Entergy

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Pilgrim Nuclear Power Station
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May 13, 2010

U.S. Nuclear Regulatory Commission
Attention: Document Control Desk
Washington, D.C. 20555

SUBJECT: Entergy Nuclear Operations, Inc.
Pilgrim Nuclear Power Station
Docket No. 50-293
License No. DPR-35

Radioactive Effluent Release Report
for January 1 through December 31, 2009

LETTER NUMBER: 2.10.030

Dear Sir or Madam:

In accordance with Pilgrim Technical Specifications 5.6.3, Entergy Nuclear Operations, Inc. submits the attached Annual Radiological Effluent Release Report for January 1 through December 31, 2009.

Should you have questions or require additional information, I can be contacted at (508) 830-8403.

This letter contains no commitments.

Sincerely,

Joseph R. Lynch
Manager, Licensing

JRL/wgl

Attachment: Pilgrim Nuclear Power Station Radioactive Effluent Release Report
January 1 through December 31, 2009

cc: U.S. Nuclear Regulatory Commission
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PILGRIM NUCLEAR POWER STATION

Facility Operating License DPR-35

Radioactive Effluent Release Report

January 1 through December 31, 2009

PILGRIM NUCLEAR POWER STATION
Facility Operating License DPR-35

RADIOACTIVE EFFLUENT RELEASE REPORT

JANUARY 01 THROUGH DECEMBER 31, 2009

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EXECUTIVE SUMMARY

PILGRIM NUCLEAR POWER STATION
RADIOACTIVE EFFLUENT RELEASE REPORT
JANUARY 01 THROUGH DECEMBER 31, 2009

INTRODUCTION

This report quantifies the radioactive gaseous, liquid, and radwaste releases, and summarizes the local meteorological data for the period from January 01 through December 31, 2009. This document has been prepared in accordance with the requirements set forth in the Pilgrim Nuclear Power Station (PNPS) Technical Specifications and Revision 1 of Regulatory Guide 1.21, "Measuring, Evaluating, and Reporting Radioactivity in Solid Wastes and Releases of Radioactive Material in Liquid and Gaseous Effluents from Light Water Cooled Nuclear Power Plants".

The quantity of radioactive material released from PNPS was determined from sample analyses and continuous on-line monitoring of gaseous releases from the main stack, reactor building vent, turbine building, and various decontamination facilities, and liquid releases into the discharge canal.

The quantity and volume of radioactive waste shipped offsite from PNPS for processing and burial were determined from data contained on the radwaste shipping documentation. The meteorological data were obtained from monitoring instruments located on the 220-foot meteorological tower located at Pilgrim Station.

GASEOUS EFFLUENTS

Gaseous radioactive releases for the reporting period are quantified in Tables 2.2-A, 2.2-B, and 2.2-C. Radioactive noble gases released during the period totaled 115 Curies. Releases of radioactive iodines and particulates with half-life of greater than 8 days totaled 0.0154 Curies, and tritium releases totaled 67.6 Curies. No gross alpha radioactivity was detected in gaseous effluents.

Noble gases released in gaseous effluents resulted in a maximum total body dose of 0.021 mrem, with a corresponding skin dose of 0.13 mrem. The release of radioactive particulates, iodines, and tritium in gaseous effluents from PNPS during the reporting period resulted in a total body dose to the maximum-exposed hypothetical individual of about 0.027 mrem. The maximum hypothetical dose to any organ from radioactive particulates, iodines, and tritium was about 0.062 mrem. The maximum, hypothetical total body dose from the combined release of all airborne radioactivity in gaseous effluents was 0.048 mrem.

The maximum individual doses from gaseous radioactive effluents were compared to the applicable ODCM dose limits. Noble gas doses were less than 1.1% of the corresponding 10CFR50 dose objectives. Maximum doses resulting from releases of particulates, iodines, and tritium in gaseous effluents were less than 0.41% of corresponding 10CFR50 objectives.

LIQUID EFFLUENTS

Liquid radioactive releases for the reporting period are quantified in Tables 2.3-A and 2.3-B. Four discharges of liquid effluents containing radioactivity occurred during the reporting period. The resulting maximum total body dose was 0.000031 mrem, with a corresponding organ dose of 0.00021 mrem. All doses from liquid discharges were less than 0.0053% of corresponding 10CFR50 objectives.

METEOROLOGICAL DATA

Meteorological joint frequency distributions are listed in Appendix A. Data recovery for the entire annual period was 97.8% for both the 33-ft and 220-ft levels of the tower. The predominant wind direction was from the south-southwest, which occurred approximately 13% of the time during the reporting period. The predominant stability class was Class D, which occurred about 50% of the time during the reporting period

OFFSITE AMBIENT RADIATION MEASUREMENTS

Ambient radiation exposure was evaluated to complete the assessment of radiological impact on humans. A small number of thermoluminescent dosimeters (TLDs) indicated an elevation in ambient radiation exposure on Entergy property in close proximity to the station, when compared to background levels in the region. This elevation is due to nitrogen-16 contained within the plant steam system, as opposed to radioactive effluent released from the plant. The dose to the maximum-exposed member of the public, even though they are within the owner-controlled area, was estimated as being about 1.4 mrem during 2009. There was no measurable increase during 2009 in ambient radiation measurements at the location of the nearest resident 0.8 km southeast of PNPS.

COMBINED DOSE IMPACT

The collective total body dose to a maximum-exposed hypothetical member of the public from radioactive gases, liquids, and ambient radiation exposure resulting from PNPS operation during 2009 was calculated as being about 0.70 mrem. This amount is less than 0.2% of the typical dose of 300 to 400 mrem received each year by an average person from other sources of natural and man-made radiation. Although this calculated collective dose occurs to a maximum-exposed hypothetical individual, it is also well below the NRC dose limit of 100 mrem/yr specified in 10CFR20.1301, as well as the EPA dose limit of 25 mrem/yr specified in 40CFR190. Both of these limits are to be applied to real members of the general public, so the fact that the dose to the hypothetical maximum-exposed individual is within the limits ensures that any dose received by a real member of the public would be smaller and well within any applicable limit.

RADIOACTIVE SOLID WASTE DISPOSAL

Solid radioactive wastes shipped offsite for processing and disposal during the reporting period are described in Table 7.0. Approximately 913 cubic meters of solid waste, containing almost 165 Curies of radioactivity, were shipped during the reporting period.

ONSITE GROUNDWATER MONITORING PROGRAM

In response to the Nuclear Energy Institute Groundwater Protection Initiative, Pilgrim Station instituted a groundwater monitoring program during 2007. Four monitoring wells were installed onsite during the fourth quarter of 2007, and the first samples were collected in late November 2007. This sampling program was continued in 2009. Low levels of tritium, a radioactive isotope of hydrogen, were detected in these onsite wells. No other plant-related radioactivity was detected in the samples. Concentrations of tritium ranged from non-detectable at less than 411 picoCuries per Liter up to 1726 picoCuries per Liter, well below the voluntary communications reporting level established by the EPA Drinking Water Standard of 20,000 pCi/L. Although the EPA Standard provides a standard for comparison, no drinking water sources are affected by this tritium. Results of the groundwater monitoring program are presented in Appendix B.

CONCLUSION

The PNPS Offsite Dose Calculation Manual contains effluent controls to limit doses resulting from releases of radioactivity to the environment. None of the effluent controls associated with liquid or gaseous effluents were exceeded during the reporting period, as confirmed by conservative dose assessments performed at weekly and monthly intervals. Conformance to the PNPS ODCM effluent control limits ensures that releases of radioactivity in liquid and gaseous effluents are kept as low as reasonably achievable in accordance with 10 CFR Part 50, Appendix I. Compliance with the ODCM also demonstrates that requirements of the Environmental Protection Agency's nuclear fuel cycle standard, 40CFR190.10, Subpart B, have been met. Based on the dose assessment results for 2009, there was no significant radiological impact on the general public from PNPS operation.

2.0 RADIOACTIVE EFFLUENT DATA

Radioactive gaseous and liquid releases for the reporting period are given in the standard format presented in Tables 1A, 1B, 1C, 2A, 2B, and Supplemental Information table from NRC Regulatory Guide 1.21 (Reference 1) format.

2.1 Supplemental Effluent Release Data

Supplemental information related to radioactive gaseous and liquid releases for the reporting period are given in the standard NRC Regulatory Guide 1.21 format in Table 2.1.

2.2 Gaseous Effluent Data

Gaseous radioactivity is released from Pilgrim Station to the atmosphere from the main stack, reactor building vent, turbine building, and various decontamination facilities. Combined gaseous effluent releases from all release points are summarized in Table 2.2-A. No alpha activity was detected on any of the particulate filters collected during the reporting period. The total gaseous releases for various categories of radionuclides, as well as the corresponding average release rates, can be summarized as follows:

- Noble gases: 115 Ci, 3.65 μCi/sec
- Iodines and particulates with half-life greater than 8 days: 0.0154 Ci, 0.000488 μCi/sec
- Tritium: 67.6 Ci, 2.14 μCi/sec

Effluent releases from the main stack are detailed in Table 2.2-B. The main stack is 335 feet tall, and represents an elevated release point with a total height of approximately 400 feet above sea level. The main stack is located about 700 feet west-northwest of the reactor building.

Ground-level effluent releases are detailed in Table 2.2-C. Data in this table include releases from the reactor building vent, turbine building, and assorted equipment decontamination facilities (e.g., hot machine shop, carbon dioxide pellet decon trailer, plastic media decon trailer, etc.) used during the period. Due to the close proximity of the reactor building, all of these release points are considered to be mixed-mode/ground level release points.

2.3 Liquid Effluent Data

Liquid radioactivity is released from PNPS to Cape Cod Bay via the circulating water discharge canal. These effluents enter Cape Cod Bay at the outfall of the canal, which is located about 1100 feet north of the reactor building.

Liquid effluent releases are summarized in Table 2.3-A. Detailed breakdowns for individual radionuclides are listed in Table 2.3-B. There were four discharge of liquid effluents containing radioactivity during the reporting period. Total releases for the various categories of radionuclides, as well as their corresponding mean concentrations, can be summarized as follows:

- Total Effluent Volume: 244,000 Liters
- Total Dilution Volume: 571 billion Liters
- Fission/Activation products: 0.00135 Ci, 0.00000000000237 μCi/mL
- Tritium: 1.98 Ci, 0.00000000346 μCi/mL
- Dissolved/entrained noble gases: 0 Ci, 0 μCi/mL

Table 2.1
Pilgrim Nuclear Power Station
Radioactive Effluent Release Report
Supplemental Information
January-December 2009

FACILITY: PILGRIM NUCLEAR POWER STATION **LICENSE: DPR-35**

1. REGULATORY LIMITS					
a. Fission and activation gases:	500 mrem/yr total body and 3000 mrem/yr for skin at site boundary				
b,c. Iodines, particulates with half-life: >8 days, tritium	1500 mrem/yr to any organ at site boundary				
d. Liquid effluents:	0.06 mrem/month for whole body and 0.2 mrem/month for any organ (without radwaste treatment)				
2. EFFLUENT CONCENTRATION LIMITS					
a. Fission and activation gases:	10CFR20 Appendix B Table II				
b. Iodines:	10CFR20 Appendix B Table II				
c. Particulates with half-life > 8 days:	10CFR20 Appendix B Table II				
d. Liquid effluents:	2E-04 μCi/mL for entrained noble gases; 10CFR20 Appendix B Table II values for all other radionuclides				
3. AVERAGE ENERGY	Not Applicable				
4. MEASUREMENTS AND APPROXIMATIONS OF TOTAL RADIOACTIVITY					
a. Fission and activation gases: b. Iodines: c. Particulates: d. Liquid effluents:	High purity germanium gamma spectroscopy for all gamma emitters; radiochemistry analysis for H-3, Fe-55 (liquid effluents), Sr-89, and Sr-90				
5. BATCH RELEASES	Jan-Mar 2009	Apr-Jun 2009	Jul-Sep 2009	Oct-Dec 2009	Jan-Dec 2009
a. Liquid Effluents					
1. Total number of releases:	1	3	0	0	4
2. Total time period (minutes):	1.05E+02	2.70E+02	0.00E+00	0.00E+00	3.75E+02
3. Maximum time period (minutes):	1.05E+02	9.00E+01	0.00E+00	0.00E+00	1.05E+02
4. Average time period (minutes):	1.05E+02	9.00E+01	0.00E+00	0.00E+00	9.38E+01
5. Minimum time period (minutes):	1.05E+02	9.00E+01	0.00E+00	0.00E+00	9.00E+01
6. Average stream flow during periods of release of effluents into a flowing stream (Liters/min):	1.17E+06	7.82E+05	N/A	N/A	8.92E+05
b. Gaseous Effluents	None	None	None	None	None
6. ABNORMAL RELEASES					
a. Liquid Effluents	None	None	None	None	None
b. Gaseous Effluents	None	None	None	None	None

Table 2.2-A
Pilgrim Nuclear Power Station
Radioactive Effluent Release Report
Gaseous Effluents - Summation of All Releases
January-December 2009

RELEASE PERIOD	Jan-Mar 2009	Apr-Jun 2009	Jul-Sep 2009	Oct-Dec 2009	Jan-Dec 2009	Est. Total Error
A. FISSION AND ACTIVATION GASES						
Total Release: Ci	9.75E+01	1.20E+01	2.82E+00	2.73E+00	1.15E+02	±22%
Average Release Rate: µCi/sec	1.24E+01	1.52E+00	3.57E-01	3.46E-01	3.65E+00	
Percent of Effluent Control Limit*	*	*	*	*	*	
B. IODINE-131						
Total Iodine-131 Release: Ci	1.92E-03	1.41E-03	5.09E-04	3.99E-04	4.24E-03	±20%
Average Release Rate: µCi/sec	2.43E-04	1.79E-04	6.46E-05	5.06E-05	1.34E-04	
Percent of Effluent Control Limit*	*	*	*	*	*	
C. PARTICULATES WITH HALF-LIVES > 8 DAYS						
Total Release: Ci	1.06E-02	2.71E-03	1.18E-03	9.32E-04	1.54E-02	±21%
Average Release Rate: µCi/sec	1.34E-03	3.43E-04	1.49E-04	1.18E-04	4.88E-04	
Percent of Effluent Control Limit*	*	*	*	*	*	
Gross Alpha Radioactivity: Ci	NDA	NDA	NDA	NDA	NDA	
D. TRITIUM						
Total Release: Ci	2.66E+01	1.07E+01	1.34E+01	1.70E+01	6.76E+01	±20%
Average Release Rate: µCi/sec	3.37E+00	1.35E+00	1.70E+00	2.15E+00	2.14E+00	
Percent of Effluent Control Limit*	*	*	*	*	*	

Notes for Table 2.2-A:

* Percent of Effluent Control Limit values based on dose assessments are provided in Section 7 of this report.

1. NDA stands for No Detectable Activity.
2. LLD for airborne gross alpha activity listed as NDA is 1E-11 µCi/cc.

Table 2.2-B
Pilgrim Nuclear Power Station
Radioactive Effluent Release Report
Gaseous Effluents – Elevated Release
January-December 2009

CONTINUOUS MODE RELEASES FROM ELEVATED RELEASE POINT					
Nuclide Released	Jan-Mar 2009	Apr-Jun 2009	Jul-Sep 2009	Oct-Dec 2009	Jan-Dec 2009
1. FISSION AND ACTIVATION GASES: Ci					
Ar-41	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Kr-85	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Kr-85m	2.58E-02	2.37E-01	2.78E-01	0.00E+00	5.40E-01
Kr-87	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Kr-88	0.00E+00	4.25E-02	0.00E+00	0.00E+00	4.25E-02
Xe-131m	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Xe-133	0.00E+00	6.08E-01	3.37E-01	0.00E+00	9.45E-01
Xe-133m	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Xe-135	5.24E-01	2.35E+00	0.00E+00	0.00E+00	2.87E+00
Xe-135m	8.35E-01	1.00E+00	0.00E+00	0.00E+00	1.83E+00
Xe-137	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Xe-138	6.94E+00	0.00E+00	0.00E+00	0.00E+00	6.94E+00
Total for Period	8.33E+00	4.24E+00	6.14E-01	0.00E+00	1.32E+01
2. IODINES: Ci					
I-131	1.17E-04	7.68E-05	2.41E-05	2.03E-05	2.38E-04
I-133	1.69E-04	1.19E-04	3.61E-05	2.68E-05	3.51E-04
Total for Period	2.86E-04	1.96E-04	6.02E-05	4.71E-05	5.89E-04
3. PARTICULATES WITH HALF-LIVES > 8 DAYS: Ci					
Cr-51	0.00E+00	1.18E-06	0.00E+00	0.00E+00	1.18E-06
Mn-54	0.00E+00	1.32E-06	0.00E+00	0.00E+00	1.32E-06
Fe-59	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Co-58	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Co-60	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Zn-65	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Sr-89	9.26E-06	5.40E-06	2.88E-06	2.94E-06	2.05E-05
Sr-90	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Ru-103	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Cs-134	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Cs-137	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Ba/La-140	7.03E-05	5.19E-06	0.00E+00	0.00E+00	7.55E-05
Total for Period	7.95E-05	1.31E-05	2.88E-06	2.94E-06	9.84E-05
4. TRITIUM: Ci					
H-3	9.56E-02	3.25E-02	4.43E-02	4.18E-02	2.14E-01

Notes for Table 2.2-B:

1. N/A stands for not applicable.
2. NDA stands for No Detectable Activity.
3. LLDs for airborne radionuclides listed as NDA are as follows:
   Fission Gases: 1E-04 μCi/cc
   Iodines: 1E-12 μCi/cc
   Particulates: 1E-11 μCi/cc

Table 2.2-B (continued)
Pilgrim Nuclear Power Station
Radioactive Effluent Release Report
Gaseous Effluents – Elevated Release
January-December 2009

BATCH MODE RELEASES FROM ELEVATED RELEASE POINT					
Nuclide Released	Jan-Mar 2009	Apr-Jun 2009	Jul-Sep 2009	Oct-Dec 2009	Jan-Dec 2009
1. FISSION AND ACTIVATION GASES: Ci					
Ar-41	N/A	N/A	N/A	N/A	N/A
Kr-85	N/A	N/A	N/A	N/A	N/A
Kr-85m	N/A	N/A	N/A	N/A	N/A
Kr-87	N/A	N/A	N/A	N/A	N/A
Kr-88	N/A	N/A	N/A	N/A	N/A
Xe-131m	N/A	N/A	N/A	N/A	N/A
Xe-133	N/A	N/A	N/A	N/A	N/A
Xe-133m	N/A	N/A	N/A	N/A	N/A
Xe-135	N/A	N/A	N/A	N/A	N/A
Xe-135m	N/A	N/A	N/A	N/A	N/A
Xe-137	N/A	N/A	N/A	N/A	N/A
Xe-138	N/A	N/A	N/A	N/A	N/A
Total for period	N/A	N/A	N/A	N/A	N/A
2. IODINES: Ci					
I-131	N/A	N/A	N/A	N/A	N/A
I-133	N/A	N/A	N/A	N/A	N/A
Total for period	N/A	N/A	N/A	N/A	N/A
3. PARTICULATES WITH HALF-LIVES > 8 DAYS: Ci					
Cr-51	N/A	N/A	N/A	N/A	N/A
Mn-54	N/A	N/A	N/A	N/A	N/A
Fe-59	N/A	N/A	N/A	N/A	N/A
Co-58	N/A	N/A	N/A	N/A	N/A
Co-60	N/A	N/A	N/A	N/A	N/A
Zn-65	N/A	N/A	N/A	N/A	N/A
Sr-89	N/A	N/A	N/A	N/A	N/A
Sr-90	N/A	N/A	N/A	N/A	N/A
Ru-103	N/A	N/A	N/A	N/A	N/A
Cs-134	N/A	N/A	N/A	N/A	N/A
Cs-137	N/A	N/A	N/A	N/A	N/A
Ba/La-140	N/A	N/A	N/A	N/A	N/A
Total for period	N/A	N/A	N/A	N/A	N/A
4. TRITIUM: Ci					
H-3	N/A	N/A	N/A	N/A	N/A

Notes for Table 2.2-B:

1. N/A stands for not applicable.
2. NDA stands for No Detectable Activity.
3. LLDs for airborne radionuclides listed as NDA are as follows:
   Fission Gases: 1E-04 μCi/cc
   Iodines: 1E-12 μCi/cc
   Particulates: 1E-11 μCi/cc

Table 2.2-C
Pilgrim Nuclear Power Station
Radioactive Effluent Release Report
Gaseous Effluents – Ground-Level Release
January-December 2009

CONTINUOUS MODE RELEASES FROM GROUND-LEVEL RELEASE POINT					
Nuclide Released	Jan-Mar 2009	Apr-Jun 2009	Jul-Sep 2009	Oct-Dec 2009	Jan-Dec 2009
1. FISSION AND ACTIVATION GASES: Ci					
Ar-41	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Kr-85	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Kr-85m	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Kr-87	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Kr-88	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Xe-131m	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Xe-133	0.00E+00	3.33E-01	0.00E+00	0.00E+00	3.33E-01
Xe-133m	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Xe-135	2.91E+00	0.00E+00	2.53E-01	9.69E-01	4.13E+00
Xe-135m	8.90E+00	1.94E+00	0.00E+00	0.00E+00	1.08E+01
Xe-137	3.77E+01	0.00E+00	0.00E+00	0.00E+00	3.77E+01
Xe-138	3.96E+01	5.47E+00	1.95E+00	1.76E+00	4.88E+01
Total for period	8.91E+01	7.75E+00	2.20E+00	2.73E+00	1.02E+02
2. IODINES: Ci					
I-131	1.80E-03	1.33E-03	4.85E-04	3.79E-04	4.00E-03
I-133	5.41E-03	1.43E-03	8.01E-04	8.32E-04	8.47E-03
Total for period	7.21E-03	2.76E-03	1.29E-03	1.21E-03	1.25E-02
3. PARTICULATES WITH HALF-LIVES > 8 DAYS: Ci					
Cr-51	0.00E+00	6.82E-05	0.00E+00	0.00E+00	6.82E-05
Mn-54	3.27E-06	1.24E-04	0.00E+00	0.00E+00	1.27E-04
Fe-59	0.00E+00	7.73E-06	0.00E+00	0.00E+00	7.73E-06
Co-58	0.00E+00	6.01E-06	0.00E+00	0.00E+00	6.01E-06
Co-60	0.00E+00	7.36E-05	0.00E+00	0.00E+00	7.36E-05
Zn-65	0.00E+00	8.59E-06	0.00E+00	0.00E+00	8.59E-06
Sr-89	1.22E-03	2.58E-04	1.74E-04	1.06E-04	1.76E-03
Sr-90	1.79E-06	0.00E+00	0.00E+00	0.00E+00	1.79E-06
Ru-103	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Cs-134	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Cs-137	0.00E+00	9.45E-06	8.75E-06	0.00E+00	1.82E-05
Ba/La-140	9.27E-03	2.14E-03	9.91E-04	8.23E-04	1.32E-02
Total for period	1.05E-02	2.69E-03	1.17E-03	9.29E-04	1.53E-02
4. TRITIUM: Ci					
H-3	2.65E+01	1.06E+01	1.33E+01	1.69E+01	6.74E+01

Notes for Table 2.2-C:

1. N/A stands for not applicable.
2. NDA stands for No Detectable Activity.
3. LLDs for airborne radionuclides listed as NDA are as follows:
   Fission Gases: 1E-04 μCi/cc
   Iodines: 1E-12 μCi/cc
   Particulates: 1E-11 μCi/cc

Table 2.2-C (continued)
Pilgrim Nuclear Power Station
Radioactive Effluent Release Report
Gaseous Effluents – Ground-Level Release
January-December 2009

BATCH MODE RELEASES FROM GROUND-LEVEL RELEASE POINT					
Nuclide Released	Jan-Mar 2009	Apr-Jun 2009	Jul-Sep 2009	Oct-Dec 2009	Jan-Dec 2009
1. FISSION AND ACTIVATION GASES: Ci					
Ar-41	N/A	N/A	N/A	N/A	N/A
Kr-85	N/A	N/A	N/A	N/A	N/A
Kr-85m	N/A	N/A	N/A	N/A	N/A
Kr-87	N/A	N/A	N/A	N/A	N/A
Kr-88	N/A	N/A	N/A	N/A	N/A
Xe-131m	N/A	N/A	N/A	N/A	N/A
Xe-133	N/A	N/A	N/A	N/A	N/A
Xe-133m	N/A	N/A	N/A	N/A	N/A
Xe-135	N/A	N/A	N/A	N/A	N/A
Xe-135m	N/A	N/A	N/A	N/A	N/A
Xe-137	N/A	N/A	N/A	N/A	N/A
Xe-138	N/A	N/A	N/A	N/A	N/A
Total for period	N/A	N/A	N/A	N/A	N/A
2. IODINES: Ci					
I-131	N/A	N/A	N/A	N/A	N/A
I-133	N/A	N/A	N/A	N/A	N/A
Total for period	N/A	N/A	N/A	N/A	N/A
3. PARTICULATES WITH HALF-LIVES > 8 DAYS: Ci					
Cr-51	N/A	N/A	N/A	N/A	N/A
Mn-54	N/A	N/A	N/A	N/A	N/A
Fe-59	N/A	N/A	N/A	N/A	N/A
Co-58	N/A	N/A	N/A	N/A	N/A
Co-60	N/A	N/A	N/A	N/A	N/A
Zn-65	N/A	N/A	N/A	N/A	N/A
Sr-89	N/A	N/A	N/A	N/A	N/A
Sr-90	N/A	N/A	N/A	N/A	N/A
Ru-103	N/A	N/A	N/A	N/A	N/A
Cs-134	N/A	N/A	N/A	N/A	N/A
Cs-137	N/A	N/A	N/A	N/A	N/A
Ba/La-140	N/A	N/A	N/A	N/A	N/A
Total for period	N/A	N/A	N/A	N/A	N/A
4. TRITIUM: Ci					
H-3	N/A	N/A	N/A	N/A	N/A

Notes for Table 2.2-C:

1. N/A stands for not applicable.
2. NDA stands for No Detectable Activity.
3. LLDs for airborne radionuclides listed as NDA are as follows:
   Fission Gases: 1E-04 μCi/cc
   Iodines: 1E-12 μCi/cc
   Particulates: 1E-11 μCi/cc

Table 2.3-A
Pilgrim Nuclear Power Station
Radioactive Effluent Release Report
Liquid Effluents - Summation of All Releases
January-December 2009

RELEASE PERIOD	Jan-Mar 2009	Apr-Jun 2009	Jul-Sep 2009	Oct-Dec 2009	Jan-Dec 2009	Est. Total Error
A. FISSION AND ACTIVATION PRODUCTS						
Total Release (not including tritium, gases, alpha): Ci	3.93E-05	1.32E-03	N/A	N/A	1.35E-03	±12%
Average Diluted Concentration During Period: μCi/mL	2.59E-13	1.21E-11	N/A	N/A	2.37E-12	
Percent of Effluent Concentration Limit*	2.09E-05%	9.32E-05%	N/A	N/A	2.33E-05%	
B. TRITIUM						
Total Release: Ci	2.08E-02	1.96E+00	N/A	N/A	1.98E+00	±9.4%
Average Diluted Concentration During Period: μCi/mL	1.37E-10	1.79E-08	N/A	N/A	3.46E-09	
Percent of Effluent Concentration Limit*	1.37E-05%	1.79E-03%	N/A	N/A	3.46E-04%	
C. DISSOLVED AND ENTRAINED GASES						
Total Release: Ci	NDA	NDA	N/A	N/A	NDA	±16%
Average Diluted Concentration During Period: μCi/mL	NDA	NDA	N/A	N/A	NDA	
Percent of Effluent Concentration Limit*	0.00E+00	0.00E+00	N/A	N/A	0.00E+00	
D. GROSS ALPHA RADIOACTIVITY						
Total Release: Ci	N/A	N/A	N/A	N/A	N/A	±34%
E. VOLUME OF WASTE RELEASED PRIOR TO DILUTION						
Waste Volume: Liters	3.92E+04	2.04E+05	N/A	N/A	2.44E+05	±5.7%
F. VOLUME OF DILUTION WATER USED DURING PERIOD						
Dilution Volume: Liters	1.52E+11	1.09E+11	1.55E+11	1.55E+11	5.71E+11	±10%

Notes for Table 2.3-A:

* Additional percent of Effluent Control Limit values based on dose assessments are provided in Section 7 of this report.

