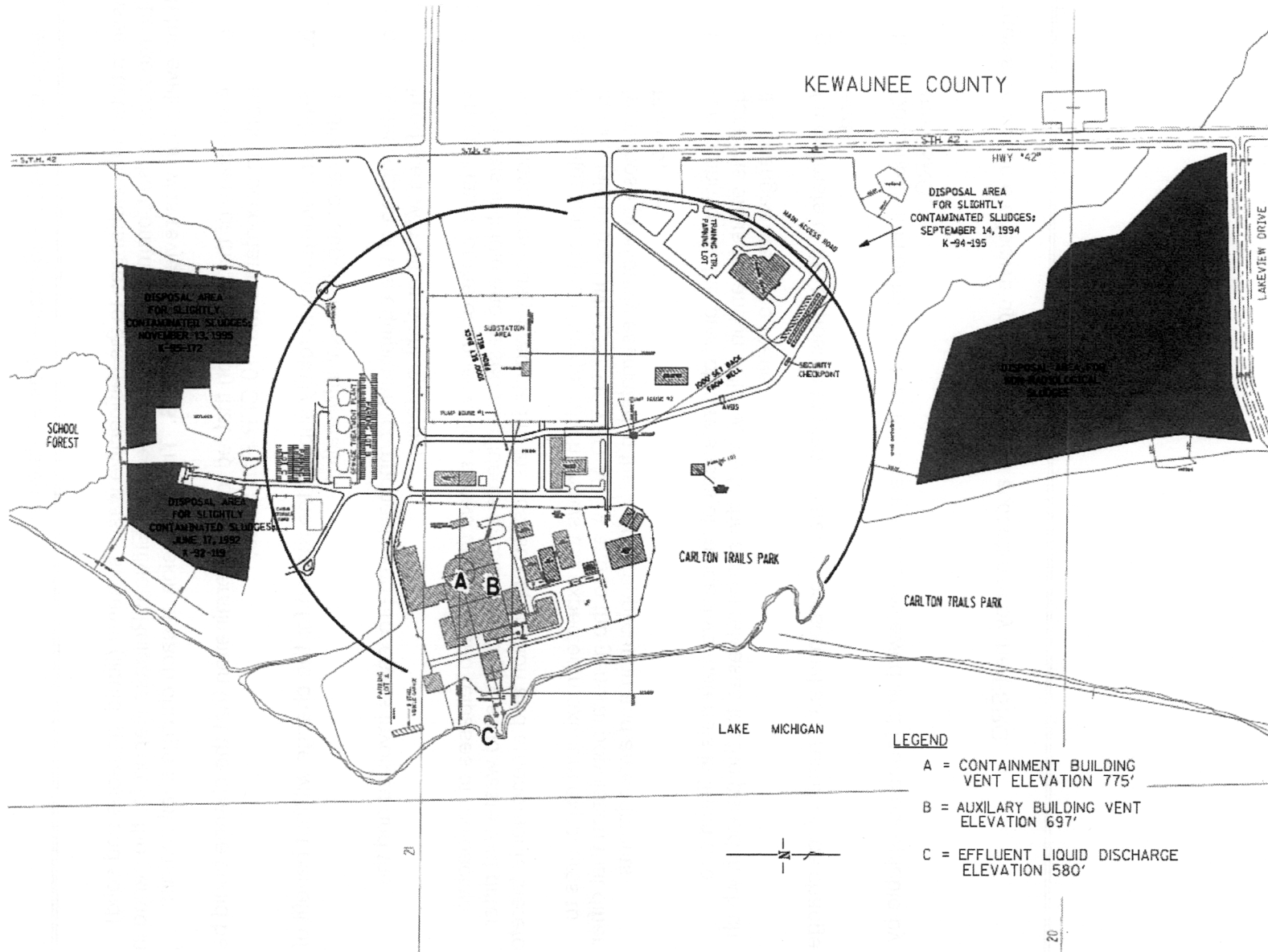
## 14.0 DESIGN FEATURES

### 14.1 GASEOUS AND LIQUID EFFLUENT RELEASE POINTS

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- 14.1.1 Figure 14.1-1 presents the locations of radioactive effluent release points at the plant. The Figure does not depict changes made at the facility since permanent plant shutdown, however no changes have been made to radioactive effluent release points depicted on the Figure.
- 14.1.2 Plant drawing A-408, "Radiological Survey Site Map" depicts the site area by illustrating the SITE BOUNDARY.
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FIGURE 14.1-1



## 15.0 ADMINISTRATIVE CONTROLS

### 15.1 Major Changes to Radioactive Waste Systems<sup>(1)</sup>

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Licensee initiated major changes to the radioactive waste systems (liquid, gaseous and solid) shall be reported to the Commission in the Radioactive Effluent Release Report for the period in which the evaluation was reviewed by FSRG. The discussion of each change shall contain:

- a. A summary of the evaluation that led to the determination that the change could be made in accordance with 10 CFR Part 50.59,
- b. Sufficient information to totally support the reason for the change without benefit of additional or supplemental information,
- c. A description of the equipment, components and processes involved and the interfaces with other plant systems,
- d. An evaluation of the change, which shows the predicted releases of radioactive materials in liquid and gaseous effluents and/or quantity of solid waste that differ from those previously predicted in the license application and amendments thereto,
- e. An evaluation of the change, which shows the expected maximum exposures to individuals in the UNRESTRICTED AREA and to the general population that differ from those previously estimated in the license application and amendments thereto,
- f. A comparison of the predicted releases of radioactive materials in liquid and gaseous effluents and in solid waste to the actual releases for the period in which the changes are to be made;
- g. An estimate of the exposure to plant operating personnel as a result of the change, and
- h. Documentation of the fact that the change was reviewed and found acceptable by the FSRG.

Changes shall become effective upon review and acceptance by the FSRG.

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<sup>(1)</sup>Licensees may choose to submit the information called for in this requirement as part of the periodic USAR update.



## 15.0 ADMINISTRATIVE CONTROLS

### 15.2 Radioactive Effluent Release Report

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The Radioactive Effluent Release Report to be submitted by May 1 of each year shall include:

- a. A summary of the quantities of radioactive liquid and gaseous effluents and solid waste released from the facility following the format of Regulatory Guide 1.21, "Measuring, Evaluating, and Reporting Radioactivity in Solid Wastes and Releases of Radioactive Materials in Liquid Gaseous Effluents from Light-Water-Cooled Nuclear Power Plants," Revision 1, June 1974.
- b. An assessment of the radiation doses due to the radioactive liquid and gaseous effluents released from the facility during the previous calendar year.
- c. An assessment of radiation doses to the likely most exposed MEMBER OF THE PUBLIC from facility releases and other nearby uranium fuel cycle sources, including doses from primary effluent pathways and direct radiation, the previous calendar year to show conformance with 40 CFR Part 190, Environmental Radiation Protection Standards for Nuclear Power Operation.

All assumptions used in making these assessments, i.e., specific activity, exposure time and location, shall be included in these reports. The assessment of radiation doses shall be performed in accordance with the methodology and parameters in the OFFSITE DOSE CALCULATION MANUAL (ODCM).

- d. The report shall include a summary of the quantities of radioactive liquid and gaseous effluents and solid waste released from the facility. The material provided shall be consistent with the objectives outlined in the ODCM and the PCP, and in conformance with 10 CFR 50.36a and Section IV.B.1 of Appendix I to 10 CFR Part 50.
  - e. A list and description of unplanned releases from the site to UNRESTRICTED AREAS of radioactive materials in gaseous and liquid effluents made during the reporting period.
  - f. Any changes made during the reporting period to the PROCESS CONTROL PROGRAM (PCP) and to the OFFSITE DOSE CALCULATION MANUAL (ODCM), as well as a listing of new locations for dose calculations and/or environmental monitoring identified by the land use census pursuant to DNC 13.5.2.
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## 15.0 ADMINISTRATIVE CONTROLS

### 15.3 Special Reports

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Special reports may be required covering inspections, tests, and maintenance activities. These special reports are determined on an individual basis. Their preparation and submittal are designated in the ODCM Contingency Measures for each Normal Condition.

Special reports shall be submitted to the Director of the NRC Regional Office listed in Appendix D, 10 CFR Part 20, with a copy to the Director, Office of Inspection and Enforcement, U.S. Nuclear Regulatory Commission, Washington D.C. 20555 within the time period specified for each report.

These Special Report(s) are in lieu of a Licensee Event Report

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**Kewaunee Power Station**

**Offsite Dose Calculation Manual**

**PART II - CALCULATIONAL METHODOLOGIES**

## 1.0 LIQUID EFFLUENTS METHODOLOGY

### 1.1 Radiation Monitoring Instrumentation and Controls

The liquid effluent monitoring instrumentation and controls installed at Kewaunee for controlling and monitoring normal radioactive material releases in accordance with July 1967 AEC General Design Criteria 17 and 70, are summarized as follows:

- 1) Alarm (and Automatic Termination) – R-18 provides this function on the liquid radwaste effluent line.
- 2) Liquid Tank Controls – All radioactive liquid tanks are located inside the Auxiliary Building and contain the suitable confinement systems and drains to prevent direct, unmonitored release to the environment. A liquid radioactive waste flow diagram with the applicable, associated radiation monitoring instrumentation and controls is presented as Figure 1.

### 1.2 Liquid Effluent Monitor Setpoint Determination

Per the requirements of Technical Requirements Manual 10.1.2 and ODCM Normal Condition 13.3.1, alarm setpoints shall be established for the liquid effluent monitoring instrumentation to ensure that the release concentration limits of ODCM Normal Condition 13.1.1 are met (i.e., the concentration of radioactive material released in liquid effluents to UNRESTRICTED AREA shall be limited to ten times the concentrations specified in 10 CFR 20, Appendix B, Table 2, Column 2, for radionuclides. The following equation<sup>1</sup> must be satisfied to meet the liquid effluent restrictions:

$$c \leq \frac{10 \times C(F+f)}{f} \quad (1.1)$$

<sup>1</sup> Adapted from NUREG-0133 to include the application of 10 times the Effluent Concentration (EC) of 10 CFR 20, Appendix B, Table 2, Column 2.

where:

$10 \times C$  = ten times the effluent concentration limit of 10 CFR 20, Appendix B, Table 2, Column 2, in  $\mu\text{Ci/ml}$ .

$c$  = the setpoint, in  $\mu\text{Ci/ml}$ , of the radioactivity monitor measuring the radioactivity concentration in the effluent line prior to dilution and subsequent release; the setpoint, which is inversely proportional to the volumetric flow of the effluent line and proportional to the volumetric flow of the dilution stream plus the effluent stream, represents a value which, if exceeded, would result in concentrations exceeding the limits of ODCM Normal Condition 13.1.1.

$f$  = the flow rate at the radiation monitor location in volume per unit time, but in the same units as  $F$ , below.

$F$  = the dilution water flow rate as measured prior to the release point, in volume per unit time.

[Note that if no dilution is provided,  $c \leq C$ . Also, note that when  $(F)$  is large compared to  $(f)$ , then  $(F + f) \approx F$ .]

### 1.2.1 Liquid Effluent Monitors (Radwaste)

The setpoints for the liquid effluent monitors at the Kewaunee Power Station are determined by the following equations:

$$SP \leq \frac{(DW+RR) \times \sum (C_i \times SEN_i)}{\sum_{10 \times EC_i} \times RR} + \text{bkg} \quad (1.2)$$

where:

$SP$  = alarm setpoint corresponding to the maximum allowable release rate (cpm)

$C_i$  = the concentration of radionuclide "i" in the liquid effluent ( $\mu\text{Ci/ml}$ ), to include gamma emitters only

$10 \times EC_i$  = ten times the EC value corresponding to radionuclide "i" from 10 CFR 20, Appendix B, Table 2, Column 2 ( $\mu\text{Ci/ml}$ )

- SEN<sub>i</sub> = the sensitivity value to which the monitor is calibrated for radionuclide "i" (cpm per μCi/ml). The default calibration value from Table 1.1 may be used for gamma emitting radionuclides in lieu of nuclide specific values.
- DW = the dilution water flow rate at the time of release (gal/min).
- RR = the liquid effluent release rate (gal/min).
- bkg = the background of the monitor (cpm).

The radioactivity monitor setpoint equation (1.2) remains valid during periods when the dilution water is at its lowest or zero. Reduction of the waste stream flow (RR) may be necessary during these periods to meet the discharge criteria. At its lowest value, (DW + RR) equals RR and equation (1.2) reverts to the following equation:

$$SP \leq \frac{\sum (C_i \times SEN_i)}{\sum \frac{C_i}{(10 \times EC_i)}} + bkg \quad (1.3)$$

### 1.2.2 Conservative Default Values

Non-gamma emitting radionuclides (H-3, Fe-55, Ni-63, Sr-90) are not detected by the effluent monitor and, therefore, are not directly included in the above setpoint equation. These non-gamma radionuclides can, however, contribute a sizable fraction of the total EC limit. The method specified below for establishing default setpoints provides conservatism to account for these non-gamma emitters and ensures that the setpoint meets the requirements of ODCM Normal Condition 13.3.1 including all radionuclides.

Conservative alarm setpoints can be determined through the use of generic default parameters based on the following:

- a) substitution of a default effective EC (EC<sub>e</sub>) value

where:

$$EC_e = \frac{\sum C_i}{\sum \frac{C_i}{(EC_i)}} \quad (1.4)$$

- b) substitution of the lowest operational dilution water flow, in gal/min and,
- c) substitution of the highest effluent release rate, in gal/min,
- d) substitution of a default monitor sensitivity.

The default setpoint equation is provided below:

$$SP \leq \frac{10 \times EC_e \times SEN \times (DW + RR)}{RR} + bkg \quad (1.5)$$

### 1.3 Liquid Effluent Concentration Limits – 10 CFR 20

ODCM Normal Condition 13.1.1 limits the concentration of radioactive material in liquid effluents (after dilution) to less than ten times the concentrations as specified in 10 CFR 20, Appendix B, Table 2, Column 2 for radionuclides other than noble gases. Release rates are controlled and radiation monitor alarm setpoints are established to ensure that these concentration limits are not exceeded. In the event any liquid release results in an alarm setpoint being exceeded, an evaluation of compliance with the concentration limits of ODCM Normal Condition 13.1.1 may be performed using the following equation:

where:

$$\sum[(C_i \div (10 \times EC_i)) \times (RR \div (RR + DW))] \leq 1 \quad (1.6)$$

- $C_i$  = concentration of radionuclide "i" in the undiluted liquid effluent ( $\mu\text{Ci/ml}$ )
- $10 \times EC_i$  = ten times the EC value corresponding to radionuclide "i" from 10 CFR 20, Appendix B, Table 2, Column 2 ( $\mu\text{Ci/ml}$ )
- RR = the liquid effluent release rate (gal/min)
- DW = the dilution water flow rate at the time of the release (gal/min)

1.4 Liquid Effluent Dose Calculation – 10 CFR 50

ODCM Normal Condition 13.1.2 limits the dose or dose commitment to MEMBERS OF THE PUBLIC from radioactive materials in liquid effluents from the Kewaunee Power Station to:

- during any calendar quarter;
  - ≤ 1.5 mrem to total body
  - ≤ 5.0 mrem to any organ
- during any calendar year;
  - ≤ 3.0 mrem to total body
  - ≤ 10.0 mrem to any organ.

Per Verification Requirement 13.1.2.1, the following calculational methods may be used for determining the dose or dose commitment due to the liquid radioactive effluents from Kewaunee.

$$D_o = \frac{1.67E - 02 \times VOL}{RR + DW} \times \sum (C_i \times A_{i_o}) \quad (1.7)$$

where:

- $D_o$  = dose or dose commitment to organ "o", including total body (mrem)
- $A_{i_o}$  = site-related ingestion dose commitment factor to the total body or any organ "o" for radionuclide "i" (mrem/hr per  $\mu$ Ci/ml) (Table 1.2)
- $C_i$  = average concentration of radionuclide "i", in undiluted liquid effluent representative of the volume VOL ( $\mu$ Ci/ml)
- VOL = volume of liquid effluent released (gal)
- RR = the liquid effluent release rate (gal/min)
- DW = average dilution water discharge rate during release period (gal/min)
- .1.67E-02 = conversion factor (hr/min)



The site-related ingestion doses/dose commitment factors ( $A_{io}$ ) are presented in Table 1.2 and have been derived in accordance with guidance of NUREG-0133 by the equation:

$$A_{io} = 1.14E + 05[(U_w \div D_w) + (U_F \times BF_i)]DF_i \quad (1.8)$$

where:

- $A_{io}$  = composite dose parameter for the total body or critical organ "o" of an adult for radionuclide "i", for the fish ingestion and water consumption pathways (mrem/hr per  $\mu$ Ci/ml)
- 1.14E+05 = conversion factor ( $\mu$ Ci/ $\mu$ Ci  $\times$  ml/kg  $\div$  hr/yr)
- $U_w$  = adult water consumption (730 kg/yr)
- $D_w$  = dilution factor from the near field area within  $\frac{1}{4}$  mile of the release point to the nearest potable water intake for the adult water consumption (84<sup>(2)</sup>, unitless)
- $U_F$  = adult fish consumption (21 kg/yr)
- $BF_i$  = bioaccumulation factor for radionuclide "i" in fish from Table 1.3 (pCi/kg per pCi/l)
- $DF_i$  = dose conversion factor for radionuclide "i" for adults in pre-selected organ "o", from Table E-11 of Regulatory Guide 1.109, 1977 and NUREG 0172, 1977 (mrem/pCi)

The radionuclides included in the periodic dose assessment per the requirements of ODCM Normal Condition 13.1.2 and Verification Requirement 13.1.2.1 are those as identified by gamma spectral analysis of the liquid waste samples collected and analyzed per Verification Requirement 13.1.1.1, Table 13.1.1-1.

Radionuclides requiring radiochemical analysis (e.g., Sr-90) will be added to the dose analysis at a frequency consistent with the required minimum analysis frequency of Table 13.1.1-1.

<sup>2</sup> Adapted from the Kewaunee Final Environmental Statement, Section V.

1.5 Liquid Effluent Dose Projections

ODCM Normal Condition 13.1.3 requires that the liquid radioactive waste processing system be used to reduce the radioactive material levels in the liquid waste prior to release when the 31 day projected doses exceed:

- 0.06 mrem to the total body, or
- 0.2 mrem to any organ.

The applicable liquid waste streams and processing systems are as delineated in Figure 1.

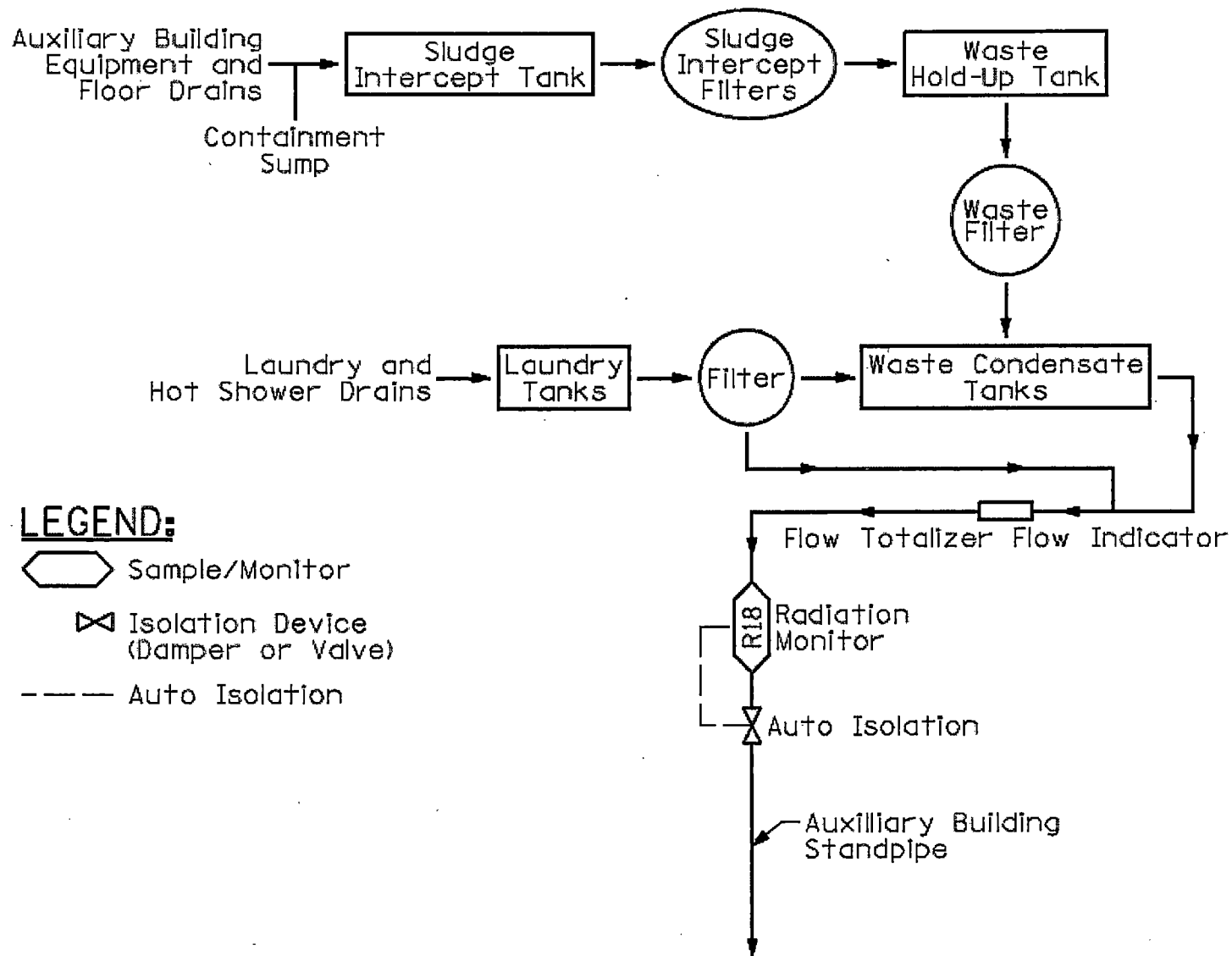
Dose projections are made at least once per 31 days by the following equations:

$$D_{tbp} = D_{tb} (31 \div d) \tag{1.9}$$

$$D_{maxp} = D_{max} (31 \div d) \tag{1.10}$$

where:

- $D_{tbp}$  = the total body dose projection for current 31 day period (mrem)
- $D_{tb}$  = the total body dose to date for current 31 day period as determined by equation (1.7) (mrem)
- $D_{maxp}$  = the maximum organ dose projection for current 31 day period (mrem)
- $D_{max}$  = the maximum organ dose to date for current 31 day period as determined by equation (1.7) (mrem)
- $d$  = the number of days to date for current 31 day period
- 31 = the number of days in a 31 day period



ODCM FIGURE 1  
LIQUID RADIOACTIVE EFFLUENT FLOW DIAGRAM

Table 1.1  
Parameters for Liquid Alarm Setpoint Determinations

Parameter	Actual Value	Units	Comments
EC <sub>e</sub>	calculated	μCi/ml	Calculate as needed
C <sub>i</sub>	measured	μCi/ml	Taken from gamma spectral analysis of liquid effluent
EC <sub>i</sub>	as determined	μCi/ml	Taken from 10 CFR 20, Appendix B, Table 2, Col. 2
Sensitivity (SEN) R-18	1.0E+08	cpm per μCi/ml	Radwaste effluent (value based on Cs-137) Refer to Plant Drawing E-2021
Release Rate (RR) R-18	as determined	gpm	Determined prior to release; release rate can be adjusted for ODCM limit compliance
Background (bkg) R-18	as determined	cpm	Determined prior to release
Setpoint (SP) R-18*	calculated	cpm	Default alarm setpoints at conservative values may be used as deemed appropriate and desirable for assuring regulatory compliance and for maintaining releases ALARA.
* The alarm setpoint for R-18 cannot exceed the linear calibration range of the radiation monitor in accordance with CAP 37265 and DCR 26981 (5.00E+05+bkg cpm).			

Table 1.2 (Page 1 of 2)  
Site Related Ingestion Dose Commitment Factors  
(mrem/hr per  $\mu\text{Ci/ml}$ )

Nuclide	Bone	Liver	T.Body	Thyroid	Kidney	Lung	GI-LLI
H-3	-	3.30E-1	3.30E-1	3.30E-1	3.30E-1	3.30E-1	3.30E-1
C-14	3.13E+4	6.26E+3	6.26E+3	6.26E+3	6.26E+3	6.26E+3	6.26E+3
Na-24	4.09E+2	4.09E+2	4.09E+2	4.09E+2	4.09E+2	4.09E+2	4.09E+2
P-32	1.39E+6	8.62E+4	5.36E+4	-	-	-	1.56E+5
Cr-51	-	-	1.28E+0	7.63E-1	2.81E-1	1.69E+0	3.21E+2
Mn-54	-	4.38E+3	8.36E+2	-	1.30E+3	-	1.34E+4
Mn-56	-	1.10E+2	1.96E+1	-	1.40E+2	-	3.52E+3
Fe-55	6.61E+2	4.57E+2	1.06E+2	-	-	2.55E+2	2.62E+2
Fe-59	1.04E+3	2.45E+3	9.40E+2	-	-	6.85E+2	8.17E+3
Co-57	-	2.11E+1	3.51E+1	-	-	-	5.36E+2
Co-58	-	8.99E+1	2.02E+2	-	-	-	1.82E+3
Co-60	-	2.58E+2	5.70E+2	-	-	-	4.85E+3
Ni-63	3.13E+4	2.17E+3	1.05E+3	-	-	-	4.52E+2
Ni-65	1.27E+2	1.65E+1	7.52E+0	-	-	-	4.18E+2
Cu-64	-	1.01E+1	4.72E+0	-	2.53E+1	-	8.57E+2
Zn-65	2.32E+4	7.38E+4	3.33E+4	-	4.93E+4	-	4.65E+4
Zn-69	4.93E+1	9.43E+1	6.56E+0	-	6.13E+1	-	1.42E+1
Br-82	-	-	2.27E+3	-	-	-	2.61E+3
Br-83	-	-	4.05E+1	-	-	-	5.83E+1
Br-84	-	-	5.24E+1	-	-	-	4.12E-4
Br-85	-	-	2.15E+0	-	-	-	-
Rb-86	-	1.01E+5	4.71E+4	-	-	-	1.99E+4
Rb-88	-	2.90E+2	1.54E+2	-	-	-	4.00E-9
Rb-89	-	1.92E+2	1.35E+2	-	-	-	-
Sr-89	2.24E+4	-	6.44E+2	-	-	-	3.60E+3
Sr-90	5.52E+5	-	1.35E+5	-	-	-	1.59E+4
Sr-91	4.13E+2	-	1.67E+1	-	-	-	1.97E+3
Sr-92	1.57E+2	-	6.77E+0	-	-	-	3.10E+3
Y-90	5.85E-1	-	1.57E-2	-	-	-	6.21E+3
Y-91m	5.53E-3	-	2.14E-4	-	-	-	1.62E-2
Y-91	8.58E+0	-	2.29E-1	-	-	-	4.72E+3
Y-92	5.14E-2	-	1.50E-3	-	-	-	9.00E+2
Y-93	1.63E-1	-	4.50E-3	-	-	-	5.17E+3
Zr-95	2.70E-1	8.67E-2	5.87E-2	-	1.36E-1	-	2.75E+2
Zr-97	1.49E-2	3.01E-3	1.38E-3	-	4.55E-3	-	9.34E+2
Nb-95	4.47E+2	2.49E+2	1.34E+2	-	2.46E+2	-	1.51E+6
Nb-97	3.75E+0	9.48E-1	3.46E-1	-	1.11E+0	-	3.50E+3
Mo-99	-	1.07E+2	2.04E+1	-	2.43E+2	-	2.49E+2
Tc-99m	9.11E-3	2.58E-2	3.28E-1	-	3.91E-1	1.26E-2	1.52E+1
Tc-101	9.37E-3	1.35E-2	1.32E-1	-	2.43E-1	6.90E-3	-
Ru-103	4.61E+0	-	1.99E+0	-	1.76E+1	-	5.39E+2
Ru-105	3.84E-1	-	1.52E-1	-	4.96E+0	-	2.35E+2
Ru-106	6.86E+1	-	8.68E+0	-	1.32E+2	-	4.44E+3
Rh-103m	-	-	-	-	-	-	-
Rh-106	-	-	-	-	-	-	-

Table 1.2 (Page 2 of 2)  
Site Related Ingestion Dose Commitment Factors  
(mrem/hr per  $\mu\text{Ci/ml}$ )

Nuclide	Bone	Liver	T.Body	Thyroid	Kidney	Lung	GI-LLI
Ag-110m	1.04E+0	9.62E-1	5.71E-1	-	1.89E+0	-	3.92E+2
Sb-124	9.48E+0	1.79E-1	3.76E+0	2.30E-2	-	7.38E+0	2.69E+2
Sb-125	6.06E+0	6.77E-2	1.44E+0	6.16E-3	-	4.67E+0	6.67E+1
Te-125m	2.57E+3	9.31E+2	3.44E+2	7.73E+2	1.04E+4	-	1.03E+4
Te-127m	6.49E+3	2.32E+3	7.91E+2	1.66E+3	2.64E+4	-	2.18E+4
Te-127	1.05E+2	3.79E+1	2.28E+1	7.81E+1	4.29E+2	-	8.32E+3
Te-129m	1.10E+4	4.11E+3	1.74E+3	3.79E+3	4.60E+4	-	5.55E+4
Te-129	3.01E+1	1.13E+1	7.33E+0	2.31E+1	1.27E+2	-	2.27E+1
Te-131m	1.66E+3	8.11E+2	6.76E+2	1.28E+3	8.22E+3	-	8.05E+4
Te-131	1.89E+1	7.89E+0	5.96E+0	1.55E+1	8.27E+1	-	2.67E+0
Te-132	2.42E+3	1.56E+3	1.47E+3	1.73E+3	1.50E+4	-	7.39E+4
I-130	2.79E+1	8.23E+1	3.25E+1	6.97E+3	1.28E+2	-	7.08E+1
I-131	1.54E+2	2.20E+2	1.26E+2	7.20E+4	3.76E+2	-	5.79E+1
I-132	7.49E+0	2.00E+1	7.01E+0	7.01E+2	3.19E+1	-	3.76E+0
I-133	5.24E+1	9.11E+1	2.78E+1	1.34E+4	1.59E+2	-	8.19E+1
I-134	3.91E+0	1.06E+1	3.80E+0	1.84E+2	1.69E+1	-	9.26E-3
I-135	1.63E+1	4.28E+1	1.58E+1	2.82E+3	6.86E+1	-	4.83E+1
Cs-134	2.98E+5	7.09E+5	5.79E+5	-	2.29E+5	7.61E+4	1.24E+4
Cs-136	3.12E+4	1.23E+5	8.86E+4	-	6.85E+4	9.39E+3	1.40E+4
Cs-137	3.82E+5	5.22E+5	3.42E+5	-	1.77E+5	5.89E+4	1.01E+4
Cs-138	2.64E+2	5.22E+2	2.59E+2	-	3.84E+2	3.79E+1	2.23E-3
Ba-139	1.02E+0	7.30E-4	3.00E-2	-	6.83E-4	4.14E-4	1.82E+0
Ba-140	2.15E+2	2.69E-1	1.41E+1	-	9.16E-2	1.54E-1	4.42E+2
Ba-141	4.98E-1	3.76E-4	1.68E-2	-	3.50E-4	2.13E-4	-
Ba-142	2.25E-1	2.31E-4	1.42E-2	-	1.95E-4	1.31E-4	-
La-140	1.52E-1	7.67E-2	2.03E-2	-	-	-	5.63E+3
La-142	7.79E-3	3.54E-3	8.82E-4	-	-	-	2.59E+1
Ce-141	3.17E-2	2.14E-2	2.43E-3	-	9.95E-3	-	8.19E+1
Ce-143	5.58E-3	4.13E+0	4.57E-4	-	1.82E-3	-	1.54E+2
Ce-144	1.65E+0	6.90E-1	8.87E-2	-	4.10E-1	-	5.58E+2
Pr-143	5.60E-1	2.25E-1	2.77E-2	-	1.30E-1	-	2.45E+3
Pr-144	1.83E-3	7.61E-4	9.31E-5	-	4.29E-4	-	-
Nd-147	3.83E-1	4.42E-1	2.65E-2	-	2.59E-1	-	2.12E+3
W-187	2.96E+2	2.47E+2	8.65E+1	-	-	-	8.10E+4
Np-239	2.97E-2	2.92E-3	1.61E-3	-	9.10E-3	-	5.98E+2

Table 1.3  
 Bioaccumulation Factors (BFI)  
 (pCi/kg per pCi/liter)\*

Element	Freshwater Fish
H	9.0E-01
C	4.6E+03
Na	1.0E+02
P	3.0E+03
Cr	2.0E+02
Mn	4.0E+02
Fe	1.0E+02
Co	5.0E+01
Ni	1.0E+02
Cu	5.0E+01
Zn	2.0E+03
Br	4.2E+02
Rb	2.0E+03
Sr	3.0E+01
Y	2.5E+01
Zr	3.3E+00
Nb	3.0E+04
Mo	1.0E+01
Tc	1.5E+01
Ru	1.0E+01
Rh	1.0E+01
Ag	2.3E+00
Sb	1.0E+00
Te	4.0E+02
I	1.5E+01
Cs	2.0E+03
Ba	4.0E+00
La	2.5E+01
Ce	1.0E+00
Pr	2.5E+01
Nd	2.5E+01
W	1.2E+03
Np	1.0E+01

\* Values in this Table are taken from Regulatory Guide 1.109 except for phosphorus which is adapted from NUREG/CR-1336 and silver and antimony which are taken from UCRL 50564, Rev. 1, October 1972.

## 2.0 Gaseous Effluents Methodology

### 2.1 Radiation Monitoring Instrumentation and Controls

The gaseous effluent monitoring instrumentation and controls at Kewaunee for controlling and monitoring normal radioactive material releases in accordance with July 1967 AEC General Design Criteria 17 and 70, are summarized as follows:

#### 2.1.1 Auxiliary Building Vent

The Auxiliary Building vent receives discharges from the Auxiliary Building radwaste processing area ventilation and Auxiliary Building general area. All effluents pass through the R-13 and/or R-14 channels which contain a particulate sampler.

Effluent flow rates are determined by installed flow measurement equipment, if available, or fan operation (fan configuration). Sampler flow rates are determined by flow rate instrumentation.

#### 2.1.2 Non-routine Discharge Locations

Periodically, non-routine breaches are made in the Auxiliary and Containment buildings that might allow the release of the atmosphere, which contains some levels of radioactivity. These breaches include, but are not limited to, opening the Containment equipment hatch, holes cut in walls or ceilings to allow for moving equipment in or out of the Radiologically Controlled Areas (RCAs). All efforts to maintain these areas at negative pressure will be made. IF negative pressure cannot be maintained (i.e., more exhaust than supply fan volume), THEN supply ventilation to the area must be secured. If the auxiliary building ventilation is out of service (e.g., loss of power or fan failure), a conservative release rate of 5125 cfm may be used (KPS Modification No. KW-16-02022, SAFSTOR III Ventilation). Criteria for determining if and when a release occurs from these areas is provided in implementing procedures. As possible, the effects of these possible releases shall be evaluated beforehand. Any actual releases shall be documented and included in the monthly, quarterly and annual reports as appropriate.

A gaseous radioactive waste flow diagram with the applicable, associated radiation monitoring instrumentation and controls is presented as Figure 2.