1. N/A stands for not applicable.
2. NDA stands for No Detectable Activity.
3. LLD for dissolved and entrained gases listed as NDA is 1E-05 μCi/mL.
4. LLD for liquid gross alpha activity listed as NDA is 1E-07 μCi/mL.

Table 2.3-B
Pilgrim Nuclear Power Station
Radioactive Effluent Release Report
Liquid Effluents
January-December 2009

CONTINUOUS MODE RELEASES					
Nuclide Released	Jan-Mar 2009	Apr-Jun 2009	Jul-Sep 2009	Oct-Dec 2009	Jan-Dec 2009
1. FISSION AND ACTIVATION PRODUCTS: Ci					
Cr-51	N/A	N/A	N/A	N/A	N/A
Mn-54	N/A	N/A	N/A	N/A	N/A
Fe-55	N/A	N/A	N/A	N/A	N/A
Fe-59	N/A	N/A	N/A	N/A	N/A
Co-58	N/A	N/A	N/A	N/A	N/A
Co-60	N/A	N/A	N/A	N/A	N/A
Zn-65	N/A	N/A	N/A	N/A	N/A
Zn-69m	N/A	N/A	N/A	N/A	N/A
Sr-89	N/A	N/A	N/A	N/A	N/A
Sr-90	N/A	N/A	N/A	N/A	N/A
Zr/Nb-95	N/A	N/A	N/A	N/A	N/A
Mo/Tc-99	N/A	N/A	N/A	N/A	N/A
Ag-110m	N/A	N/A	N/A	N/A	N/A
Sb-124	N/A	N/A	N/A	N/A	N/A
I-131	N/A	N/A	N/A	N/A	N/A
I-133	N/A	N/A	N/A	N/A	N/A
Cs-134	N/A	N/A	N/A	N/A	N/A
Cs-137	N/A	N/A	N/A	N/A	N/A
Ba/La-140	N/A	N/A	N/A	N/A	N/A
Ce-141	N/A	N/A	N/A	N/A	N/A
Total for period	N/A	N/A	N/A	N/A	N/A
2. DISSOLVED AND ENTRAINED GASES: Ci					
Xe-133	N/A	N/A	N/A	N/A	N/A
Xe-135	N/A	N/A	N/A	N/A	N/A
Total for period	N/A	N/A	N/A	N/A	N/A

Notes for Table 2.3-B:

1. N/A stands for not applicable.
2. NDA stands for No Detectable Activity.
3. LLDs for liquid radionuclides listed as NDA are as follows:
   - Strontium: 5E-08 μCi/mL
   - Iodines: 1E-06 μCi/mL
   - Noble Gases: 1E-05 μCi/mL
   - All Others: 5E-07 μCi/mL

Table 2.3-B (continued)
Pilgrim Nuclear Power Station
Radioactive Effluent Release Report
Liquid Effluents
January-December 2009

BATCH MODE RELEASES					
Nuclide Released	Jan-Mar 2009	Apr-Jun 2009	Jul-Sep 2009	Oct-Dec 2009	Jan-Dec 2009
1. FISSION AND ACTIVATION PRODUCTS: Ci					
Cr-51	NDA	2.38E-05	N/A	N/A	2.38E-05
Mn-54	4.21E-06	1.05E-03	N/A	N/A	1.06E-03
Fe-55	NDA	NDA	N/A	N/A	NDA
Fe-59	NDA	3.20E-05	N/A	N/A	3.20E-05
Co-58	NDA	1.96E-05	N/A	N/A	1.96E-05
Co-60	7.99E-06	1.87E-04	N/A	N/A	1.95E-04
Zn-65	NDA	NDA	N/A	N/A	NDA
Zn-69m	NDA	NDA	N/A	N/A	NDA
Sr-89	NDA	NDA	N/A	N/A	NDA
Sr-90	1.55E-06	NDA	N/A	N/A	1.55E-06
Zr/Nb-95	NDA	NDA	N/A	N/A	NDA
Mo/Tc-99	NDA	NDA	N/A	N/A	NDA
Ag-110m	NDA	NDA	N/A	N/A	NDA
Sb-124	NDA	NDA	N/A	N/A	NDA
I-131	NDA	NDA	N/A	N/A	NDA
I-133	NDA	NDA	N/A	N/A	NDA
Cs-134	2.26E-06	NDA	N/A	N/A	2.26E-06
Cs-137	2.33E-05	NDA	N/A	N/A	2.33E-05
Ba/La-140	NDA	NDA	N/A	N/A	NDA
Ce-141	NDA	NDA	N/A	N/A	NDA
Total for period	3.93E-05	1.32E-03	N/A	N/A	1.35E-03
2. DISSOLVED AND ENTRAINED GASES: Ci					
Xe-133	NDA	NDA	N/A	N/A	NDA
Xe-135	NDA	NDA	N/A	N/A	NDA
Total for period	NDA	NDA	N/A	N/A	NDA

Notes for Table 2.3-B:

1. N/A stands for not applicable.
2. NDA stands for No Detectable Activity.
3. LLDs for liquid radionuclides listed as NDA are as follows:
   - Strontium: 5E-08 μCi/mL
   - Iodines: 1E-06 μCi/mL
   - Noble Gases: 1E-05 μCi/mL
   - All Others: 5E-07 μCi/mL

3.0 METEOROLOGICAL DATA

Meteorological data are summarized for the reporting period in Appendix A, in the standard joint frequency distribution format as given in NRC Regulatory Guide 1.21.

The predominant meteorological conditions observed during the annual reporting period can be summarized with their corresponding frequencies as follows:

- Stability Class: Class D, 50%
- 33-ft Wind Direction (from): South-southwest, 14%
- 33-ft Wind Speed: 3.5-7.5 mph, 55%
- 220-ft Wind Direction (from): South-southwest, 12%
- 220-ft Wind Speed: 12.5-18.5 mph, 33%

Recent upgrades to the equipment on the 220-ft primary meteorological tower have improved overall data recovery and reliability. Data recovery for both levels of the 220-ft tower was 97.8%, well in excess of the 90% annual data recovery goal specified by the NRC.

4.0 MAXIMUM INDIVIDUAL DOSES

Doses to the maximum exposed individual resulting from radionuclides in effluents released offsite were calculated using methods presented in the PNPS Offsite Dose Calculation Manual (ODCM, Reference 2), NRC Regulatory Guide 1.109 (Reference 3), NRC Regulatory Guide 1.111 (Reference 4), and the Pilgrim Station Unit 1 Appendix I Evaluation (Reference 5). Maximum individual doses are calculated separately for: (1) noble gases in gaseous effluents, (2) particulates, iodines, and tritium in gaseous effluents; and, (3) liquid effluents. Maximum consumption and use factors for various pathways from Table E-5 of the PNPS ODCM are used for calculating the doses to the maximum exposed individual.

Information related to liquid and gaseous effluent releases are summarized Section 2 of this report. These effluent release data were used as input to computer programs to calculate the resulting doses. PNPS ODCM methodologies were used to calculate the dose contributions to the various organs in each age class from major exposure pathways.

4.1 Doses From Noble Gas Releases

Gaseous effluent release data presented in Tables 2.2-A, 2.2-B, and 2.2-C from this effluent release report were used as input to a dose assessment computer program to calculate radiation doses. These data include gaseous releases from the PNPS main stack, reactor building vent, and turbine building roof exhausters. Meteorological data obtained from the PNPS 220-foot meteorological tower during the 10-year period from 1994 through 2003 were used as input to the "AEOLUS-3" computer program (Reference 6). This program was used to calculate the annual average atmospheric dispersion and deposition factors used in the dose assessment computer program to calculate maximum individual doses.

The maximum individual doses resulting from radioactive noble gases released in gaseous effluents are presented in Table 4.1 according to specific receptor locations. This table includes all noble gas doses for the individual calendar quarters and total calendar year.

Noble gases released in gaseous effluents from PNPS during 2009 resulted in a maximum total body dose of 0.021 mrem. The maximum skin dose was 0.13 mrem. Both of these doses occurred to a hypothetical individual, assumed to be present 24 hours per day, 365 days per year, at the site boundary location yielding the highest dose (0.64 km ESE of the Reactor Building). For the more "realistic" individuals at offsite locations, the maximum total body dose was 0.016 mrem (nearest residence, 0.80 kilometers ESE from the Reactor Building), while the maximum skin dose was 0.090 mrem (nearest residence, 0.80 kilometers ESE from the Reactor Building).

Table 4.1

Maximum Doses From Noble Gas Releases During 2009[a]

Release Period	Gamma Air Dose mrad/period (location)	Beta Air Dose mrad/period (location)	Total Body Dose mrem/period (location)	Skin Dose mrem/period (location)
Jan-Mar	2.56E-02 (0.64 km ESE)	1.09E-01 (0.64 km ESE)	1.71E-02 (0.64 km ESE)	1.22E-01 (0.64 km ESE)
Apr-Jun	3.20E-03 (0.64 km ESE)	4.46E-03 (0.64 km ESE)	2.14E-03 (0.64 km ESE)	6.35E-03 (0.64 km ESE)
Jul-Sep	1.03E-03 (0.64 km ESE)	1.59E-03 (0.64 km ESE)	6.88E-04 (0.64 km ESE)	2.17E-03 (0.64 km ESE)
Oct-Dec	1.00E-03 (0.64 km ESE)	1.72E-03 (0.64 km ESE)	6.71E-04 (0.64 km ESE)	2.23E-03 (0.64 km ESE)
Jan-Dec	3.08E-02 (0.64 km ESE)	1.17E-01 (0.64 km ESE)	2.06E-02 (0.64 km ESE)	1.33E-01 (0.64 km ESE)

[a] All directions and distances are with respect to the reactor building vent.

4.2 Doses From Gaseous Effluent Releases

Gaseous effluent release data presented in Tables 2.2-A, 2.2-B, and 2.2-C from this effluent release report were used as input to a dose assessment computer program to calculate radiation doses. These data include gaseous releases from the PNPS main stack, reactor building vent, and turbine building roof exhausters. Meteorological data obtained from the PNPS 220-foot meteorological tower during the 10-year period from 1994 through 2003 were used as input to the "AEOLUS-3" computer program (Reference 6). This program was used to calculate the annual average atmospheric dispersion and deposition factors used in the dose assessment computer program to calculate maximum individual doses.

The maximum individual doses resulting from radioactive particulates, iodines, and tritium released in gaseous effluents are presented in Tables 4.2-A through 4.2-E. These tables cover the individual calendar quarters and the total calendar year, respectively. Doses resulting from releases of noble gases are addressed independently in the PNPS ODCM. Therefore, none of these tables for maximum individual doses include any dose contribution from noble gases. The presentation and analysis of doses resulting from noble gases are addressed in Section 4.1 of this report.

Tables 4.2-A through 4.2-E summarize the maximum total body and organ doses for the adult, teen, child, and infant age classes resulting from the major gaseous exposure pathways. These tables present the dose data according to specific receptor location and the exposure pathways assumed to occur at that location. For example, the second column of the tables presents the information for the hypothetical maximum-exposed at the most restrictive site boundary, location, where only inhalation and ground deposition exposure pathways are assumed to occur. Since this is a shoreline location controlled by Entergy, the other pathways of garden vegetable production, milk production, and meat production are assumed not to occur. Doses for other offsite locations not under Entergy control, where other exposure pathways can and do occur, are presented in subsequent columns of the tables, and represent the potential maximum doses to individuals at these locations.

Radioactivity (particulates, radioiodines, and tritium) released in gaseous effluents from PNPS during 2009 resulted in a maximum total body dose (child age class) of 0.0269 mrem (child age class at nearest garden location, 0.87 kilometers SE from the Reactor Building), while the maximum organ dose was 0.0619 mrem (child thyroid at nearest garden location, 0.87 kilometers SE from the Reactor Building).

Table 4.2-A

Maximum Individual Organ Dose at Receptor Location -- mrem
From Gaseous Release Period: Jan-Mar 2009

Receptor: Direction: Distance[1]: Pathway[2]:	Bound NNW 0.28 km DI	Resident ESE 0.80 km DI	Garden SE 0.87 km DIV[3]	Cow/Goat WSW 3.97 km DIVCG[3]	Cow/Meat W 5.77 km DIVCM[3]	Meat S 3.80 km DIVM[3]
Age Class: Adult						
Bone	1.01E-04	6.68E-05	4.89E-03	2.84E-04	1.54E-04	2.79E-04
GI-LLI	3.48E-03	2.35E-03	7.85E-03	5.90E-04	3.50E-04	4.58E-04
Kidney	3.00E-03	2.02E-03	6.51E-03	5.27E-04	3.12E-04	3.79E-04
Liver	2.98E-03	2.01E-03	6.48E-03	5.18E-04	3.08E-04	3.77E-04
Lung	4.15E-03	2.79E-03	7.03E-03	5.40E-04	3.20E-04	4.03E-04
Thyroid	7.75E-03	5.17E-03	1.91E-02	4.17E-03	2.28E-03	1.20E-03
T.Body	2.97E-03	2.01E-03	6.60E-03	5.21E-04	3.09E-04	3.84E-04
Age Class: Teen						
Bone	1.41E-04	9.34E-05	7.41E-03	4.46E-04	2.36E-04	4.15E-04
GI-LLI	3.54E-03	2.38E-03	8.68E-03	6.77E-04	3.87E-04	4.87E-04
Kidney	3.04E-03	2.05E-03	7.31E-03	6.20E-04	3.54E-04	4.10E-04
Liver	3.02E-03	2.04E-03	7.28E-03	6.06E-04	3.47E-04	4.08E-04
Lung	4.92E-03	3.30E-03	8.21E-03	6.42E-04	3.67E-04	4.52E-04
Thyroid	9.09E-03	6.06E-03	1.89E-02	5.97E-03	3.19E-03	1.13E-03
T.Body	3.00E-03	2.03E-03	7.47E-03	6.10E-04	3.49E-04	4.18E-04
Age Class: Child						
Bone	1.91E-04	1.27E-04	1.74E-02	1.05E-03	5.56E-04	9.68E-04
GI-LLI	2.89E-03	1.95E-03	1.12E-02	9.17E-04	5.20E-04	6.27E-04
Kidney	2.68E-03	1.81E-03	1.03E-02	9.07E-04	5.13E-04	5.76E-04
Liver	2.67E-03	1.80E-03	1.03E-02	8.86E-04	5.02E-04	5.74E-04
Lung	4.31E-03	2.89E-03	1.11E-02	9.01E-04	5.11E-04	6.11E-04
Thyroid	9.88E-03	6.58E-03	2.70E-02	1.12E-02	5.95E-03	1.63E-03
T.Body	2.66E-03	1.79E-03	1.08E-02	9.01E-04	5.10E-04	6.00E-04
Age Class: Infant						
Bone	1.32E-04	8.77E-05	6.65E-05	4.47E-04	2.06E-04	3.19E-06
GI-LLI	1.61E-03	1.09E-03	8.26E-04	3.81E-04	1.87E-04	4.40E-05
Kidney	1.55E-03	1.04E-03	7.94E-04	4.48E-04	2.22E-04	4.24E-05
Liver	1.54E-03	1.04E-03	7.92E-04	4.35E-04	2.15E-04	4.23E-05
Lung	3.06E-03	2.05E-03	1.55E-03	4.06E-04	2.02E-04	7.88E-05
Thyroid	8.17E-03	5.43E-03	4.12E-03	2.37E-02	1.23E-02	2.04E-04
T.Body	1.53E-03	1.03E-03	7.85E-04	4.06E-04	1.99E-04	4.20E-05

[1] Distances are measured with respect to the reactor building vent.

[2] Pathway designations are as follows:

D = Deposition (Ground Plane) I = Inhalation V = Vegetable Garden
C = Cow Milk G = Goat Milk M = Meat

[3] Doses are conservative since it is unlikely for vegetables to be grown outside or for animals to be fed on pasture during winter months.

Table 4.2-B

Maximum Individual Organ Dose at Receptor Location -- mrem
From Gaseous Release Period: Apr-Jun 2009

Receptor: Direction: Distance[1]: Pathway[2]:	Bound NNW 0.28 km DI	Resident ESE 0.80 km DI	Garden SE 0.87 km DIV	Cow/Goat WSW 3.97 km DIVCG	Cow/Meat W 5.77 km DIVCM	Meat S 3.80 km DIVM
Age Class: Adult						
Bone	2.49E-05	1.65E-05	9.71E-04	6.23E-05	3.37E-05	5.66E-05
GI-LLI	1.31E-03	8.84E-04	3.03E-03	2.30E-04	1.38E-04	1.79E-04
Kidney	1.20E-03	8.13E-04	2.64E-03	2.19E-04	1.29E-04	1.54E-04
Liver	1.20E-03	8.09E-04	2.66E-03	2.17E-04	1.28E-04	1.56E-04
Lung	1.55E-03	1.04E-03	2.76E-03	2.14E-04	1.27E-04	1.59E-04
Thyroid	3.93E-03	2.62E-03	1.13E-02	2.84E-03	1.54E-03	7.26E-04
T.Body	1.19E-03	8.06E-04	2.66E-03	2.13E-04	1.26E-04	1.55E-04
Age Class: Teen						
Bone	3.52E-05	2.33E-05	1.48E-03	9.99E-05	5.27E-05	8.44E-05
GI-LLI	1.33E-03	8.96E-04	3.35E-03	2.64E-04	1.52E-04	1.90E-04
Kidney	1.22E-03	8.25E-04	2.97E-03	2.62E-04	1.49E-04	1.67E-04
Liver	1.21E-03	8.19E-04	3.01E-03	2.58E-04	1.47E-04	1.69E-04
Lung	1.77E-03	1.19E-03	3.19E-03	2.52E-04	1.44E-04	1.77E-04
Thyroid	4.62E-03	3.08E-03	1.08E-02	4.11E-03	2.19E-03	6.62E-04
T.Body	1.21E-03	8.14E-04	3.00E-03	2.49E-04	1.42E-04	1.68E-04
Age Class: Child						
Bone	4.80E-05	3.19E-05	3.51E-03	2.39E-04	1.25E-04	1.99E-04
GI-LLI	1.12E-03	7.54E-04	4.41E-03	3.62E-04	2.06E-04	2.46E-04
Kidney	1.08E-03	7.29E-04	4.21E-03	3.85E-04	2.17E-04	2.35E-04
Liver	1.07E-03	7.24E-04	4.28E-03	3.80E-04	2.14E-04	2.39E-04
Lung	1.54E-03	1.04E-03	4.36E-03	3.57E-04	2.03E-04	2.41E-04
Thyroid	4.98E-03	3.31E-03	1.55E-02	7.79E-03	4.12E-03	9.58E-04
T.Body	1.07E-03	7.20E-04	4.28E-03	3.66E-04	2.07E-04	2.39E-04
Age Class: Infant						
Bone	3.45E-05	2.29E-05	1.74E-05	1.38E-04	6.45E-05	8.39E-07
GI-LLI	6.31E-04	4.26E-04	3.23E-04	1.53E-04	7.55E-05	1.72E-05
Kidney	6.23E-04	4.21E-04	3.20E-04	2.11E-04	1.05E-04	1.71E-05
Liver	6.22E-04	4.20E-04	3.19E-04	2.14E-04	1.05E-04	1.70E-05
Lung	1.03E-03	6.87E-04	5.22E-04	1.59E-04	7.82E-05	2.68E-05
Thyroid	4.20E-03	2.79E-03	2.12E-03	1.70E-02	8.81E-03	1.05E-04
T.Body	6.14E-04	4.15E-04	3.15E-04	1.73E-04	8.53E-05	1.69E-05

[1] Distances are measured with respect to the reactor building vent.

[2] Pathway designations are as follows:

D = Deposition (Ground Plane) I = Inhalation V = Vegetable Garden
C = Cow Milk G = Goat Milk M = Meat

Table 4.2-C

Maximum Individual Organ Dose at Receptor Location -- mrem
From Gaseous Release Period: Jul-Sep 2009

Receptor:	Bound	Resident	Garden	Cow/Goat	Cow/Meat	Meat
Direction:	NNW	ESE	SE	WSW	W	S
Distance[1]:	0.28 km	0.80 km	0.87 km	3.97 km	5.77 km	3.80 km
Pathway[2]:	DI	DI	DIV	DIVCG	DIVCM	DIVM
Age Class: Adult						
Bone	1.39E-05	9.19E-06	6.44E-04	4.01E-05	2.15E-05	3.72E-05
GI-LLI	1.55E-03	1.04E-03	3.41E-03	2.65E-04	1.58E-04	1.99E-04
Kidney	1.50E-03	1.01E-03	3.26E-03	2.61E-04	1.55E-04	1.90E-04
Liver	1.49E-03	1.01E-03	3.27E-03	2.61E-04	1.55E-04	1.91E-04
Lung	1.62E-03	1.09E-03	3.31E-03	2.59E-04	1.54E-04	1.92E-04
Thyroid	2.57E-03	1.72E-03	6.49E-03	1.22E-03	6.70E-04	4.00E-04
T.Body	1.49E-03	1.01E-03	3.28E-03	2.60E-04	1.54E-04	1.91E-04
Age Class: Teen						
Bone	1.96E-05	1.30E-05	9.92E-04	6.45E-05	3.38E-05	5.60E-05
GI-LLI	1.56E-03	1.05E-03	3.82E-03	3.07E-04	1.76E-04	2.14E-04
Kidney	1.51E-03	1.02E-03	3.67E-03	3.06E-04	1.75E-04	2.06E-04
Liver	1.51E-03	1.02E-03	3.69E-03	3.06E-04	1.74E-04	2.07E-04
Lung	1.72E-03	1.16E-03	3.75E-03	3.02E-04	1.73E-04	2.09E-04
Thyroid	2.87E-03	1.92E-03	6.59E-03	1.71E-03	9.18E-04	3.88E-04
T.Body	1.50E-03	1.02E-03	3.68E-03	3.01E-04	1.72E-04	2.06E-04
Age Class: Child						
Bone	2.69E-05	1.78E-05	2.35E-03	1.54E-04	8.04E-05	1.32E-04
GI-LLI	1.35E-03	9.14E-04	5.28E-03	4.38E-04	2.48E-04	2.94E-04
Kidney	1.34E-03	9.01E-04	5.20E-03	4.46E-04	2.52E-04	2.89E-04
Liver	1.33E-03	8.99E-04	5.24E-03	4.48E-04	2.53E-04	2.92E-04
Lung	1.52E-03	1.02E-03	5.26E-03	4.36E-04	2.47E-04	2.92E-04
Thyroid	2.91E-03	1.95E-03	9.41E-03	3.15E-03	1.68E-03	5.57E-04
T.Body	1.33E-03	8.97E-04	5.23E-03	4.39E-04	2.49E-04	2.91E-04
Age Class: Infant						
Bone	1.90E-05	1.26E-05	9.53E-06	8.07E-05	3.66E-05	4.59E-07
GI-LLI	7.73E-04	5.22E-04	3.96E-04	1.85E-04	9.06E-05	2.12E-05
Kidney	7.69E-04	5.19E-04	3.94E-04	2.08E-04	1.02E-04	2.11E-05
Liver	7.69E-04	5.19E-04	3.94E-04	2.14E-04	1.04E-04	2.11E-05
Lung	9.40E-04	6.33E-04	4.80E-04	1.89E-04	9.25E-05	2.52E-05
Thyroid	2.22E-03	1.48E-03	1.12E-03	6.32E-03	3.27E-03	5.65E-05
T.Body	7.65E-04	5.17E-04	3.92E-04	1.93E-04	9.46E-05	2.10E-05

[1] Distances are measured with respect to the reactor building vent.

[2] Pathway designations are as follows:

D = Deposition (Ground Plane) I = Inhalation V = Vegetable Garden
C = Cow Milk G = Goat Milk M = Meat

Table 4.2-D

Maximum Individual Organ Dose at Receptor Location -- mrem
From Gaseous Release Period: Oct-Dec 2009

Receptor: Direction: Distance[1]: Pathway[2]:	Bound NNW 0.28 km DI	Resident ESE 0.80 km DI	Garden SE 0.87 km DIV[3]	Cow/Goat WSW 3.97 km DIVCG[3]	Cow/Meat W 5.77 km DIVCM[3]	Meat S 3.80 km DIVM[3]
Age Class: Adult						
Bone	9.44E-06	6.26E-06	3.86E-04	2.37E-05	1.29E-05	2.25E-05
GI-LLI	1.94E-03	1.31E-03	4.23E-03	3.31E-04	1.97E-04	2.46E-04
Kidney	1.90E-03	1.28E-03	4.12E-03	3.27E-04	1.95E-04	2.40E-04
Liver	1.89E-03	1.28E-03	4.11E-03	3.26E-04	1.94E-04	2.39E-04
Lung	1.99E-03	1.35E-03	4.16E-03	3.26E-04	1.94E-04	2.41E-04
Thyroid	2.80E-03	1.88E-03	6.69E-03	1.08E-03	6.00E-04	4.07E-04
T.Body	1.89E-03	1.28E-03	4.12E-03	3.25E-04	1.93E-04	2.40E-04
Age Class: Teen						
Bone	1.34E-05	8.86E-06	5.91E-04	3.78E-05	2.01E-05	3.37E-05
GI-LLI	1.96E-03	1.32E-03	4.74E-03	3.83E-04	2.19E-04	2.66E-04
Kidney	1.92E-03	1.29E-03	4.63E-03	3.81E-04	2.18E-04	2.59E-04
Liver	1.91E-03	1.29E-03	4.62E-03	3.79E-04	2.17E-04	2.59E-04
Lung	2.08E-03	1.40E-03	4.70E-03	3.80E-04	2.17E-04	2.63E-04
Thyroid	3.06E-03	2.05E-03	6.98E-03	1.49E-03	8.04E-04	4.06E-04
T.Body	1.91E-03	1.29E-03	4.64E-03	3.78E-04	2.16E-04	2.60E-04
Age Class: Child						
Bone	1.83E-05	1.21E-05	1.40E-03	9.04E-05	4.78E-05	7.95E-05
GI-LLI	1.71E-03	1.15E-03	6.63E-03	5.51E-04	3.13E-04	3.69E-04
Kidney	1.69E-03	1.14E-03	6.56E-03	5.56E-04	3.15E-04	3.65E-04
Liver	1.69E-03	1.14E-03	6.55E-03	5.51E-04	3.13E-04	3.65E-04
Lung	1.83E-03	1.23E-03	6.61E-03	5.49E-04	3.12E-04	3.67E-04
Thyroid	3.04E-03	2.03E-03	9.95E-03	2.69E-03	1.44E-03	5.79E-04
T.Body	1.69E-03	1.14E-03	6.59E-03	5.51E-04	3.13E-04	3.67E-04
Age Class: Infant						
Bone	1.31E-05	8.72E-06	6.61E-06	4.60E-05	2.16E-05	3.19E-07
GI-LLI	9.77E-04	6.59E-04	5.01E-04	2.33E-04	1.14E-04	2.68E-05
Kidney	9.74E-04	6.57E-04	4.99E-04	2.49E-04	1.22E-04	2.67E-05
Liver	9.73E-04	6.57E-04	4.99E-04	2.46E-04	1.21E-04	2.67E-05
Lung	1.10E-03	7.44E-04	5.65E-04	2.35E-04	1.15E-04	2.99E-05
Thyroid	2.21E-03	1.48E-03	1.12E-03	5.06E-03	2.62E-03	5.69E-05
T.Body	9.70E-04	6.55E-04	4.98E-04	2.39E-04	1.17E-04	2.66E-05

[1] Distances are measured with respect to the reactor building vent.