## 2.2 Gaseous Effluent Instantaneous Dose Rate Calculations - 10 CFR 20

### 2.2.1 SITE BOUNDARY Dose Rate – Tritium and Particulates

ODCM Normal Condition 13.2.1.a limits the dose rate to  $\leq 1500$  mrem/yr to any organ for tritium and particulates with half-lives greater than 8 days. To demonstrate compliance with this limit, an evaluation is performed at a frequency no greater than that corresponding to the sampling and analysis time period for continuous releases per Table 13.2.1-1. The following equation may be used for the dose rate evaluation:

$$\dot{D}_o = \chi/Q \times \sum(R_i \times \dot{Q}_i) + D/Q \times \sum(R_i \times \dot{Q}_i) \quad (2.1)$$

where:

- $\dot{D}_o$  = average organ dose rate over the sampling time period (mrem/yr)
- $\chi/Q$  = atmospheric dispersion to the controlling SITE BOUNDARY location for the inhalation pathway (sec/m<sup>3</sup>) from Table 2.1
- $D/Q$  = atmospheric deposition to the controlling SITE BOUNDARY location for the ground plane exposure pathway (1/m<sup>2</sup>) from Table 2.1
- $R_i$  = dose factor for radionuclide "i", (mrem/yr per  $\mu\text{Ci}/\text{m}^3$ ) for the TEEN inhalation pathway from Table 2.3 and the ground plane exposure pathway (m<sup>2</sup> – mrem/yr per  $\mu\text{Ci}/\text{sec}$ ) from Table 2.13
- $\dot{Q}_i$  = average release rate over the appropriate sampling period and analysis frequency for radionuclide "i", tritium or other radionuclide in particulate form with half-life greater than 8 days ( $\mu\text{Ci}/\text{sec}$ )

2.3 Gaseous Effluent Dose Calculations - 10 CFR 50

2.3.1 UNRESTRICTED AREA Dose - Tritium and Particulates

Per the requirements of ODCM Normal Condition 13.2.3, a periodic assessment shall be performed to evaluate compliance with the quarterly dose limit ( $\leq 7.5$  mrem) and calendar year limit ( $\leq 15$  mrem) to any organ. The following equation may be used to evaluate the maximum organ dose due to releases of tritium and particulates with half-lives greater than 8 days:

$$D_{aop} = 3.17E-08 \times W \times SF_p \times \sum (R_i \times Q_i) \quad (2.2)$$

where:

- $D_{aop}$  = dose or dose commitment for age group "a" to organ "o", including the total body, via pathway "p" from tritium and radionuclides in particulate form with half-life greater than eight days (mrem)
- $W$  = atmospheric dispersion or deposition parameter to the controlling location(s) as identified in Table 2.1
- $\chi/Q$  = atmospheric dispersion for inhalation pathway and H-3 dose contribution via other pathways ( $\text{sec}/\text{m}^3$ )
- $D/Q$  = atmospheric deposition for ground plane, vegetation, and milk exposure pathways ( $1/\text{m}^2$ )
- $R_i$  = dose factor for radionuclide "i", ( $\text{mrem}/\text{yr}$  per  $\mu\text{Ci}/\text{m}^3$ ) or ( $\text{m}^2 - \text{mrem}/\text{yr}$  per  $\mu\text{Ci}/\text{sec}$ ) from Table 2.2 through 2.13 for each age group "a" and the applicable pathway "p" as identified in Table 2.1. Values for  $R_i$  were derived in accordance with the methods described in NUREG-0133. For additional ODCM DCFs that may be used in active DECON, refer to Table D-1 through D-3 in Calculation RA-0065, Rev 0.
- $Q_i$  = cumulative release over the period of interest for radionuclide "i" -- radioactive material in particulate form with half-life greater than 8 days ( $\mu\text{Ci}$ ).

$SF_p$  = seasonal correction factor to account for the fraction of the period that the applicable exposure pathway does exist.

1) For milk and vegetation exposure pathways:

$$= \frac{\text{\# of months in the period that grazing occurs}}{\text{total \# of months in period}}$$

$$= 0.5 \text{ for annual calculations}$$

2) For inhalation and ground plane exposure pathways: = 1.0

The location of exposure pathways and the maximum organ dose calculation may be based on the available pathways in the surrounding environment of Kewaunee as identified by the annual land-use census. Otherwise, the dose will be evaluated based on the predetermined controlling pathways as identified in Table 2.1.

## 2.4 Gaseous Effluent Dose Projection

ODCM Normal Condition 13.2.4 requires that the VENTILATION EXHAUST TREATMENT SYSTEM be used to reduce radioactive material levels prior to discharge when projected doses exceed one-half the annual design objective rate in any 31 days, i.e., exceeding:

- 0.3 mrem, maximum organ.

The applicable gaseous release sources and processing systems are as delineated in Figure 2.

Dose projections are performed at least once per 31 days by the following equations:

$$D_{maxp} = D_{max} \times (31 \div d) \quad (2.3)$$

where:

$D_{maxp}$	=	maximum organ dose projection for current 31 day period (mrem)
$D_{max}$	=	maximum organ dose to date for current 31 day period as determined by equation (2.2) (mrem)
$d$	=	number of days to date in current 31 day period
31	=	number of days in a 31 day period

## 2.5 Environmental Radiation Protection Standards 40 CFR 190

For the purpose of implementing ODCM Normal Condition 13.4.1 on the EPA environmental radiation protection standard and Technical Requirements Manual 10.3.2 on reporting requirements, dose calculations may be performed using the above equations with the substitution of average or actual meteorological parameters for the period of interest and actual applicable pathways as needed. Any exposure attributable to on-site sources will be evaluated based on the results of the environmental monitoring program (TLD measurements) or by calculational methods. NUREG-0543 describes acceptable methods for demonstrating compliance with 40 CFR Part 190 when radioactive effluents exceed the Appendix I portion of the specifications.

## 2.6 Total Dose

The purpose of this section is to describe the method used to calculate the cumulative dose contributions from liquid and gaseous effluents in accordance with KPS Technical Requirements Manual 10.1.2 for total dose. This method can also be used to demonstrate compliance with the Environmental Protection Agency (EPA) 40CFR190, "Environmental Standards for the Uranium Fuel Cycle".

Compliance with the KPS Technical Requirements Manual 10.1.2 dose objectives for the maximum individual demonstrates compliance with the EPA limits to any MEMBER OF THE PUBLIC, since the design dose objectives from 10CFR50, Appendix I are much lower than the 40CFR190 dose limits to the general public. With the calculated doses from the releases of radioactive materials in liquid or gaseous effluents exceeding twice the limits outlined in ODCM DNC 13.1.2 and 13.2.3, a special analysis shall be performed. The purpose of this analysis is to demonstrate if the total dose to any MEMBER OF THE PUBLIC (real individual) from all uranium fuel cycle sources (including direct radiation contributions from the facility, from outside storage areas and from all real pathways) is limited to less than or equal to 25 mrem per year to the total body or any organ, except the thyroid, which is limited to 75 mrem per year.

If required, the total dose to a MEMBER OF THE PUBLIC will be calculated for all significant effluent release points for all real pathways including direct radiation. Effluent releases from Point Beach Nuclear Plant must also be considered due to its proximity. Calculations will be based on the equations in Sections 1.4 and 2.3.1, with the exception that usage factors and other site specific parameters may be modified using more realistic assumptions, where appropriate.

The direct radiation component from the facility can be determined using environmental TLD results. These results will be corrected for natural background and for actual occupancy time of any areas accessible to the general public at the location of maximum direct radiation. It is recognized that by including the results from the environmental TLDs into the sum of total dose component, the direct radiation dose may be overestimated. The TLD measurements may include the exposure from ground plane deposition, and shoreline deposition, which have already been included in the summation of the significant dose pathways to the general public. However, this conservative method can be used, if required, as well as any other method for estimating the direct radiation dose from contained radioactive sources within the facility. The methodology used to incorporate the direct radiation component into total dose estimates will be outlined whenever total doses are reported.

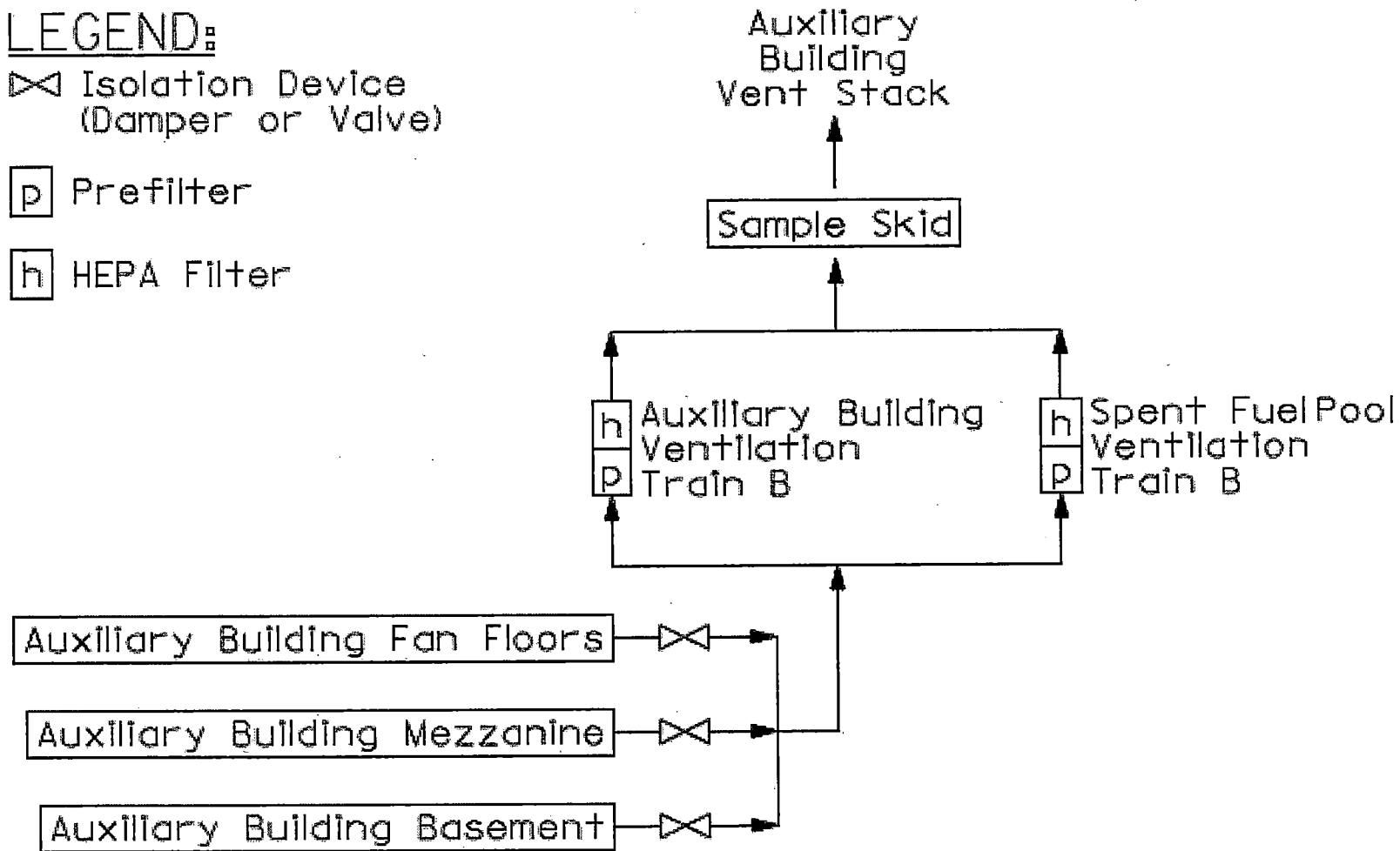
Therefore, the total dose will be determined based on the most realistic site specific data and parameters to assess the real dose to any MEMBER OF THE PUBLIC.

LEGEND:

⊗ Isolation Device  
(Damper or Valve)

□ p Prefilter

□ h HEPA Filter



ODCM FIGURE 2  
GASEOUS RADIOACTIVE EFFLUENT FLOW DIAGRAM

Table 2.1  
Controlling Locations, Pathways and  
Atmospheric Dispersion for Dose Calculations

ODCM Normal Condition	Location	Pathways	Atmospheric Dispersion	
			$\chi/Q$ (sec/m <sup>3</sup> )	D/Q (1/m <sup>2</sup> )
13.2.1.b	Site Boundary (0.81 mile, N)	Inhalation, Ground Plane	2.50E-06	8.7E-09
13.2.3	Garden 4 (0.96 mile SSW)	Inhalation, Vegetation, Milk, and Ground Plane	8.30E-07	3.20E-09

The following tables from TSD 18-017, Dispersion and Deposition Coefficients for KPS SAFSTOR and DECON, are placed here as a reference as needed for additional detailed calculations. Table 2.1 uses the  $\chi/Q$  values as listed under Auxiliary Vent SAFSTOR Winter under column No Decay and Undepleted.

Table 18 - Recommended X/Q and D/Q Values for Site Boundary Calculations

Release Type	cfm	Sector	Distance from Site (miles)	X/Q No Decay Undepleted (sec/m <sup>3</sup> )	X/Q 2.260 Day Decay Undepleted (sec/m <sup>3</sup> )	X/Q 8.000 Day Decay Depleted (sec/m <sup>3</sup> )	D/Q (m <sup>-2</sup> )
Ground Release	0	NNW	0.81	1.8E-06	1.8E-06	1.6E-06	7.7E-09
Auxiliary Vent Normal Ops	54,000	N	0.81	1.2E-06	1.2E-06	1.0E-06	6.4E-09
Reactor Vent Normal Ops	26,000	N	0.99	7.7E-08	7.7E-08	7.6E-08	2.7E-09
Auxiliary Vent SAFSTOR Summer	36,125	N	0.81	1.8E-06	1.8E-06	1.6E-06	7.9E-09
Auxiliary Vent SAFSTOR Winter	9,000	N	0.81	2.5E-06	2.5E-06	2.2E-06	8.7E-09
Auxiliary Vent Out-Of-Service	5,125	N	0.81	2.6E-06	2.5E-06	2.3E-06	8.7E-09

**Table 69 - Release Point Critical Receptors, Dispersion and Deposition Coefficients**

Release Type	cfm	Critical Receptor	Sector	Distance from Site (miles)	X/Q No Decay Undepleted (sec/m <sup>3</sup> )	X/Q 2.260 Day Decay Undepleted (sec/m <sup>3</sup> )	X/Q 8:000 Day Decay Depleted (sec/m <sup>3</sup> )	D/Q (m <sup>-2</sup> )
Ground Release	0	Garden 4	SSW	0.96	5.40E-07	5.40E-07	4.70E-07	4.30E-09
Auxiliary Vent Normal Ops	54000	Garden 4	SSW	0.96	3.20E-07	3.20E-07	2.90E-07	2.40E-09
Reactor Vent Normal Ops	26000	Milk 4	SW	1.3	6.50E-08	6.40E-08	6.30E-08	1.30E-09
Auxiliary Vent SAFSTOR Summer	36125	Garden 4	SSW	0.96	5.00E-07	4.90E-07	4.40E-07	2.80E-09
Auxiliary Vent SAFSTOR Winter	9000	Garden 4	SSW	0.96	8.30E-07	8.20E-07	7.30E-07	3.20E-09
Auxiliary Vent Out-Of-Service	5125	Garden 4	SW	1.3	8.90E-07	8.80E-07	7.50E-07	3.20E-09



Table 2.2 (Page 1 of 2)  
R<sub>i</sub> Inhalation Pathway Dose Factors – ADULT  
(mrem/yr per  $\mu\text{Ci}/\text{m}^3$ )

Nuclide	Bone	Liver	Thyroid	Kidney	Lung	GI-LLI	T.Body
H-3	-	1.26E+3	1.26E+3	1.26E+3	1.26E+3	1.26E+3	1.26E+3
C-14	1.82E+4	3.41E+3	3.41E+3	3.41E+3	3.41E+3	3.41E+3	3.41E+3
Na-24	1.02E+4	1.02E+4	1.02E+4	1.02E+4	1.02E+4	1.02E+4	1.02E+4
P-32	1.32E+6	7.71E+4	-	-	-	8.64E+4	5.01E+4
Cr-51	-	-	5.95E+1	2.28E+1	1.44E+4	3.32E+3	1.00E+2
Mn-54	-	3.96E+4	-	9.84E+3	1.40E+6	7.74E+4	6.30E+3
Mn-56	-	1.24E+0	-	1.30E+0	9.44E+3	2.02E+4	1.83E-1
Fe-55	2.46E+4	1.70E+4	-	-	7.21E+4	6.03E+3	3.94E+3
Fe-59	1.18E+4	2.78E+4	-	-	1.02E+6	1.88E+5	1.06E+4
Co-57	-	6.92E+2	-	-	3.70E+5	3.14E+4	6.71E+2
Co-58	-	1.58E+3	-	-	9.28E+5	1.06E+5	2.07E+3
Co-60	-	1.15E+4	-	-	5.97E+6	2.85E+5	1.48E+4
Ni-63	4.32E+5	3.14E+4	-	-	1.78E+5	1.34E+4	1.45E+4
Ni-65	1.54E+0	2.10E-1	-	-	5.60E+3	1.23E+4	9.12E-2
Cu-64	-	1.46E+0	-	4.62E+0	6.78E+3	4.90E+4	6.15E-1
Zn-65	3.24E+4	1.03E+5	-	6.90E+4	8.64E+5	5.34E+4	4.66E+4
Zn-69	3.38E-2	6.51E-2	-	4.22E-2	9.20E+2	1.63E+1	4.52E-3
Br-82	-	-	-	-	-	1.04E+4	1.35E+4
Br-83	-	-	-	-	-	2.32E+2	2.41E+2
Br-84	-	-	-	-	-	1.64E-3	3.13E+2
Br-85	-	-	-	-	-	-	1.28E+1
Rb-86	-	1.35E+5	-	-	-	1.66E+4	5.90E+4
Rb-88	-	3.87E+2	-	-	-	3.34E-9	1.93E+2
Rb-89	-	2.56E+2	-	-	-	-	1.70E+2
Sr-89	3.04E+5	-	-	-	1.40E+6	3.50E+5	8.72E+3
Sr-90	9.92E+7	-	-	-	9.60E+6	7.22E+5	6.10E+6
Sr-91	6.19E+1	-	-	-	3.65E+4	1.91E+5	2.50E+0
Sr-92	6.74E+0	-	-	-	1.65E+4	4.30E+4	2.91E-1
Y-90	2.09E+3	-	-	-	1.70E+5	5.06E+5	5.61E+1
Y-91m	2.61E-1	-	-	-	1.92E+3	1.33E+0	1.02E-2
Y-91	4.62E+5	-	-	-	1.70E+6	3.85E+5	1.24E+4
Y-92	1.03E+1	-	-	-	1.57E+4	7.35E+4	3.02E-1
Y-93	9.44E+1	-	-	-	4.85E+4	4.22E+5	2.61E+0
Zr-95	1.07E+5	3.44E+4	-	5.42E+4	1.77E+6	1.50E+5	2.33E+4
Zr-97	9.68E+1	1.96E+1	-	2.97E+1	7.87E+4	5.23E+5	9.04E+0
Nb-95	1.41E+4	7.82E+3	-	7.74E+3	5.05E+5	1.04E+5	4.21E+3
Nb-97	2.22E-1	5.62E-2	-	6.54E-2	2.40E+3	2.42E+2	2.05E-2
Mo-99	-	1.21E+2	-	2.91E+2	9.12E+4	2.48E+5	2.30E+1
Tc-99m	1.03E-3	2.91E-3	-	4.42E-2	7.64E+2	4.16E+3	3.70E-2
Tc-101	4.18E-5	6.02E-5	-	1.08E-3	3.99E+2	-	5.90E-4

Table 2.2 (Page 2 of 2)  
R<sub>i</sub> Inhalation Pathway Dose Factors – ADULT  
(mrem/yr per  $\mu\text{Ci}/\text{m}^3$ )