[2] Pathway designations are as follows:

D = Deposition (Ground Plane) I = Inhalation V = Vegetable Garden
C = Cow Milk G = Goat Milk M = Meat

[3] Doses are conservative since it is unlikely for vegetables to be grown outside or for animals to be fed on pasture during winter months.

Table 4.2-E

Maximum Individual Organ Dose at Receptor Location -- mrem
From Gaseous Release Period: Jan-Dec 2009

Receptor: Direction: Distance[1]: Pathway[2]:	Bound NNW 0.28 km DI	Resident ESE 0.80 km DI	Garden SE 0.87 km DIV[3]	Cow/Goat WSW 3.97 km DIVCG[3]	Cow/Meat W 5.77 km DIVCM[3]	Meat S 3.80 km DIVM[3]
Age Class: Adult						
Bone	1.49E-04	9.88E-05	6.89E-03	4.10E-04	2.22E-04	3.96E-04
GI-LLI	8.28E-03	5.58E-03	1.85E-02	1.42E-03	8.42E-04	1.08E-03
Kidney	7.59E-03	5.12E-03	1.65E-02	1.33E-03	7.91E-04	9.63E-04
Liver	7.57E-03	5.11E-03	1.65E-02	1.32E-03	7.84E-04	9.63E-04
Lung	9.32E-03	6.27E-03	1.73E-02	1.34E-03	7.94E-04	9.95E-04
Thyroid	1.71E-02	1.14E-02	4.36E-02	9.30E-03	5.09E-03	2.73E-03
T.Body	7.55E-03	5.10E-03	1.67E-02	1.32E-03	7.83E-04	9.70E-04
Age Class: Teen						
Bone	2.09E-04	1.39E-04	1.05E-02	6.48E-04	3.43E-04	5.89E-04
GI-LLI	8.39E-03	5.65E-03	2.06E-02	1.63E-03	9.34E-04	1.16E-03
Kidney	7.69E-03	5.19E-03	1.86E-02	1.57E-03	8.96E-04	1.04E-03
Liver	7.65E-03	5.16E-03	1.86E-02	1.55E-03	8.85E-04	1.04E-03
Lung	1.05E-02	7.05E-03	1.99E-02	1.58E-03	9.01E-04	1.10E-03
Thyroid	1.96E-02	1.31E-02	4.32E-02	1.33E-02	7.10E-03	2.59E-03
T.Body	7.62E-03	5.15E-03	1.88E-02	1.54E-03	8.80E-04	1.05E-03
Age Class: Child						
Bone	2.84E-04	1.89E-04	2.46E-02	1.54E-03	8.09E-04	1.38E-03
GI-LLI	7.07E-03	4.77E-03	2.76E-02	2.27E-03	1.29E-03	1.54E-03
Kidney	6.79E-03	4.58E-03	2.63E-02	2.29E-03	1.30E-03	1.47E-03
Liver	6.76E-03	4.56E-03	2.64E-02	2.27E-03	1.28E-03	1.47E-03
Lung	9.21E-03	6.18E-03	2.73E-02	2.24E-03	1.27E-03	1.51E-03
Thyroid	2.08E-02	1.39E-02	6.19E-02	2.48E-02	1.32E-02	3.73E-03
T.Body	6.74E-03	4.55E-03	2.69E-02	2.26E-03	1.28E-03	1.50E-03
Age Class: Infant						
Bone	1.99E-04	1.32E-04	1.00E-04	7.11E-04	3.29E-04	4.81E-06
GI-LLI	3.99E-03	2.69E-03	2.05E-03	9.52E-04	4.67E-04	1.09E-04
Kidney	3.91E-03	2.64E-03	2.01E-03	1.12E-03	5.51E-04	1.07E-04
Liver	3.91E-03	2.64E-03	2.00E-03	1.11E-03	5.45E-04	1.07E-04
Lung	6.13E-03	4.11E-03	3.12E-03	9.89E-04	4.88E-04	1.61E-04
Thyroid	1.68E-02	1.12E-02	8.48E-03	5.20E-02	2.70E-02	4.23E-04
T.Body	3.88E-03	2.62E-03	1.99E-03	1.01E-03	4.96E-04	1.06E-04

[1] Distances are measured with respect to the reactor building vent.

[2] Pathway designations are as follows:

D = Deposition (Ground Plane) I = Inhalation V = Vegetable Garden
C = Cow Milk G = Goat Milk M = Meat

[3] Doses are conservative since it is unlikely for vegetables to be grown outside or for animals to be fed on pasture during winter months.

4.3 Doses From Liquid Effluent Releases

Liquid effluent release data presented in Tables 2.3-A and 2.3-B were used as input to the dose assessment computer program to calculate radiation doses. The maximum individual doses resulting from radionuclides released in liquid effluents are presented in Tables 4.3-A through 4.3-E. These tables cover the individual calendar quarters and the total calendar year, respectively.

Tables 4.3-A through 4.3-E summarize the maximum total body and organ doses for the adult, teen, and child age classes resulting from the major liquid exposure pathways. NRC Regulatory Guide 1.109 does not recognize the infant age class as being exposed to the liquid effluent pathways. Therefore, doses for this age class are not included in any of the tables.

It should be noted that doses calculated for the entire year might not equal the sum of the doses for the individual quarters. Doses from liquid effluents are based on the concentration (activity divided by volume) of radionuclides released in the effluent, as prescribed by the NRC in Regulatory Guide 1.109. If a larger proportion of activity is released with a relatively smaller volume of dilution water during a given quarter, the resulting concentration for that quarter will be higher than concentrations from other quarters. This will result in a proportionally higher dose for that quarter. However, when that quarter's activity values are included in the annual sum, and divided by the total annual dilution flow, the resulting dose contribution will be smaller. In such a situation, the annual dose will actually be less than the sum of the individual quarterly doses.

Radioactivity released in liquid effluents from PNPS during the reporting period resulted in a maximum total body dose (teen age class) of 0.000031 mrem. The maximum organ dose (adult age class, GI-LLI) was 0.00021 mrem.

Table 4.3-A

Maximum Individual Organ Doses -- mrem
From Liquid Release Period: Jan-Mar 2009

No Liquid Effluent Discharges Occurred During This Period

Organ	Age Class Organ Dose – mrem *		
	Adult	Teen	Child
Bone	1.70E-06	2.15E-06	1.74E-06
GI-LLI	1.67E-06	1.74E-06	5.36E-07
Kidney	5.28E-07	1.17E-06	5.02E-07
Liver	1.32E-06	1.96E-06	1.24E-06
Lung	2.72E-07	9.28E-07	2.85E-07
Thyroid	1.60E-07	7.95E-07	1.76E-07
T.Body	1.20E-06	1.47E-06	6.54E-07

* These doses are conservative since the same usage factor was applied for each quarter. In reality, it is unlikely that anyone would be swimming or boating during the entire year. However, the resulting dose is considerably lower than those from other pathways and does not contribute much to the total dose.

Table 4.3-B

Maximum Individual Organ Doses -- mrem
From Liquid Release Period: Apr-Jun 2009

Organ	Age Class Organ Dose – mrem		
	Adult	Teen	Child
Bone	1.77E-05	2.80E-05	2.21E-05
GI-LLI	2.66E-04	1.84E-04	6.82E-05
Kidney	1.50E-05	2.52E-05	1.18E-05
Liver	7.63E-05	8.27E-05	6.31E-05
Lung	1.50E-05	2.62E-05	1.35E-05
Thyroid	5.06E-06	1.57E-05	4.53E-06
T.Body	2.98E-05	3.91E-05	3.20E-05

Table 4.3-C

Maximum Individual Organ Doses -- mrem
From Liquid Release Period: Jul-Sep 2009

Organ	Age Class Organ Dose – mrem		
	Adult	Teen	Child
Bone	0.00E+00	0.00E+00	0.00E+00
GI-LLI	0.00E+00	0.00E+00	0.00E+00
Kidney	0.00E+00	0.00E+00	0.00E+00
Liver	0.00E+00	0.00E+00	0.00E+00
Lung	0.00E+00	0.00E+00	0.00E+00
Thyroid	0.00E+00	0.00E+00	0.00E+00
T.Body	0.00E+00	0.00E+00	0.00E+00

Table 4.3-D

Maximum Individual Organ Doses -- mrem
From Liquid Release Period: Oct-Dec 2009

Organ	Age Class Organ Dose – mrem *		
	Adult	Teen	Child
Bone	0.00E+00	0.00E+00	0.00E+00
GI-LLI	0.00E+00	0.00E+00	0.00E+00
Kidney	0.00E+00	0.00E+00	0.00E+00
Liver	0.00E+00	0.00E+00	0.00E+00
Lung	0.00E+00	0.00E+00	0.00E+00
Thyroid	0.00E+00	0.00E+00	0.00E+00
T.Body	0.00E+00	0.00E+00	0.00E+00

* These doses are conservative since the same usage factor was applied for each quarter. In reality, it is unlikely that anyone would be swimming or boating during these months. However, the resulting dose is considerably lower than those from other pathways and does not contribute much to the total dose.

Table 4.3-E

Maximum Individual Organ Doses -- mrem
From Liquid Release Period: Jan-Dec 2009

Organ	Age Class Organ Dose – mrem *		
	Adult	Teen	Child
Bone	1.53E-05	2.37E-05	1.87E-05
GI-LLI	2.05E-04	1.43E-04	5.26E-05
Kidney	1.20E-05	2.05E-05	9.51E-06
Liver	5.97E-05	6.52E-05	4.95E-05
Lung	1.18E-05	2.10E-05	1.06E-05
Thyroid	4.03E-06	1.28E-05	3.65E-06
T.Body	2.40E-05	3.14E-05	2.51E-05

* These doses are conservative since the same usage factor was applied for each quarter. In reality, it is unlikely that anyone would be swimming or boating during the entire year. However, the resulting dose is considerably lower than those from other pathways and does not contribute much to the total dose.

5.0 OFFSITE AMBIENT RADIATION MEASUREMENTS

The PNPS ODCM does not contain control limits related specifically to offsite ambient radiation exposure. However, Regulatory Guide 1.21 (Reference 1) recommends calculation of ambient radiation exposure as part of the overall assessment of radiological impact on man.

Thermoluminescent dosimeters (TLDs) are located at 83 sites beyond the boundary of the PNPS restricted/protected area. A number of these TLDs are located within the site boundary, on Entergy property in close proximity to the station proper. The TLDs are collected on a quarterly basis and used to calculate the ambient radiation exposure in milliRoentgen (mR) over the exposure period. These TLDs are grouped into four zones of increasing distance from the station. Average exposure values for each of these zones were calculated for each calendar quarter and the total year. The average exposure values (mR) for the four zones are presented in Table 5.0.

In addition to responding to ambient radiation exposure, TLDs will also record radiation resulting from noble gases (plume and immersion exposure), particulate materials deposited on the ground, cosmic rays from outer space, and from naturally-occurring radioactivity in the soil and air. Typically, the exposure from cosmic rays and other natural radioactivity components is about 40 to 70 mR/year. As calculated in Sections 4.1 and 4.2 of this report, the ambient radiation component of doses from PNPS effluent emissions are below 1 mrem/yr and would not be discernible above the natural radiation exposure levels.

The major source of ambient radiation exposure from PNPS results from high-energy gamma rays emitted from nitrogen-16 (N-16) contained in steam flowing through the turbine. Although the N-16 is enclosed in the process lines and turbine and is not released into the environment, the ambient radiation exposure and sky shine from this contained source accounts for the majority of the radiation dose, especially in close proximity to the station. Other sources of ambient radiation exposure include radiation emitted from contained radioactive materials and/or radwaste at the facility. Despite these sources of ambient radiation exposure at PNPS, increases in exposure from ambient radiation are typically not observable above background levels at locations beyond Entergy controlled property.

The average exposure values presented in Table 5.0 appear to indicate an elevation in ambient exposures in Zone 1, those TLDs within 2 miles of PNPS. Most of this elevation is due to increases in exposure levels measured at TLD locations on Entergy property in close proximity to the station proper. For example, the annual exposure at TLD location OA, located at the Overlook Area near the PNPS Health Club (I&S Building), was 205 mR for the entire year. This location is immediately adjacent to the station proper and overlooks the turbine building, therefore receiving the highest direct ambient and sky shine exposure. When the near-site TLDs (those located within 0.6 km of the Reactor Building) are removed from the calculation of averages, the mean annual exposure in Zone 1 falls from 76.4 ± 27.1 mR/yr to 65.3 ± 10.8 mR/yr. Such a corrected dose is not statistically different from the Zone 4 average of 62.5 ± 9.3 mR/yr, and is indicative of natural background radiation.

Although the annual exposure at TLD location OA was 143 mR above the average Zone 4 exposure, members of the general public do not continuously occupy this area. When adjusted for such occupancy, a hypothetical member of the public who was at this location for 40 hours per year would only receive an incremental dose of 0.7 mrem over natural background radiation levels. At the nearest residence 0.8 kilometers (0.5 miles) southeast of the PNPS Reactor Building, the annual exposure was calculated as being 66.1 ± 16.1 mR (based on continuous occupancy at this location), which compares quite well to the Zone 4 annual average background radiation level of 62.5 ± 9.3 mR. Statistically, there is no difference between these two values.

It must be emphasized that the projected ambient exposures discussed on the previous page are calculated to occur to a maximum-exposed hypothetical individual. Even though conservative assumptions are made in the projection of these dose consequences, all of the projected doses are well below the NRC dose limit of 100 mrem/yr specified in 10CFR20.1301, as well as the EPA dose limit of 25 mrem/yr specified in 40CFR190. Both of these limits are to be applied to real members of the general public, so the fact that the dose to the hypothetical maximum-exposed individual is within the limits ensures that any dose received by a real member of the public would be smaller and well within any applicable limit.

In 1994, Pilgrim Station opened the old training facility (I&S Building) overlooking the plant as a health club for its employees. This site is immediately adjacent to the protected area boundary near monitoring location OA and receives appreciable amounts of direct ambient and sky shine exposure from the turbine building. Although personnel using this facility are employees of Entergy, they are considered to be members of the public. Due to their extended presence in the facility (500 hr/yr, assuming utilization of the facility for 2 hr/day, 5 days a week, for 50 weeks/yr), these personnel represent the most conservative case in regards to ambient radiation exposure to a member of the public within the PNPS owner controlled area. Their annual incremental radiation dose above background during 2009 is estimated as being about 1.4 mrem, based on the average exposure measured by the TLD in the building.

The exposures measured by the TLD located in the health club would also include any increase in ambient radiation resulting from noble gases and/or particulate activity deposited on the ground from gaseous releases. However, they would not indicate any internal dose received by personnel in this facility from inhalation of small amounts of PNPS-related radioactivity contained in the air. An environmental air sampler located immediately adjacent to the health club did not indicate any PNPS-related activity during 2009. Dose calculations performed in the same manner as those outlined in Section 4.2 for airborne effluent releases yielded a projected total body dose to the maximum-exposed individual (500 hr/yr exposure) of about 0.0017 mrem, resulting from inhalation.

Again, it must be emphasized that the above-described exposures were received by personnel who are employees or contractors of Entergy, accessing areas or facilities on property under the ownership and control of Entergy. Since this exposure was received within the owner-controlled area, it is not used for comparison to the annual dose limit of 25 mrem/yr specified in 40CFR190. This regulation expressly applies to areas at or beyond the owner-controlled property, and is not applicable in this situation. As stated earlier, TLDs at and beyond the site boundary do not indicate elevated ambient radiation levels resulting from the operation of Pilgrim Station.

Although some of the TLDs in close proximity to PNPS indicate increases in exposure levels from ambient radiation, such increases are localized to areas under Entergy control. For members of the general public who are not employed or contracted with Entergy and are accessing Entergy controlled areas (e.g., parking lots, etc.), such increases in dose from ambient radiation exposure are estimated as being less than 1.0 mrem/year.

Table 5.0

Average TLD Exposures By Distance Zone During 2009

Exposure Period	Average Exposure ± Standard Deviation: mR/period			
	Zone 1* 0-3 km	Zone 2 3-8 km	Zone 3 8-15 km	Zone 4 >15 km
Jan-Mar	18.8 ± 5.7	15.6 ± 1.8	14.9 ± 1.5	16.4 ± 2.2
Apr-Jun	18.2 ± 5.1	14.5 ± 1.7	13.6 ± 2.0	14.2 ± 1.4
Jul-Sep	20.7 ± 8.1	15.6 ± 2.3	13.8 ± 1.9	16.7 ± 2.6
Oct-Dec	18.7 ± 7.7	14.8 ± 2.2	14.1 ± 1.3	15.3 ± 2.6
Jan-Dec	76.4 ± 27.1**	60.5 ± 8.1	56.4 ± 6.7	62.5 ± 9.3

* Zone 1 extends from the PNPS restricted/protected area boundary outward to 3 kilometers (2 miles), and includes several TLDs located within the site boundary.

** When corrected for TLDs located within the site boundary, the Zone 1 annual average is calculated to be 65.3 ± 10.8 mR/yr.

6.0 PERCENT OF ODCM EFFLUENT CONTROL LIMITS

The PNPS ODCM contains dose and concentration limits for radioactive effluents. In addition, the effluent controls specified ensure that radioactive releases are maintained as low as reasonably achievable. The percentage of the PNPS ODCM Control limit values were determined from doses calculated in Section 4, the effluent releases summarized in Section 2, and the ODCM Control limits/objectives listed in Tables 6.1 and 6.2.

The percent of applicable control limit values are provided to supplement the information provided in the Section 2 of this report. The format for the percent of applicable limits is modified from that prescribed in Regulatory Guide 1.21 (Reference 1) to accommodate the Radioactive Effluents Technical Specifications (RETS) that became effective March 01, 1986. The percentages have been grouped according to whether the releases were via liquid or gaseous effluent pathways.

6.1 Gaseous Effluent Releases

Dose-based effluent controls related to exposures arising from gaseous effluent releases are presented in Table 6.1. The maximum quarterly air doses and annual whole body doses listed in Table 4.1 were used to calculate the percentage values shown in Table 6.1. All doses resulting from noble gas exposure were a small percentage of the applicable effluent control.

Organ dose limits for the maximum-exposed individual from radioactive particulates, iodines, and tritium from the PNPS ODCM are also shown in Table 6.1. The maximum quarterly and annual organ doses from Tables 4.2-A through 4.2-E were used to calculate the percentages shown in Table 6.1. The resulting organ doses from Pilgrim Station's gaseous releases during 2009 were a small percentage of the corresponding effluent control.

Table 6.1

Percent of ODCM Effluent Control Limits
for Gaseous Effluent Releases During 2009

A. Instantaneous Dose Rate Limit - Noble Gases
PNPS ODCM Control 3.3.1.a
Limit: 500 mrem/yr Total Body Dose

Period	Value - mrem/yr	Fraction of Limit
Jan-Dec	2.06E-02	4.12E-03%

B. Instantaneous Dose Rate Limit - Noble Gases
PNPS ODCM Control 3.3.1.a
Limit: 3000 mrem/yr Skin Dose

Period	Value - mrem/yr	Fraction of Limit
Jan-Dec	1.33E-01	4.42E-03%

C. Instantaneous Dose Rate Limit - Particulates, Iodines, & Tritium
PNPS ODCM Control 3.3.1.b
Limit: 1500 mrem/yr Organ Dose

Period	Value - mrem/yr	Fraction of Limit
Jan-Dec	6.19E-02	4.13E-03%

D. Quarterly Dose Objective - Noble Gas Gamma Air Dose
PNPS ODCM Control 3.3.2.a
Objective: 5 mrad Gamma Air Dose

Period	Value – mrad	Fraction of Limit
Jan-Mar	2.56E-02	5.12E-01%
Apr-Jun	3.20E-03	6.39E-02%
Jul-Sep	1.03E-03	2.05E-02%
Oct-Dec	1.00E-03	2.00E-02%

E. Annual Dose Objective - Noble Gas Gamma Air Dose
PNPS ODCM Control 3.3.2.b
Objective: 10 mrad Gamma Air Dose

Period	Value - mrad/yr	Fraction of Limit
Jan-Dec	3.08E-02	3.08E-01%

Table 6.1 (continued)

Percent of ODCM Effluent Control Limits
for Gaseous Effluent Releases During 2009

F. Quarterly Dose Objective - Noble Gas Beta Air Dose
PNPS ODCM Control 3.3.2.a
Objective: 10 mrad Beta Air Dose

Period	Value - mrad	Fraction of Limit
Jan-Mar	1.09E-01	1.09E+00%
Apr-Jun	4.46E-03	4.46E-02%
Jul-Sep	1.59E-03	1.59E-02%
Oct-Dec	1.72E-03	1.72E-02%

G. Annual Dose Objective - Noble Gas Beta Air Dose
PNPS ODCM Control 3.3.2.b
Objective: 20 mrad Beta Air Dose

Period	Value - mrad/yr	Fraction of Limit
Jan-Dec	1.17E-01	5.85E-01%

H. Quarterly Dose Objective - Particulates, Iodines, & Tritium
PNPS ODCM Control 3.3.3.a
Objective: 7.5 mrem Organ Dose

Period	Value - mrem	Fraction of Limit
Jan-Mar	2.70E-02	3.61E-01%
Apr-Jun	1.70E-02	2.26E-01%
Jul-Sep	9.41E-03	1.26E-01%
Oct-Dec	9.95E-03	1.33E-01%

I. Annual Dose Objective - Particulates, Iodines, & Tritium
PNPS ODCM Control 3.3.3.b
Objective: 15 mrem Organ Dose

Period	Value - mrem/yr	Fraction of Limit
Jan-Dec	6.19E-02	4.13E-01%

6.2 Liquid Effluent Releases

Liquid effluent concentration limits and dose objectives from the PNPS ODCM are shown in Table 6.2. The quarterly average concentrations from Table 2.3-A were used to calculate the percent concentration limits. The maximum quarterly and annual whole body and organ doses from Tables 4.3-A through 4.3-E were used to calculate the percentages shown in Table 6.2. The resulting concentrations, as well as organ and total body doses from Pilgrim Station's liquid releases during the reporting period were a small percentage of the corresponding effluent controls.

Table 6.2

Percent of ODCM Effluent Control Limits
for Liquid Effluent Releases During 2009

A. Fission and Activation Product Effluent Concentration Limit
PNPS ODCM Control 3.2.1
Limit: 10CFR20 Appendix B, Table 2, Column 2 Value

Period	Value - μCi/mL	Fraction of Limit
Jan-Mar	2.59E-13	2.09E-05%
Apr-Jun	1.21E-11	9.32E-05%
Jul-Sep	0.00E+00	0.00E+00%
Oct-Dec	0.00E+00	0.00E+00%
Jan-Dec	2.37E-12	2.33E-05%

B. Tritium Average Concentration Limit
PNPS ODCM Control 3.2.1
Limit: 1.0E-03 μCi/mL

Period	Value - μCi/mL	Fraction of Limit
Jan-Mar	1.37E-10	1.37E-05%
Apr-Jun	1.79E-08	1.79E-03%
Jul-Sep	0.00E+00	0.00E+00%
Oct-Dec	0.00E+00	0.00E+00%
Jan-Dec	3.46E-09	3.46E-04%

C. Dissolved and Entrained Noble Gases Concentration Limit
PNPS ODCM Control 3.2.1
Limit: 2.0E-04 μCi/mL

Period	Value - μCi/mL	Fraction of Limit
Jan-Mar	0.00E+00	0.00E+00%
Apr-Jun	0.00E+00	0.00E+00%
Jul-Sep	0.00E+00	0.00E+00%
Oct-Dec	0.00E+00	0.00E+00%
Jan-Dec	0.00E+00	0.00E+00%

Table 6.2 (continued)

Percent of ODCM Effluent Control Limits
for Liquid Effluent Releases During 2009

D. Quarterly Total Body Dose Objective
PNPS ODCM Control 3.2.2.a
Objective: 1.5 mrem Total Body Dose

Period	Value - mrem	Fraction of Limit
Jan-Mar	1.47E-06	9.77E-05%
Apr-Jun	3.91E-05	2.61E-03%
Jul-Sep	0.00E+00	0.00E+00%
Oct-Dec	0.00E+00	0.00E+00%

E. Annual Total Body Dose Objective
PNPS ODCM Control 3.2.2.b
Objective: 3 mrem Total Body Dose

Period	Value - mrem	Fraction of Limit
Jan-Dec	3.14E-05	1.05E-03%

F. Quarterly Organ Dose Objective
PNPS ODCM Control 3.2.2.a
Objective: 5 mrem Organ Dose

Period	Value - mrem	Fraction of Limit
Jan-Mar	2.15E-06	4.30E-05%
Apr-Jun	2.66E-04	5.33E-03%
Jul-Sep	0.00E+00	0.00E+00%
Oct-Dec	0.00E+00	0.00E+00%

G. Annual Organ Dose Objective
PNPS ODCM Control 3.2.2.b
Objective: 10 mrem Organ Dose

Period	Value - mrem	Fraction of Limit
Jan-Dec	2.05E-04	2.05E-03%

7.0 RADIOACTIVE WASTE DISPOSAL DATA

Radioactive wastes that were shipped offsite for processing and disposal during the reporting period are described in Table 7.0, in the standard NRC Regulatory Guide 1.21 format.

The total quantity of radioactivity in Curies and the total volume in cubic meters are summarized in Table 7.0 for the following waste categories:

- Spent resins, filter sludges, and evaporator bottoms;
- Dry activated wastes, contaminated equipment, etc.;
- Irradiated components, control rods, etc.; and,
- Other.

During the reporting period approximately 36.6 cubic meters of spent resins, filter sludges, etc., containing a total activity of about 117 Curies were shipped from PNPS for processing and disposal. Dry activated wastes and contaminated equipment shipped during the period totaled 812 cubic meters and contained 44.1 Curies of radioactivity. There were no shipments of irradiated components during the reporting period. The "Other" category, made up from "Hi Rad Trash" consisted of 64.0 cubic meters and 3.68 curies. No shipments of irradiated fuel were made during the reporting period.

Estimates of major radionuclides, those comprising greater than 1% of the total activity in each waste category shipped, are listed in Table 7.0. There were 15 shipments to Energy Solutions' Bear Creek Facility; 2 shipments to IMPACT Services in Oak Ridge, TN; 7 shipments to Studsvik in Erwin, TN and 3 shipment to Toxco Materials Management Center in Oak Ridge, TN.

Table 7.0
Pilgrim Nuclear Power Station
Radioactive Effluent Release Report
Solid Waste and Irradiated Fuel Shipments
January-December 2009

A. SOLID WASTE SHIPPED OFFSITE FOR BURIAL OR DISPOSAL (Not irradiated fuel)

1. Estimate of volume and activity content by type of waste

Type of waste	Jan-Dec 2009		
	Volume - m^3	Curies	Total Error
a. Spent resins, filters, filter sludges, evaporator bottoms, etc.	3.66 E+01	1.17 E+02	± 25%
b. Dry activated waste, contaminated equipment, etc.	8.12 E+02	4.41 E+01	± 25%
c. Irradiated components, control rods, etc.	Not Applicable	Not Applicable	±25%
d. Other (describe): "Hi Rad" Trash; Recirc Pump	6.40 E+01	3.68E+00	±25%

2. Estimate of major nuclide composition by type of waste[1]

Type of waste	Radionuclide	Abundance	Total Error
a. Spent resins, filters, filter sludges, evaporator bottoms, etc.	C-14	1.93%	± 25%
	Mn-54	5.91%	± 25%
	Fe-55	42.45%	± 25%
	Co-60	18.20%	± 25%
	Ni-63	2.96%	± 25%
	Zn-65	3.02%	± 25%
	Cs-134	1.77%	± 25%
	Cs-137	22.62%	± 25%
b. Dry activated waste, contaminated equipment, etc.	C-14	2.07%	± 25%
	Mn-54	11.24%	± 25%
	Fe-55	60.42%	± 25%
	Co-60	10.48%	± 25%
	Ni-63	8.12%	± 25%
	Cs-137	5.12%	± 25%
c. Irradiated components, control rods, etc.	Not Applicable	Not Applicable	± 25%
			± 25%
d. Other (describe): "Hi Rad" Trash; Recirc Pump	Cr-51	13.20%	± 25%
	Mn-54	7.62%	± 25%
	Fe-55	51.61%	± 25%
	Co-60	22.15%	± 25%
	Zn-65	2.07%	± 25%

[1] *"Major" is defined as any radionuclide comprising >1% of the total activity in the waste category.*

3. Solid Waste Disposition

Number of Shipments	Mode of Transportation	Destination
1	Tractor-trailer (Eastern Technologies)	Energy Solutions Bear Creek Facility[2] Oak Ridge, TN
14	Tractor-trailer (Hittman Transport)	Energy Solutions Bear Creek Facility[2] Oak Ridge, TN
2	Tractor-trailer (Eastern Technologies)	IMPACT Services,[2] Oak Ridge, TN
7	Tractor-trailer (Hittman Transport)	Studsvik Processing Facility,[2] Erwin, TN
3	Tractor-trailer (Hittman Transport)	TOXCO Materials Mgmt Center,[2] Oak Ridge, TN

[2] *This processor provides volume reduction services for dry compressible waste, contaminated equipment, etc. Remaining radioactive wastes will be shipped to Chem Nuclear Systems, Inc. in Barnwell, SC, or Envirocare, Inc. in Clive, UT for final disposal.*

B. IRRADIATED FUEL SHIPMENTS & DISPOSITION

Number of Shipments	Mode of Transportation	Destination
None	N/A	N/A

8.0 OFFSITE DOSE CALCULATION MANUAL REVISIONS

The PNPS Offsite Dose Calculation Manual (ODCM) was revised during the calendar year of 2009. Information regarding revisions to the ODCM can be found attached as Appendix C of this report.

9.0 REFERENCES

1. U.S. Nuclear Regulatory Commission, "Measuring, Evaluating, and Reporting Radioactivity in Solid Wastes and Releases of Radioactive Materials in Liquid and Gaseous Effluents from Light-Water Cooled Nuclear Power Plants", Regulatory Guide 1.21, Revision 1, June 1974.

2. "Pilgrim Nuclear Power Station Offsite Dose Calculation Manual", Revision 9, June 2003.

3. U.S. Nuclear Regulatory Commission, "Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10CFR50 Appendix I", Regulatory Guide 1.109, Revision 1, October 1977.

4. U.S. Nuclear Regulatory Commission, "Methods for Estimating Atmospheric Transport and Dispersion of Gaseous Effluents in Routine Releases from Light-Water-Cooled Reactors", Regulatory Guide 1.111, July 1977.

5. Boston Edison Company, "Pilgrim Station Unit 1 Appendix I Evaluation", April 1977.

6. Entech Engineering Inc., P100-R19, "AEOLUS-3 - A Computer Code for the Determination of Atmospheric Dispersion and Deposition of Nuclear Power Plant Effluents During Continuous, Intermittent and Accident Conditions in Open-Terrain Sites, Coastal Sites and Deep-River Valleys"

APPENDIX A

Meteorological Joint Frequency Distributions

TABLE	TABLE TITLE	PAGE
A-1	Joint Frequency Distribution of Wind Directions and Speeds for the 33-ft Level of the 220-ft Tower	48
A-2	Joint Frequency Distribution of Wind Directions and Speeds for the 220-ft Level of the 220-ft Tower	58

Table A-1
Joint Frequency Distribution of Wind Directions and Speeds
For the 33-ft level of the 220-ft Tower

Jan-Mar 2009

Class A Freq: 0.028

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.95-3.5	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
3.5-7.5	5	3	8	0	0	0	0	0	0	0	1	0	1	2	0	4	24
7.5-12.5	8	4	5	0	0	0	0	0	0	0	1	2	4	3	3	3	33
12.5-18.5	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
18.5-24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	13	8	13	0	0	0	0	0	0	0	2	2	6	5	3	7	59

Class B Freq: 0.024

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.95-3.5	0	1	0	0	0	0	0	0	0	0	0	0	0	1	1	0	3
3.5-7.5	9	4	3	2	0	0	1	0	0	0	0	1	3	2	1	1	27
7.5-12.5	2	8	6	0	0	0	0	0	0	0	2	1	0	2	0	0	21
12.5-18.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18.5-24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	11	13	9	2	0	0	1	0	0	0	2	2	3	5	2	1	51

Class C Freq: 0.051

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.95-3.5	0	1	0	0	0	1	1	1	0	0	0	0	0	0	1	0	5
3.5-7.5	12	5	5	1	0	0	0	0	0	1	0	2	4	7	12	2	51
7.5-12.5	8	13	2	0	0	0	0	0	0	0	0	0	4	8	6	5	46
12.5-18.5	0	5	0	0	0	0	0	0	0	1	0	0	0	0	0	0	6
18.5-24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	20	24	7	1	0	1	1	1	0	2	0	2	8	15	19	7	108

Class D Freq: 0.651

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
0.95-3.5	7	4	7	4	5	4	9	14	17	15	8	14	11	9	10	5	143
3.5-7.5	31	43	13	18	26	22	29	25	28	47	36	102	181	105	81	39	826
7.5-12.5	10	30	2	0	5	8	7	2	16	85	12	19	115	52	20	11	394
12.5-18.5	0	2	0	0	0	0	0	0	0	5	0	0	0	0	0	0	7
18.5-24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	49	79	22	22	36	34	45	41	61	152	56	135	307	166	111	55	1371

Table A-1 (continued)

Jan-Mar 2009

Class E Freq: 0.216

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.95-3.5	3	1	3	2	1	2	3	14	9	18	20	25	9	7	9	9	135
3.5-7.5	7	14	8	8	13	2	2	13	8	32	82	48	19	14	12	4	286
7.5-12.5	0	0	0	0	0	0	0	0	5	9	11	2	5	1	0	0	33
12.5-18.5	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1
18.5-24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	10	15	11	10	14	4	5	27	22	60	113	75	33	22	21	13	455

Class F Freq: 0.027

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.95-3.5	0	0	1	0	0	0	1	4	2	4	2	0	0	2	0	2	18
3.5-7.5	0	0	0	3	2	0	1	0	2	4	20	2	0	0	0	0	34
7.5-12.5	0	0	0	0	0	0	0	0	0	1	3	0	0	0	0	0	4
12.5-18.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18.5-24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	0	0	1	3	2	0	2	4	4	9	25	2	0	2	0	2	56

Class G Freq: 0.002

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.95-3.5	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	2
3.5-7.5	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	3
7.5-12.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12.5-18.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18.5-24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	0	0	1	1	0	0	0	0	0	0	3	0	0	0	0	0	5

Class All Freq: 1.000

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
0.95-3.5	10	8	12	7	6	7	14	33	28	37	30	39	20	19	21	16	307
3.5-7.5	64	69	37	32	41	24	33	38	38	84	142	155	208	130	106	50	1251
7.5-12.5	28	55	15	0	5	8	7	2	21	95	29	24	128	66	29	19	531
12.5-18.5	0	7	0	0	0	0	0	0	0	7	0	0	1	0	0	0	15
18.5-24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	103	139	64	39	52	39	54	73	87	223	201	218	357	215	156	85	2105

Table A-1 (continued)

Apr-Jun 2009

Class A Freq: 0.034

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.95-3.5	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0	0	4
3.5-7.5	0	7	24	4	3	2	0	0	0	2	2	2	1	0	1	0	48
7.5-12.5	0	2	0	0	1	0	0	0	1	3	2	0	0	3	0	5	17
12.5-18.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18.5-24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	0	9	24	4	4	2	0	0	1	5	5	3	2	4	1	5	69

Class B Freq: 0.018

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.95-3.5	0	0	1	0	0	0	0	0	0	0	0	0	2	0	0	0	3
3.5-7.5	1	3	3	3	2	4	0	0	0	3	1	2	1	1	0	1	25
7.5-12.5	0	1	0	0	1	1	0	0	0	3	0	0	0	1	1	0	8
12.5-18.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18.5-24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	1	4	4	3	3	5	0	0	0	6	1	2	3	2	1	1	36

Class C Freq: 0.029

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.95-3.5	0	0	0	0	1	0	1	0	1	0	0	0	0	0	0	1	4
3.5-7.5	0	7	5	2	1	3	2	0	2	7	4	2	1	2	2	1	41
7.5-12.5	0	0	0	0	1	0	0	0	1	5	1	0	2	4	0	1	15
12.5-18.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18.5-24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	0	7	5	2	3	3	3	0	4	12	5	2	3	6	2	3	60

Class D Freq: 0.506

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
0.95-3.5	33	28	26	15	25	11	24	17	11	5	15	13	9	9	15	21	277
3.5-7.5	33	59	42	10	14	29	29	25	36	91	38	38	36	18	6	12	516
7.5-12.5	5	31	2	0	0	11	1	3	32	89	26	7	22	4	9	0	242
12.5-18.5	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
18.5-24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	71	118	70	25	40	51	54	45	80	185	79	58	67	31	30	33	1037

Table A-1 (continued)

Apr-Jun 2009

Class E Freq: 0.315

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	2	1	0	0	1	0	0	0	0	1	1	0	0	1	0	7
0.95-3.5	24	19	13	22	14	4	17	22	28	18	17	9	24	18	13	20	282
3.5-7.5	9	11	10	12	26	21	10	5	29	62	49	36	13	13	2	2	310
7.5-12.5	1	0	0	0	0	0	0	0	1	25	17	2	0	0	0	0	46
12.5-18.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18.5-24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	34	32	24	34	40	26	27	27	58	105	84	48	37	31	16	22	645

Class F Freq: 0.081

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.95-3.5	5	8	5	18	9	4	2	3	3	1	9	11	3	1	5	3	90
3.5-7.5	4	0	0	8	11	2	2	0	2	6	19	8	0	0	1	1	64
7.5-12.5	0	0	0	0	0	0	0	0	0	4	6	1	0	0	0	0	11
12.5-18.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18.5-24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	9	8	5	26	20	6	4	3	5	11	34	20	3	1	6	4	165

Class G Freq: 0.018

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.95-3.5	1	1	4	5	1	0	0	1	1	0	2	4	3	0	0	0	23
3.5-7.5	0	0	0	2	3	0	0	0	0	0	3	2	1	0	0	1	12
7.5-12.5	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
12.5-18.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18.5-24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	1	1	4	7	4	0	0	1	1	0	6	6	4	0	0	1	36

Class All Freq: 1.000

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	2	1	0	1	1	0	0	0	0	1	1	0	0	1	0	8
0.95-3.5	63	56	49	60	50	19	44	43	44	24	44	38	42	29	33	45	683
3.5-7.5	47	87	84	41	60	61	43	30	69	171	116	90	53	34	12	18	1016
7.5-12.5	6	34	2	0	3	12	1	3	35	129	53	10	24	12	10	6	340
12.5-18.5	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
18.5-24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	116	179	136	101	114	93	88	76	149	324	214	139	119	75	56	69	2048

Table A-1 (continued)

Jul-Sep 2009

Class A Freq: 0.016

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.95-3.5	0	0	3	0	0	0	0	0	0	0	0	0	0	1	0	0	4
3.5-7.5	0	0	11	5	6	0	1	1	0	2	2	1	1	0	2	0	32
7.5-12.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12.5-18.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18.5-24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	0	0	14	5	6	0	1	1	0	2	2	1	1	1	2	0	36

Class B Freq: 0.009

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.95-3.5	0	0	3	2	1	0	0	0	0	0	0	0	0	0	1	0	7
3.5-7.5	3	0	2	1	0	1	0	1	0	2	1	1	0	0	0	0	12
7.5-12.5	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1
12.5-18.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18.5-24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	3	0	5	3	1	1	0	1	0	3	1	1	0	0	1	0	20

Class C Freq: 0.015

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.95-3.5	1	0	1	0	0	1	0	0	0	0	0	1	0	1	0	0	5
3.5-7.5	2	6	11	1	2	0	0	2	0	1	3	0	0	0	0	0	28
7.5-12.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12.5-18.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18.5-24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	3	6	12	1	2	1	0	2	0	1	3	1	0	1	0	0	33

Class D Freq: 0.331

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	2
0.95-3.5	15	21	10	9	20	21	6	13	17	12	14	7	1	3	16	10	195
3.5-7.5	4	27	57	29	23	31	20	6	27	180	50	19	4	7	14	4	502
7.5-12.5	1	0	0	2	3	0	0	0	3	16	1	1	0	0	4	0	31
12.5-18.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18.5-24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	21	48	67	40	46	52	27	19	47	208	65	27	5	10	34	14	730

Table A-1 (continued)

Jul-Sep 2009

Class E Freq: 0.427

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	1	0	0	0	0	0	0	2	0	0	1	0	0	4
0.95-3.5	12	16	18	26	42	15	21	15	24	18	15	38	32	29	23	19	363
3.5-7.5	4	9	7	6	18	15	7	9	32	153	125	78	45	12	11	4	535
7.5-12.5	0	0	0	0	0	0	0	0	0	25	16	0	0	0	0	0	41
12.5-18.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18.5-24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	16	25	25	33	60	30	28	24	56	196	158	116	77	42	34	23	943

Class F Freq: 0.177

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	1	0	0	1	1	0	1	2	0	1	0	1	0	0	8
0.95-3.5	13	18	16	28	12	4	7	5	10	20	25	39	25	5	6	14	247
3.5-7.5	3	0	1	7	3	1	0	0	0	13	94	5	1	1	1	0	130
7.5-12.5	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	6
12.5-18.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18.5-24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	16	18	18	35	15	6	8	5	11	35	125	45	26	7	7	14	391

Class G Freq: 0.025

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
0.95-3.5	1	1	0	10	4	0	0	0	1	0	4	14	5	0	1	1	42
3.5-7.5	0	0	0	1	0	0	0	0	0	1	9	0	0	0	0	0	11
7.5-12.5	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
12.5-18.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18.5-24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	1	1	0	11	4	0	0	0	1	1	14	14	5	0	2	1	55

Class All Freq: 1.000

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	1	0	1	1	0	1	2	0	1	2	2	1	0	2	1	0	15
0.95-3.5	42	56	51	75	79	41	34	33	52	50	58	99	63	39	47	44	863
3.5-7.5	16	42	89	50	52	48	28	19	59	352	284	104	51	20	28	8	1250
7.5-12.5	1	0	0	2	3	0	0	0	3	42	24	1	0	0	4	0	80
12.5-18.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18.5-24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	60	98	141	128	134	90	64	52	115	446	368	205	114	61	80	52	2208

Table A-1 (continued)

Oct-Dec 2009

Class A Freq: 0.062

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.95-3.5	0	2	6	0	0	0	0	0	0	0	0	0	1	0	0	1	10
3.5-7.5	8	12	17	1	1	2	0	0	0	0	0	0	3	19	10	6	79
7.5-12.5	0	5	17	1	0	0	0	0	0	0	0	0	6	12	3	0	44
12.5-18.5	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	3
18.5-24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	8	19	40	2	1	2	0	0	0	0	0	0	10	34	13	7	136

Class B Freq: 0.041

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.95-3.5	0	2	1	1	0	0	0	0	0	0	0	0	0	1	1	0	6
3.5-7.5	0	8	13	1	0	0	4	1	0	0	2	0	5	13	1	2	50
7.5-12.5	0	3	17	1	0	0	0	0	0	2	0	0	6	2	0	1	32
12.5-18.5	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	2
18.5-24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	0	14	31	3	0	0	4	1	0	2	2	0	11	17	2	3	90

Class C Freq: 0.067

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.95-3.5	2	2	1	2	1	1	0	0	0	0	0	0	1	1	0	1	12
3.5-7.5	2	5	24	0	0	2	0	1	0	2	5	2	6	4	3	3	59
7.5-12.5	1	15	30	5	0	0	0	0	2	1	1	3	2	6	0	3	69
12.5-18.5	3	3	0	0	0	0	0	0	0	0	0	0	0	2	0	0	8
18.5-24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	8	25	55	7	1	3	0	1	2	3	6	5	9	13	3	7	148

Class D Freq: 0.507

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1
0.95-3.5	14	11	9	4	5	3	7	12	3	5	7	8	12	7	9	9	125
3.5-7.5	17	54	65	22	16	18	17	12	22	43	24	66	89	84	53	17	619
7.5-12.5	9	36	39	9	4	13	6	5	18	35	8	8	56	53	39	9	347
12.5-18.5	3	10	2	0	0	6	0	0	2	1	1	0	0	1	0	0	26
18.5-24	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
>24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	43	112	115	35	25	40	30	29	45	85	40	82	157	145	101	35	1119

Table A-1 (continued)

Oct-Dec 2009

Class E Freq: 0.245

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	2
0.95-3.5	8	8	4	3	6	3	11	21	29	15	21	30	27	14	9	9	218
3.5-7.5	0	4	4	0	8	8	9	14	10	31	42	81	44	11	13	2	281
7.5-12.5	0	0	1	0	3	1	10	0	1	2	4	4	6	7	0	0	39
12.5-18.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18.5-24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	8	12	9	3	17	12	30	35	40	48	69	115	77	32	22	11	540

Class F Freq: 0.067

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1
0.95-3.5	1	2	1	0	0	0	2	3	9	13	21	24	5	4	0	3	88
3.5-7.5	0	0	0	0	0	0	0	1	0	7	41	8	1	0	0	0	58
7.5-12.5	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1
12.5-18.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18.5-24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	1	2	1	0	0	0	2	4	9	22	62	32	6	4	0	3	148

Class G Freq: 0.012

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.95-3.5	0	0	0	0	0	0	0	0	0	1	5	7	0	0	0	0	13
3.5-7.5	0	0	0	0	0	0	0	0	0	0	13	1	0	0	0	0	14
7.5-12.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12.5-18.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18.5-24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	0	0	0	0	0	0	0	0	0	1	18	8	0	0	0	0	27

Class All Freq: 1.000

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	2	2	0	0	0	0	0	4
0.95-3.5	25	27	22	10	12	7	20	36	41	34	54	69	46	27	19	23	472
3.5-7.5	27	83	123	24	25	30	30	29	32	83	127	158	148	131	80	30	1160
7.5-12.5	10	59	104	16	7	14	16	5	21	41	13	15	76	80	42	13	532
12.5-18.5	6	14	2	0	0	6	0	0	2	1	1	0	0	7	0	0	39
18.5-24	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
>24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	68	184	251	50	44	57	66	70	96	161	197	242	270	245	141	66	2208

Table A-1 (continued)

Jan-Dec 2009

Class A Freq: 0.035

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.95-3.5	0	3	9	0	0	0	0	0	0	0	1	1	2	2	0	1	19
3.5-7.5	13	22	60	10	10	4	1	1	0	4	5	3	6	21	13	10	183
7.5-12.5	8	11	22	1	1	0	0	0	1	3	3	2	10	18	6	8	94
12.5-18.5	0	0	0	0	0	0	0	0	0	0	0	0	1	3	0	0	4
18.5-24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	21	36	91	11	11	4	1	1	1	7	9	6	19	44	19	19	300

Class B Freq: 0.023

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.95-3.5	0	3	5	3	1	0	0	0	0	0	0	0	2	2	3	0	19
3.5-7.5	13	15	21	7	2	5	5	2	0	5	4	4	9	16	2	4	114
7.5-12.5	2	12	23	1	1	1	0	0	0	6	2	1	6	5	1	1	62
12.5-18.5	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	2
18.5-24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	15	31	49	11	4	6	5	2	0	11	6	5	17	24	6	5	197

Class C Freq: 0.041

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.95-3.5	3	3	2	2	2	3	2	1	1	0	0	1	1	2	1	2	26
3.5-7.5	16	23	45	4	3	5	2	3	2	11	12	6	11	13	17	6	179
7.5-12.5	9	28	32	5	1	0	0	0	3	6	2	3	8	18	6	9	130
12.5-18.5	3	8	0	0	0	0	0	0	0	1	0	0	0	2	0	0	14
18.5-24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	31	62	79	11	6	8	4	4	6	18	14	10	20	35	24	17	349

Class D Freq: 0.497

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	2	0	0	0	1	0	1	0	0	1	0	0	0	0	0	0	5
0.95-3.5	69	64	52	32	55	39	46	56	48	37	44	42	33	28	50	45	740
3.5-7.5	85	183	177	79	79	100	95	68	113	361	148	225	310	214	154	72	2463
7.5-12.5	25	97	43	11	12	32	14	10	69	225	47	35	193	109	72	20	1014
12.5-18.5	3	12	2	0	0	6	0	0	3	6	1	0	0	1	0	0	34
18.5-24	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
>24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	184	357	274	122	147	177	156	134	233	630	240	302	536	352	276	137	4257

Table A-1 (continued)

Jan-Dec 2009

Class E Freq: 0.301

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	2	1	1	0	1	0	0	0	0	5	1	0	1	1	0	13
0.95-3.5	47	44	38	53	63	24	52	72	90	69	73	102	92	68	54	57	998
3.5-7.5	20	38	29	26	65	46	28	41	79	278	298	243	121	50	38	12	1412
7.5-12.5	1	0	1	0	3	1	10	0	7	61	48	8	11	8	0	0	159
12.5-18.5	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1
18.5-24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	68	84	69	80	131	72	90	113	176	409	424	354	224	127	93	69	2583

Class F Freq: 0.089

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	1	0	0	1	1	0	1	3	0	1	0	1	0	0	9
0.95-3.5	19	28	23	46	21	8	12	15	24	38	57	74	33	12	11	22	443
3.5-7.5	7	0	1	18	16	3	3	1	4	30	174	23	2	1	2	1	286
7.5-12.5	0	0	0	0	0	0	0	0	0	6	15	1	0	0	0	0	22
12.5-18.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18.5-24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	26	28	25	64	37	12	16	16	29	77	246	99	35	14	13	23	760

Class G Freq: 0.014

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
0.95-3.5	2	2	5	16	5	0	0	1	2	1	11	25	8	0	1	1	80
3.5-7.5	0	0	0	3	3	0	0	0	0	1	28	3	1	0	0	1	40
7.5-12.5	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	2
12.5-18.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18.5-24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	2	2	5	19	8	0	0	1	2	2	41	28	9	0	2	2	123

Class All Freq: 1.000

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	2	2	2	1	1	2	2	0	1	4	5	2	0	2	2	0	28
0.95-3.5	140	147	134	152	147	74	112	145	165	145	186	245	171	114	120	128	2325
3.5-7.5	154	281	333	147	178	163	134	116	198	690	669	507	460	315	226	106	4677
7.5-12.5	45	148	121	18	18	34	24	10	80	307	119	50	228	158	85	38	1483
12.5-18.5	6	21	2	0	0	6	0	0	3	8	1	0	1	7	0	0	55
18.5-24	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
>24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	347	600	592	318	344	279	272	271	447	1154	980	804	860	596	433	272	8569

Table A-2
Joint Frequency Distribution of Wind Directions and Speeds
For the 220-ft level of the 220-ft Tower

Jan-Mar 2009

Class A Freq: 0.028

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.95-3.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3.5-7.5	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
7.5-12.5	0	0	3	0	0	0	0	0	0	0	0	0	0	1	0	0	4
12.5-18.5	4	0	8	0	0	0	0	0	0	0	1	0	1	0	1	1	16
18.5-24	3	1	2	0	0	0	0	0	0	0	0	3	0	0	2	1	12
>24	9	0	0	0	0	0	0	0	0	0	0	0	1	9	3	4	26
TOTAL	16	2	13	0	0	0	0	0	0	0	1	3	2	10	6	6	59

Class B Freq: 0.024

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.95-3.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3.5-7.5	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	2
7.5-12.5	0	1	2	1	0	1	0	0	0	0	0	0	0	2	0	0	7
12.5-18.5	2	1	6	0	0	0	0	0	0	0	0	0	2	2	0	3	16
18.5-24	1	5	1	0	0	0	0	0	0	0	2	1	1	0	2	4	17
>24	5	1	0	0	0	0	0	0	0	0	0	0	0	2	0	1	9
TOTAL	8	8	10	1	0	1	0	0	0	0	2	1	3	6	3	8	51

Class C Freq: 0.051

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.95-3.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3.5-7.5	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	4
7.5-12.5	1	0	1	1	0	0	0	2	0	1	0	1	0	0	0	0	7
12.5-18.5	4	2	5	0	0	0	0	0	0	0	1	0	3	5	6	4	30
18.5-24	5	3	0	0	0	0	0	0	0	1	0	0	0	4	8	3	24
>24	17	2	0	0	0	0	0	0	0	0	0	0	1	8	8	7	43
TOTAL	28	8	7	2	0	0	0	2	0	2	1	1	4	17	22	14	108