Nuclide	Bone	Liver	Thyroid	Kidney	Lung	GI-LLI	T.Body
Ru-103	1.53E+3	-	-	5.83E+3	5.05E+5	1.10E+5	6.58E+2
Ru-105	7.90E-1	-	-	1.02E+0	1.10E+4	4.82E+4	3.11E-1
Ru-106	6.91E+4	-	-	1.34E+5	9.36E+6	9.12E+5	8.72E+3
Rh-103m	-	-	-	-	-	-	-
Rh-106	-	-	-	-	-	-	-
Ag-110m	1.08E+4	1.00E+4	-	1.97E+4	4.63E+6	3.02E+5	5.94E+3
Sb-124	3.12E+4	5.89E+2	7.55E+1	-	2.48E+6	4.06E+5	1.24E+4
Sb-125	5.34E+4	5.95E+2	5.40E+1	-	1.74E+6	1.01E+5	1.26E+4
Te-125m	3.42E+3	1.58E+3	1.05E+3	1.24E+4	3.14E+5	7.06E+4	4.67E+2
Te-127m	1.26E+4	5.77E+3	3.29E+3	4.58E+4	9.60E+5	1.50E+5	1.57E+3
Te-127	1.40E+0	6.42E-1	1.06E+0	5.10E+0	6.51E+3	5.74E+4	3.10E-1
Te-129m	9.76E+3	4.67E+3	3.44E+3	3.66E+4	1.16E+6	3.83E+5	1.58E+3
Te-129	4.98E-2	2.39E-2	3.90E-2	1.87E-1	1.94E+3	1.57E+2	1.24E-2
Te-131m	6.99E+1	4.36E+1	5.50E+1	3.09E+2	1.46E+5	5.56E+5	2.90E+1
Te-131	1.11E-2	5.95E-3	9.36E-3	4.37E-2	1.39E+3	1.84E+1	3.59E-3
Te-132	2.60E+2	2.15E+2	1.90E+2	1.46E+3	2.88E+5	5.10E+5	1.62E+2
I-130	4.58E+3	1.34E+4	1.14E+6	2.09E+4	-	7.69E+3	5.28E+3
I-131	2.52E+4	3.58E+4	1.19E+7	6.13E+4	-	6.28E+3	2.05E+4
I-132	1.16E+3	3.26E+3	1.14E+5	5.18E+3	-	4.06E+2	1.16E+3
I-133	8.64E+3	1.48E+4	2.15E+6	2.58E+4	-	8.88E+3	4.52E+3
I-134	6.44E+2	1.73E+3	2.98E+4	2.75E+3	-	1.01E+0	6.15E+2
I-135	2.68E+3	6.98E+3	4.48E+5	1.11E+4	-	5.25E+3	2.57E+3
Cs-134	3.73E+5	8.48E+5	-	2.87E+5	9.76E+4	1.04E+4	7.28E+5
Cs-136	3.90E+4	1.46E+5	-	8.56E+4	1.20E+4	1.17E+4	1.10E+5
Cs-137	4.78E+5	6.21E+5	-	2.22E+5	7.52E+4	8.40E+3	4.28E+5
Cs-138	3.31E+2	6.21E+2	-	4.80E+2	4.86E+1	1.86E-3	3.24E+2
Ba-139	9.36E-1	6.66E-4	-	6.22E-4	3.76E+3	8.96E+2	2.74E-2
Ba-140	3.90E+4	4.90E+1	-	1.67E+1	1.27E+6	2.18E+5	2.57E+3
Ba-141	1.00E-1	7.53E-5	-	7.00E-5	1.94E+3	1.16E-7	3.36E-3
Ba-142	2.63E-2	2.70E-5	-	2.29E-5	1.19E+3	-	1.66E-3
La-140	3.44E+2	1.74E+2	-	-	1.36E+5	4.58E+5	4.58E+1
La-142	6.83E-1	3.10E-1	-	-	6.33E+3	2.11E+3	7.72E-2
Ce-141	1.99E+4	1.35E+4	-	6.26E+3	3.62E+5	1.20E+5	1.53E+3
Ce-143	1.86E+2	1.38E+2	-	6.08E+1	7.98E+4	2.26E+5	1.53E+1
Ce-144	3.43E+6	1.43E+6	-	8.48E+5	7.78E+6	8.16E+5	1.84E+5
Pr-143	9.36E+3	3.75E+3	-	2.16E+3	2.81E+5	2.00E+5	4.64E+2
Pr-144	3.01E-2	1.25E-2	-	7.05E-3	1.02E+3	2.15E-8	1.53E-3
Nd-147	5.27E+3	6.10E+3	-	3.56E+3	2.21E+5	1.73E+5	3.65E+2
W-187	8.48E+0	7.08E+0	-	-	2.90E+4	1.55E+5	2.48E+0
Np-239	2.30E+2	2.26E+1	-	7.00E+1	3.76E+4	1.19E+5	1.24E+1

Table 2.3 (Page 1 of 2)  
R<sub>i</sub> Inhalation Pathway Dose Factors – TEEN  
(mrem/yr per  $\mu\text{Ci}/\text{m}^3$ )

Nuclide	Bone	Liver	Thyroid	Kidney	Lung	GI-LLI	T.Body
H-3	-	1.27E+3	1.27E+3	1.27E+3	1.27E+3	1.27E+3	1.27E+3
C-14	2.60E+4	4.87E+3	4.87E+3	4.87E+3	4.87E+3	4.87E+3	4.87E+3
Na-24	1.38E+4	1.38E+4	1.38E+4	1.38E+4	1.38E+4	1.38E+4	1.38E+4
P-32	1.89E+6	1.10E+5	-	-	-	9.28E+4	7.16E+4
Cr-51	-	-	7.50E+1	3.07E+1	2.10E+4	3.00E+3	1.35E+2
Mn-54	-	5.11E+4	-	1.27E+4	1.98E+6	6.68E+4	8.40E+3
Mn-56	-	1.70E+0	-	1.79E+0	1.52E+4	5.74E+4	2.52E-1
Fe-55	3.34E+4	2.38E+4	-	-	1.24E+5	6.39E+3	5.54E+3
Fe-59	1.59E+4	3.70E+4	-	-	1.53E+6	1.78E+5	1.43E+4
Co-57	-	6.92E+2	-	-	5.86E+5	3.14E+4	9.20E+2
Co-58	-	2.07E+3	-	-	1.34E+6	9.52E+4	2.78E+3
Co-60	-	1.51E+4	-	-	8.72E+6	2.59E+5	1.98E+4
Ni-63	5.80E+5	4.34E+4	-	-	3.07E+5	1.42E+4	1.98E+4
Ni-65	2.18E+0	2.93E-1	-	-	9.36E+3	3.67E+4	1.27E-1
Cu-64	-	2.03E+0	-	6.41E+0	1.11E+4	6.14E+4	8.48E-1
Zn-65	3.86E+4	1.34E+5	-	8.64E+4	1.24E+6	4.66E+4	6.24E+4
Zn-69	4.83E-2	9.20E-2	-	6.02E-2	1.58E+3	2.85E+2	6.46E-3
Br-82	-	-	-	-	-	-	1.82E+4
Br-83	-	-	-	-	-	-	3.44E+2
Br-84	-	-	-	-	-	-	4.33E+2
Br-85	-	-	-	-	-	-	1.83E+1
Rb-86	-	1.90E+5	-	-	-	1.77E+4	8.40E+4
Rb-88	-	5.46E+2	-	-	-	2.92E-5	2.72E+2
Rb-89	-	3.52E+2	-	-	-	3.38E-7	2.33E+2
Sr-89	4.34E+5	-	-	-	2.42E+6	3.71E+5	1.25E+4
Sr-90	1.08E+8	-	-	-	1.65E+7	7.65E+5	6.68E+6
Sr-91	8.80E+1	-	-	-	6.07E+4	2.59E+5	3.51E+0
Sr-92	9.52E+0	-	-	-	2.74E+4	1.19E+5	4.06E-1
Y-90	2.98E+3	-	-	-	2.93E+5	5.59E+5	8.00E+1
Y-91m	3.70E-1	-	-	-	3.20E+3	3.02E+1	1.42E-2
Y-91	6.61E+5	-	-	-	2.94E+6	4.09E+5	1.77E+4
Y-92	1.47E+1	-	-	-	2.68E+4	1.65E+5	4.29E-1
Y-93	1.35E+2	-	-	-	8.32E+4	5.79E+5	3.72E+0
Zr-95	1.46E+5	4.58E+4	-	6.74E+4	2.69E+6	1.49E+5	3.15E+4
Zr-97	1.38E+2	2.72E+1	-	4.12E+1	1.30E+5	6.30E+5	1.26E+1
Nb-95	1.86E+4	1.03E+4	-	1.00E+4	7.51E+5	9.68E+4	5.66E+3
Nb-97	3.14E-1	7.78E-2	-	9.12E-2	3.93E+3	2.17E+3	2.84E-2
Mo-99	-	1.69E+2	-	4.11E+2	1.54E+5	2.69E+5	3.22E+1
Tc-99m	1.38E-3	3.86E-3	-	5.76E-2	1.15E+3	6.13E+3	4.99E-2
Tc-101	5.92E-5	8.40E-5	-	1.52E-3	6.67E+2	8.72E-7	8.24E-4

Table 2.3 (Page 2 of 2)  
R<sub>i</sub> Inhalation Pathway Dose Factors – TEEN  
(mrem/yr per  $\mu\text{Ci}/\text{m}^3$ )

Nuclide	Bone	Liver	Thyroid	Kidney	Lung	GI-LLI	T.Body
Ru-103	2.10E+3	-	-	7.43E+3	7.83E+5	1.09E+5	8.96E+2
Ru-105	1.12E+0	-	-	1.41E+0	1.82E+4	9.04E+4	4.34E-1
Ru-106	9.84E+4	-	-	1.90E+5	1.61E+7	9.60E+5	1.24E+4
Rh-103m	-	-	-	-	-	-	-
Rh-106	-	-	-	-	-	-	-
Ag-110m	1.38E+4	1.31E+4	-	2.50E+4	6.75E+6	2.73E+5	7.99E+3
Sb-124	4.30E+4	7.94E+2	9.76E+1	-	3.85E+6	3.98E+5	1.68E+4
Sb-125	7.38E+4	8.08E+2	7.04E+1	-	2.74E+6	9.92E+4	1.72E+4
Te-125m	4.88E+3	2.24E+3	1.40E+3	-	5.36E+5	7.50E+4	6.67E+2
Te-127m	1.80E+4	8.16E+3	4.38E+3	6.54E+4	1.66E+6	1.59E+5	2.18E+3
Te-127	2.01E+0	9.12E-1	1.42E+0	7.28E+0	1.12E+4	8.08E+4	4.42E-1
Te-129m	1.39E+4	6.58E+3	4.58E+3	5.19E+4	1.98E+6	4.05E+5	2.25E+3
Te-129	7.10E-2	3.38E-2	5.18E-2	2.66E-1	3.30E+3	1.62E+3	1.76E-2
Te-131m	9.84E+1	6.01E+1	7.25E+1	4.39E+2	2.38E+5	6.21E+5	4.02E+1
Te-131	1.58E-2	8.32E-3	1.24E-2	6.18E-2	2.34E+3	1.51E+1	5.04E-3
Te-132	3.60E+2	2.90E+2	2.46E+2	1.95E+3	4.49E+5	4.63E+5	2.19E+2
I-130	6.24E+3	1.79E+4	1.49E+6	2.75E+4	-	9.12E+3	7.17E+3
I-131	3.54E+4	4.91E+4	1.46E+7	8.40E+4	-	6.49E+3	2.64E+4
I-132	1.59E+3	4.38E+3	1.51E+5	6.92E+3	-	1.27E+3	1.58E+3
I-133	1.22E+4	2.05E+4	2.92E+6	3.59E+4	-	1.03E+4	6.22E+3
I-134	8.88E+2	2.32E+3	3.95E+4	3.66E+3	-	2.04E+1	8.40E+2
I-135	3.70E+3	9.44E+3	6.21E+5	1.49E+4	-	6.95E+3	3.49E+3
Cs-134	5.02E+5	1.13E+6	-	3.75E+5	1.46E+5	9.76E+3	5.49E+5
Cs-136	5.15E+4	1.94E+5	-	1.10E+5	1.78E+4	1.09E+4	1.37E+5
Cs-137	6.70E+5	8.48E+5	-	3.04E+5	1.21E+5	8.48E+3	3.11E+5
Cs-138	4.66E+2	8.56E+2	-	6.62E+2	7.87E+1	2.70E-1	4.46E+2
Ba-139	1.34E+0	9.44E-4	-	8.88E-4	6.46E+3	6.45E+3	3.90E-2
Ba-140	5.47E+4	6.70E+1	-	2.28E+1	2.03E+6	2.29E+5	3.52E+3
Ba-141	1.42E-1	1.06E-4	-	9.84E-5	3.29E+3	7.46E-4	4.74E-3
Ba-142	3.70E-2	3.70E-5	-	3.14E-5	1.91E+3	-	2.27E-3
La-140	4.79E+2	2.36E+2	-	-	2.14E+5	4.87E+5	6.26E+1
La-142	9.60E-1	4.25E-1	-	-	1.02E+4	1.20E+4	1.06E-1
Ce-141	2.84E+4	1.90E+4	-	8.88E+3	6.14E+5	1.26E+5	2.17E+3
Ce-143	2.66E+2	1.94E+2	-	8.64E+1	1.30E+5	2.55E+5	2.16E+1
Ce-144	4.89E+6	2.02E+6	-	1.21E+6	1.34E+7	8.64E+5	2.62E+5
Pr-143	1.34E+4	5.31E+3	-	3.09E+3	4.83E+5	2.14E+5	6.62E+2
Pr-144	4.30E-2	1.76E-2	-	1.01E-2	1.75E+3	2.35E-4	2.18E-3
Nd-147	7.86E+3	8.56E+3	-	5.02E+3	3.72E+5	1.82E+5	5.13E+2
W-187	1.20E+1	9.76E+0	-	-	4.74E+4	1.77E+5	3.43E+0
Np-239	3.38E+2	3.19E+1	-	1.00E+2	6.49E+4	1.32E+5	1.77E+1

Table 2.4 (Page 1 of 2)  
R<sub>i</sub> Inhalation Pathway Dose Factors - CHILD  
(mrem/yr per  $\mu\text{Ci}/\text{m}^3$ )

Nuclide	Bone	Liver	Thyroid	Kidney	Lung	GI-LLI	T.Body
H-3	-	1.12E+3	1.12E+3	1.12E+3	1.12E+3	1.12E+3	1.12E+3
C-14	3.59E+4	6.73E+3	6.73E+3	6.73E+3	6.73E+3	6.73E+3	6.73E+3
Na-24	1.61E+4	1.61E+4	1.61E+4	1.61E+4	1.61E+4	1.61E+4	1.61E+4
P-32	2.60E+6	1.14E+5	-	-	-	4.22E+4	9.88E+4
Cr-51	-	-	8.55E+1	2.43E+1	1.70E+4	1.08E+3	1.54E+2
Mn-54	-	4.29E+4	-	1.00E+4	1.58E+6	2.29E+4	9.51E+3
Mn-56	-	1.66E+0	-	1.67E+0	1.31E+4	1.23E+5	3.12E-1
Fe-55	4.74E+4	2.52E+4	-	-	1.11E+5	2.87E+3	7.77E+3
Fe-59	2.07E+4	3.34E+4	-	-	1.27E+6	7.07E+4	1.67E+4
Co-57	-	9.03E+2	-	-	5.07E+5	1.32E+4	1.07E+3
Co-58	-	1.77E+3	-	-	1.11E+6	3.44E+4	3.16E+3
Co-60	-	1.31E+4	-	-	7.07E+6	9.62E+4	2.26E+4
Ni-63	8.21E+5	4.63E+4	-	-	2.75E+5	6.33E+3	2.80E+4
Ni-65	2.99E+0	2.96E-1	-	-	8.18E+3	8.40E+4	1.64E-1
Cu-64	-	1.99E+0	-	6.03E+0	9.58E+3	3.67E+4	1.07E+0
Zn-65	4.26E+4	1.13E+5	-	7.14E+4	9.95E+5	1.63E+4	7.03E+4
Zn-69	6.70E-2	9.66E-2	-	5.85E-2	1.42E+3	1.02E+4	8.92E-3
Br-82	-	-	-	-	-	-	2.09E+4
Br-83	-	-	-	-	-	-	4.74E+2
Br-84	-	-	-	-	-	-	5.48E+2
Br-85	-	-	-	-	-	-	2.53E+1
Rb-86	-	1.98E+5	-	-	-	7.99E+3	1.14E+5
Rb-88	-	5.62E+2	-	-	-	1.72E+1	3.66E+2
Rb-89	-	3.45E+2	-	-	-	1.89E+0	2.90E+2
Sr-89	5.99E+5	-	-	-	2.16E+6	1.67E+5	1.72E+4
Sr-90	1.01E+8	-	-	-	1.48E+7	3.43E+5	6.44E+6
Sr-91	1.21E+2	-	-	-	5.33E+4	1.74E+5	4.59E+0
Sr-92	1.31E+1	-	-	-	2.40E+4	2.42E+5	5.25E-1
Y-90	4.11E+3	-	-	-	2.62E+5	2.68E+5	1.11E+2
Y-91m	5.07E-1	-	-	-	2.81E+3	1.72E+3	1.84E-2
Y-91	9.14E+5	-	-	-	2.63E+6	1.84E+5	2.44E+4
Y-92	2.04E+1	-	-	-	2.39E+4	2.39E+5	5.81E-1
Y-93	1.86E+2	-	-	-	7.44E+4	3.89E+5	5.11E+0
Zr-95	1.90E+5	4.18E+4	-	5.96E+4	2.23E+6	6.11E+4	3.70E+4
Zr-97	1.88E+2	2.72E+1	-	3.89E+1	1.13E+5	3.51E+5	1.60E+1
Nb-95	2.35E+4	9.18E+3	-	8.62E+3	6.14E+5	3.70E+4	6.55E+3
Nb-97	4.29E-1	7.70E-2	-	8.55E-2	3.42E+3	2.78E+4	3.60E-2
Mo-99	-	1.72E+2	-	3.92E+2	1.35E+5	1.27E+5	4.26E+1
Tc-99m	1.78E-3	3.48E-3	-	5.07E-2	9.51E+2	4.81E+3	5.77E-2
Tc-101	8.10E-5	8.51E-5	-	1.45E-3	5.85E+2	1.63E+1	1.08E-3

Table 2.4 (Page 2 of 2)  
R<sub>i</sub> Inhalation Pathway Dose Factors - CHILD  
(mrem/yr per  $\mu\text{Ci}/\text{m}^3$ )