Class D Freq: 0.651

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.95-3.5	0	0	1	0	0	0	1	0	2	2	0	2	0	0	0	1	9
3.5-7.5	0	1	5	4	2	2	1	4	2	6	1	2	3	1	1	1	36
7.5-12.5	8	9	11	15	17	19	11	16	10	23	22	22	30	24	27	10	274
12.5-18.5	23	11	1	3	7	7	23	12	13	47	23	52	98	71	42	23	456
18.5-24	17	6	1	0	8	6	17	2	6	55	24	17	78	75	38	28	378
>24	32	5	0	0	4	2	1	0	4	20	0	2	34	73	19	22	218
TOTAL	80	32	19	22	38	36	54	34	37	153	70	97	243	244	127	85	1371

Table A-2 (continued)

Jan-Mar 2009

Class E Freq: 0.216

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.95-3.5	0	1	0	0	0	0	0	1	2	0	1	0	0	1	0	1	7
3.5-7.5	6	6	7	5	2	0	3	1	9	10	11	8	0	9	11	6	94
7.5-12.5	13	2	0	0	8	5	6	7	8	19	19	18	24	26	6	3	164
12.5-18.5	5	1	0	0	0	2	4	10	4	9	22	22	31	6	3	2	121
18.5-24	3	0	0	0	0	0	0	0	7	9	25	10	1	1	0	3	59
>24	0	0	0	0	0	0	0	0	0	3	0	0	2	5	0	0	10
TOTAL	27	10	7	5	10	7	13	19	30	50	78	58	58	48	20	15	455

Class F Freq: 0.027

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.95-3.5	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
3.5-7.5	1	0	1	0	1	1	1	0	0	2	1	3	0	0	0	0	11
7.5-12.5	0	0	0	0	0	1	0	1	4	3	4	0	5	2	0	0	20
12.5-18.5	1	0	0	0	0	0	0	2	2	1	3	7	3	0	0	0	19
18.5-24	0	0	0	0	0	0	0	0	0	1	4	0	0	0	0	0	5
>24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	2	0	2	0	1	2	1	3	6	7	12	10	8	2	0	0	56

Class G Freq: 0.002

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.95-3.5	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1
3.5-7.5	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1
7.5-12.5	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	2
12.5-18.5	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1
18.5-24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	0	0	0	0	0	1	0	0	0	1	0	2	1	0	0	0	5

Class All Freq: 1.000

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.95-3.5	0	1	2	0	0	0	1	1	4	3	1	2	0	1	0	2	18
3.5-7.5	8	9	15	10	5	4	5	5	11	18	13	13	3	10	13	7	149
7.5-12.5	22	12	17	17	25	26	17	26	22	46	45	42	60	55	33	13	478
12.5-18.5	39	15	20	3	7	9	27	24	19	57	50	82	138	84	52	33	659
18.5-24	29	15	4	0	8	6	17	2	13	66	55	31	80	80	50	39	495
>24	63	8	0	0	4	2	1	0	4	23	0	2	38	97	30	34	306
TOTAL	161	60	58	30	49	47	68	58	73	213	164	172	319	327	178	128	2105

Table A-2 (continued)

Apr-Jun 2009

Class A Freq: 0.034

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.95-3.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
3.5-7.5	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	2
7.5-12.5	0	6	11	1	0	0	0	0	0	1	3	1	1	1	0	0	25
12.5-18.5	2	3	6	2	3	1	0	0	0	3	2	1	0	0	1	0	24
18.5-24	5	0	0	0	1	1	0	0	1	1	0	0	0	2	3	1	15
>24	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	2
TOTAL	7	9	18	3	4	3	0	0	1	5	5	2	1	4	4	3	69

Class B Freq: 0.018

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.95-3.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3.5-7.5	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	2
7.5-12.5	0	2	0	2	0	0	0	0	0	1	0	2	0	1	0	0	8
12.5-18.5	0	2	1	0	2	1	0	0	0	2	1	2	1	0	0	0	12
18.5-24	2	1	0	0	2	3	0	0	0	2	0	0	0	2	0	0	12
>24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	2
TOTAL	2	5	2	3	4	4	0	0	0	5	1	4	1	3	2	0	36

Class C Freq: 0.029

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.95-3.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3.5-7.5	0	0	0	1	0	0	0	0	0	1	1	0	0	0	0	0	3
7.5-12.5	0	2	3	2	0	2	0	1	0	2	2	2	1	0	0	0	17
12.5-18.5	3	1	0	0	1	2	1	1	1	6	2	0	0	0	0	1	19
18.5-24	2	0	1	0	2	0	0	0	0	4	0	0	1	3	2	1	16
>24	0	0	0	0	0	0	0	0	0	0	0	0	1	3	1	0	5
TOTAL	5	3	4	3	3	4	1	2	1	13	5	2	3	6	3	2	60

Class D Freq: 0.506

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.95-3.5	0	0	2	2	0	0	0	2	0	0	0	0	0	0	0	1	7
3.5-7.5	9	8	21	9	7	6	2	7	5	6	4	4	2	5	7	5	107
7.5-12.5	21	15	24	10	23	19	26	9	15	27	22	22	7	7	5	18	270
12.5-18.5	21	11	13	8	6	7	26	22	31	98	36	15	26	10	6	29	365
18.5-24	24	13	1	3	2	7	4	9	23	44	18	1	22	12	6	6	195
>24	40	15	0	0	0	7	0	0	1	3	3	0	8	3	12	1	93
TOTAL	115	62	61	32	38	46	58	49	75	178	83	42	65	37	36	60	1037

Table A-2 (continued)

Apr-Jun 2009

Class E Freq: 0.315

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.95-3.5	3	5	5	4	2	3	1	1	0	0	0	0	1	1	1	3	30
3.5-7.5	20	18	11	12	9	9	10	12	7	3	3	5	8	8	4	13	152
7.5-12.5	14	8	2	7	10	26	21	14	20	29	12	10	9	12	12	5	211
12.5-18.5	2	1	1	0	0	7	11	17	23	34	18	10	7	8	5	6	150
18.5-24	4	1	1	2	1	0	1	0	4	21	33	11	6	4	1	0	90
>24	5	0	0	0	0	0	0	0	0	0	4	0	0	2	1	0	12
TOTAL	48	33	20	25	22	45	44	44	54	87	70	36	31	35	24	27	645

Class F Freq: 0.081

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.95-3.5	2	2	5	0	0	0	1	2	2	2	1	0	1	0	2	0	20
3.5-7.5	6	5	4	5	14	2	1	1	6	2	2	1	4	4	1	3	61
7.5-12.5	1	0	0	0	0	6	5	3	2	1	3	3	6	4	0	0	34
12.5-18.5	2	0	1	0	0	0	1	4	3	3	1	1	6	3	0	1	26
18.5-24	1	0	0	0	0	0	0	1	0	1	10	4	0	0	0	0	17
>24	0	0	0	0	0	0	0	0	0	3	2	0	0	0	0	2	7
TOTAL	12	7	10	5	14	8	8	11	13	12	19	9	17	11	3	6	165

Class G Freq: 0.018

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.95-3.5	0	0	0	0	1	0	0	0	1	1	0	0	0	1	0	0	4
3.5-7.5	1	2	0	0	1	3	1	3	1	1	1	2	3	1	2	0	22
7.5-12.5	0	0	0	0	0	0	1	1	0	0	0	0	3	1	0	0	6
12.5-18.5	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	2
18.5-24	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1
>24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
TOTAL	1	2	0	0	2	3	2	4	2	3	1	2	7	4	2	1	36

Class All Freq: 1.000

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.95-3.5	5	7	12	6	3	3	2	5	3	3	1	0	2	2	3	5	62
3.5-7.5	36	33	38	28	31	21	14	23	19	13	11	12	17	18	14	21	349
7.5-12.5	36	33	40	22	33	53	53	28	37	61	42	40	27	26	17	23	571
12.5-18.5	30	18	22	10	12	18	39	44	58	146	60	29	41	22	12	37	598
18.5-24	38	15	3	5	8	11	5	10	28	74	61	16	29	23	12	8	346
>24	45	15	0	0	0	7	0	0	1	6	9	0	9	9	16	5	122
TOTAL	190	121	115	71	87	113	113	110	146	303	184	97	125	100	74	99	2048

Table A-2 (continued)

Jul-Sep 2009

Class A Freq: 0.016

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.95-3.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3.5-7.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7.5-12.5	0	0	5	1	0	0	0	0	0	2	0	3	0	0	0	0	11
12.5-18.5	0	0	4	6	1	0	0	1	0	1	0	0	0	1	0	0	14
18.5-24	0	0	4	4	0	1	0	0	0	0	0	0	0	0	1	0	10
>24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
TOTAL	0	0	13	11	1	1	0	1	0	3	0	3	0	1	2	0	36

Class B Freq: 0.009

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.95-3.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3.5-7.5	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	2
7.5-12.5	0	1	1	2	1	0	0	0	0	0	1	1	0	0	0	0	7
12.5-18.5	0	0	1	1	0	0	0	1	0	3	0	0	0	0	0	1	7
18.5-24	3	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	4
>24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	3	1	4	3	2	0	0	1	0	3	1	1	0	0	0	1	20

Class C Freq: 0.015

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.95-3.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3.5-7.5	0	0	2	0	0	0	0	0	0	0	0	1	0	0	0	0	3
7.5-12.5	0	1	3	0	1	0	0	0	0	0	3	0	0	0	1	0	9
12.5-18.5	1	5	4	0	0	0	0	2	0	1	0	0	0	0	0	0	13
18.5-24	1	0	2	2	1	0	0	0	0	0	0	0	0	0	0	0	6
>24	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
TOTAL	4	6	11	2	2	0	0	2	0	1	3	1	0	0	1	0	33

Class D Freq: 0.331

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.95-3.5	0	1	0	0	1	0	0	0	0	1	0	0	0	0	0	1	4
3.5-7.5	5	1	7	3	2	0	0	0	2	1	4	2	1	0	2	3	33
7.5-12.5	16	15	18	9	13	12	10	14	14	29	27	3	1	3	3	11	198
12.5-18.5	9	10	24	30	14	4	13	5	19	128	56	7	11	3	6	4	343
18.5-24	3	11	3	35	13	4	10	0	1	22	9	3	1	4	7	1	127
>24	3	1	0	7	1	0	0	0	0	0	0	0	0	1	7	5	25
TOTAL	36	39	52	84	44	20	33	19	36	181	96	15	14	11	25	25	730

Table A-2 (continued)

Jul-Sep 2009

Class E Freq: 0.427

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.95-3.5	0	0	4	1	0	0	1	1	1	1	1	1	0	0	0	1	12
3.5-7.5	10	6	17	15	20	18	10	4	2	6	9	6	4	5	4	12	148
7.5-12.5	17	6	8	5	18	22	34	18	27	33	21	25	37	24	18	11	324
12.5-18.5	13	3	0	2	3	1	10	12	25	91	59	51	62	12	14	8	366
18.5-24	1	0	0	2	0	1	1	2	2	31	34	2	2	5	3	2	88
>24	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	5
TOTAL	42	15	29	25	41	42	56	37	57	162	124	85	105	46	39	38	943

Class F Freq: 0.177

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.95-3.5	5	4	10	5	2	1	1	2	1	0	0	0	2	0	2	1	36
3.5-7.5	19	11	3	8	20	15	7	2	2	6	6	6	6	5	13	17	146
7.5-12.5	3	0	1	0	4	4	5	7	6	2	8	13	13	9	9	6	90
12.5-18.5	2	0	0	0	0	0	0	5	9	11	29	18	16	1	3	2	96
18.5-24	0	0	0	0	0	0	0	0	0	2	13	3	0	2	0	0	20
>24	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
TOTAL	32	15	14	13	26	20	13	16	18	21	56	40	37	17	27	26	391

Class G Freq: 0.025

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.95-3.5	2	2	2	1	2	1	0	0	2	0	0	0	0	0	1	1	14
3.5-7.5	2	0	0	1	2	6	3	1	1	1	0	0	1	0	1	3	22
7.5-12.5	0	0	0	0	0	0	0	1	1	1	1	1	5	2	0	0	12
12.5-18.5	0	0	0	0	0	0	0	0	0	0	2	1	3	0	0	0	6
18.5-24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>24	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
TOTAL	5	2	2	2	4	7	3	2	4	2	3	2	9	2	2	4	55

Class All Freq: 1.000

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.95-3.5	7	7	16	7	5	2	2	3	4	2	1	1	2	0	3	4	66
3.5-7.5	36	18	31	27	44	39	20	7	7	14	19	15	12	10	20	35	354
7.5-12.5	36	23	36	17	37	38	49	40	48	67	61	46	56	38	31	28	651
12.5-18.5	25	18	33	39	18	5	23	26	53	235	146	77	92	17	23	15	845
18.5-24	8	11	9	43	15	6	11	2	3	55	56	8	3	11	11	3	255
>24	10	1	0	7	1	0	0	0	0	0	0	0	0	1	8	9	37
TOTAL	122	78	125	140	120	90	105	78	115	373	283	147	165	77	96	94	2208

Table A-2 (continued)

Oct-Dec 2009

Class A Freq: 0.062

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.95-3.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3.5-7.5	4	4	4	0	0	0	0	0	0	0	0	0	0	0	1	1	14
7.5-12.5	2	1	3	0	1	3	0	0	0	0	0	1	2	9	4	1	27
12.5-18.5	4	7	19	1	0	0	0	0	0	0	0	0	2	6	1	3	43
18.5-24	0	5	5	2	0	0	0	0	0	0	0	0	3	11	2	2	30
>24	0	0	2	2	0	0	0	0	0	0	0	0	0	13	3	2	22
TOTAL	10	17	33	5	1	3	0	0	0	0	0	1	7	39	11	9	136

Class B Freq: 0.041

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.95-3.5	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
3.5-7.5	1	1	0	1	1	0	0	0	0	0	0	1	0	2	0	0	7
7.5-12.5	0	0	1	0	0	1	2	0	0	0	0	0	2	2	0	1	9
12.5-18.5	0	5	5	0	0	0	2	0	0	2	1	1	1	5	0	0	22
18.5-24	0	5	10	4	0	0	0	0	0	0	0	0	4	5	3	1	32
>24	1	4	6	2	0	0	0	0	0	0	0	0	0	3	1	2	19
TOTAL	2	15	23	7	1	1	4	0	0	2	1	2	7	17	4	4	90

Class C Freq: 0.067

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.95-3.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3.5-7.5	1	2	1	3	1	2	0	0	0	0	1	0	1	1	0	1	14
7.5-12.5	0	0	2	0	0	1	0	1	0	0	2	2	1	0	0	0	9
12.5-18.5	0	4	20	0	0	0	0	0	0	3	3	3	4	2	0	4	43
18.5-24	0	8	18	4	0	0	0	0	2	0	0	0	0	4	6	0	42
>24	10	5	8	4	0	0	0	0	0	0	0	0	1	4	2	5	39
TOTAL	11	19	49	11	1	3	0	1	2	3	6	5	7	11	8	10	147

Class D Freq: 0.506

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.95-3.5	1	1	0	1	0	0	0	1	0	1	0	2	1	1	0	1	10
3.5-7.5	5	3	7	7	0	4	8	2	2	2	2	3	2	5	1	2	55
7.5-12.5	10	18	24	10	0	3	3	10	6	10	14	7	11	8	14	7	155
12.5-18.5	11	19	25	15	8	11	5	11	15	32	21	20	50	48	27	8	326
18.5-24	10	12	18	19	7	11	9	9	10	32	7	16	55	47	41	14	317
>24	31	23	16	17	6	7	6	0	3	3	2	0	14	61	45	18	252
TOTAL	68	76	90	69	21	36	31	33	36	80	46	48	133	170	128	50	1115

Table A-2 (continued)

Oct-Dec 2009

Class E Freq: 0.245

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.95-3.5	0	1	1	0	1	1	2	1	0	0	0	0	0	0	0	0	7
3.5-7.5	5	3	4	5	4	4	1	3	2	4	1	3	6	3	5	4	57
7.5-12.5	9	5	5	2	1	1	6	13	13	12	8	15	32	10	8	11	151
12.5-18.5	2	2	1	0	0	7	14	19	16	19	11	31	51	29	8	2	212
18.5-24	0	1	0	3	3	5	4	0	1	4	10	17	5	15	7	1	76
>24	0	0	1	1	4	1	9	1	1	0	0	0	3	9	6	1	37
TOTAL	16	12	12	11	13	19	36	37	33	39	30	66	97	66	34	19	540

Class F Freq: 0.067

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.95-3.5	1	2	0	2	2	0	0	1	1	0	2	2	0	0	0	1	14
3.5-7.5	4	0	0	0	0	0	1	2	1	2	6	2	1	3	1	0	23
7.5-12.5	2	1	0	0	0	1	8	4	10	1	7	6	9	9	1	0	59
12.5-18.5	1	0	0	0	0	1	0	1	1	1	20	8	7	2	3	0	45
18.5-24	0	0	0	0	0	0	0	0	0	2	2	2	1	0	0	0	7
>24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	8	3	0	2	2	2	9	8	13	6	37	20	18	14	5	1	148

Class G Freq: 0.012

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.95-3.5	0	1	0	0	1	0	0	0	0	0	0	0	1	0	0	1	4
3.5-7.5	1	0	0	1	0	0	0	1	0	0	0	0	0	2	0	1	6
7.5-12.5	0	0	0	0	0	0	0	1	0	0	2	5	1	0	0	0	9
12.5-18.5	0	0	0	0	0	0	0	1	0	0	3	2	2	0	0	0	8
18.5-24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	1	1	0	1	1	0	0	3	0	0	5	7	4	2	0	2	27

Class All Freq: 1.000

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.95-3.5	2	5	2	3	4	1	2	3	1	1	2	4	2	1	0	3	36
3.5-7.5	21	13	16	17	6	10	10	8	5	8	10	9	10	16	8	9	176
7.5-12.5	23	25	35	12	2	10	19	29	29	23	33	36	58	38	27	20	419
12.5-18.5	18	37	70	16	8	19	21	32	32	57	59	65	117	92	39	17	699
18.5-24	10	31	51	32	10	16	13	9	13	38	19	35	68	82	59	18	504
>24	42	32	33	26	10	8	15	1	4	3	2	0	18	90	57	28	369
TOTAL	116	143	207	106	40	64	80	82	84	130	125	149	273	319	190	95	2203

Table A-2 (continued)

Jan-Dec 2009

Class A Freq: 0.035

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.95-3.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
3.5-7.5	4	5	5	0	0	1	0	0	0	0	0	0	0	0	1	1	17
7.5-12.5	2	7	22	2	1	3	0	0	0	3	3	5	3	11	4	1	67
12.5-18.5	10	10	37	9	4	1	0	1	0	4	3	1	3	7	3	4	97
18.5-24	8	6	11	6	1	2	0	0	1	1	0	3	3	13	8	4	67
>24	9	0	2	2	0	0	0	0	0	0	0	0	1	23	7	7	51
TOTAL	33	28	77	19	6	7	0	1	1	8	6	9	10	54	23	18	300

Class B Freq: 0.023

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.95-3.5	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
3.5-7.5	1	1	4	2	1	0	0	0	0	0	0	1	0	2	1	0	13
7.5-12.5	0	4	4	5	1	2	2	0	0	1	1	3	2	5	0	1	31
12.5-18.5	2	8	13	1	2	1	2	1	0	7	2	3	4	7	0	4	57
18.5-24	6	11	11	4	3	3	0	0	0	2	2	1	5	7	5	5	65
>24	6	5	6	2	0	0	0	0	0	0	0	0	0	5	3	3	30
TOTAL	15	29	39	14	7	6	4	1	0	10	5	8	11	26	9	13	197

Class C Freq: 0.041

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.95-3.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3.5-7.5	2	3	4	5	1	2	0	0	0	1	2	1	1	1	0	1	24
7.5-12.5	1	3	9	3	1	3	0	4	0	3	7	5	2	0	1	0	42
12.5-18.5	8	12	29	0	1	2	1	3	1	10	6	3	7	7	6	9	105
18.5-24	8	11	21	6	3	0	0	0	2	5	0	0	1	11	16	4	88
>24	29	7	8	4	0	0	0	0	0	0	0	0	3	15	11	12	89
TOTAL	48	36	71	18	6	7	1	7	3	19	15	9	14	34	34	26	348

Class D Freq: 0.497

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.95-3.5	1	2	3	3	1	0	1	3	2	4	0	4	1	1	0	4	30
3.5-7.5	19	13	40	23	11	12	11	13	11	15	11	11	8	11	11	11	231
7.5-12.5	55	57	77	44	53	53	50	49	45	89	85	54	49	42	49	46	897
12.5-18.5	64	51	63	56	35	29	67	50	78	305	136	94	185	132	81	64	1490
18.5-24	54	42	23	57	30	28	40	20	40	153	58	37	156	138	92	49	1017
>24	106	44	16	24	11	16	7	0	8	26	5	2	56	138	83	46	588
TOTAL	299	209	222	207	141	138	176	135	184	592	295	202	455	462	316	220	4253

Table A-2 (continued)

Jan-Dec 2009

Class E Freq: 0.302

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.95-3.5	3	7	10	5	3	4	4	4	3	1	2	1	1	2	1	5	56
3.5-7.5	41	33	39	37	35	31	24	20	20	23	24	22	18	25	24	35	451
7.5-12.5	53	21	15	14	37	54	67	52	68	93	60	68	102	72	44	30	850
12.5-18.5	22	7	2	2	3	17	39	58	68	153	110	114	151	55	30	18	849
18.5-24	8	2	1	7	4	6	6	2	14	65	102	40	14	25	11	6	313
>24	6	0	1	1	4	1	9	1	1	3	4	0	5	16	7	5	64
TOTAL	133	70	68	66	86	113	149	137	174	338	302	245	291	195	117	99	2583

Class F Freq: 0.089

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.95-3.5	8	8	16	7	4	1	2	5	4	2	3	2	3	0	4	2	71
3.5-7.5	30	16	8	13	35	18	10	5	9	12	15	12	11	12	15	20	241
7.5-12.5	6	1	1	0	4	12	18	15	22	7	22	22	33	24	10	6	203
12.5-18.5	6	0	1	0	0	1	1	12	15	16	53	34	32	6	6	3	186
18.5-24	1	0	0	0	0	0	0	1	0	6	29	9	1	2	0	0	49
>24	3	0	0	0	0	0	0	0	0	3	2	0	0	0	0	2	10
TOTAL	54	25	26	20	43	32	31	38	50	46	124	79	80	44	35	33	760

Class G Freq: 0.014

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.95-3.5	2	3	2	1	4	1	0	0	3	2	0	0	1	1	1	2	23
3.5-7.5	4	2	0	2	3	10	4	5	2	2	1	2	4	3	3	4	51
7.5-12.5	0	0	0	0	0	0	1	3	1	1	3	7	10	3	0	0	29
12.5-18.5	0	0	0	0	0	0	0	1	0	0	5	4	6	1	0	0	17
18.5-24	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1
>24	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2
TOTAL	7	5	2	3	7	11	5	9	6	6	9	13	21	8	4	7	123

Class All Freq: 1.000

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.95-3.5	14	20	32	16	12	6	7	12	12	9	5	7	6	4	6	14	182
3.5-7.5	101	73	100	82	86	74	49	43	42	53	53	49	42	54	55	72	1028
7.5-12.5	117	93	128	68	97	127	138	123	136	197	181	164	201	157	108	84	2119
12.5-18.5	112	88	145	68	45	51	110	126	162	495	315	253	388	215	126	102	2801
18.5-24	85	72	67	80	41	39	46	23	57	233	191	90	180	196	132	68	1600
>24	160	56	33	33	15	17	16	1	9	32	11	2	65	197	111	76	834
TOTAL	589	402	505	347	296	314	366	328	418	1019	756	565	882	823	538	416	8564

APPENDIX B

Results of Onsite Groundwater Monitoring Program

In response to the Nuclear Energy Institute (NEI) Groundwater Protection Initiative, Pilgrim Station instituted a groundwater monitoring program during 2007. Four monitoring wells were installed during the fourth quarter of 2007, and the first samples were collected in late November 2007. All four wells were installed onsite, within the protected area fence. Since these are onsite wells, they are not considered part of the Radiological Environmental Monitoring Program (REMP), and data from these wells are being reported in the annual Radiological Effluent Release Report. Also, there were no leaks or spills of radioactive material at Pilgrim Station during 2009 that could have affected onsite or offsite groundwater

Two pre-existing wells were incorporated into the groundwater monitoring program in early 2008. Monitoring well MW-3 is located in the owner-controlled area near Rocky Hill Road, and was added to the program during the first quarter of 2008. Since monitoring well MW-3 is located slightly uphill of Pilgrim Station approximately 0.2 mile southwest of the power block, it is upgradient of the PNPS power block and outside of natural groundwater flow direction. As such, it is considered to be a control well indicative of baseline levels in the vicinity of Pilgrim Station. Monitoring well MW-4 is located within the protected area near the main transformer, and was added to the program during the 2nd quarter of 2008 as an additional onsite monitoring well. Due to an obstruction in monitoring well MW-4, it was not possible to collect sufficiently large (approximately 1 gallon) sample for gamma spectroscopy analyses during 2009. Therefore, no gamma analyses were performed on samples from MW-4 during the 3rd and 4th quarters, and the insufficient volume collected in the 1st and 2nd quarters resulted in problems in achieving targeted detection sensitivities for some gamma emitters. However, tritium analyses were performed on samples from this well during each quarter of 2009.

All samples collected were analyzed for tritium, a radioactive isotope of hydrogen, and well as for gamma emitting radionuclides and hard-to-detect beta emitting nuclides. In accordance with industry practice established under the NEI initiative, lower limits of detection (LLDs) used for analysis of REMP samples were used when assessing these samples for the presence of radioactivity. Due to a change in staffing in the group that ships radioactive samples from Pilgrim Station, there was a delay in the delivery of the 3rd and 4th quarter samples to the analytical laboratory. These delays resulted in difficulties in achieving the targeted LLDs for short-lived nuclides such as Fe-59, I-131, and Ba/La-140. These difficulties in achieving LLDs are indicated in the following table by an asterisk next to those results for which targeted LLDs were not met.

Results of the quarterly samples are presented in the following tables. In these tables, a value of "NDA < xx" in the quarterly columns indicates that no activity was detected in the sample when analyzed to the minimum-detectable level following the "<" sign. For example, the sample collected from MW-201 during the first quarter of 2009 was analyzed by gamma spectroscopy for manganese-54 (Mn-54), and a minimum detectable concentration of 3.1 pCi/L was achieved on that sample. The achieved sensitivity of 3.1 pCi/L is well below the required REMP LLD of 15 pCi/L, and no Mn-54 activity was detected even when counted to this more sensitive level of detection.

As discussed earlier, naturally-occurring activity was detected in the samples. Such levels of natural radioactivity are expected as these radionuclides are dissolved into the groundwater from the rocks and soil. The fact that these low levels of naturally-occurring radioactivity can be detected demonstrated the ability of the gamma spectroscopy analyses to detect radioactivity in groundwater. If any plant-related gamma activity was contained in the groundwater, the analytical techniques used would be able to detect them.

Analyses for hard-to-detect nuclides, such as iron-55 (Fe-55), nickel-63 (Ni-63), strontium-89 (Sr-89), strontium-90 (Sr-90), and gross alpha were performed on the samples collected during the fourth quarter of 2007 and the first quarter of 2008. Since no plant-related gamma activity and no Fe-55, Ni-63, Sr-89, or Sr-90 was detected in either of these quarterly sets of samples, further analyses for these hard-to-detect nuclides will not be performed unless there is a significant increase in tritium levels, or if plant-related gamma activity is detected. The gross alpha activity detected during both quarters is commensurate with the naturally-occurring uranium/thorium activity present and detected in the groundwater.