Nuclide	Bone	Liver	Thyroid	Kidney	Lung	GI-LLI	T.Body
Ru-103	2.79E+3	-	-	7.03E+3	6.62E+5	4.48E+4	1.07E+3
Ru-105	1.53E+0	-	-	1.34E+0	1.59E+4	9.95E+4	5.55E-1
Ru-106	1.36E+5	-	-	1.84E+5	1.43E+7	4.29E+5	1.69E+4
Rh-103m	-	-	-	-	-	-	-
Rh-106	-	-	-	-	-	-	-
Ag-110m	1.69E+4	1.14E+4	-	2.12E+4	5.48E+6	1.00E+5	9.14E+3
Sb-124	5.74E+4	7.40E+2	1.26E+2	-	3.24E+6	1.64E+5	2.00E+4
Sb-125	9.84E+4	7.59E+2	9.10E+1	-	2.32E+6	4.03E+4	2.07E+4
Te-125m	6.73E+3	2.33E+3	1.92E+3	-	4.77E+5	3.38E+4	9.14E+2
Te-127m	2.49E+4	8.55E+3	6.07E+3	6.36E+4	1.48E+6	7.14E+4	3.02E+3
Te-127	2.77E+0	9.51E-1	1.96E+0	7.07E+0	1.00E+4	5.62E+4	6.11E-1
Te-129m	1.92E+4	6.85E+3	6.33E+3	5.03E+4	1.76E+6	1.82E+5	3.04E+3
Te-129	9.77E-2	3.50E-2	7.14E-2	2.57E-1	2.93E+3	2.55E+4	2.38E-2
Te-131m	1.34E+2	5.92E+1	9.77E+1	4.00E+2	2.06E+5	3.08E+5	5.07E+1
Te-131	2.17E-2	8.44E-3	1.70E-2	5.88E-2	2.05E+3	1.33E+3	6.59E-3
Te-132	4.81E+2	2.72E+2	3.17E+2	1.77E+3	3.77E+5	1.38E+5	2.63E+2
I-130	8.18E+3	1.64E+4	1.85E+6	2.45E+4	-	5.11E+3	8.44E+3
I-131	4.81E+4	4.81E+4	1.62E+7	7.88E+4	-	2.84E+3	2.73E+4
I-132	2.12E+3	4.07E+3	1.94E+5	6.25E+3	-	3.20E+3	1.88E+3
I-133	1.66E+4	2.03E+4	3.85E+6	3.38E+4	-	5.48E+3	7.70E+3
I-134	1.17E+3	2.16E+3	5.07E+4	3.30E+3	-	9.55E+2	9.95E+2
I-135	4.92E+3	8.73E+3	7.92E+5	1.34E+4	-	4.44E+3	4.14E+3
Cs-134	6.51E+5	1.01E+6	-	3.30E+5	1.21E+5	3.85E+3	2.25E+5
Cs-136	6.51E+4	1.71E+5	-	9.55E+4	1.45E+4	4.18E+3	1.16E+5
Cs-137	9.07E+5	8.25E+5	-	2.82E+5	1.04E+5	3.62E+3	1.28E+5
Cs-138	6.33E+2	8.40E+2	-	6.22E+2	6.81E+1	2.70E+2	5.55E+2
Ba-139	1.84E+0	9.84E-4	-	8.62E-4	5.77E+3	5.77E+4	5.37E-2
Ba-140	7.40E+4	6.48E+1	-	2.11E+1	1.74E+6	1.02E+5	4.33E+3
Ba-141	1.96E-1	1.09E-4	-	9.47E-5	2.92E+3	2.75E+2	6.36E-3
Ba-142	5.00E-2	3.60E-5	-	2.91E-5	1.64E+3	2.74E+0	2.79E-3
La-140	6.44E+2	2.25E+2	-	-	1.83E+5	2.26E+5	7.55E+1
La-142	1.30E+0	4.11E-1	-	-	8.70E+3	7.59E+4	1.29E-1
Ce-141	3.92E+4	1.95E+4	-	8.55E+3	5.44E+5	5.66E+4	2.90E+3
Ce-143	3.66E+2	1.99E+2	-	8.36E+1	1.15E+5	1.27E+5	2.87E+1
Ce-144	6.77E+6	2.12E+6	-	1.17E+6	1.20E+7	3.89E+5	3.61E+5
Pr-143	1.85E+4	5.55E+3	-	3.00E+3	4.33E+5	9.73E+4	9.14E+2
Pr-144	5.96E-2	1.85E-2	-	9.77E-3	1.57E+3	1.97E+2	3.00E-3
Nd-147	1.08E+4	8.73E+3	-	4.81E+3	3.28E+5	8.21E+4	6.81E+2
W-187	1.63E+1	9.66E+0	-	-	4.11E+4	9.10E+4	4.33E+0
Np-239	4.66E+2	3.34E+1	-	9.73E+1	5.81E+4	6.40E+4	2.35E+1

Table 2.5 (Page 1 of 2)  
R<sub>i</sub> Inhalation Pathway Dose Factors - INFANT  
(mrem/yr per  $\mu\text{Ci}/\text{m}^3$ )

Nuclide	Bone	Liver	Thyroid	Kidney	Lung	GI-LLI	T.Body
H-3	-	6.47E+2	6.47E+2	6.47E+2	6.47E+2	6.47E+2	6.47E+2
C-14	2.65E+4	5.31E+3	5.31E+3	5.31E+3	5.31E+3	5.31E+3	5.31E+3
Na-24	1.06E+4	1.06E+4	1.06E+4	1.06E+4	1.06E+4	1.06E+4	1.06E+4
P-32	2.03E+6	1.12E+5	-	-	-	1.61E+4	7.74E+4
Cr-51	-	-	5.75E+1	1.32E+1	1.28E+4	3.57E+2	8.95E+1
Mn-54	-	2.53E+4	-	4.98E+3	1.00E+6	7.06E+3	4.98E+3
Mn-56	-	1.54E+0	-	1.10E+0	1.25E+4	7.17E+4	2.21E-1
Fe-55	1.97E+4	1.17E+4	-	-	8.69E+4	1.09E+3	3.33E+3
Fe-59	1.36E+4	2.35E+4	-	-	1.02E+6	2.48E+4	9.48E+3
Co-57	-	6.51E+2	-	-	3.79E+5	4.86E+3	6.41E+2
Co-58	-	1.22E+3	-	-	7.77E+5	1.11E+4	1.82E+3
Co-60	-	8.02E+3	-	-	4.51E+6	3.19E+4	1.18E+4
Ni-63	3.39E+5	2.04E+4	-	-	2.09E+5	2.42E+3	1.16E+4
Ni-65	2.39E+0	2.84E-1	-	-	8.12E+3	5.01E+4	1.23E-1
Cu-64	-	1.88E+0	-	3.98E+0	9.30E+3	1.50E+4	7.74E-1
Zn-65	1.93E+4	6.26E+4	-	3.25E+4	6.47E+5	5.14E+4	3.11E+4
Zn-69	5.39E-2	9.67E-2	-	4.02E-2	1.47E+3	1.32E+4	7.18E-3
Br-82	-	-	-	-	-	-	1.33E+4
Br-83	-	-	-	-	-	-	3.81E+2
Br-84	-	-	-	-	-	-	4.00E+2
Br-85	-	-	-	-	-	-	2.04E+1
Rb-86	-	1.90E+5	-	-	-	3.04E+3	8.82E+4
Rb-88	-	5.57E+2	-	-	-	3.39E+2	2.87E+2
Rb-89	-	3.21E+2	-	-	-	6.82E+1	2.06E+2
Sr-89	3.98E+5	-	-	-	2.03E+6	6.40E+4	1.14E+4
Sr-90	4.09E+7	-	-	-	1.12E+7	1.31E+5	2.59E+6
Sr-91	9.56E+1	-	-	-	5.26E+4	7.34E+4	3.46E+0
Sr-92	1.05E+1	-	-	-	2.38E+4	1.40E+5	3.91E-1
Y-90	3.29E+3	-	-	-	2.69E+5	1.04E+5	8.82E+1
Y-91m	4.07E-1	-	-	-	2.79E+3	2.35E+3	1.39E-2
Y-91	5.88E+5	-	-	-	2.45E+6	7.03E+4	1.57E+4
Y-92	1.64E+1	-	-	-	2.45E+4	1.27E+5	4.61E-1
Y-93	1.50E+2	-	-	-	7.64E+4	1.67E+5	4.07E+0
Zr-95	1.15E+5	2.79E+4	-	3.11E+4	1.75E+6	2.17E+4	2.03E+4
Zr-97	1.50E+2	2.56E+1	-	2.59E+1	1.10E+5	1.40E+5	1.17E+1
Nb-95	1.57E+4	6.43E+3	-	4.72E+3	4.79E+5	1.27E+4	3.78E+3
Nb-97	3.42E-1	7.29E-2	-	5.70E-2	3.32E+3	2.69E+4	2.63E-2
Mo-99	-	1.65E+2	-	2.65E+2	1.35E+5	4.87E+4	3.23E+1
Tc-99m	1.40E-3	2.88E-3	-	3.11E-2	8.11E+2	2.03E+3	3.72E-2
Tc-101	6.51E-5	8.23E-5	-	9.79E-4	5.84E+2	8.44E+2	8.12E-4

Table 2.5 (Page 2 of 2)  
R<sub>i</sub> Inhalation Pathway Dose Factors - INFANT  
(mrem/yr per  $\mu\text{Ci}/\text{m}^3$ )

Nuclide	Bone	Liver	Thyroid	Kidney	Lung	GI-LLI	T.Body
Ru-103	2.02E+3	-	-	4.24E+3	5.52E+5	1.61E+4	6.79E+2
Ru-105	1.22E+0	-	-	8.99E-1	1.57E+4	4.84E+4	4.10E-1
Ru-106	8.68E+4	-	-	1.07E+5	1.16E+7	1.64E+5	1.09E+4
Rh-103m	-	-	-	-	-	-	-
Rh-106	-	-	-	-	-	-	-
Ag-110m	9.98E+3	7.22E+3	-	1.09E+4	3.67E+6	3.30E+4	5.00E+3
Sb-124	3.79E+4	5.56E+2	1.01E+2	-	2.65E+6	5.91E+4	1.20E+4
Sb-125	5.17E+4	4.77E+2	6.23E+1	-	1.64E+6	1.47E+4	1.09E+4
Te-125m	4.76E+3	1.99E+3	1.62E+3	-	4.47E+5	1.29E+4	6.58E+2
Te-127m	1.67E+4	6.90E+3	4.87E+3	3.75E+4	1.31E+6	2.73E+4	2.07E+3
Te-127	2.23E+0	9.53E-1	1.85E+0	4.86E+0	1.03E+4	2.44E+4	4.89E-1
Te-129m	1.41E+4	6.09E+3	5.47E+3	3.18E+4	1.68E+6	6.90E+4	2.23E+3
Te-129	7.88E-2	3.47E-2	6.75E-2	1.75E-1	3.00E+3	2.63E+4	1.88E-2
Te-131m	1.07E+2	5.50E+1	8.93E+1	2.65E+2	1.99E+5	1.19E+5	3.63E+1
Te-131	1.74E-2	8.22E-3	1.58E-2	3.99E-2	2.06E+3	8.22E+3	5.00E-3
Te-132	3.72E+2	2.37E+2	2.79E+2	1.03E+3	3.40E+5	4.41E+4	1.76E+2
I-130	6.36E+3	1.39E+4	1.60E+6	1.53E+4	-	1.99E+3	5.57E+3
I-131	3.79E+4	4.44E+4	1.48E+7	5.18E+4	-	1.06E+3	1.96E+4
I-132	1.69E+3	3.54E+3	1.69E+5	3.95E+3	-	1.90E+3	1.26E+3
I-133	1.32E+4	1.92E+4	3.56E+6	2.24E+4	-	2.16E+3	5.60E+3
I-134	9.21E+2	1.88E+3	4.45E+4	2.09E+3	-	1.29E+3	6.65E+2
I-135	3.86E+3	7.60E+3	6.96E+5	8.47E+3	-	1.83E+3	2.77E+3
Cs-134	3.96E+5	7.03E+5	-	1.90E+5	7.97E+4	1.33E+3	7.45E+4
Cs-136	4.83E+4	1.35E+5	-	5.64E+4	1.18E+4	1.43E+3	5.29E+4
Cs-137	5.49E+5	6.12E+5	-	1.72E+5	7.13E+4	1.33E+3	4.55E+4
Cs-138	5.05E+2	7.81E+2	-	4.10E+2	6.54E+1	8.76E+2	3.98E+2
Ba-139	1.48E+0	9.84E-4	-	5.92E-4	5.95E+3	5.10E+4	4.30E-2
Ba-140	5.60E+4	5.60E+1	-	1.34E+1	1.60E+6	3.84E+4	2.90E+3
Ba-141	1.57E-1	1.08E-4	-	6.50E-5	2.97E+3	4.75E+3	4.97E-3
Ba-142	3.98E-2	3.30E-5	-	1.90E-5	1.55E+3	6.93E+2	1.96E-3
La-140	5.05E+2	2.00E+2	-	-	1.68E+5	8.48E+4	5.15E+1
La-142	1.03E+0	3.77E-1	-	-	8.22E+3	5.95E+4	9.04E-2
Ce-141	2.77E+4	1.67E+4	-	5.25E+3	5.17E+5	2.16E+4	1.99E+3
Ce-143	2.93E+2	1.93E+2	-	5.64E+1	1.16E+5	4.97E+4	2.21E+1
Ce-144	3.19E+6	1.21E+6	-	5.38E+5	9.84E+6	1.48E+5	1.76E+5
Pr-143	1.40E+4	5.24E+3	-	1.97E+3	4.33E+5	3.72E+4	6.99E+2
Pr-144	4.79E-2	1.85E-2	-	6.72E-3	1.61E+3	4.28E+3	2.41E-3
Nd-147	7.94E+3	8.13E+3	-	3.15E+3	3.22E+5	3.12E+4	5.00E+2
W-187	1.30E+1	9.02E+0	-	-	3.96E+4	3.56E+4	3.12E+0
Np-239	3.71E+2	3.32E+1	-	6.62E+1	5.95E+4	2.49E+4	1.88E+1



Table 2.6 (Page 1 of 2)  
R<sub>i</sub> Vegetation Pathway Dose Factors - ADULT  
(mrem/yr per  $\mu\text{Ci}/\text{m}^3$ ) for H-3 and C-14 ( $\text{m}^2 \times \text{mrem}/\text{yr}$   $\mu\text{Ci}/\text{sec}$ ) for others

Nuclide	Bone	Liver	Thyroid	Kidney	Lung	GI-LLI	T.Body
H-3	-	2.26E+3	2.26E+3	2.26E+3	2.26E+3	2.26E+3	2.26E+3
C-14	8.97E+5	1.79E+5	1.79E+5	1.79E+5	1.79E+5	1.79E+5	1.79E+5
Na-24	2.76E+5	2.76E+5	2.76E+5	2.76E+5	2.76E+5	2.76E+5	2.76E+5
P-32	1.40E+9	8.73E+7	-	-	-	1.58E+8	5.42E+7
Cr-51	-	-	2.79E+4	1.03E+4	6.19E+4	1.17E+7	4.66E+4
Mn-54	-	3.11E+8	-	9.27E+7	-	9.54E+8	5.94E+7
Mn-56	-	1.61E+1	-	2.04E+1	-	5.13E+2	2.85E+0
Fe-55	2.09E+8	1.45E+8	-	-	8.06E+7	8.29E+7	3.37E+7
Fe-59	1.27E+8	2.99E+8	-	-	8.35E+7	9.96E+8	1.14E+8
Co-57	-	1.17E+7	-	-	-	2.97E+8	1.95E+7
Co-58	-	3.09E+7	-	-	-	6.26E+8	6.92E+7
Co-60	-	1.67E+8	-	-	-	3.14E+9	3.69E+8
Ni-63	1.04E+10	7.21E+8	-	-	-	1.50E+8	3.49E+8
Ni-65	6.15E+1	7.99E+0	-	-	-	2.03E+2	3.65E+0
Cu-64	-	9.27E+3	-	2.34E+4	-	7.90E+5	4.35E+3
Zn-65	3.17E+8	1.01E+9	-	6.75E+8	-	6.36E+8	4.56E+8
Zn-69	8.75E-6	1.67E-5	-	1.09E-5	-	2.51E-6	1.16E-6
Br-82	-	-	-	-	-	1.73E+6	1.51E+6
Br-83	-	-	-	-	-	4.63E+0	3.21E+0
Br-84	-	-	-	-	-	-	-
Br-85	-	-	-	-	-	-	-
Rb-86	-	2.19E+8	-	-	-	4.32E+7	1.02E+8
Rb-88	-	-	-	-	-	-	-
Rb-89	-	-	-	-	-	-	-
Sr-89	9.96E+9	-	-	-	-	1.60E+9	2.86E+8
Sr-90	6.05E+11	-	-	-	-	1.75E+10	1.48E+11
Sr-91	3.20E+5	-	-	-	-	1.52E+6	1.29E+4
Sr-92	4.27E+2	-	-	-	-	8.46E+3	1.85E+1
Y-90	1.33E+4	-	-	-	-	1.41E+8	3.56E+2
Y-91m	5.83E-9	-	-	-	-	1.71E-8	-
Y-91	5.13E+6	-	-	-	-	2.82E+9	1.37E+5
Y-92	9.01E-1	-	-	-	-	1.58E+4	2.63E-2
Y-93	1.74E+2	-	-	-	-	5.52E+6	4.80E+0
Zr-95	1.19E+6	3.81E+5	-	5.97E+5	-	1.21E+9	2.58E+5
Zr-97	3.33E+2	6.73E+1	-	1.02E+2	-	2.08E+7	3.08E+1
Nb-95	1.42E+5	7.91E+4	-	7.81E+4	-	4.80E+8	4.25E+4
Nb-97	2.90E-6	7.34E-7	-	8.56E-7	-	2.71E-3	2.68E-7
Mo-99	-	6.25E+6	-	1.41E+7	-	1.45E+7	1.19E+6
Tc-99m	3.06E+0	8.66E+0	-	1.32E+2	4.24E+0	5.12E+3	1.10E+2
Tc-101	-	-	-	-	-	-	-

Table 2.6 (Page 2 of 2)

R<sub>i</sub> Vegetation Pathway Dose Factors - ADULT  
(mrem/yr per  $\mu\text{Ci}/\text{m}^3$ ) for H-3 and C-14 ( $\text{m}^2 \times \text{mrem}/\text{yr} \mu\text{Ci}/\text{sec}$ ) for others