Low levels of tritium, a radioactive isotope of hydrogen, were detected in the onsite wells. Although gamma spectroscopy and gross alpha analyses indicated the presence of naturally-occurring radioactivity, such as potassium-40 and radon daughters from the uranium/thorium decay chains, there was no indication of any plant-related radioactivity in the samples, other than tritium.

Concentrations of tritium ranged from non-detectable at less than 411 pCi/L, up to a maximum concentration of 1726 pCi/L. Such levels are well below the voluntary communication reporting level of 20,000 pCi/L as established by the EPA Drinking Water Standard. Although the EPA Standard provides a baseline for comparison, no drinking water sources are affected by this tritium. All of the affected wells are onsite, and the general groundwater flow pathway is under Pilgrim Station and out into the salt water of Cape Cod Bay. As such, there is no potential to influence any off-site drinking water wells. Even if worst-case assumptions were made and the water from monitoring well MW-201 (1726 pCi/L) was consumed as drinking water, the maximum dose consequence would be less than 0.10 mrem/yr. In actuality, any dose consequence would be much less than this, as any tritium-laden water potentially leaving the site would be diluted into the seawater of Cape Cod Bay before being incorporated into any ingestion pathways. No drinking water ingestion pathway exists.

Although there are no indications that the groundwater containing low concentrations of tritium is actually migrating offsite, a bounding calculation was performed to assess the potential dose impact of such a scenario. Based on the tritium concentrations detected during 2009, the annual average concentration of tritium in groundwater in the vicinity of the onsite shorefront of the protected area would be 890 pCi/L. Hydrological characteristics of the compacted backfill onsite indicate the hydraulic conductivity to be about 0.019 cm/sec, or 16.4 meters per day. When coupled with an assumed horizontal interface area 200 meters long by 5 meters deep that could potentially transmit groundwater into the intake bay, the annual discharge of groundwater would be about 6 billion Liters of water per year. Assuming this volume of 6 billion liters contained the average concentration of 890 pCi/L, the annual discharge of tritium into the intake bay under this hypothetical scenario would be 5.3 Curies. This activity represents less than 10% of the annual airborne effluent of tritium released from the reactor building vent (see Table 2.2-C). Such airborne effluents can be washed down to the ground surface during precipitation events and infiltrate into the ground, thereby introducing tritium into the groundwater.

In the hypothetical scenario described above, the 5.3 Curies of tritium entering the intake bay would be further diluted into the circulating water flow of the plant. As documented in Table 2.3-A, the total volume of circulating water flow during 2009 was 571 billion Liters, yielding an effective concentration of tritium in the intake bay of about 9.2 pCi/L. Such a concentration would be well below the detection sensitivity of about 450 pCi/L used to analyze water collected from the discharge canal as part of the radiological environmental monitoring program (REMP). The calculated dose to the maximum-exposed member of the public from such a hypothetical release would be 0.0000053 millirem, resulting from tritium incorporated into fish and shellfish. Since the tritium would be incorporated into seawater, there is no drinking water ingestion pathway in the described scenario.

In conclusion, there were no leaks or spills of radioactive material at Pilgrim Station during 2009 that could have affected onsite or offsite groundwater. The only radionuclide detected in groundwater during the 2009 monitoring effort that is attributable to Pilgrim Station operations is tritium, and all concentrations were well below any reporting criteria established in the Pilgrim Station Offsite Dose Calculation Manual and through EPA safe drinking water standards.

Monitoring Well MW-201 Results – 2009

Nuclide	Required LLD pCi/L	Radionuclide Concentration in Water – pCi/L Monitoring Well-201 Qtr-1 18-Mar-2009	Qtr-2 27-May-2009	Qtr-3 23-Sep-2009	Qtr-4 15-Dec-2009
H-3	3000	1292 ± 137	1205 ± 137	1726 ± 140	987 ± 134
K-40	Natural	NDA < 32.5	360 ± 14.1	40.2 ± 11.3	211 ± 10.2
Mn-54	15	NDA < 3.1	NDA < 2.1	NDA < 3.6	NDA < 1.9
Fe-59	30	NDA < 7.7	NDA < 7.0	NDA < 38.9*	NDA < 7.1
Co-58	15	NDA < 3.1	NDA < 2.4	NDA < 8.0	NDA < 2.2
Co-60	15	NDA < 2.9	NDA < 2.0	NDA < 3.9	NDA < 2.0
Zn-65	30	NDA < 4.4	NDA < 2.9	NDA < 9.0	NDA < 4.4
Zr-95	30	NDA < 7.0	NDA < 4.4	NDA < 13.2	NDA < 3.9
Nb-95	15	NDA < 4.1	NDA < 3.2	NDA < 18.2	NDA < 3.3
I-131	15	NDA < 9.2	NDA < 14.2	NDA <7451*	NDA < 29.5*
Cs-134	15	NDA < 2.3	NDA < 1.5	NDA < 2.7	NDA < 1.1
Cs-137	18	NDA < 3.4	NDA < 2.1	NDA < 3.0	NDA < 1.7
Ba/La-140	15	NDA < 7.3	NDA < 7.5	NDA < 479*	NDA < 13.9
Fe-55	N/A	No Analysis	No Analysis	No Analysis	No Analysis
Ni-63	N/A	No Analysis	No Analysis	No Analysis	No Analysis
Sr-89	N/A	No Analysis	No Analysis	No Analysis	No Analysis
Sr-90	N/A	No Analysis	No Analysis	No Analysis	No Analysis
Gross alpha	N/A	No Analysis	No Analysis	No Analysis	No Analysis

Monitoring Well MW-202 Results – 2009

Nuclide	Required LLD pCi/L	Radionuclide Concentration in Water - pCi/L Monitoring Well-202 Qtr-1 18-Mar-2009	Qtr-2 27-May-2009	Qtr-3 23-Sep-2009	Qtr-4 15-Dec-2009
H-3	3000	688 ± 131	615 ± 131	757 ± 131	919 ± 133
K-40	Natural	162 ± 20.1	72.7 ± 10.5	110 ± 20.2	437 ± 13.1
Mn-54	15	NDA < 4.0	NDA < 2.3	NDA < 5.0	NDA < 1.9
Fe-59	30	NDA < 10.8	NDA < 6.3	NDA < 41.6*	NDA < 8.0
Co-58	15	NDA < 4.4	NDA < 2.3	NDA < 8.9	NDA < 2.4
Co-60	15	NDA < 3.7	NDA < 2.3	NDA < 3.3	NDA < 1.9
Zn-65	30	NDA < 4.5	NDA < 3.1	NDA < 8.2	NDA < 2.9
Zr-95	30	NDA < 6.3	NDA < 3.9	NDA < 17.8	NDA < 4.4
Nb-95	15	NDA < 3.5	NDA < 2.7	NDA < 19.6	NDA < 3.4
I-131	15	NDA < 11.5	NDA < 13.3	NDA <8865*	NDA < 35.3*
Cs-134	15	NDA < 3.9	NDA < 1.7	NDA < 4.9	NDA < 1.3
Cs-137	18	NDA < 3.6	NDA < 1.8	NDA < 4.0	NDA < 1.8
Ba/La-140	15	NDA < 8.7	NDA < 9.0	NDA < 600*	NDA < 13.7
Fe-55	N/A	No Analysis	No Analysis	No Analysis	No Analysis
Ni-63	N/A	No Analysis	No Analysis	No Analysis	No Analysis
Sr-89	N/A	No Analysis	No Analysis	No Analysis	No Analysis
Sr-90	N/A	No Analysis	No Analysis	No Analysis	No Analysis
Gross alpha	N/A	No Analysis	No Analysis	No Analysis	No Analysis

* Required LLD not achieved due to delay in analysis of sample.

Monitoring Well MW-203 Results - 2009

Nuclide	Required LLD pCi/L	Radionuclide Concentration in Water - pCi/L			
		Monitoring Well-203			
		Qtr-1 18-Mar-2009	Qtr-2 27-May-2009	Qtr-3 23-Sep-2009	Qtr-4 15-Dec-2009
H-3	3000	681 ± 131	419 ± 129	663 ± 130	632 ± 130
K-40	Natural	NDA < 41.1	104 ± 9.3	NDA < 60.3	438 ± 10.3
Mn-54	15	NDA < 4.4	NDA < 1.8	NDA < 4.9	NDA < 1.6
Fe-59	30	NDA < 12.0	NDA < 5.7	NDA < 48.8*	NDA < 6.0
Co-58	15	NDA < 4.6	NDA < 2.2	NDA < 10.8	NDA < 2.1
Co-60	15	NDA < 4.7	NDA < 2.0	NDA < 4.4	NDA < 1.5
Zn-65	30	NDA < 10.4	NDA < 4.1	NDA < 11.6	NDA < 2.1
Zr-95	30	NDA < 7.8	NDA < 4.2	NDA < 18.2	NDA < 3.6
Nb-95	15	NDA < 4.4	NDA < 2.5	NDA < 26.4	NDA < 2.8
I-131	15	NDA < 13.0	NDA < 12.3	NDA <9144*	NDA < 27.4*
Cs-134	15	NDA < 3.4	NDA < 2.1	NDA < 5.5	NDA < 1.0
Cs-137	18	NDA < 3.7	NDA < 1.8	NDA < 4.4	NDA < 1.4
Ba/La-140	15	NDA < 10.6	NDA < 6.8	NDA < 823*	NDA < 10.0
Fe-55	N/A	No Analysis	No Analysis	No Analysis	No Analysis
Ni-63	N/A	No Analysis	No Analysis	No Analysis	No Analysis
Sr-89	N/A	No Analysis	No Analysis	No Analysis	No Analysis
Sr-90	N/A	No Analysis	No Analysis	No Analysis	No Analysis
Gross alpha	N/A	No Analysis	No Analysis	No Analysis	No Analysis

Monitoring Well MW-204 Results - 2009

Nuclide	Required LLD pCi/L	Radionuclide Concentration in Water - pCi/L			
		Monitoring Well-204			
		Qtr-1 18-Mar-2009	Qtr-2 27-May-2009	Qtr-3 23-Sep-2009	Qtr-4 15-Dec-2009
H-3	3000	774 ± 132	959 ± 134	1004 ± 133	875 ± 133
K-40	Natural	224 ± 26.4	126 ± 8.0	112 ± 19.4	77.4 ± 5.1
Mn-54	15	NDA < 4.1	NDA < 1.5	NDA < 4.5	NDA < 1.1
Fe-59	30	NDA < 14.6	NDA < 5.3	NDA < 36.3*	NDA < 4.1
Co-58	15	NDA < 4.7	NDA < 1.8	NDA < 10.2	NDA < 1.4
Co-60	15	NDA < 3.3	NDA < 1.5	NDA < 3.9	NDA < 1.1
Zn-65	30	NDA < 11.7	NDA < 1.9	NDA < 13.5	NDA < 1.5
Zr-95	30	NDA < 9.1	NDA < 3.3	NDA < 20.0	NDA < 2.6
Nb-95	15	NDA < 6.3	NDA < 1.5	NDA < 20.1	NDA < 2.0
I-131	15	NDA < 14.6	NDA < 11.1	NDA <9981*	NDA < 22.3*
Cs-134	15	NDA < 3.4	NDA < 1.6	NDA < 6.1	NDA < 0.8
Cs-137	18	NDA < 4.8	NDA < 1.4	NDA < 4.0	NDA < 1.1
Ba/La-140	15	NDA < 11.1	NDA < 5.3	NDA < 678*	NDA < 8.2
Fe-55	N/A	No Analysis	No Analysis	No Analysis	No Analysis
Ni-63	N/A	No Analysis	No Analysis	No Analysis	No Analysis
Sr-89	N/A	No Analysis	No Analysis	No Analysis	No Analysis
Sr-90	N/A	No Analysis	No Analysis	No Analysis	No Analysis
Gross alpha	N/A	No Analysis	No Analysis	No Analysis	No Analysis

* Required LLD not achieved due to delay in analysis of sample.

Monitoring Well MW-3 Results - 2009

Nuclide	Required LLD pCi/L	Radionuclide Concentration in Water - pCi/L Monitoring Well-3			
		Qtr-1 18-Mar-2009	Qtr-2 27-May-2009	Qtr-3 23-Sep-2009	Qtr-4 15-Dec-2009
H-3	3000	498 ± 129	NDA < 417	NDA < 411	NDA < 415
K-40	Natural	426 ± 31.4	106 ± 7.1	130 ± 29.7	126 ± 7.1
Mn-54	15	NDA < 4.9	NDA < 1.5	NDA < 5.7	NDA < 1.4
Fe-59	30	NDA < 14.7	NDA < 4.7	NDA < 58.6*	NDA < 5.7
Co-58	15	NDA < 5.1	NDA < 1.7	NDA < 11.4	NDA < 1.7
Co-60	15	NDA < 5.0	NDA < 1.4	NDA < 5.9	NDA < 1.3
Zn-65	30	NDA < 8.0	NDA < 1.9	NDA < 13.9	NDA < 1.9
Zr-95	30	NDA < 8.9	NDA < 3.2	NDA < 21.5	NDA < 2.9
Nb-95	15	NDA < 6.6	NDA < 2.1	NDA < 29.9	NDA < 2.2
I-131	15	NDA < 14.4	NDA < 10.5	NDA<12170*	NDA < 21.8*
Cs-134	15	NDA < 4.9	NDA < 1.1	NDA < 5.5	NDA < 1.6
Cs-137	18	NDA < 4.8	NDA < 1.3	NDA < 5.0	NDA < 1.3
Ba/La-140	15	NDA < 10.8	NDA < 5.6	NDA < 813*	NDA < 8.9
Fe-55	N/A	No Analysis	No Analysis	No Analysis	No Analysis
Ni-63	N/A	No Analysis	No Analysis	No Analysis	No Analysis
Sr-89	N/A	No Analysis	No Analysis	No Analysis	No Analysis
Sr-90	N/A	No Analysis	No Analysis	No Analysis	No Analysis
Gross alpha	N/A	No Analysis	No Analysis	No Analysis	No Analysis

Monitoring Well MW-4 Results - 2009

Nuclide	Required LLD pCi/L	Radionuclide Concentration in Water - pCi/L Monitoring Well-4			
		Qtr-1 18-Mar-2009	Qtr-2 27-May-2009	Qtr-3 23-Sep-2009	Qtr-4 15-Dec-2009
H-3	3000	627 ± 130	734 ± 132	818 ± 131	623 ± 130
K-40	Natural	2961 ± 177	265 ± 23.0	No Analysis	No Analysis
Mn-54	15	NDA<24.9**	NDA < 4.6	No Analysis	No Analysis
Fe-59	30	NDA<71.3**	NDA < 16.6	No Analysis	No Analysis
Co-58	15	NDA<28.8**	NDA < 5.5	No Analysis	No Analysis
Co-60	15	NDA<24.8**	NDA < 4.6	No Analysis	No Analysis
Zn-65	30	NDA<58.6**	NDA < 10.7	No Analysis	No Analysis
Zr-95	30	NDA<47.1**	NDA < 10.0	No Analysis	No Analysis
Nb-95	15	NDA<33.9**	NDA < 7.1	No Analysis	No Analysis
I-131	15	NDA<77.6**	NDA<24.6**	No Analysis	No Analysis
Cs-134	15	NDA<18.0**	NDA < 3.3	No Analysis	No Analysis
Cs-137	18	NDA<26.3**	NDA < 4.1	No Analysis	No Analysis
Ba/La-140	15	NDA<54.5**	NDA<17.4**	No Analysis	No Analysis
Fe-55	N/A	No Analysis	No Analysis	No Analysis	No Analysis
Ni-63	N/A	No Analysis	No Analysis	No Analysis	No Analysis
Sr-89	N/A	No Analysis	No Analysis	No Analysis	No Analysis
Sr-90	N/A	No Analysis	No Analysis	No Analysis	No Analysis
Gross alpha	N/A	No Analysis	No Analysis	No Analysis	No Analysis

*Required LLD not achieved due to delay in analysis of sample.
** Required LLD not achieved due to insufficient sample volume for analysis.

APPENDIX C

PILGRIM NUCLEAR POWER STATION
OFFSITE DOSE CALCULATION MANUAL

One revision was made to the PNPS Offsite Dose Calculation Manual (ODCM) during calendar year 2009. The latest version is attached.

PILGRIM NUCLEAR POWER STATION
OFFSITE DOSE CALCULATION MANUAL

APPROVED BY: _____ 5/20/09
CHEMISTRY DEPARTMENT MANAGER — Date

APPROVED BY: Jim Fitzsimmons for Jack Priest 5/20/09
RADIATION PROTECTION MANAGER — Date

REVIEWED BY: _____ 5/20/09
OSRC CHAIRMAN — Date

Rev. 0 was originally reviewed by ORC on June 10, 1983.

OSRC REVIEW REQUIRED
SAFETY REVIEW REQUIRED

RECORD OF DOCUMENT CHANGES

REV. NO.	IDENTIFICATION OF CHANGE	DATE APPROVED	DOCUMENT SECTION AND PAGE
0	Original Submittal	06/10/1983	All Sections
4	Update signature page to reflect new responsible organization. Update record of document changes. Renumber pages iii through vii to include list of effective page revisions. Revise pages containing equations and definitions to include machine-generated scientific characters. Address gardens identified during 1990 garden census in Table 7-5 in accordance with Technical Specification 7.1.B.2. Expand definition of Lower Limit of detection in Appendix B.	09/27/1991	Page i through vii; pages 13-15, 17-23, 25-28, 30-32, 49, and A-4; Appendix B.
5	Add Steam Jet Air Ejector Monitor to section addressing monitor setpoints.	10/30/1991	Pages i, ii, iii, v, 34a
6	Update revision Log; renumber pages ii through viii; clarify definition of dilution flow used for liquid effluent discharges; clarify assumptions used in gaseous effluent dose calculations and SJAE monitor setpoints.	08/11/1994	Pages i through viii; 14, 17, 33, 34a, A-35
7	Reference NRC Safety Evaluation and 10CFR20.302 permit for onsite disposal of slightly contaminated construction soil; repaginate preliminary pages.	11/22/1995	Pages i through vi, Appendix C, page C-1
8	Relocate Effluent Controls from PNPS Technical Specifications to the ODCM in accordance with Generic Letter 89-01; Repaginate and sectionalize entire ODCM; update distance and direction information for environmental sampling locations.	08/27/1998	Entire document
9	Relocate Effluent Control Bases within Control; align Definitions with NUREG-1302; align gaseous sampling requirements with NUREG-1302; revise REMP sampling program for samples and locations no longer required; align REMP LLDs and reporting levels with NUREG-1302; enhance discussion of alarm setpoint methodologies.	06/19/2003	Pages i through v, vii, viii; page 1-1; section 2; section 3/4; page 7-5; section 8; page 9-1, section 11, page 13-2
10	Add turbine building and reactor feed pump gaseous effluent monitors (GEMS) for gaseous effluent monitoring; revise action statements for steam jet air ejector monitors inoperable; revise liquid effluent concentration limits to conform with STS requirements; clarify total dose limit at or beyond site boundary; revise REMP sampling table to address availability of various sample types; change title of annual report; correct typographical error on ingestion dose tables	05/20/2009	Pages i through v, vii, viii; pages 3/4-7 through 3/4-12; 3/4-17 through 3/4-19; 3/4-24; 3/4-28; 3/4-31; 3/4-40 through 3/4-43; 7-2; 7-4; 12-1; A-28 through A-42;

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ii	10	3/4-17	10	5-2	10	9-2	10	A-2	10	B-2	10
iii	10	3/4-18	10			9-3	10	A-3	10	B-3	10
iv	10	3/4-19	10			9-4	10	A-4	10		
v	10	3/4-20	10			9-5	10	A-5	10		
vi	10	3/4-21	10			9-6	10	A-6	10		
vii	10	3/4-22	10			9-7	10	A-7	10		
viii	10	3/4-23	10			9-8	10	A-8	10		
ix	10	3/4-24	10	6-1	10	9-9	10	A-9	10	C-1	10
		3/4-25	10	6-2	10	9-10	10	A-10	10		
		3/4-26	10			9-11	10	A-11	10		
		3/4-27	10			9-12	10	A-12	10		
		3/4-28	10			9-13	10	A-13	10		
		3/4-29	10			9-14	10	A-14	10		
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I-2	10	3/4-31	10					A-16	10		
I-3	10	3/4-32	10	7-1	10			A-17	10		
		3/4-33	10	7-2	10			A-18	10		
		3/4-34	10	7-3	10			A-19	10		
		3/4-35	10	7-4	10			A-20	10		
		3/4-36	10	7-5	10			A-21	10		
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1.0 INTRODUCTION

This manual contains the current methodology, parameters, data, and information used in the calculation of offsite doses due to radioactive gaseous and liquid effluents, in the calculation of gaseous and liquid effluent monitor alarm/trip setpoints, and in the conduct of the radiological environmental monitoring program.

All effluent controls contained in the Offsite Dose Calculation Manual (ODCM) were originally part of the PNPS Technical Specifications (Reference 1). In response to Generic Letter 89-01 (Reference 2) from the Nuclear Regulatory Commission, these Radiological Effluent Technical Specifications (RETS) were removed from the main body of the Technical Specifications and relocated to the ODCM.

The effluent controls previously existed as parts of Section 3/4.8 and Section 7/8 of the PNPS Technical Specifications. In conjunction with the transfer of the effluent controls from the RETS to the ODCM, the numbering scheme for the individual effluent controls were changed to agree with the numbering scheme present in NUREG-1302, "Offsite Dose Calculation Manual Guidance: Standard Radiological Effluent Controls for Boiling Water Reactors" (reference 27).

The original Technical Specification 3/4.8.F, "Gaseous Effluent Treatment", addressed both offgas treatment and explosive gas monitoring. In accordance with the guidance in Generic Letter 89-01, monitoring of explosive gas concentrations was to be retained in the main body of the Technical Specifications. Subsequent to GL89-01, the improved standard technical specifications removed the requirement for explosive gas monitoring, in accordance with NEDO-31466. Therefore, the original Technical Specification 3/4.8.F was partitioned and the portion addressing offgas treatment was relocated to the ODCM Effluent Controls (Control 3/4.3.4). The portion of the original Specification 3/4.8.F addressing explosive gas monitoring was relocated to the FSAR (Reference 3). A cross-reference of the original Technical Specification Section to the revised ODCM Effluent Control Section is included in Table 1.1.

In conjunction with the GL89-01 change, the ODCM was restructured from that which previously existed. None of the requirements or methodologies were changed. Rather, the various sections were reorganized to facilitate support of the effluent controls relocated from the Technical Specifications. Descriptions of effluent monitoring systems and setpoint calculations were moved to the sections immediately following the controls, followed by dose calculation methodologies, and finally by the environmental monitoring program section. Supporting information is listed in the appendices at the rear of the manual.

TABLE 1.1

EFFLUENT CONTROLS CROSS-REFERENCE

Effluent Control Topic	Original Technical Specification Section	Revised ODCM Control Section
Liquid Effluents Concentration	3.8.A.1 4.8.A.1 4.8.A.2 Table 4.8-1	3.2.1 4.2.1.a 4.2.1.b Table 4.2-1
Radioactive Liquid Effluent Instrumentation	3.8.B.1 4.8.B.1 4.8.B.2 Table 3.8-1 Table 4.8-2	3.1.1 4.1.1.a 4.1.1.b Table 3.1-1 Table 4.1-1
Liquid Radwaste Treatment	3.8.C.1 4.8.C.1 4.8.C.2 Figure 4.8-1	3.2.3 4.2.3.a 4.2.3.b Figure 4.2-1
Gaseous Effluents Dose Rate	3.8.D.1 4.8.D.1 4.8.D.2 Table 4.8-3	3.3.1 4.3.1.a 4.3.1.b Table 4.3-1
Radioactive Gaseous Effluent Instrumentation	3.8.E.1 4.8.E.1 4.8.E.2 Table 3.8-2 (partial) Table 4.8-4 (partial)	3.1.2 4.1.2.a 4.1.2.b Table 3.1-2 Table 4.1-2
Gaseous Effluent Treatment	3.8.F.a 3.8.F.1 4.8.F.1 4.8.F.2 Figure 4.8-2	3.3.4 Relocated to FSAR 4.3.4 Relocated to FSAR Figure 4.3-1
Environmental Monitoring	7.1.A 8.1.A Table 7.1-1 Table 8.1-1 Table 8.1-2 Table 8.1-3 Table 8.1-4	3.5.1 4.5.1 Table 3.5-4 Table 3.5-1 Table 3.5-3 Table 3.5-2 Table 4.5-1
Land Use Census	7.1.B 8.1.B	3.5.2 4.5.2

TABLE 1.1 (continued)

EFFLUENT CONTROLS CROSS-REFERENCE

Effluent Control Topic	Original Technical Specification Section	Revised ODCM Control Section
Dose - Liquids	7.2.A 8.2.A	3.2.2 4.2.2
Dose - Noble Gases	7.3.A 8.3.A	3.3.2 4.3.2
Dose - Iodine-131, Iodine-133, Radioactive Material in Particulate Form, and Tritium	7.4.A 8.4.A	3.3.3 4.3.3
Total Dose	7.5.A 8.5.A	3.4.1 4.4.1

2.0 DEFINITIONS

This section lists definitions which are unique to the ODCM. Other definitions pertaining to actions and surveillance requirements for the various controls can be found in the Technical Specifications (Reference 1).

2.1 ACTION – ACTION shall be that part of a Control that prescribes remedial measures required under designated conditions.

2.2 CHANNEL CALIBRATION – A CHANNEL CALIBRATION shall be the adjustment, as necessary, of the channel such that it responds within the required range and accuracy to known values of input. The CHANNEL CALIBRATION shall encompass the entire channel including the sensor and alarm, interlock and/or trip functions, and shall include the CHANNEL FUNCTIONAL TEST. The CHANNEL CALIBRATION may be performed by any series of sequential, overlapping, or total channel steps such that the entire channel is calibrated.

2.3 CHANNEL CHECK – A CHANNEL CHECK shall be the qualitative assessment of channel behavior during operation by observation. This determination shall include, where possible, comparison of the channel indication and/or status with other indications and/or status derived from independent channels measuring the same parameter.

2.4 CHANNEL FUNCTIONAL TEST – A CHANNEL FUNCTIONAL TEST shall be:

a. Analog channels – the injection of a simulated signal into the channel as close to the sensor as practicable to verify OPERABILITY including alarm and/or trip functions and channel failure trips.

b. Bistable channels – the injection of a simulated signal into the sensor to verify OPERABILITY including alarm and/or trip functions.

The CHANNEL FUNCTIONAL TEST may be performed by any series of sequential, overlapping, or total channel steps such that the entire channel is tested.

2.5 DOSE EQUIVALENT I-131 – DOSE EQUIVALENT I-131 shall be that concentration of I-131 (microcuries/gram) that alone would produce the same thyroid dose as the quantity and isotopic mixture of I-131, I-132, I-133, I-134, and I-135 actually present. The thyroid dose conversion factors used for this calculation shall be those listed in ICRP 30, Supplement to Part 1, page 192-212, Table titled, "Committed Dose Equivalent in Target Organs or Tissues per Intake of Unit Activity".

2.6 MEMBER(S) OF THE PUBLIC – MEMBER(S) OF THE PUBLIC shall include all persons who are not occupationally associated with the plant. This category does not include employees of the licensee, its contractors, or vendors. Also excluded from this category are persons who enter the site to service equipment or to make deliveries. This category does include persons who use portions of the site for recreational, occupational or other purposes not associated with the site.

2.7 NOMINAL STEADY STATE LEVEL – NOMINAL STEADY STATE LEVEL shall be the baseline level of radionuclide concentrations and/or radiation monitor readings resulting from at least 72 hours of operation at a given reactor power level and hydrogen injection rate.

2.8 OFFSITE DOSE CALCULATION MANUAL (ODCM) – The OFFSITE DOSE CALCULATION MANUAL (ODCM) shall contain the methodology and parameters used in the calculation of offsite doses resulting from radioactive gaseous and liquid effluents, in the calculation of gaseous and liquid effluent monitoring Alarm/Trip Setpoints, and in the conduct of the Radiological Environmental Monitoring Program. The ODCM shall also contain: (1) the Radioactive Effluent Controls and Radiological Environmental Monitoring Programs required by Technical Specifications Administrative Controls 5.5.1 and 5.5.4; and, (2) descriptions of the information that should be included in the Annual Radiological Environmental Operating and Annual Radioactive Effluent Release Reports required by Technical Specifications Administrative Controls 5.6.2 and 5.6.3.

2.9 OPERABLE – OPERABILITY – A system, subsystem, train, component, or device shall be OPERABLE or have OPERABILITY when it is capable of performing its specified function(s), and when all necessary attendant instrumentation, controls, electrical power, cooling or seal water, lubrication, or other auxiliary equipment that are required for the system, subsystem, train, component, or device to perform its function(s) are also capable of performing their related support function(s).

2.10 RADWASTE TREATMENT SYSTEM

a. Gaseous Radwaste Treatment System - The gaseous radwaste treatment system is that system identified in Figure 4.3-1.

b. Liquid Radwaste Treatment System - The liquid radwaste treatment system is that system identified in Figure 4.2-1.

2.11 RATED THERMAL POWER – RATED THERMAL POWER shall be a total reactor core heat transfer rate to the reactor coolant of 2028 MWt.

2.12 REPORTABLE EVENT – A REPORTABLE EVENT shall be any of those conditions specified in Section 50.73 of 10CFR Part 50.

2.13 SITE BOUNDARY – The SITE BOUNDARY is shown in Figure 1.6-1 in the FSAR (Reference 3).

2.14 SOURCE CHECK – A SOURCE CHECK shall be the qualitative assessment of channel response when the channel sensor is exposed to a source of increased radioactivity.

2.15 THERMAL POWER – THERMAL POWER shall be the total reactor core heat transfer rate to the reactor coolant.

2.16 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 the 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.

3/4.0 EFFLUENT AND ENVIRONMENTAL CONTROLS

This section includes the effluent and environmental controls that were originally part of the PNPS Technical Specifications. With the exception of the environmental monitoring program previously listed in the Technical Specifications (Reference 1), these controls were relocated into the ODCM without any substantial changes, in accordance with Generic Letter 89-01 (Reference 2). Text and tables were reformatted to the style of the ODCM. The various controls were renumbered from the original numbering scheme of the Technical Specifications. A cross-reference of the old Technical Specifications section to the new ODCM section is presented in Table 1.1.

Prior to the Generic Letter 89-01 change to the ODCM (Revision 8), the ODCM contained an enhanced radiological environmental monitoring program (REMP), above that required by the Technical Specifications. To prevent confusion and capture the more inclusive monitoring program that existed in the ODCM, the original Technical Specification REMP was replaced with the REMP described in the ODCM. Therefore, the monitoring program listed in section 3/4.5 contains more samples and monitoring locations than existed in the Technical Specifications REMP prior to the Generic Letter 89-01 change.

In addition to the changes in the REMP program described above, all of the tables were revised with the latest distance and direction information available. The global positioning system (GPS) was used to verify the locations of the various sampling and monitoring stations, and the tables were updated accordingly. In keeping with governmental efforts to adopt the metric system of measurement, all distances have been listed in metric units (meters and/or kilometers) in the various tables and figures.

Any changes in distances and directions to the various monitoring locations from those originally listed in the Technical Specifications REMP are corrections based on new information. None of the locations of the sampling stations were actually changed. Some of the verbal descriptions, especially those for near-plant TLDs, have been updated to reflect current names of buildings and other areas near Pilgrim Station. Again, none of the physical locations were altered, and the change merely reflects up-to-date place names adopted by station management.

In 1977, Boston Edison Company was pursuing construction of a second unit on the PNPS site. As part of the preliminary licensing efforts for this second unit, Pilgrim Station committed to a special marine sampling program under the REMP. This program was much more aggressive than that outlined in standard NRC guidance for an environmental monitoring program, and included collecting many more samples, duplicate/split sampling, analysis of special radionuclides, and analysis to detection limits lower than those recommended by the NRC. This specialized sampling program was agreed to by Boston Edison Company for a period not to exceed 10 years. Due to the inclusion of the REMP in the Technical Specifications at that time, the program was carried forward beyond the 10-year period.

Following an evaluation of results obtained from this specialized marine sampling program over the past 25 years, it has been determined that the analyses have shown that the impact of radioactivity in liquid discharges on the general public and environment is negligible. In light of the fact that the terms of the sampling program have expired, the specialized program is no longer warranted. Furthermore, replacement of the specialized program with a marine sampling program such as that prescribed by the NRC in NUREG-1302 (reference 27) and the Branch Technical Position on Environmental Monitoring (reference 28) will still allow PNPS personnel to evaluate the impact of its operations on the environment and general public. Therefore, PNPS has dropped most of the specialized requirements and has adopted the standard model for marine sampling recommended by the NRC.

In order to streamline the flow of information for each of the applicable effluent controls, the technical bases for the controls were relocated from the end of Section 3/4 to within the applicable control. As is the case with Technical Specifications, the bases are not considered to be part of the control or its requirements. Rather, the bases provide the technical rationale behind the applicable control, and are listed to provide additional clarification regarding the specific control.

3/4.1 INSTRUMENTATION

3/4.1.1 Radioactive Liquid Effluent Instrumentation

CONTROLS

3.1.1 The radioactive liquid effluent monitoring instrumentation channels shown in Table 3.1-1 shall be OPERABLE with their alarm/trip setpoints set to ensure that the limits of Controls 3.2.1 are not exceeded during periods when liquid wastes are being discharged via the radwaste discharge header.

For releases other than the radwaste discharge header, the above specification does not apply, these releases shall be made in accordance with Action 1 of Table 3.1-1.

APPLICABILITY: As shown in Table 3.1-1.

ACTION:

a. With a radioactive liquid effluent monitoring instrumentation channel alarm/trip setpoint less conservative than a value which will ensure that the limits of Control 3.2.1 are met, without delay suspend the release of radioactive liquid effluents monitored by the affected channel or change the setpoint so that it is acceptably conservative or declare the channel inoperable.

b. With one or more radioactive liquid effluent monitoring instrumentation channels inoperable, take the action shown in Table 3.1-1.

SURVEILLANCE REQUIREMENTS

4.1.1.a The setpoints for monitoring instrumentation shall be determined in accordance with the ODCM.

4.1.1.b Each radioactive liquid effluent monitoring instrumentation channel shall be demonstrated OPERABLE at the frequencies shown in Table 4.1-1.

BASES

3/4.1.1 Radioactive Liquid Effluent Instrumentation

The radioactive liquid effluent instrumentation is provided to monitor and control, as applicable, the releases of radioactive materials in liquid effluents during actual or potential releases of liquid effluents. The alarm/trip setpoints for these instruments shall be calculated in accordance with NRC approved methods in the Offsite Dose Calculation Manual (ODCM) to ensure that the alarm/trip will occur prior to exceeding the limits of 10CFR20. The OPERABILITY and use of this instrumentation is consistent with the requirements of General Design Criteria 60, 63, and 64 of Appendix A to 10CFR50.

TABLE 3.1-1

RADIOACTIVE LIQUID EFFLUENT MONITORING INSTRUMENTATION

Instrument	Minimum Channels Operable	Applicability	Action[1]
1. GROSS RADIOACTIVITY MONITORS PROVIDING ALARM AND AUTOMATIC TERMINATION OF RELEASE			
a. Liquid Radwaste Effluent Line	1	During actual discharge of liquid wastes	1
2. FLOW RATE MEASUREMENT DEVICES			
a. Liquid Radwaste Effluent Line	1	During actual discharge of liquid wastes	2
b. Discharge Canal	N/A	During actual discharge of liquid wastes	3
3. GROSS RADIOACTIVITY MONITORS PROVIDING ALARM BUT NOT PROVIDING AUTOMATIC TERMINATION OF RELEASE			
a. Reactor Building Closed Cooling Water Loop "A"	1	During operation of the reactor building closed cooling system	4
b. Reactor Building Closed Cooling Water Loop "B"	1	During operation of the reactor building closed cooling system	4

[1] Actions Required --

ACTION 1: With the number of OPERABLE channels less than required by the minimum channels OPERABLE requirement, effluent releases may be resumed provided that prior to initiating a release:

a. At least two independent samples are analyzed in accordance with Control 4.2.1.a; and,

b. An independent verification of the release rate calculations is performed; and,

c. An independent verification of the discharge line valving is performed.

ACTION 2: With the number of OPERABLE channels less than required by the minimum channels OPERABLE requirement, effluent releases via this pathway may continue provided that the flow rate is verified at least once per 4 hours during actual releases. Flow will be estimated based on design flow rate of the operating circulating water pumps and/or operating salt service water pumps.

ACTION 3: Flow will be estimated based on the sum of the operating waste discharge pumps, operating circulating water pumps, and/or operating salt service water pumps.

ACTION 4: With the number of OPERABLE channels less than required by the minimum channels OPERABLE requirement, effluent releases via this pathway may continue provided that at least once per day grab samples are collected and analyzed for radioactivity at a lower limit of detection of no more than 5E-07 uCi/mL.

TABLE 4.1-1

RADIOACTIVE LIQUID EFFLUENT MONITORING INSTRUMENTATION SURVEILLANCE REQUIREMENTS

Instrument	Channel Check	Source Check	Channel Calibration	Channel Functional Test
1. GROSS RADIOACTIVITY MONITORS PROVIDING ALARM AND AUTOMATIC TERMINATION OF RELEASE				
a. Liquid Radwaste Effluents Line	(1)	N/A	Once per 24 months(2)	Quarterly
2. FLOW RATE MEASUREMENT DEVICES				
a. Liquid Radwaste Effluents Line	(1)	N/A	Once per 24 months	Quarterly
3. GROSS RADIOACTIVITY MONITORS PROVIDING ALARM BUT NOT PROVIDING AUTOMATIC TERMINATION OF RELEASE				
a. Reactor Building Closed Cooling Water Loop "A"	(3)	N/A	Once per 24 months(2)	Quarterly
b. Reactor Building Closed Cooling Water Loop "B"	(3)	N/A	Once per 24 months(2)	Quarterly

(1) During or prior to release via this pathway.

(2) Previously established calibration procedures will be used for these requirements.

(3) During operation of the reactor building closed cooling water system.

3/4.1 INSTRUMENTATION

3/4.1.2 Radioactive Gaseous Effluent Instrumentation

CONTROLS

3.1.2 The radioactive gaseous effluent monitoring instrumentation channels shown in Table 3.1-2 shall be OPERABLE with their alarm/trip setpoints set to ensure that the limits of Control 3.3.1 are not exceeded.

APPLICABILITY: As shown in Table 3.1-2

ACTION:

a. With a radioactive gaseous effluent monitoring instrumentation channel alarm/trip setpoint less conservative than a value which will ensure that the limits of Control 3.3.1 are met, change the setpoint so that it is acceptably conservative or declare the channel inoperable.

b. With one or more radioactive gaseous effluent monitoring instrumentation channels inoperable, take the action shown in Table 3.1-2.

SURVEILLANCE REQUIREMENTS

4.1.2.a The setpoints shall be determined in accordance with ODCM.

4.1.2.b Each radioactive gaseous effluent monitoring instrumentation channel shall be demonstrated OPERABLE at the frequencies shown in Table 4.1-2.

BASES

3/4.1.2 Radioactive Gaseous Effluent Instrumentation

The radioactive gaseous effluent instrumentation 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 alarm/trip setpoints for these instruments shall be calculated in accordance with NRC approved methods in the ODCM to ensure that the alarm/trip will occur prior to exceeding the limits of 10CFR20. The OPERABILITY and use of this instrumentation is consistent with the requirements of General design Criteria 60, 63, and 64 of Appendix A to 10CFR50.

TABLE 3.1-2

RADIOACTIVE GASEOUS EFFLUENT MONITORING INSTRUMENTATION

Instrument	Minimum Channels Operable	Applicability	Parameter	Action[1]
1. MAIN STACK EFFLUENT MONITORING SYSTEM				
a. Noble Gas Activity Monitor Providing Alarm	1	[2]	Radioactivity Rate Measurement	1
b. Iodine Sampler Cartridge	1	[2]	Collect Halogen Sample	2
c. Particulate Sampler Filter	1	[2]	Collect Particulate Sample	2
d. Effluent System Flow Rate Measuring Device	1	[2]	System Flow Rate Measurement	3
e. Sampler Flow Rate Measuring Device	1	[2]	Sampler Flow Rate Measurement	3
2. REACTOR BUILDING VENTILATION EFFLUENT MONITORING SYSTEM				
a. Noble Gas Activity Monitor Providing Alarm	1	[2]	Radioactivity Rate Measurement	1
b. Iodine Sampler Cartridge	1	[2]	Collect Halogen Sample	2
c. Particulate Sampler Filter	1	[2]	Collect Particulate Sample	2
d. Effluent System Flow Rate Measuring Device	1	[2]	System Flow Rate Measurement	3
e. Sampler Flow Rate Measuring Device	1	[2]	Sampler Flow Rate Measurement	3
3. STEAM JET AIR EJECTOR RADIOACTIVITY MONITOR				
a. Noble Gas Activity Monitor (Providing Alarm and Auto-isolation of Stack)	1	[3]	Noble Gas Radioactivity Rate Measurement	4
4. POST-TREATMENT RADIATION MONITOR				
a. Noble Gas Activity Monitor (Providing Alarm and Auto-isolation of Stack)	1	[4]	Noble Gas Radioactivity Rate Measurement	5

TABLE 3.1-2 (continued)

RADIOACTIVE GASEOUS EFFLUENT MONITORING INSTRUMENTATION

Instrument	Minimum Channels Operable	Applicability	Parameter	Action[1]
5. TURBINE BUILDING GASEOUS EFFLUENT MONITORING SYSTEM (GEMS)				
a. Noble Gas Activity Monitor Providing Alarm	1	[2]	Radioactivity Rate Measurement	5
b. Iodine Sampler Cartridge	1	[2]	Collect Halogen Sample	2
c. Particulate Sampler Filter	1	[2]	Collect Particulate Sample	2
d. Sampler Flow Rate Measuring Device	1	[2]	Sampler Flow Rate Measurement	3
6. FEED PUMP GASEOUS EFFLUENT MONITORING SYSTEM (GEMS)				
a. Noble Gas Activity Monitor Providing Alarm	1	[2]	Radioactivity Rate Measurement	5
b. Iodine Sampler Cartridge	1	[2]	Collect Halogen Sample	2
c. Particulate Sampler Filter	1	[2]	Collect Particulate Sample	2
d. Sampler Flow Rate Measuring Device	1	[2]	Sampler Flow Rate Measurement	3

[1] Actions Required --

ACTION 1*: With the number of OPERABLE channels less than required by the minimum channels OPERABLE requirement, effluent releases via this pathway may continue provided grab samples are taken at least once per 12 hours and these samples are analyzed for activity within 24 hours.

ACTION 2*: With the number of OPERABLE channels less than required by the minimum channels OPERABLE requirement, effluent releases via this pathway may continue provided samples are continuously collected with auxiliary sampling equipment as required in Table 4.3-1.

ACTION 3*: With the number of OPERABLE channels less than required by the minimum channels OPERABLE requirement, effluent releases via this pathway may continue provided the flow rate is estimated at least once per 4 hours.

ACTION 4: With the number of operable channels less than required, gases from the steam jet air ejector may continue to be released to the offgas system provided the following is met:

a.1 The augmented offgas (AOG) treatment system is not bypassed,

AND

a.2 Two channels of the post-treatment radiation monitors are OPERABLE or tripped and capable of alarm and auto-isolation of the main stack.

AND

a.3 The AOG charcoal vault area radiation monitor (ARM) and control room alarm are FUNCTIONAL.

AND

a.4 Technical Specification Surveillance Requirement 4.8.1.1 is performed at least once every 24 hours.

OR

b.1 Technical Specification Surveillance Requirement 4.8.1.1 is performed at least every four hours.

Otherwise, be in Hot Standby within 12 hours.

ACTION 5*: With the number of OPERABLE channels less than required by the minimum channels OPERABLE requirement, effluent releases via this pathway may continue provided grab samples are taken at least once per week and these samples are analyzed for activity within 24 hours.

* Note: (For Actions 1, 2, 3, and 5) If the instruments are not returned to OPERABLE status within 30 days, explain in the next Annual Radioactive Effluent Release Report why the inoperability was not corrected in a timely manner.

(2) During releases via this pathway.

(3) During operation of steam jet air ejector.

(4) During operation of augmented offgas treatment system.

TABLE 4.1-2

RADIOACTIVE GASEOUS EFFLUENT MONITORING INSTRUMENTATION SURVEILLANCE REQUIREMENTS

Instrument	Channel Check	Source Check	Channel Calibration	Channel Functional Test
1. MAIN STACK EFFLUENT MONITORING SYSTEM				
a. Noble Gas Activity Monitor (2 channels)	Daily[1]	Monthly	Once per 24 months [2]	Quarterly
b. Iodine Sampler Cartridge	N/A	N/A	N/A	N/A
c. Particulate Sampler Filter	N/A	N/A	N/A	N/A
d. Effluent System Flow Rate Measuring Device	Daily[1]	N/A	Once per 24 months	Quarterly
e. Sampler Flow Rate Measuring Device	Daily[1]	N/A	Once per 24 months	Quarterly
2. REACTOR BUILDING VENTILATION EFFLUENT MONITORING SYSTEM				
a. Noble Gas Activity Monitor (2 channels)	Daily[1]	Monthly	Once per 24 months [2]	Quarterly
b. Iodine Sampler Cartridge	N/A	N/A	N/A	N/A
c. Particulate Sampler Filter	N/A	N/A	N/A	N/A
d. Effluent System Flow Rate Measuring Device	Daily[1]	N/A	Once per 24 months	Quarterly
e. Sampler Flow Rate Measuring Device	Daily[1]	N/A	Once per 24 months	Quarterly
3. STEAM JET AIR EJECTOR RADIOACTIVITY MONITOR				
a. Noble Gas Activity Monitor (2 channels)	Daily[3]	N/A	Once per 24 months[2]	Quarterly
4. POST-TREATMENT RADIATION MONITOR				
a. Noble Gas Activity Monitor (2 channels)	Daily[4]	N/A	Once per 24 months[2]	Quarterly

TABLE 4.1-2 (continued)

RADIOACTIVE GASEOUS EFFLUENT MONITORING INSTRUMENTATION
SURVEILLANCE REQUIREMENTS

Instrument	Channel Check	Source Check	Channel Calibration	Channel Functional Test
5. TURBINE BUILDING GASEOUS EFFLUENT MONITORING SYSTEM (GEMS)				
a. Noble Gas Activity Monitor (1 channels)	Daily(1)	Monthly	Once per 24 months (2)	Quarterly
b. Iodine Sampler Cartridge	N/A	N/A	N/A	N/A
c. Particulate Sampler Filter	N/A	N/A	N/A	N/A
d. Sampler Flow Rate Measuring Device	Daily(1)	N/A	Once per 24 months	Quarterly
6. FEED PUMP GASEOUS EFFLUENT MONITORING SYSTEM (GEMS)				
a. Noble Gas Activity Monitor (1 channels)	Daily(1)	Monthly	Once per 24 months (2)	Quarterly
b. Iodine Sampler Cartridge	N/A	N/A	N/A	N/A
c. Particulate Sampler Filter	N/A	N/A	N/A	N/A
d. Sampler Flow Rate Measuring Device	Daily(1)	N/A	Once per 24 months	Quarterly

(1) During releases via this pathway.

(2) Previously established calibration procedures will be used for these requirements.

(3) During operation of the steam jet air ejector.

(4) During operation of the augmented offgas treatment system.

3/4.2 RADIOACTIVE LIQUID EFFLUENTS

3/4.2.1 Liquid Effluents Concentration

CONTROLS

3.2.1 The concentration of radioactive material released in liquid effluents to areas at and beyond the SITE BOUNDARY shall be limited to ten times the concentration values specified in Appendix B, Table 2, Column 2, to 10 CFR 20.1001-20.2402, for radionuclides other than dissolved or entrained noble gases. For dissolved or entrained noble gases, the concentration of individual isotopes shall be limited to 2E-04 μCi/mL.

APPLICABILITY: At all times.

ACTION:

With the concentration of radioactive material released from the site to areas at and beyond the SITE BOUNDARY exceeding the above limits, without delay restore concentration within the above limits.

SURVEILLANCE REQUIREMENTS

4.2.1.a The radioactivity content of each batch of radioactive liquid waste to be discharged shall be determined prior to release by sampling and analysis in accordance with Table 4.2-1.

4.2.1.b The results of pre-release analyses shall be used with calculational methods in the Offsite Dose Calculation Manual (ODCM) to assure that the concentration at the point of release is limited to the values in Control 3.2.1.

BASES

3/4.2.1 Liquid Effluents Concentration

This control is provided to ensure that the concentration of radioactive materials released in liquid waste effluents to areas at and beyond the SITE BOUNDARY will be less than ten times the concentration values specified in Appendix B, Table 2, Column 2, to 10 CFR 20.1001-20.2402. This limitation provides additional assurance that the levels of radioactive materials in bodies of water at and beyond the SITE BOUNDARY will result in exposures within (1) the Section II.A design objectives of Appendix I, 10CFR50, to a MEMBER OF THE PUBLIC and (2) restrictions authorized by 10 CFR 20.1301(e).

TABLE 4.2-1

RADIOACTIVE LIQUID WASTE SAMPLING AND ANALYSIS PROGRAM

Liquid Release Type	Sampling Frequency	Minimum Analysis Frequency	Type of Activity Analysis	Lower Limit of Detection[1] µCi/mL
1. Batch Waste Release Tanks[2] a. Non-treatable Releases (e.g., Neutralizer Sumps), AND b. Treatable Releases (e.g., Radwaste Tanks)	Each Batch	Prior to Each Batch Release	Principal Gamma Emitters[3]	5E-07
			I-131	1E-06
			Dissolved and Entrained Gases	1E-05
	Composite from Each Batch	Monthly Composite[4]	H-3	1E-05
			Gross Alpha	1E-07
		Quarterly Composite[4]	Sr-89, Sr-90	5E-08
			Fe-55	1E-06
2. Continuous Releases a. Salt Service Water	Weekly Grab Sample	Weekly	Principal Gamma Emitters[3]	5E-07

(1) Refer to Appendix B of the ODCM for definition of lower limit of detection (LLD).

(2) A batch release is the discharge of liquid wastes of a discrete volume.

(3) The principal gamma emitters for which the LLD control applies exclusively are the following radionuclides: Mn-54, Fe-59, Co-58, Co-60, Zn-65, Mo-99, Cs-134, Cs-137, Ce-141, and Ce-144. 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 be analyzed and reported in the Annual Radioactive Effluent Release Report.

(4) 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 which is representative of the liquids released.

3/4.2 RADIOACTIVE LIQUID EFFLUENTS

3/4.2.2 Dose - Liquids

CONTROLS

3.2.2 The dose or dose commitment to a MEMBER OF THE PUBLIC from radioactive materials in liquid effluents released at and beyond the SITE BOUNDARY shall be limited:

a. During any calendar quarter to $\leq$ 1.5 mrem to the total body and to $\leq$ 5 mrem to any organ; and,

b. During any calendar year to $\leq$ 3 mrem to the total body and to $\leq$ 10 mrem to any organ.

APPLICABILITY: At all times

ACTION:

With the calculated dose from the release of radioactive materials in liquid effluents exceeding any of the above limits, prepare and submit to the Commission within 30 days, a special report that identifies the cause(s), corrective actions taken, and corrective actions to be taken.

SURVEILLANCE REQUIREMENTS

4.2.2 Dose Calculations - Cumulative dose contributions from liquid effluents shall be determined in accordance with the ODCM for each calendar month during which releases occurred.

BASES

3/4.2.2 Dose - Liquids

This section is provided to implement the requirements of Sections II.A, III.A, and IV.A of 10CFR50, Appendix I, to assure that the releases of radioactive material in liquid effluents will be kept "as low as is reasonably achievable." Because Pilgrim is not a site where plant operations can conceivably affect drinking water, none of these requirements are intended to assure compliance with 40CFR141. The dose calculations in the ODCM implement the requirements of 10CFR50, Appendix I, Section III.A to ensure 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 will be 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 10CFR50, 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. NUREG-0133 provides methods for dose calculations consistent with Regulatory Guides 1.109 and 1.113.

3/4.2 RADIOACTIVE LIQUID EFFLUENTS

3/4.2.3 Liquid Radwaste Treatment

CONTROLS

3.2.3 The liquid radwaste treatment system shall be maintained and used to reduce the radioactive materials in liquid wastes prior to their discharge when the dose due to liquid effluent releases to areas at and beyond the SITE BOUNDARY averaged over a 31-day period would exceed 0.06 mrem to the total body or 0.20 mrem to any organ.

APPLICABILITY: At all times.

ACTION:

With radioactive liquid waste being discharged without treatment and in excess of the above limits, prepare and submit to the Commission within 30 days a special report which includes the following information:

1. Explanation of why liquid radwaste was being discharged without treatment, identification of any inoperable equipment or subsystems, and the reason for the inoperability; and,

2. Action(s) taken to restore the inoperable equipment to OPERABLE status; and,

3. Summary description of action(s) taken to prevent a recurrence.

SURVEILLANCE REQUIREMENTS

4.2.3.a Doses due to liquid releases at and beyond the SITE BOUNDARY shall be calculated at least once per 31-day period in accordance with the ODCM, only if releases in that period have occurred.

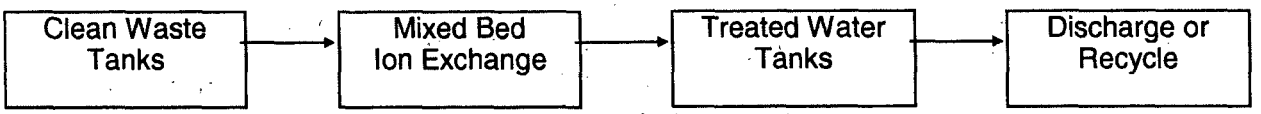
4.2.3.b The liquid radwaste treatment system schematic is shown in Figure 4.2-1.