Nuclide	Bone	Liver	Thyroid	Kidney	Lung	GI-LLI	T.Body
Ru-103	4.80E+6	-	-	1.83E+7	-	5.61E+8	2.07E+6
Ru-105	5.39E+1	-	-	6.96E+2	-	3.30E+4	2.13E+1
Ru-106	1.93E+8	-	-	3.72E+8	-	1.25E+10	2.44E+7
Rh-103m	-	-	-	-	-	-	-
Rh-106	-	-	-	-	-	-	-
Ag-110m	1.06E+7	9.76E+6	-	1.92E+7	-	3.98E+9	5.80E+6
Sb-124	1.04E+8	1.96E+6	2.52E+5	-	8.08E+7	2.95E+9	4.11E+7
Sb-125	1.36E+8	1.52E+6	1.39E+5	-	1.05E+8	1.50E+9	3.25E+7
Te-125m	9.66E+7	3.50E+7	2.90E+7	3.93E+8	-	3.86E+8	1.29E+7
Te-127m	3.49E+8	1.25E+8	8.92E+7	1.42E+9	-	1.17E+9	4.26E+7
Te-127	5.76E+3	2.07E+3	4.27E+3	2.35E+4	-	4.54E+5	1.25E+3
Te-129m	2.55E+8	9.50E+7	8.75E+7	1.06E+9	-	1.28E+9	4.03E+7
Te-129	6.65E-4	2.50E-4	5.10E-4	2.79E-3	-	5.02E-4	1.62E-4
Te-131m	9.12E+5	4.46E+5	7.06E+5	4.52E+6	-	4.43E+7	3.72E+5
Te-131	-	-	-	-	-	-	-
Te-132	4.29E+6	2.77E+6	3.06E+6	2.67E+7	-	1.31E+8	2.60E+6
I-130	3.96E+5	1.17E+6	9.90E+7	1.82E+6	-	1.01E+6	4.61E+5
I-131	8.09E+7	1.16E+8	3.79E+10	1.98E+8	-	3.05E+7	6.63E+7
I-132	5.74E+1	1.54E+2	5.38E+3	2.45E+2	-	2.89E+1	5.38E+1
I-133	2.12E+6	3.69E+6	5.42E+8	6.44E+6	-	3.31E+6	1.12E+6
I-134	1.06E-4	2.88E-4	5.00E-3	4.59E-4	-	2.51E-7	1.03E-4
I-135	4.08E+4	1.07E+5	7.04E+6	1.71E+5	-	1.21E+5	3.94E+4
Cs-134	4.66E+9	1.11E+10	-	3.59E+9	1.19E+9	1.94E+8	9.07E+9
Cs-136	4.20E+7	1.66E+8	-	9.24E+7	1.27E+7	1.89E+7	1.19E+8
Cs-137	6.36E+9	8.70E+9	-	2.95E+9	9.81E+8	1.68E+8	5.70E+9
Cs-138	-	-	-	-	-	-	-
Ba-139	2.95E-2	2.10E-5	-	1.96E-5	1.19E-5	5.23E-2	8.64E-4
Ba-140	1.29E+8	1.62E+5	-	5.49E+4	9.25E+4	2.65E+8	8.43E+6
Ba-141	-	-	-	-	-	-	-
Ba-142	-	-	-	-	-	-	-
La-140	1.97E+3	9.92E+2	-	-	-	7.28E+7	2.62E+2
La-142	1.40E-4	6.35E-5	-	-	-	4.64E-1	1.58E-5
Ce-141	1.96E+5	1.33E+5	-	6.17E+4	-	5.08E+8	1.51E+4
Ce-143	1.00E+3	7.42E+5	-	3.26E+2	-	2.77E+7	8.21E+1
Ce-144	3.29E+7	1.38E+7	-	8.16E+6	-	1.11E+10	1.77E+6
Pr-143	6.34E+4	2.54E+4	-	1.47E+4	-	2.78E+8	3.14E+3
Pr-144	-	-	-	-	-	-	-
Nd-147	3.34E+4	3.86E+4	-	2.25E+4	-	1.85E+8	2.31E+3
W-187	3.82E+4	3.19E+4	-	-	-	1.05E+7	1.12E+4
Np-239	1.42E+3	1.40E+2	-	4.37E+2	-	2.87E+7	7.72E+1

Table 2.7 (Page 1 of 2)

R<sub>i</sub> Vegetation Pathway Dose Factors - TEEN

(mrem/yr per  $\mu\text{Ci}/\text{m}^3$ ) for H-3 and C-14 ( $\text{m}^2 \times \text{mrem}/\text{yr} \mu\text{Ci}/\text{sec}$ ) for others

Nuclide	Bone	Liver	Thyroid	Kidney	Lung	GI-LLI	T.Body
H-3	-	2.59E+3	2.59E+3	2.59E+3	2.59E+3	2.59E+3	2.59E+3
C-14	1.45E+6	2.91E+5	2.91E+5	2.91E+5	2.91E+5	2.91E+5	2.91E+5
Na-24	2.45E+5	2.45E+5	2.45E+5	2.45E+5	2.45E+5	2.45E+5	2.45E+5
P-32	1.61E+9	9.96E+7	-	-	-	1.35E+8	6.23E+7
Cr-51	-	-	3.44E+4	1.36E+4	8.85E+4	1.04E+7	6.20E+4
Mn-54	-	4.52E+8	-	1.35E+8	-	9.27E+8	8.97E+7
Mn-56	-	1.45E+1	-	1.83E+1	-	9.54E+2	2.58E+0
Fe-55	3.25E+8	2.31E+8	-	-	1.46E+8	9.98E+7	5.38E+7
Fe-59	1.81E+8	4.22E+8	-	-	1.33E+8	9.98E+8	1.63E+8
Co-57	-	1.79E+7	-	-	-	3.34E+8	3.00E+7
Co-58	-	4.38E+7	-	-	-	6.04E+8	1.01E+8
Co-60	-	2.49E+8	-	-	-	3.24E+9	5.60E+8
Ni-63	1.61E+10	1.13E+9	-	-	-	1.81E+8	5.45E+8
Ni-65	5.73E+1	7.32E+0	-	-	-	3.97E+2	3.33E+0
Cu-64	-	8.40E+3	-	2.12E+4	-	6.51E+5	3.95E+3
Zn-65	4.24E+8	1.47E+9	-	9.41E+8	-	6.23E+8	6.86E+8
Zn-69	8.19E-6	1.56E-5	-	1.02E-5	-	2.88E-5	1.09E-6
Br-82	-	-	-	-	-	-	1.33E+6
Br-83	-	-	-	-	-	-	3.01E+0
Br-84	-	-	-	-	-	-	-
Br-85	-	-	-	-	-	-	-
Rb-86	-	2.73E+8	-	-	-	4.05E+7	1.28E+8
Rb-88	-	-	-	-	-	-	-
Rb-89	-	-	-	-	-	-	-
Sr-89	1.51E+10	-	-	-	-	1.80E+9	4.33E+8
Sr-90	7.51E+11	-	-	-	-	2.11E+10	1.85E+11
Sr-91	2.99E+5	-	-	-	-	1.36E+6	1.19E+4
Sr-92	3.97E+2	-	-	-	-	1.01E+4	1.69E+1
Y-90	1.24E+4	-	-	-	-	1.02E+8	3.34E+2
Y-91m	5.43E-9	-	-	-	-	2.56E-7	-
Y-91	7.87E+6	-	-	-	-	3.23E+9	2.11E+5
Y-92	8.47E-1	-	-	-	-	2.32E+4	2.45E-2
Y-93	1.63E+2	-	-	-	-	4.98E+6	4.47E+0
Zr-95	1.74E+6	5.49E+5	-	8.07E+5	-	1.27E+9	3.78E+5
Zr-97	3.09E+2	6.11E+1	-	9.26E+1	-	1.65E+7	2.81E+1
Nb-95	1.92E+5	1.06E+5	-	1.03E+5	-	4.55E+8	5.86E+4
Nb-97	2.69E-6	6.67E-7	-	7.80E-7	-	1.59E-2	2.44E-7
Mo-99	-	5.74E+6	-	1.31E+7	-	1.03E+7	1.09E+6
Tc-99m	2.70E+0	7.54E+0	-	1.12E+2	4.19E+0	4.95E+3	9.77E+1
Tc-101	-	-	-	-	-	-	-

Table 2.7 (Page 2 of 2)

R<sub>i</sub> Vegetation Pathway Dose Factors - TEEN

(mrem/yr per  $\mu\text{Ci}/\text{m}^3$ ) for H-3 and C-14 ( $\text{m}^2 \times \text{mrem}/\text{yr} \mu\text{Ci}/\text{sec}$ ) for others

Nuclide	Bone	Liver	Thyroid	Kidney	Lung	GI-LLI	T.Body
Ru-103	6.87E+6	-	-	2.42E+7	-	5.74E+8	2.94E+6
Ru-105	5.00E+1	-	-	6.31E+2	-	4.04E+4	1.94E+1
Ru-106	3.09E+8	-	-	5.97E+8	-	1.48E+10	3.90E+7
Rh-103m	-	-	-	-	-	-	-
Rh-106	-	-	-	-	-	-	-
Ag-110m	1.52E+7	1.44E+7	-	2.74E+7	-	4.04E+9	8.74E+6
Sb-124	1.55E+8	2.85E+6	3.51E+5	-	1.35E+8	3.11E+9	6.03E+7
Sb-125	2.14E+8	2.34E+6	2.04E+5	-	1.88E+8	1.66E+9	5.00E+7
Te-125m	1.48E+8	5.34E+7	4.14E+7	-	-	4.37E+8	1.98E+7
Te-127m	5.51E+8	1.96E+8	1.31E+8	2.24E+9	-	1.37E+9	6.56E+7
Te-127	5.43E+3	1.92E+3	3.74E+3	2.20E+4	-	4.19E+5	1.17E+3
Te-129m	3.67E+8	1.36E+8	1.18E+8	1.54E+9	-	1.38E+9	5.81E+7
Te-129	6.22E-4	2.32E-4	4.45E-4	2.61E-3	-	3.40E-3	1.51E-4
Te-131m	8.44E+5	4.05E+5	6.09E+5	4.22E+6	-	3.25E+7	3.38E+5
Te-131	-	-	-	-	-	-	-
Te-132	3.90E+6	2.47E+6	2.60E+6	2.37E+7	-	7.82E+7	2.32E+6
I-130	3.54E+5	1.02E+6	8.35E+7	1.58E+6	-	7.87E+5	4.09E+5
I-131	7.70E+7	1.08E+8	3.14E+10	1.85E+8	-	2.13E+7	5.79E+7
I-132	5.18E+1	1.36E+2	4.57E+3	2.14E+2	-	5.91E+1	4.87E+1
I-133	1.97E+6	3.34E+6	4.66E+8	5.86E+6	-	2.53E+6	1.02E+6
I-134	9.59E-5	2.54E-4	4.24E-3	4.01E-4	-	3.35E-6	9.13E-5
I-135	3.68E+4	9.48E+4	6.10E+6	1.50E+5	-	1.05E+5	3.52E+4
Cs-134	7.09E+9	1.67E+10	-	5.30E+9	2.02E+9	2.08E+8	7.74E+9
Cs-136	4.29E+7	1.69E+8	-	9.19E+7	1.45E+7	1.36E+7	1.13E+8
Cs-137	1.01E+10	1.35E+10	-	4.59E+9	1.78E+9	1.92E+8	4.69E+9
Cs-138	-	-	-	-	-	-	-
Ba-139	2.77E-2	1.95E-5	-	1.84E-5	1.34E-5	2.47E-1	8.08E-4
Ba-140	1.38E+8	1.69E+5	-	5.75E+4	1.14E+5	2.13E+8	8.91E+6
Ba-141	-	-	-	-	-	-	-
Ba-142	-	-	-	-	-	-	-
La-140	1.80E+3	8.84E+2	-	-	-	5.08E+7	2.35E+2
La-142	1.28E-4	5.69E-5	-	-	-	1.73E+0	1.42E-5
Ce-141	2.82E+5	1.88E+5	-	8.86E+4	-	5.38E+8	2.16E+4
Ce-143	9.37E+2	6.82E+5	-	3.06E+2	-	2.05E+7	7.62E+1
Ce-144	5.27E+7	2.18E+7	-	1.30E+7	-	1.33E+10	2.83E+6
Pr-143	7.12E+4	2.84E+4	-	1.65E+4	-	2.34E+8	3.55E+3
Pr-144	-	-	-	-	-	-	-
Nd-147	3.63E+4	3.94E+4	-	2.32E+4	-	1.42E+8	2.36E+3
W-187	3.55E+4	2.90E+4	-	-	-	7.84E+6	1.02E+4
Np-239	1.38E+3	1.30E+2	-	4.09E+2	-	2.10E+7	7.24E+1

Table 2.8 (Page 1 of 2)

R<sub>i</sub> Vegetation Pathway Dose Factors - CHILD

(mrem/yr per  $\mu\text{Ci}/\text{m}^3$ ) for H-3 and C-14 ( $\text{m}^2 \times \text{mrem}/\text{yr} \mu\text{Ci}/\text{sec}$ ) for others

Nuclide	Bone	Liver	Thyroid	Kidney	Lung	GI-LLI	T.Body
H-3	-	4.01E+3	4.01E+3	4.01E+3	4.01E+3	4.01E+3	4.01E+3
C-14	3.50E+6	7.01E+5	7.01E+5	7.01E+5	7.01E+5	7.01E+5	7.01E+5
Na-24	3.83E+5	3.83E+5	3.83E+5	3.83E+5	3.83E+5	3.83E+5	3.83E+5
P-32	3.37E+9	1.58E+8	-	-	-	9.30E+7	1.30E+8
Cr-51	-	-	6.54E+4	1.79E+4	1.19E+5	6.25E+6	1.18E+5
Mn-54	-	6.61E+8	-	1.85E+8	-	5.55E+8	1.76E+8
Mn-56	-	1.90E+1	-	2.29E+1	-	2.75E+3	4.28E+0
Fe-55	8.00E+8	4.24E+8	-	-	2.40E+8	7.86E+7	1.31E+8
Fe-59	4.01E+8	6.49E+8	-	-	1.88E+8	6.76E+8	3.23E+8
Co-57	-	2.99E+7	-	-	-	2.45E+8	6.04E+7
Co-58	-	6.47E+7	-	-	-	3.77E+8	1.98E+8
Co-60	-	3.78E+8	-	-	-	2.10E+9	1.12E+9
Ni-63	3.95E+10	2.11E+9	-	-	-	1.42E+8	1.34E+9
Ni-65	1.05E+2	9.89E+0	-	-	-	1.21E+3	5.77E+0
Cu-64	-	1.11E+4	-	2.68E+4	-	5.20E+5	6.69E+3
Zn-65	8.12E+8	2.16E+9	-	1.36E+9	-	3.80E+8	1.35E+9
Zn-69	1.51E-5	2.18E-5	-	1.32E-5	-	1.38E-3	2.02E-6
Br-82	-	-	-	-	-	-	2.04E+6
Br-83	-	-	-	-	-	-	5.55E+0
Br-84	-	-	-	-	-	-	-
Br-85	-	-	-	-	-	-	-
Rb-86	-	4.52E+8	-	-	-	2.91E+7	2.78E+8
Rb-88	-	-	-	-	-	-	-
Rb-89	-	-	-	-	-	-	-
Sr-89	3.59E+10	-	-	-	-	1.39E+9	1.03E+9
Sr-90	1.24E+12	-	-	-	-	1.67E+10	3.15E+11
Sr-91	5.50E+5	-	-	-	-	1.21E+6	2.08E+4
Sr-92	7.28E+2	-	-	-	-	1.38E+4	2.92E+1
Y-90	2.30E+4	-	-	-	-	6.56E+7	6.17E+2
Y-91m	9.94E-9	-	-	-	-	1.95E-5	-
Y-91	1.87E+7	-	-	-	-	2.49E+9	5.01E+5
Y-92	1.56E+0	-	-	-	-	4.51E+4	4.46E-2
Y-93	3.01E+2	-	-	-	-	4.48E+6	8.25E+0
Zr-95	3.90E+6	8.58E+5	-	1.23E+6	-	8.95E+8	7.64E+5
Zr-97	5.64E+2	8.15E+1	-	1.17E+2	-	1.23E+7	4.81E+1
Nb-95	4.10E+5	1.59E+5	-	1.50E+5	-	2.95E+8	1.14E+5
Nb-97	4.90E-6	8.85E-7	-	9.82E-7	-	2.73E-1	4.13E-7
Mo-99	-	7.83E+6	-	1.67E+7	-	6.48E+6	1.94E+6
Tc-99m	4.65E+0	9.12E+0	-	1.33E+2	4.63E+0	5.19E+3	1.51E+2
Tc-101	-	-	-	-	-	-	-

Table 2.8 (Page 2 of 2)

R<sub>i</sub> Vegetation Pathway Dose Factors - CHILD  
(mrem/yr per  $\mu\text{Ci}/\text{m}^3$ ) for H-3 and C-14 ( $\text{m}^2 \times \text{mrem}/\text{yr} \mu\text{Ci}/\text{sec}$ ) for others

Nuclide	Bone	Liver	Thyroid	Kidney	Lung	GI-LLI	T.Body
Ru-103	1.55E+7	-	-	3.89E+7	-	3.99E+8	5.94E+6
Ru-105	9.17E+1	-	-	8.06E+2	-	5.98E+4	3.33E+1
Ru-106	7.45E+8	-	-	1.01E+9	-	1.16E+10	9.30E+7
Rh-103m	-	-	-	-	-	-	-
Rh-106	-	-	-	-	-	-	-
Ag-110m	3.22E+7	2.17E+7	-	4.05E+7	-	2.58E+9	1.74E+7
Sb-124	3.52E+8	4.57E+6	7.78E+5	-	1.96E+8	2.20E+9	1.23E+8
Sb-125	4.99E+8	3.85E+6	4.62E+5	-	2.78E+8	1.19E+9	1.05E+8
Te-125m	3.51E+8	9.50E+7	9.84E+7	-	-	3.38E+8	4.67E+7
Te-127m	1.32E+9	3.56E+8	3.16E+8	3.77E+9	-	1.07E+9	1.57E+8
Te-127	1.00E+4	2.70E+3	6.93E+3	2.85E+4	-	3.91E+5	2.15E+3
Te-129m	8.54E+8	2.39E+8	2.75E+8	2.51E+9	-	1.04E+9	1.33E+8
Te-129	1.15E-3	3.22E-4	8.22E-4	3.37E-3	-	7.17E-2	2.74E-4
Te-131m	1.54E+6	5.33E+5	1.10E+6	5.16E+6	-	2.16E+7	5.68E+5
Te-131	-	-	-	-	-	-	-
Te-132	6.98E+6	3.09E+6	4.50E+6	2.87E+7	-	3.11E+7	3.73E+6
I-130	6.21E+5	1.26E+6	1.38E+8	1.88E+6	-	5.87E+5	6.47E+5
I-131	1.43E+8	1.44E+8	4.76E+10	2.36E+8	-	1.28E+7	8.18E+7
I-132	9.20E+1	1.69E+2	7.84E+3	2.59E+2	-	1.99E+2	7.77E+1
I-133	3.59E+6	4.44E+6	8.25E+8	7.40E+6	-	1.79E+6	1.68E+6
I-134	1.70E-4	3.16E-4	7.28E-3	4.84E-4	-	2.10E-4	1.46E-4
I-135	6.54E+4	1.18E+5	1.04E+7	1.81E+5	-	8.98E+4	5.57E+4
Cs-134	1.60E+10	2.63E+10	-	8.14E+9	2.92E+9	1.42E+8	5.54E+9
Cs-136	8.06E+7	2.22E+8	-	1.18E+8	1.76E+7	7.79E+6	1.43E+8
Cs-137	2.39E+10	2.29E+10	-	7.46E+9	2.68E+9	1.43E+8	3.38E+9
Cs-138	-	-	-	-	-	-	-
Ba-139	5.11E-2	2.73E-5	-	2.38E-5	1.61E-5	2.95E+0	1.48E-3
Ba-140	2.77E+8	2.43E+5	-	7.90E+4	1.45E+5	1.40E+8	1.62E+7
Ba-141	-	-	-	-	-	-	-
Ba-142	-	-	-	-	-	-	-
La-140	3.23E+3	1.13E+3	-	-	-	3.15E+7	3.81E+2
La-142	2.32E-4	7.40E-5	-	-	-	1.47E+1	2.32E-5
Ce-141	6.35E+5	3.26E+5	-	1.43E+5	-	4.07E+8	4.84E+4
Ce-143	1.73E+3	9.36E+5	-	3.93E+2	-	1.37E+7	1.36E+2
Ce-144	1.27E+8	3.98E+7	-	2.21E+7	-	1.04E+10	6.78E+6
Pr-143	1.48E+5	4.46E+4	-	2.41E+4	-	1.60E+8	7.37E+3
Pr-144	-	-	-	-	-	-	-
Nd-147	7.16E+4	5.80E+4	-	3.18E+4	-	9.18E+7	4.49E+3
W-187	6.47E+4	3.83E+4	-	-	-	5.38E+6	1.72E+4
Np-239	2.55E+3	1.83E+2	-	5.30E+2	-	1.36E+7	1.29E+2

Table 2.9 (Page 1 of 2)

$R_i$  Grass-Cow-Milk Pathway Dose Factors - ADULT  
(mrem/yr per  $\mu\text{Ci}/\text{m}^3$ ) for H-3 and C-14 ( $\text{m}^2 \times \text{mrem}/\text{yr} \mu\text{Ci}/\text{sec}$ ) for others

Nuclide	Bone	Liver	Thyroid	Kidney	Lung	GI-LLI	T.Body
H-3	-	7.63E+2	7.63E+2	7.63E+2	7.63E+2	7.63E+2	7.63E+2
C-14	3.63E+5	7.26E+4	7.26E+4	7.26E+4	7.26E+4	7.26E+4	7.26E+4
Na-24	2.54E+6	2.54E+6	2.54E+6	2.54E+6	2.54E+6	2.54E+6	2.54E+6
P-32	1.71E+10	1.06E+9	-	-	-	1.92E+9	6.60E+8
Cr-51	-	-	1.71E+4	6.30E+3	3.80E+4	7.20E+6	2.86E+4
Mn-54	-	8.40E+6	-	2.50E+6	-	2.57E+7	1.60E+6
Mn-56	-	4.23E-3	-	5.38E-3	-	1.35E-1	7.51E-4
Fe-55	2.51E+7	1.73E+7	-	-	9.67E+6	9.95E+6	4.04E+6
Fe-59	2.98E+7	7.00E+7	-	-	1.95E+7	2.33E+8	2.68E+7
Co-57	-	1.28E+6	-	-	-	3.25E+7	2.13E+6
Co-58	-	4.72E+6	-	-	-	9.57E+7	1.06E+7
Co-60	-	1.64E+7	-	-	-	3.08E+8	3.62E+7
Ni-63	6.73E+9	4.66E+8	-	-	-	9.73E+7	2.26E+8
Ni-65	3.70E-1	4.81E-2	-	-	-	1.22E+0	2.19E-2
Cu-64	-	2.41E+4	-	6.08E+4	-	2.05E+6	1.13E+4
Zn-65	1.37E+9	4.36E+9	-	2.92E+9	-	2.75E+9	1.97E+9
Zn-69	-	-	-	-	-	-	-
Br-82	-	-	-	-	-	3.72E+7	3.25E+7
Br-83	-	-	-	-	-	1.49E-1	1.03E-1
Br-84	-	-	-	-	-	-	-
Br-85	-	-	-	-	-	-	-
Rb-86	-	2.59E+9	-	-	-	5.11E+8	1.21E+9
Rb-88	-	-	-	-	-	-	-
Rb-89	-	-	-	-	-	-	-
Sr-89	1.45E+9	-	-	-	-	2.33E+8	4.16E+7
Sr-90	4.68E+10	-	-	-	-	1.35E+9	1.15E+10
Sr-91	3.13E+4	-	-	-	-	1.49E+5	1.27E+3
Sr-92	4.89E-1	-	-	-	-	9.68E+0	2.11E-2
Y-90	7.07E+1	-	-	-	-	7.50E+5	1.90E+0
Y-91m	-	-	-	-	-	-	-
Y-91	8.60E+3	-	-	-	-	4.73E+6	2.30E+2
Y-92	5.42E-5	-	-	-	-	9.49E-1	1.58E-6
Y-93	2.33E-1	-	-	-	-	7.39E+3	6.43E-3
Zr-95	9.46E+2	3.03E+2	-	4.76E+2	-	9.62E+5	2.05E+2
Zr-97	4.26E-1	8.59E-2	-	1.30E-1	-	2.66E+4	3.93E-2
Nb-95	8.25E+4	4.59E+4	-	4.54E+4	-	2.79E+8	2.47E+4
Nb-97	-	-	-	-	-	5.47E-9	-
Mo-99	-	2.52E+7	-	5.72E+7	-	5.85E+7	4.80E+6
Tc-99m	3.25E+0	9.19E+0	-	1.40E+2	4.50E+0	5.44E+3	1.17E+2
Tc-101	-	-	-	-	-	-	-

Table 2.9 (Page 2 of 2)

R<sub>i</sub> Grass-Cow-Milk Pathway Dose Factors - ADULT  
(mrem/yr per  $\mu\text{Ci}/\text{m}^3$ ) for H-3 and C-14 ( $\text{m}^2 \times \text{mrem}/\text{yr} \mu\text{Ci}/\text{sec}$ ) for others

Nuclide	Bone	Liver	Thyroid	Kidney	Lung	GI-LLI	T.Body
Ru-103	1.02E+3	-	-	3.89E+3	-	1.19E+5	4.39E+2
Ru-105	8.57E-4	-	-	1.11E-2	-	5.24E-1	3.38E-4
Ru-106	2.04E+4	-	-	3.94E+4	-	1.32E+6	2.58E+3
Rh-103m	-	-	-	-	-	-	-
Rh-106	-	-	-	-	-	-	-
Ag-110m	5.83E+7	5.39E+7	-	1.06E+8	-	2.20E+10	3.20E+7
Sb-124	2.57E+7	4.86E+5	6.24E+4	-	2.00E+7	7.31E+8	1.02E+7
Sb-125	2.04E+7	2.28E+5	2.08E+4	-	1.58E+7	2.25E+8	4.86E+6
Te-125m	1.63E+7	5.90E+6	4.90E+6	6.63E+7	-	6.50E+7	2.18E+6
Te-127m	4.58E+7	1.64E+7	1.17E+7	1.86E+8	-	1.54E+8	5.58E+6
Te-127	6.72E+2	2.41E+2	4.98E+2	2.74E+3	-	5.30E+4	1.45E+2
Te-129m	6.04E+7	2.25E+7	2.08E+7	2.52E+8	-	3.04E+8	9.57E+6
Te-129	-	-	-	-	-	-	-
Te-131m	3.61E+5	1.77E+5	2.80E+5	1.79E+6	-	1.75E+7	1.47E+5
Te-131	-	-	-	-	-	-	-
Te-132	2.39E+6	1.55E+6	1.71E+6	1.49E+7	-	7.32E+7	1.45E+6
I-130	4.26E+5	1.26E+6	1.07E+8	1.96E+6	-	1.08E+6	4.96E+5
I-131	2.96E+8	4.24E+8	1.39E+11	7.27E+8	-	1.12E+8	2.43E+8
I-132	1.64E-1	4.37E-1	1.53E+1	6.97E-1	-	8.22E-2	1.53E-1
I-133	3.97E+6	6.90E+6	1.01E+9	1.20E+7	-	6.20E+6	2.10E+6
I-134	-	-	-	-	-	-	-
I-135	1.39E+4	3.63E+4	2.40E+6	5.83E+4	-	4.10E+4	1.34E+4
Cs-134	5.65E+9	1.34E+10	-	4.35E+9	1.44E+9	2.35E+8	1.10E+10
Cs-136	2.61E+8	1.03E+9	-	5.74E+8	7.87E+7	1.17E+8	7.42E+8
Cs-137	7.38E+9	1.01E+10	-	3.43E+9	1.14E+9	1.95E+8	6.61E+9
Cs-138	-	-	-	-	-	-	-
Ba-139	4.70E-8	-	-	-	-	8.34E-8	1.38E-9
Ba-140	2.69E+7	3.38E+4	-	1.15E+4	1.93E+4	5.54E+7	1.76E+6
Ba-141	-	-	-	-	-	-	-
Ba-142	-	-	-	-	-	-	-
La-140	4.49E+0	2.26E+0	-	-	-	1.66E+5	5.97E-1
La-142	-	-	-	-	-	3.03E-8	-
Ce-141	4.84E+3	3.27E+3	-	1.52E+3	-	1.25E+7	3.71E+2
Ce-143	4.19E+1	3.09E+4	-	1.36E+1	-	1.16E+6	3.42E+0
Ce-144	3.58E+5	1.50E+5	-	8.87E+4	-	1.21E+8	1.92E+4
Pr-143	1.59E+2	6.37E+1	-	3.68E+1	-	6.96E+5	7.88E+0
Pr-144	-	-	-	-	-	-	-
Nd-147	9.42E+1	1.09E+2	-	6.37E+1	-	5.23E+5	6.52E+0
W-187	6.56E+3	5.48E+3	-	-	-	1.80E+6	1.92E+3
Np-239	3.66E+0	3.60E-1	-	1.12E+0	-	7.39E+4	1.98E-1



Table 2.10 (Page 1 of 2)

R<sub>i</sub> Grass-Cow-Milk Pathway Dose Factors - TEEN  
(mrem/yr per  $\mu\text{Ci}/\text{m}^3$ ) for H-3 and C-14 ( $\text{m}^2 \times \text{mrem}/\text{yr}$   $\mu\text{Ci}/\text{sec}$ ) for others

Nuclide	Bone	Liver	Thyroid	Kidney	Lung	GI-LLI	T.Body
H-3	-	9.94E+2	9.94E+2	9.94E+2	9.94E+2	9.94E+2	9.94E+2
C-14	6.70E+5	1.34E+5	1.34E+5	1.34E+5	1.34E+5	1.34E+5	1.34E+5
Na-24	4.44E+6	4.44E+6	4.44E+6	4.44E+6	4.44E+6	4.44E+6	4.44E+6
P-32	3.15E+10	1.95E+9	-	-	-	2.65E+9	1.22E+9
Cr-51	-	-	2.78E+4	1.10E+4	7.13E+4	8.40E+6	5.00E+4
Mn-54	-	1.40E+7	-	4.17E+6	-	2.87E+7	2.78E+6
Mn-56	-	7.51E-3	-	9.50E-3	-	4.94E-1	1.33E-3
Fe-55	4.45E+7	3.16E+7	-	-	2.00E+7	1.37E+7	7.36E+6
Fe-59	5.20E+7	1.21E+8	-	-	3.82E+7	2.87E+8	4.68E+7
Co-57	-	2.25E+6	-	-	-	4.19E+7	3.76E+6
Co-58	-	7.95E+6	-	-	-	1.10E+8	1.83E+7
Co-60	-	2.78E+7	-	-	-	3.62E+8	6.26E+7
Ni-63	1.18E+10	8.35E+8	-	-	-	1.33E+8	4.01E+8
Ni-65	6.78E-1	8.66E-2	-	-	-	4.70E+0	3.94E-2
Cu-64	-	4.29E+4	-	1.09E+5	-	3.33E+6	2.02E+4
Zn-65	2.11E+9	7.31E+9	-	4.68E+9	-	3.10E+9	3.41E+9
Zn-69	-	-	-	-	-	-	-
Br-82	-	-	-	-	-	-	5.64E+7
Br-83	-	-	-	-	-	-	1.91E-1
Br-84	-	-	-	-	-	-	-
Br-85	-	-	-	-	-	-	-
Rb-86	-	4.73E+9	-	-	-	7.00E+8	2.22E+9
Rb-88	-	-	-	-	-	-	-
Rb-89	-	-	-	-	-	-	-
Sr-89	2.67E+9	-	-	-	-	3.18E+8	7.66E+7
Sr-90	6.61E+10	-	-	-	-	1.86E+9	1.63E+10
Sr-91	5.75E+4	-	-	-	-	2.61E+5	2.29E+3
Sr-92	8.95E-1	-	-	-	-	2.28E+1	3.81E-2
Y-90	1.30E+2	-	-	-	-	1.07E+6	3.50E+0
Y-91m	-	-	-	-	-	-	-
Y-91	1.58E+4	-	-	-	-	6.48E+6	4.24E+2
Y-92	1.00E-4	-	-	-	-	2.75E+0	2.90E-6
Y-93	4.30E-1	-	-	-	-	1.31E+4	1.18E-2
Zr-95	1.65E+3	5.22E+2	-	7.67E+2	-	1.20E+6	3.59E+2
Zr-97	7.75E-1	1.53E-1	-	2.32E-1	-	4.15E+4	7.06E-2
Nb-95	1.41E+5	7.80E+4	-	7.57E+4	-	3.34E+8	4.30E+4
Nb-97	-	-	-	-	-	6.34E-8	-
Mo-99	-	4.56E+7	-	1.04E+8	-	8.16E+7	8.69E+6
Tc-99m	5.64E+0	1.57E+1	-	2.34E+2	8.73E+0	1.03E+4	2.04E+2
Tc-101	-	-	-	-	-	-	-

Table 2.10 (Page 2 of 2)

R<sub>i</sub> Grass-Cow-Milk Pathway Dose Factors - TEEN  
(mrem/yr per μCi/m<sup>3</sup>) for H-3 and C-14 (m<sup>2</sup> x mrem/yr μCi/sec) for others

Nuclide	Bone	Liver	Thyroid	Kidney	Lung	GI-LLI	T.Body
Ru-103	1.81E+3	-	-	6.40E+3	-	1.52E+5	7.75E+2
Ru-105	1.57E-3	-	-	1.97E-2	-	1.26E+0	6.08E-4
Ru-106	3.75E+4	-	-	7.23E+4	-	1.80E+6	4.73E+3
Rh-103m	-	-	-	-	-	-	-
Rh-106	-	-	-	-	-	-	-
Ag-110m	9.63E+7	9.11E+7	-	1.74E+8	-	2.56E+10	5.54E+7
Sb-124	4.59E+7	8.46E+5	1.04E+5	-	4.01E+7	9.25E+8	1.79E+7
Sb-125	3.65E+7	3.99E+5	3.49E+4	-	3.21E+7	2.84E+8	8.54E+6
Te-125m	3.00E+7	1.08E+7	8.39E+6	-	-	8.86E+7	4.02E+6
Te-127m	8.44E+7	2.99E+7	2.01E+7	3.42E+8	-	2.10E+8	1.00E+7
Te-127	1.24E+3	4.41E+2	8.59E+2	5.04E+3	-	9.61E+4	2.68E+2
Te-129m	1.11E+8	4.10E+7	3.57E+7	4.62E+8	-	4.15E+8	1.75E+7
Te-129	-	-	-	1.67E-9	-	2.18E-9	-
Te-131m	6.57E+5	3.15E+5	4.74E+5	3.29E+6	-	2.53E+7	2.63E+5
Te-131	-	-	-	-	-	-	-
Te-132	4.28E+6	2.71E+6	2.86E+6	2.60E+7	-	8.58E+7	2.55E+6
I-130	7.49E+5	2.17E+6	1.77E+8	3.34E+6	-	1.67E+6	8.66E+5
I-131	5.38E+8	7.53E+8	2.20E+11	1.30E+9	-	1.49E+8	4.04E+8
I-132	2.90E-1	7.59E-1	2.56E+1	1.20E+0	-	3.31E-1	2.72E-1
I-133	7.24E+6	1.23E+7	1.72E+9	2.15E+7	-	9.30E+6	3.75E+6
I-134	-	-	-	-	-	-	-
I-135	2.47E+4	6.35E+4	4.08E+6	1.00E+5	-	7.03E+4	2.35E+4
Cs-134	9.81E+9	2.31E+10	-	7.34E+9	2.80E+9	2.87E+8	1.07E+10
Cs-136	4.45E+8	1.75E+9	-	9.53E+8	1.50E+8	1.41E+8	1.18E+9
Cs-137	1.34E+10	1.78E+10	-	6.06E+9	2.35E+9	2.53E+8	6.20E+9
Cs-138	-	-	-	-	-	-	-
Ba-139	8.69E-8	-	-	-	-	7.75E-7	2.53E-9
Ba-140	4.85E+7	5.95E+4	-	2.02E+4	4.00E+4	7.49E+7	3.13E+6
Ba-141	-	-	-	-	-	-	-
Ba-142	-	-	-	-	-	-	-
La-140	8.06E+0	3.96E+0	-	-	-	2.27E+5	1.05E+0
La-142	-	-	-	-	-	2.23E-7	-
Ce-141	8.87E+3	5.92E+3	-	2.79E+3	-	1.69E+7	6.81E+2
Ce-143	7.69E+1	5.60E+4	-	2.51E+1	-	1.68E+6	6.25E+0
Ce-144	6.58E+5	2.72E+5	-	1.63E+5	-	1.66E+8	3.54E+4
Pr-143	2.92E+2	1.17E+2	-	6.77E+1	-	9.61E+5	1.45E+1
Pr-144	-	-	-	-	-	-	-
Nd-147	1.81E+2	1.97E+2	-	1.16E+2	-	7.11E+5	1.18E+1
W-187	1.20E+4	9.78E+3	-	-	-	2.65E+6	3.43E+3
Np-239	6.99E+0	6.59E-1	-	2.07E+0	-	1.06E+5	3.66E-1

Table 2.11 (Page 1 of 2)

R<sub>1</sub> Grass-Cow-Milk Pathway Dose Factors - CHILD  
(mrem/yr per  $\mu\text{Ci}/\text{m}^3$ ) for H-3 and C-14 ( $\text{m}^2 \times \text{mrem}/\text{yr}$   $\mu\text{Ci}/\text{sec}$ ) for others

Nuclide	Bone	Liver	Thyroid	Kidney	Lung	GI-LLI	T.Body
H-3	-	1.57E+3	1.57E+3	1.57E+3	1.57E+3	1.57E+3	1.57E+3
C-14	1.65E+6	3.29E+5	3.29E+5	3.29E+5	3.29E+5	3.29E+5	3.29E+5
Na-24	9.23E+6	9.23E+6	9.23E+6	9.23E+6	9.23E+6	9.23E+6	9.23E+6
P-32	7.77E+10	3.64E+9	-	-	-	2.15E+9	3.00E+9
Cr-51	-	-	5.66E+4	1.55E+4	1.03E+5	5.41E+6	1.02E+5
Mn-54	-	2.09E+7	-	5.87E+6	-	1.76E+7	5.58E+6
Mn-56	-	1.31E-2	-	1.58E-2	-	1.90E+0	2.95E-3
Fe-55	1.12E+8	5.93E+7	-	-	3.35E+7	1.10E+7	1.84E+7
Fe-59	1.20E+8	1.95E+8	-	-	5.65E+7	2.03E+8	9.71E+7
Co-57	-	3.84E+6	-	-	-	3.14E+7	7.77E+6
Co-58	-	1.21E+7	-	-	-	7.08E+7	3.72E+7
Co-60	-	4.32E+7	-	-	-	2.39E+8	1.27E+8
Ni-63	2.96E+10	1.59E+9	-	-	-	1.07E+8	1.01E+9
Ni-65	1.66E+0	1.56E-1	-	-	-	1.91E+1	9.11E-2
Cu-64	-	7.55E+4	-	1.82E+5	-	3.54E+6	4.56E+4
Zn-65	4.13E+9	1.10E+10	-	6.94E+9	-	1.93E+9	6.85E+9
Zn-69	-	-	-	-	-	2.14E-9	-
Br-82	-	-	-	-	-	-	1.15E+8
Br-83	-	-	-	-	-	-	4.69E-1
Br-84	-	-	-	-	-	-	-
Br-85	-	-	-	-	-	-	-
Rb-86	-	8.77E+9	-	-	-	5.64E+8	5.39E+9
Rb-88	-	-	-	-	-	-	-
Rb-89	-	-	-	-	-	-	-
Sr-89	6.62E+9	-	-	-	-	2.56E+8	1.89E+8
Sr-90	1.12E+11	-	-	-	-	1.51E+9	2.83E+10
Sr-91	1.41E+5	-	-	-	-	3.12E+5	5.33E+3
Sr-92	2.19E+0	-	-	-	-	4.14E+1	8.76E-2
Y-90	3.22E+2	-	-	-	-	9.15E+5	8.61E+0
Y-91m	-	-	-	-	-	-	-
Y-91	3.91E+4	-	-	-	-	5.21E+6	1.04E+3
Y-92	2.46E-4	-	-	-	-	7.10E+0	7.03E-6
Y-93	1.06E+0	-	-	-	-	1.57E+4	2.90E-2
Zr-95	3.84E+3	8.45E+2	-	1.21E+3	-	8.81E+5	7.52E+2
Zr-97	1.89E+0	2.72E-1	-	3.91E-1	-	4.13E+4	1.61E-1
Nb-95	3.18E+5	1.24E+5	-	1.16E+5	-	2.29E+8	8.84E+4
Nb-97	-	-	-	-	-	1.45E-6	-
Mo-99	-	8.29E+7	-	1.77E+8	-	6.86E+7	2.05E+7
Tc-99m	1.29E+1	2.54E+1	-	3.68E+2	1.29E+1	1.44E+4	4.20E+2
Tc-101	-	-	-	-	-	-	-

Table 2.11 (Page 2 of 2)

R<sub>i</sub> Grass-Cow-Milk Pathway Dose Factors - CHILD  
(mrem/yr per μCi/m<sup>3</sup>) for H-3 and C-14 (m<sup>2</sup> x mrem/yr μCi/sec) for others

Nuclide	Bone	Liver	Thyroid	Kidney	Lung	GI-LLI	T.Body
Ru-103	4.29E+3	-	-	1.08E+4	-	1.11E+5	1.65E+3
Ru-105	3.82E-3	-	-	3.36E-2	-	2.49E+0	1.39E-3
Ru-106	9.24E+4	-	-	1.25E+5	-	1.44E+6	1.15E+4
Rh-103m	-	-	-	-	-	-	-
Rh-106	-	-	-	-	-	-	-
Ag-110m	2.09E+8	1.41E+8	-	2.63E+8	-	1.68E+10	1.13E+8
Sb-124	1.09E+8	1.41E+8	2.40E+5	-	6.03E+7	6.79E+8	3.81E+7
Sb-125	8.70E+7	1.41E+6	8.06E+4	-	4.85E+7	2.08E+8	1.82E+7
Te-125m	7.38E+7	2.00E+7	2.07E+7	-	-	7.12E+7	9.84E+6
Te-127m	2.08E+8	5.60E+7	4.97E+7	5.93E+8	-	1.68E+8	2.47E+7
Te-127	3.06E+3	8.25E+2	2.12E+3	8.71E+3	-	1.20E+5	6.56E+2
Te-129m	2.72E+8	7.61E+7	8.78E+7	8.00E+8	-	3.32E+8	4.23E+7
Te-129	-	-	-	2.87E-9	-	6.12E-8	-
Te-131m	1.60E+6	5.53E+5	1.14E+6	5.35E+6	-	2.24E+7	5.89E+5
Te-131	-	-	-	-	-	-	-
Te-132	1.02E+7	4.52E+6	6.58E+6	4.20E+7	-	4.55E+7	5.46E+6
I-130	1.75E+6	3.54E+6	3.90E+8	5.29E+6	-	1.66E+6	1.82E+6
I-131	1.30E+9	1.31E+9	4.34E+11	2.15E+9	-	1.17E+8	7.46E+8
I-132	6.86E-1	1.26E+0	5.85E+1	1.93E+0	-	1.48E+0	5.80E-1
I-133	1.76E+7	2.18E+7	4.04E+9	3.63E+7	-	8.77E+6	8.23E+6
I-134	-	-	-	-	-	-	-
I-135	5.84E+4	1.05E+5	9.30E+6	1.61E+5	-	8.00E+4	4.97E+4
Cs-134	2.26E+10	3.71E+10	-	1.15E+10	4.13E+9	2.00E+8	7.83E+9
Cs-136	1.00E+9	2.76E+9	-	1.47E+9	2.19E+8	9.70E+7	1.79E+9
Cs-137	3.22E+10	3.09E+10	-	1.01E+10	3.62E+9	1.93E+8	4.55E+9
Cs-138	-	-	-	-	-	-	-
Ba-139	2.14E-7	-	-	-	-	1.23E-5	6.19E-9
Ba-140	1.17E+8	1.03E+5	-	3.34E+4	6.12E+4	5.94E+7	6.84E+6
Ba-141	-	-	-	-	-	-	-
Ba-142	-	-	-	-	-	-	-
La-140	1.93E+1	6.74E+0	-	-	-	1.88E+5	2.27E+0
La-142	-	-	-	-	-	2.51E-6	-
Ce-141	2.19E+4	1.09E+4	-	4.78E+3	-	1.36E+7	1.62E+3
Ce-143	1.89E+2	1.02E+5	-	4.29E+1	-	1.50E+6	1.48E+1
Ce-144	1.62E+6	5.09E+5	-	2.82E+5	-	1.33E+8	8.66E+4
Pr-143	7.23E+2	2.17E+2	-	1.17E+2	-	7.80E+5	3.59E+1
Pr-144	-	-	-	-	-	-	-
Nd-147	4.45E+2	3.60E+2	-	1.98E+2	-	5.71E+5	2.79E+1
W-187	2.91E+4	1.72E+4	-	-	-	2.42E+6	7.73E+3
Np-239	1.72E+1	1.23E+0	-	3.57E+0	-	9.14E+4	8.68E-1

Table 2.12 (Page 1 of 2)  
R<sub>i</sub> Grass-Cow-Milk Pathway Dose Factors - INFANT  
(mrem/yr per  $\mu\text{Ci}/\text{m}^3$ ) for H-3 and C-14 ( $\text{m}^2 \times \text{mrem}/\text{yr} \mu\text{Ci}/\text{sec}$ ) for others

Nuclide	Bone	Liver	Thyroid	Kidney	Lung	GI-LLI	T.Body
H-3	-	2.38E+3	2.38E+3	2.38E+3	2.38E+3	2.38E+3	2.38E+3
C-14	3.23E+6	6.89E+5	6.89E+5	6.89E+5	6.89E+5	6.89E+5	6.89E+5
Na-24	1.61E+7	1.61E+7	1.61E+7	1.61E+7	1.61E+7	1.61E+7	1.61E+7
P-32	1.60E+11	9.42E+9	-	-	-	2.17E+9	6.21E+9
Cr-51	-	-	1.05E+5	2.30E+4	2.05E+5	4.71E+6	1.61E+5
Mn-54	-	3.89E+7	-	8.63E+6	-	1.43E+7	8.83E+6
Mn-56	-	3.21E-2	-	2.76E-2	-	2.91E+0	5.53E-3
Fe-55	1.35E+8	8.72E+7	-	-	4.27E+7	1.11E+7	2.33E+7
Fe-59	2.25E+8	3.93E+8	-	-	1.16E+8	1.88E+8	1.55E+8
Co-57	-	8.95E+6	-	-	-	3.05E+7	1.46E+7
Co-58	-	2.43E+7	-	-	-	6.05E+7	6.06E+7
Co-60	-	8.81E+7	-	-	-	2.10E+8	2.08E+8
Ni-63	3.49E+10	2.16E+9	-	-	-	1.07E+8	1.21E+9
Ni-65	3.51E+0	3.97E-1	-	-	-	3.02E+1	1.81E-1
Cu-64	-	1.88E+5	-	3.17E+5	-	3.85E+6	8.69E+4
Zn-65	5.55E+9	1.90E+10	-	9.23E+9	-	1.61E+10	8.78E+9
Zn-69	-	-	-	-	-	7.36E-9	-
Br-82	-	-	-	-	-	-	1.94E+8
Br-83	-	-	-	-	-	-	9.95E-1
Br-84	-	-	-	-	-	-	-
Br-85	-	-	-	-	-	-	-
Rb-86	-	2.22E+10	-	-	-	5.69E+8	1.10E+10
Rb-88	-	-	-	-	-	-	-
Rb-89	-	-	-	-	-	-	-
Sr-89	1.26E+10	-	-	-	-	2.59E+8	3.61E+8
Sr-90	1.22E+11	-	-	-	-	1.52E+9	3.10E+10
Sr-91	2.94E+5	-	-	-	-	3.48E+5	1.06E+4
Sr-92	4.65E+0	-	-	-	-	5.01E+1	1.73E-1
Y-90	6.80E+2	-	-	-	-	9.39E+5	1.82E+1
Y-91m	-	-	-	-	-	-	-
Y-91	7.33E+4	-	-	-	-	5.26E+6	1.95E+3
Y-92	5.22E-4	-	-	-	-	9.97E+0	1.47E-5
Y-93	2.25E+0	-	-	-	-	1.78E+4	6.13E-2
Zr-95	6.83E+3	1.66E+3	-	1.79E+3	-	8.28E+5	1.18E+3
Zr-97	3.99E+0	6.85E-1	-	6.91E-1	-	4.37E+4	3.13E-1
Nb-95	5.93E+5	2.44E+5	-	1.75E+5	-	2.06E+8	1.41E+5
Nb-97	-	-	-	-	-	3.70E-6	-
Mo-99	-	2.12E+8	-	3.17E+8	-	6.98E+7	4.13E+7
Tc-99m	2.69E+1	5.55E+1	-	5.97E+2	2.90E+1	1.61E+4	7.15E+2
Tc-101	-	-	-	-	-	-	-

Table 2.12 (Page 2 of 2)

R<sub>i</sub> Grass-Cow-Milk Pathway Dose Factors - INFANT  
(mrem/yr per  $\mu\text{Ci}/\text{m}^3$ ) for H-3 and C-14 ( $\text{m}^2 \times \text{mrem}/\text{yr} \mu\text{Ci}/\text{sec}$ ) for others

Nuclide	Bone	Liver	Thyroid	Kidney	Lung	GI-LLI	T.Body
Ru-103	8.69E+3	-	-	1.81E+4	-	1.06E+5	2.91E+3
Ru-105	8.06E-3	-	-	5.92E-2	-	3.21E+0	2.71E-3
Ru-106	1.90E+5	-	-	2.25E+5	-	1.44E+6	2.38E+4
Rh-103m	-	-	-	-	-	-	-
Rh-106	-	-	-	-	-	-	-
Ag-110m	3.86E+8	2.82E+8	-	4.03E+8	-	1.46E+10	1.86E+8
Sb-124	2.09E+8	3.08E+6	5.56E+5	-	1.31E+8	6.46E+8	6.49E+7
Sb-125	1.49E+8	1.45E+6	1.87E+5	-	9.38E+7	1.99E+8	3.07E+7
Te-125m	1.51E+8	5.04E+7	5.07E+7	-	-	7.18E+7	2.04E+7
Te-127m	4.21E+8	1.40E+8	1.22E+8	1.04E+9	-	1.70E+8	5.10E+7
Te-127	6.50E+3	2.18E+3	5.29E+3	1.59E+4	-	1.36E+5	1.40E+3
Te-129m	5.59E+8	1.92E+8	2.15E+8	1.40E+9	-	3.34E+8	8.62E+7
Te-129	2.08E-9	-	1.75E-9	5.18E-9	-	1.66E-7	-
Te-131m	3.38E+6	1.36E+6	2.76E+6	9.35E+6	-	2.29E+7	1.12E+6
Te-131	-	-	-	-	-	-	-
Te-132	2.10E+7	1.04E+7	1.54E+7	6.51E+7	-	3.85E+7	9.72E+6
I-130	3.60E+6	7.92E+6	8.88E+8	8.70E+6	-	1.70E+6	3.18E+6
I-131	2.72E+9	3.21E+9	1.05E+12	3.75E+9	-	1.15E+8	1.41E+9
I-132	1.42E+0	2.89E+0	1.35E+2	3.22E+0	-	2.34E+0	1.03E+0
I-133	3.72E+7	5.41E+7	9.84E+9	6.36E+7	-	9.16E+6	1.58E+7
I-134	-	-	1.01E-9	-	-	-	-
I-135	1.21E+5	2.41E+5	2.16E+7	2.69E+5	-	8.74E+4	8.80E+4
Cs-134	3.65E+10	6.80E+10	-	1.75E+10	7.18E+9	1.85E+8	6.87E+9
Cs-136	1.96E+9	5.77E+9	-	2.30E+9	4.70E+8	8.76E+7	2.15E+9
Cs-137	5.15E+10	6.02E+10	-	1.62E+10	6.55E+9	1.88E+8	4.27E+9
Cs-138	-	-	-	-	-	-	-
Ba-139	4.55E-7	-	-	-	-	2.88E-5	1.32E-8
Ba-140	2.41E+8	2.41E+5	-	5.73E+4	1.48E+5	5.92E+7	1.24E+7
Ba-141	-	-	-	-	-	-	-
Ba-142	-	-	-	-	-	-	-
La-140	4.03E+1	1.59E+1	-	-	-	1.87E+5	4.09E+0
La-142	-	-	-	-	-	5.21E-6	-
Ce-141	4.33E+4	2.64E+4	-	8.15E+3	-	1.37E+7	3.11E+3
Ce-143	4.00E+2	2.65E+5	-	7.72E+1	-	1.55E+6	3.02E+1
Ce-144	2.33E+6	9.52E+5	-	3.85E+5	-	1.33E+8	1.30E+5
Pr-143	1.49E+3	5.59E+2	-	2.08E+2	-	7.89E+5	7.41E+1
Pr-144	-	-	-	-	-	-	-
Nd-147	8.82E+2	9.06E+2	-	3.49E+2	-	5.74E+5	5.55E+1
W-187	6.12E+4	4.26E+4	-	-	-	2.50E+6	1.47E+4
Np-239	3.64E+1	3.25E+0	-	6.49E+0	-	9.40E+4	1.84E+0

Table 2.13 (Page 1 of 2)  
R<sub>i</sub> Ground Plane Pathway Dose Factors  
(m<sup>2</sup> x mrem/yr per μCi/sec)

Nuclide	Any Organ
H-3	-
C-14	-
Na-24	1.21E+7
P-32	-
Cr-51	4.68E+6
Mn-54	1.34E+9
Mn-56	9.05E+5
Fe-55	-
Fe-59	2.75E+8
Co-57	4.37E+8
Co-58	3.82E+8
Co-60	2.16E+10
Ni-63	-
Ni-65	2.97E+5
Cu-64	6.09E+5
Zn-65	7.45E+8
Zn-69	-
Br-82	4.57E+7
Br-83	4.89E+3
Br-84	2.03E+5
Br-85	-
Rb-86	8.98E+6
Rb-88	3.29E+4
Rb-89	1.21E+5
Sr-89	2.16E+4
Sr-90	-
Sr-91	2.19E+6
Sr-92	7.77E+5
Y-90	4.48E+3
Y-91m	1.01E+5
Y-91	1.08E+6
Y-92	1.80E+5
Y-93	1.85E+5
Zr-95	2.48E+8
Zr-97	2.94E+6
Nb-95	1.36E+8
Nb-97	2.28E+6
Mo-99	4.05E+6
Tc-99m	1.83E+5
Tc-101	2.04E+4
Ru-103	1.09E+8

Table 2.13 (Page 2 of 2)  
R<sub>i</sub> Ground Plane Pathway Dose Factors  
(m<sup>2</sup> x mrem/yr per μCi/sec)

Nuclide	Any Organ
Ru-105	6.36E+5
Ru-106	4.21E+8
Rh-103m	-
Rh-106	-
Ag-110m	3.47E+9
Sb-124	2.87E+9
Sb-125	6.49E+9
Te-125m	1.55E+6
Te-127m	9.17E+4
Te-127	3.00E+3
Te-129m	2.00E+7
Te-129	2.60E+4
Te-131m	8.03E+6
Te-131	2.93E+4
Te-132	4.22E+6
I-130	5.53E+6
I-131	1.72E+7
I-132	1.24E+6
I-133	2.47E+6
I-134	4.49E+5
I-135	2.56E+6
Cs-134	6.75E+9
Cs-136	1.49E+8
Cs-137	1.04E+10
Cs-138	3.59E+5
Ba-139	1.06E+5
Ba-140	2.05E+7
Ba-141	4.18E+4
Ba-142	4.49E+4
La-140	1.91E+7
La-142	7.36E+5
Ce-141	1.36E+7
Ce-143	2.32E+6
Ce-144	6.95E+7
Pr-143	-
Pr-144	1.83E+3
Nd-147	8.40E+6
W-187	2.36E+6
Np-239	1.71E+6



**APPENDIX A**

Content deleted. No longer applicable.

**APPENDIX B**

Content deleted. No longer applicable.

**APPENDIX C**

Content deleted. No longer applicable.

**APPENDIX D**

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