BASES

3/4.2.3 Liquid Radwaste Treatment

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 control implements the requirements of 10CFR50.36a, General Design Criteria 60 of Appendix A to 10CFR50 and design objective Section II.D of Appendix I to 10CFR50. The specified limits governing the use of appropriate portions of the liquid radwaste treatment system were specified as a suitable fraction of the guide set forth in Section II.A of Appendix I, 10CFR50, for liquid effluents.

HIGH PURITY WASTE SYSTEM



LOW PURITY WASTE SYSTEM

DETERGENT WASTE SYSTEM (Decon Areas)

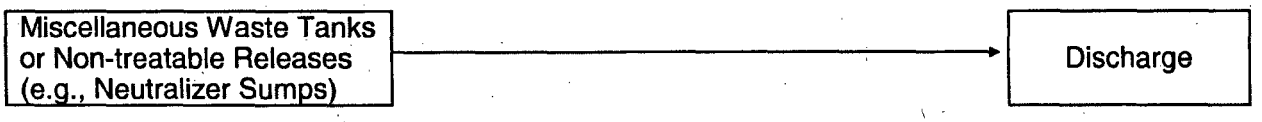


Figure 4.2-1
Liquid Radwaste Treatment System Schematic

3/4.3 RADIOACTIVE GASEOUS EFFLUENTS

3/4.3.1 Gaseous Effluents Dose Rate

CONTROLS

3.3.1 The instantaneous dose rate due to radioactive materials released in gaseous effluents from the site boundary to areas at and beyond the SITE BOUNDARY (see FSAR Figure 1.6-1) shall be limited to the following:

a. For noble gases: Less than or equal to 500 mrem/yr to the total body and less than or equal to 3000 mrem/yr to the skin; and,

b. For iodine-131, iodine-133, tritium, and all radionuclides in particulate form with half-lives greater than 8 days: Less than or equal to 1500 mrem/yr to any organ.

APPLICABILITY: At all times.

ACTION:

With the instantaneous dose rate(s) exceeding the above limits, without delay restore the release rate to within the above limit(s).

SURVEILLANCE REQUIREMENTS

4.3.1.a The instantaneous dose rate due to noble gases in gaseous effluents shall be determined to be within the limits of Control 3.3.1.a on a continuous basis using the noble gas activity monitors with appropriate setpoints and in accordance with the ODCM.

4.3.1.b The instantaneous dose rate due to iodine-131, iodine-133, tritium, and all radionuclides in particulate form with half-lives greater than 8 days in gaseous effluents shall be determined to be within the limits of Control 3.3.1.b in accordance with the ODCM by obtaining representative samples and performing analyses in accordance with the sampling and analysis program specified in Table 4.3-1.

BASES

3/4.3.1 Gaseous Effluents Dose Rate

This control is provided to ensure that the dose rate at anytime at and beyond the SITE BOUNDARY from gaseous effluents from all units on the site will be within the annual dose limits of 10CFR20. The annual dose limits are the doses associated with the concentration of 10CFR20, Appendix B, Table 2. These limits provide reasonable assurance that radioactive material discharged in gaseous effluents will not result in the exposure of a MEMBER OF THE PUBLIC outside the SITE BOUNDARY to annual average concentrations exceeding the limits specified in Appendix B, Table 2 of 10CFR20.1001-20.2402. For MEMBERS OF THE PUBLIC who may at times be within the SITE BOUNDARY, the occupancy of the individual will usually be sufficiently low to compensate for any increase in the atmospheric diffusion factor above that for the SITE BOUNDARY. The specified release rate limits restrict, at all times, the corresponding gamma and beta dose rates above background to a MEMBERS OF THE PUBLIC at or beyond the SITE BOUNDARY to ≤ 500 mrem/year to the total body or to ≤ 3000 mrem/year to the skin. These release rate limits also restrict, at all times, the corresponding thyroid dose rate above background to an infant via the cow-milk-infant pathway to ≤ 1500 mrem/year for the nearest cow to the plant.

TABLE 4.3-1

RADIOACTIVE GASEOUS WASTE SAMPLING AND ANALYSIS PROGRAM

Gaseous Release Type	Sampling Frequency	Minimum Analysis Frequency	Type of Activity Analysis	Lower Limit of Detection[1] µCi/mL
Main Stack and Reactor Building Vent	Monthly Grab Sample	Monthly[2]	Principal Gamma Emitters[3]	1E-04
			H-3	1E-06
	Continuous[4]	Weekly[5] Charcoal Sample	I-131	1E-12
	Continuous[4]	Weekly[5] Particulate Sample	Principal Gamma Emitters[3]	1E-11
	Continuous[4]	Monthly Composite Particulate Sample	Gross Alpha	1E-11
	Continuous[4]	Quarterly Composite Particulate Sample	Sr-89, Sr-90	1E-11
	Continuous[4]	Continuous Noble Gas Monitor	Noble Gas Gross Gamma	1E-06
Post-Treatment Radiation Monitor	Monthly Grab Sample	Monthly	Principal Gamma Emitters[3]	1E-04
Turbine Building GEMS and Feed Pump GEMS	Monthly Grab Sample	Monthly[2]	Principal Gamma Emitters[3]	1E-04
			H-3	1E-06
	Continuous[4]	Weekly[5] Charcoal Sample	I-131	1E-12
	Continuous[4]	Weekly[5] Particulate Sample	Principal Gamma Emitters(3)	1E-11
	Continuous[4]	Monthly Composite Particulate Sample	Gross Alpha	1E-11
	Continuous[4]	Quarterly Composite Particulate Sample	Sr-89, Sr-90	1E-11
	Continuous[4]	Continuous Noble Gas Monitor	Noble Gas Gross Gamma	1E-06

TABLE 4.3-1 (continued)

RADIOACTIVE GASEOUS WASTE SAMPLING AND ANALYSIS PROGRAM

(1) Refer to Appendix B of the ODCM for definition of lower limit of detection (LLD).

(2) A noble gas sample shall be collected and analyzed as soon as practicable following any 15-minute or longer sustained increase in noble gas release rates more than a factor of 3 above NOMINAL STEADY STATE LEVEL.

(3) The principal gamma emitters for which the LLD control applies are the following radionuclides: Kr-87, Kr-88, Xe-133, Xe-133m, Xe-135, and Xe-138 in noble gas releases; and Mn-54, Fe-59, Co-58, Co-60, Zn-65, Mo-99, I-131, Cs-134, Cs-137, Ce-141, and Ce-144 in iodine and particulate releases. 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 be analyzed and reported in the Annual Radioactive Effluent Release Report.

(4) The ratio of the sample flow rate to the sampled stream flow rate shall be known for the time period covered by each dose or dose rate calculation made in accordance with Controls 3.3.1, 3.3.2, and 3.3.3.

(5) Samples shall be changed at least once per 7 days and analyses shall be completed within 48 hours after changing, or after removal from the sampler. Sampling of the affected release point shall also be performed at least once per 24 hours for at least 7 days following each shutdown, startup, or THERMAL POWER change exceeding 15% of RATED THERMAL POWER within a 1-hour period and analyses shall be completed within 48 hours of changing. When samples collected for 24 hours are analyzed, the corresponding LLDs may be increased by a factor of 10. This requirement applies ONLY IF: (1) analysis shows that the DOSE EQUIVALENT I-131 concentration in reactor coolant has increased more than a factor of 3 above NOMINAL STEADY STATE LEVEL; OR (2) the noble gas monitor shows that effluent activity has increased by more than a factor of 3 above NOMINAL STEADY STATE LEVEL. Increased 24 hour sampling can be terminated when BOTH: (1) DOSE EQUIVALENT I-131 concentration in reactor coolant, AND (2) noble gas effluent release rate are less than a factor of 3 times above NOMINAL STEADY STATE LEVEL. When comparison is made using levels under which 72-hour steady state operation has not been achieved, DOSE EQUIVALENT I-131 concentrations and noble gas release rates should be adjusted for expected changes in response to changes in reactor power level and/or hydrogen injection rate.

3/4.3 RADIOACTIVE GASEOUS EFFLUENTS

3/4.3.2 Dose - Noble Gases

CONTROLS

3.3.2 The air dose in areas at and beyond the SITE BOUNDARY due to noble gases released in gaseous effluents shall be limited to the following:

a. During any calendar quarter, to $\leq$ 5 mrad for gamma radiation and $\leq$ 10 mrad for beta radiation; and,

b. During any calendar year, to $\leq$ 10 mrad for gamma radiation and $\leq$ 20 mrad for beta radiation.

APPLICABILITY: At all times

ACTION:

With the calculated air dose from radioactive noble gases in gaseous effluents exceeding any of the above limits, prepare and submit to the Commission within 30 days, a special report which identifies the cause(s), the corrective actions taken, and corrective actions to be taken.

SURVEILLANCE REQUIREMENTS

4.3.2 Dose Calculations - Cumulative dose contributions for the total time period shall be determined in accordance with the ODCM for each calendar month during which releases occurred.

BASES

3/4.3.2 Dose - Noble Gases

This section is provided to implement the requirements of 10CFR50, Appendix I, Sections II.B, III.A, and IV.A to ensure that the releases of radioactive material in gaseous effluents will be kept "as low as is reasonably achievable." The surveillance requirements implement the requirements of 10CFR50, Appendix I, Section III.A to ensure that the actual exposure of a MEMBER OF THE PUBLIC through the appropriate pathways is unlikely to be substantially underestimated. The dose calculations established in the ODCM for calculating the doses due to the actual release rates of radioactive noble gases in gaseous effluents are consistent with the methodology provided in Regulatory Guide 1.109 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. The ODCM equations provided for determining the air doses at and beyond the SITE BOUNDARY will be based upon the historical average atmospheric conditions. NUREG-0133 provides methods for dose calculations consistent with Regulatory Guides 1.109 and 1.111.

3/4.3 RADIOACTIVE GASEOUS EFFLUENTS

3/4.3.3 Dose - Iodine-131, Iodine-133, Radioactive Material in Particulate Form, and Tritium

CONTROLS

3.3.3 The dose to a MEMBER OF THE PUBLIC from iodine-131, iodine-133, radioactive materials in particulate form with half-lives greater than 8 days, and tritium in gaseous effluents released to areas at and beyond the SITE BOUNDARY shall be limited to the following:

a. During any calendar quarter to $\leq$ 7.5 mrem to any organ; and,

b. During any calendar year to $\leq$ 15 mrem to any organ.

APPLICABILITY: At all times

ACTION:

With the calculated dose from the release of iodine-131, iodine-133, radioactive materials in particulate form, and tritium in gaseous effluents exceeding any of the above limits; prepare and submit to the Commission within 30 days, a special report which identifies the cause(s), corrective actions taken, and the corrective actions to be taken.

SURVEILLANCE REQUIREMENTS

4.3.3 Dose Calculations - Cumulative dose contributions for the total time period shall be determined for iodine-131, iodine-133, radioactive material in particulate form with half-lives greater than 8 days, and tritium in accordance with the ODCM for each calendar month during which releases occurred.

BASES

3/4.3.3 Dose - Iodine-131, Iodine-133, Radioactive Material In Particulate Form, And Tritium

This section is provided to implement the requirements of Sections II.C, III.A and IV.A of 10CFR50, Appendix I, to assure that the releases of radioactive materials in gaseous effluents will be kept "as low as is reasonably achievable." The ODCM calculational methods specified in the surveillance requirements implement the requirements of 10CFR50, Appendix I, Section III.A to ensure that the actual exposure of a MEMBER OF THE PUBLIC through appropriate pathways is unlikely to be substantially underestimated. The ODCM calculational methods approved by the NRC for calculating the doses due to the actual release rates of the subject materials are required to be consistent with the methodology provided in Regulatory Guides 1.109 and 1.111. These equations also provide for determining the actual doses based upon the historical average atmospheric conditions. The release rate specifications for iodine-131, radioactive material in particulate form with half-lives greater than 8 days, and radionuclides other than noble gases are dependent on the existing radionuclide pathways to man, in areas at and beyond the SITE BOUNDARY. The pathways which are examined in the development of these calculations are: 1) individual inhalation of airborne radionuclides, 2) deposition of radionuclides onto green leafy 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.

3/4.3 RADIOACTIVE GASEOUS EFFLUENTS

3/4.3.4 Gaseous Effluent Treatment

CONTROLS

3.3.4 The augmented offgas system shall be put into service prior to reaching 50 percent reactor power during startup.

APPLICABILITY: Whenever the plant is operating at or above 50 percent reactor power.

ACTION:

With gaseous effluents being discharged for more than 14 days without treatment, prepare and submit to the Commission within 30 days, a special report which includes the following information:

1. Identification of any inoperable equipment or subsystems, and the reason for the inoperability; and,

2. Action(s) taken to restore the inoperable equipment to OPERABLE status; and,

3. Summary description of action(s) taken to prevent a recurrence.

SURVEILLANCE REQUIREMENTS

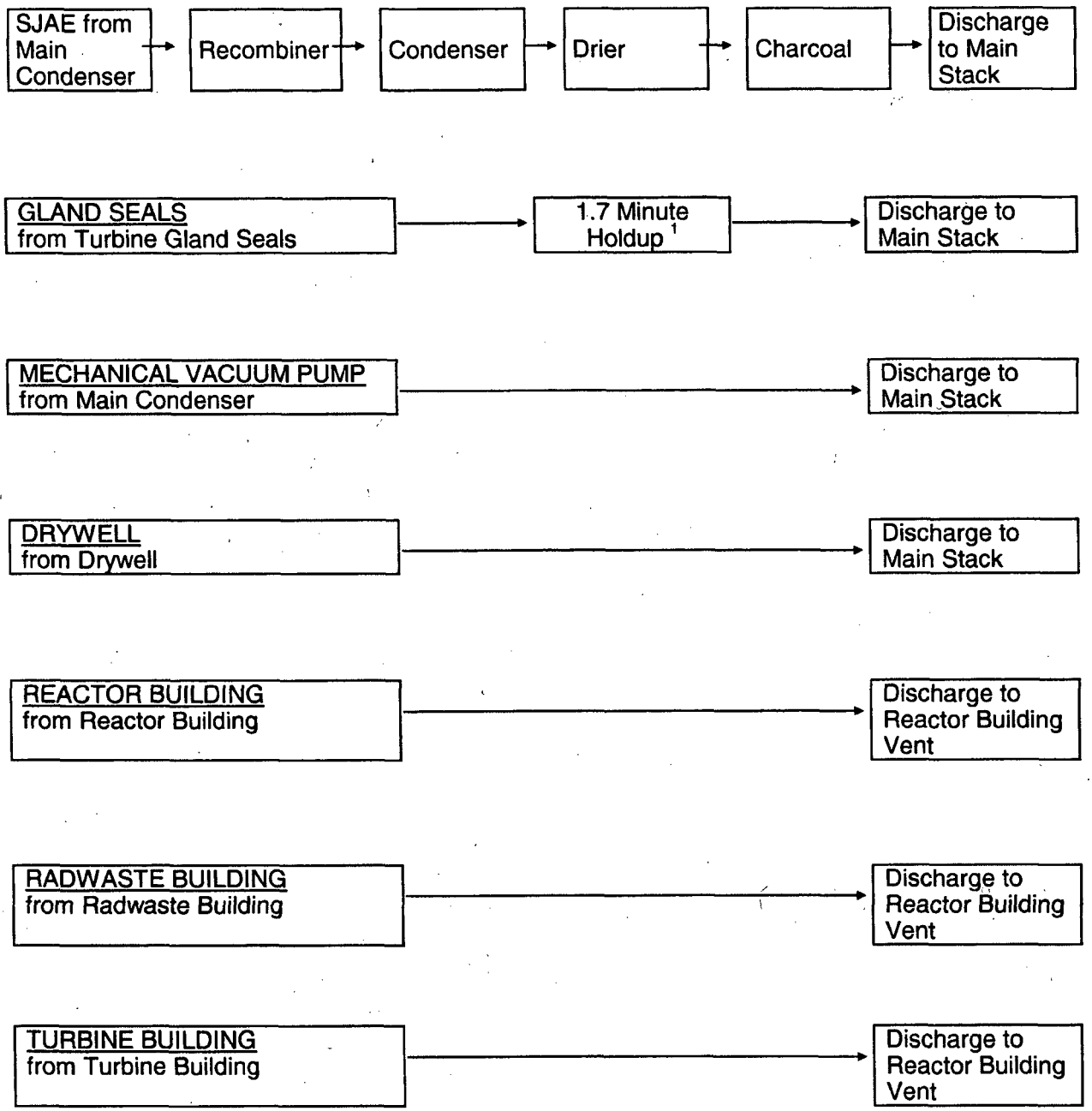
4.3.4.a Augmented offgas (post-treatment radiation monitor) annunciator OPERABILITY shall be verified once per 12 hours when the augmented offgas system is in use.

4.3.4.b The gaseous effluent treatment system schematic is shown in Figure 4.3-1.

BASES

3/4.3.4 Gaseous Effluent Treatment

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 control implements the requirements of 10CFR50.36a, General Design Criterion 60 of Appendix A to 10CFR50, and design objective Section II.D of Appendix I to 10CFR50. The specified limits governing the use of appropriate portions of the systems were specified as a suitable fraction of the guide set forth in Sections II.B and II.C of Appendix I, 10CFR50, for gaseous effluents.



(1) No significant effect in reducing offsite doses when compared to transit time required for releases to reach SITE BOUNDARY.

Figure 4.3-1
Gaseous Effluent Treatment System Schematic

3/4.4 TOTAL DOSE

3/4.4.1 Total Dose

CONTROLS

3.4.1 The dose or dose commitment to any MEMBER OF THE PUBLIC beyond the SITE BOUNDARY from Pilgrim Station sources is limited to ≤ 25 mrem to the total body or any organ (except the thyroid, which is limited to ≤ 75 mrem) over a period of any calendar year.

APPLICABILITY: At all times

ACTION:

With the calculated dose from the release of radioactive materials in liquid or gaseous effluents exceeding twice the limits of Controls 3.2.2, 3.3.2 or 3.3.3; prepare and submit a special report to the Commission and limit the subsequent releases such that the dose or dose commitment to any MEMBER OF THE PUBLIC beyond the SITE BOUNDARY from all uranium fuel cycle sources is limited to ≤ 25 mrem to the total body or any organ (except thyroid, which is limited to ≤ 75 mrem) over any calendar year. This special report shall include an analysis which demonstrates that radiation exposures to all members of the public from all uranium fuel cycle sources (including all effluent pathways and direct radiation) are less than the 40CFR190 standard. Otherwise, obtain a variance from the Commission to permit releases which exceed the 40CFR190 standard.

SURVEILLANCE REQUIREMENTS

4.4.1 Dose Calculations - Cumulative dose contributions from liquid and gaseous effluents shall be determined in accordance with Controls 3.2.2, 3.3.2, and 3.3.3; and in accordance with the ODCM.

BASES

3/4.4.1 Total Dose

This section is provided to meet the dose limitations of 40CFR190 that have now been incorporated into 10CFR20 by 46FR18525. The control requires the preparation and submittal of a special report whenever the calculated doses from plant radioactive effluents exceed twice the design objective doses of 10CFR50, Appendix I. For sites containing up to 4 reactors, it is highly unlikely that the resultant dose to a MEMBER OF THE PUBLIC beyond the SITE BOUNDARY will exceed the dose limits of 40CFR190 if the individual reactors remain within the reporting requirement level. 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 beyond the SITE BOUNDARY to within the 40CFR190 limits. For the purposes of the special report, it may be assumed that the dose commitment to the MEMBER OF THE PUBLIC beyond the SITE BOUNDARY from other uranium fuel cycle sources is negligible, except dose contributions from other nuclear fuel cycle facilities at the same site or within a radius of 8 km must be considered. If the dose to any MEMBER OF THE PUBLIC beyond the SITE BOUNDARY is estimated to exceed the limits of 40CFR190, a request for a variance in a special report in accordance with 40CFR190.11 and 10CFR20.2203(a)(4) is considered to be a timely request and fulfills the requirements of 40CFR190 until NRC staff action is completed. This is provided that the release conditions resulting in violation of 40CFR190 have not already been corrected. The variance only relates to the limits of 40CFR190, and does not apply in any way to the other requirements for dose limitation of 10CFR20. An individual is not considered a MEMBER OF THE PUBLIC during any period in which he/she is engaged in any operation that is part of the nuclear fuel cycle.

3/4.5 RADIOLOGICAL ENVIRONMENTAL MONITORING

3/4.5.1 Environmental Monitoring Program

CONTROLS

3.5.1 An environmental monitoring program shall be conducted to evaluate the effects of station operation on the environs and to verify the effectiveness of the source controls on radioactive materials

The radiological environmental monitoring program shall be conducted as specified in Tables 3.5-1 through 3.5-3.

APPLICABILITY: At all times.

ACTION:

a. With the radiological environmental monitoring program not being conducted as specified in Tables 3.5-1 through 3.5-3, prepare and submit to the Commission, in the Annual Radiological Environmental Monitoring Report required by Technical Specifications Administrative Control 5.6.2, a description of the reasons for not conducting the program as required and the plans for preventing a recurrence.

b. With the level of radioactivity as the result of plant effluents in an environmental sampling medium at a specified location exceeding the reporting levels of Table 3.5-4 when averaged over any calendar quarter, prepare and submit to the Commission within 30 days, a special report that identifies the cause(s) for exceeding the limit(s) and defines the corrective actions to be taken to reduce radioactive effluents so that the potential annual dose to a MEMBER OF THE PUBLIC is less than the calendar year limits of Controls 3.2.2, 3.3.2, or 3.3.3. When more than one of the radionuclides in Table 3.5-4 are detected in the sampling medium, this report shall be submitted if:

$$\frac{\text{Concentration (1)}}{\text{Reporting Level (1)}} + \frac{\text{Concentration (2)}}{\text{Reporting Level (2)}} + \ldots\ldots \geq 1.0$$

When radionuclides other than those in Table 3.5-4 are detected and are the result of plant effluents, this report shall be submitted if the potential annual dose to a MEMBER OF THE PUBLIC is equal to or greater than the calendar year limits of Controls 3.2.2, 3.3.2, or 3.3.3. This report is not required if the measured level of radioactivity was not the result of plant effluents; however, in such an event, the condition shall be reported and described in the Annual Radiological Environmental Monitoring Report.

3/4.5 RADIOLOGICAL ENVIRONMENTAL MONITORING

3/4.5.1 Environmental Monitoring Program (Continued)

CONTROLS

ACTION: (continued)

c. With milk or fresh leafy vegetable samples unavailable from one or more of the sample locations required by Table 3.5-1, identify locations for obtaining replacement samples and add them to the Radiological Environmental Monitoring Program within 30 days. The specific locations from which samples were unavailable may then be deleted from the monitoring program. Pursuant to Technical Specifications Administrative Control 5.6.2, identify the cause of the unavailability of samples and identify the new location(s) obtaining replacement samples in the next Annual Radiological Environmental Monitoring Report and also include in the report the table for the ODCM reflecting the new location(s).

SURVEILLANCE REQUIREMENTS

4.5.1 The radiological environmental monitoring samples shall be collected pursuant to Tables 3.5-1 through 3.5-3 in the Offsite Dose Calculation Manual (ODCM) and shall be analyzed pursuant to the requirements of Table 3.5-1 and the detection capabilities required by Table 4.5-1.

1. Cumulative dose contributions from the current calendar year from radionuclides detected in environmental samples shall be determined in accordance with the methodology and parameters in the ODCM. These results will be reported in the Annual Radiological Environmental Monitoring Report.

BASES

3/4.5.1 Environmental Monitoring Program

An environmental radiological monitoring program is conducted to verify the adequacy of in-plant controls on the release of radioactive materials. The program is designed to detect radioactivity concentrations to ensure that radiation doses to individuals do not exceed the levels set forth in 10CFR50, Appendix I.

Groundwater flow at the plant site is into Cape Cod Bay; therefore, terrestrial monitoring of groundwater is not included in this program.

Detection capabilities for environmental sample analyses are tabulated in terms of the lower limits of detection (LLD). The LLD in Table 4.5-1 is considered optimum for routine environmental measurements in industrial laboratories. 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.

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).

TABLE 3.5-1

OPERATIONAL RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

Exposure Pathway, Sample, or Measurement Type	Sampling, Measurement, and/or Collection Locations[1]	Sampling, Measurement, and/or Collection Frequency	Type and Frequency of Analysis or Measurement
DIRECT RADIATION			
Environmental TLD	110 Locations, See Table 3.5-2	Quarterly Collection	Gamma exposure[2]; Quarterly
AIRBORNE			
Particulates	11 Locations, See Table 3.5-3	Continuous sampling with particulate filter; Weekly Collection	Gross beta radioactivity analysis 24 hours or more after weekly filter change[3]; Weekly AND Gamma isotopic[4] of composite by location; Quarterly
Radioiodines	11 Locations, See Table 3.5-3	Continuous sampling with charcoal cartridge; Weekly Collection	I-131 analysis; Weekly
TERRESTRIAL			
Green Leafy Vegetables	Plymouth County Farm[5], Bridgewater Farm Control[6]	At time of harvest	Gamma isotopic analysis[4] on edible portions
Cranberries	Manomet Point Bog, Bartlett Rd. Bog, Pine St. Bog Control[6]	At time of harvest	Gamma isotopic analysis[4] on edible portions

TABLE 3.5-1 (continued)

OPERATIONAL RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

Exposure Pathway, Sample, or Measurement Type	Sampling, Measurement, and/or Collection Locations[1]	Sampling, Measurement, and/or Collection Frequency	Type and Frequency of Analysis or Measurement
MARINE/AQUATIC			
Surface Water[7]	Discharge Canal, --- Bartlett Pond, Powder Point Control[6]	Continuous Composite Sample --- Weekly grab sample	Gamma isotopic[4], analysis of monthly composite samples; AND H-3 analysis of quarterly composite samples
Sediment	Discharge Canal Outfall, Manomet Point, Plymouth Beach, Plymouth Harbor, Duxbury Bay Control[6] Green Harbor Control[6]	Semiannual Collection	Gamma isotopic analysis[4]
Irish Moss (Algae)	Discharge Canal Outfall, Manomet Point, Ellisville, Brant Rock Control[6]	Semiannual Collection	Gamma isotopic analysis[4]
Mussels	Discharge Canal Outfall, Plymouth Harbor, Green Harbor Control[6]	Semiannual Collection	Gamma isotopic analysis[4] on edible portions
Soft-shelled clams	Plymouth Harbor, Duxbury Bay Control[6]	Semiannual Collection	Gamma isotopic analysis[4] on edible portions
Lobster	Discharge Canal Outfall --- Offshore Control[6]	Four times per season, from May through October --- Once per season	Gamma isotopic analysis[4] on edible portions
Fishes	Discharge Canal Outfall --- Offshore Control[3]	Semiannual for Group I[8]; annually in season for Groups II, III, and IV[8] --- Annually for each group[8];	Gamma isotopic analysis[5] on edible portions

TABLE 3.5-1 (continued)

NOTES

(1) Specific parameters of distance and direction sector from centerline of the reactor, and additional description where pertinent, are provided for each sample location in Table 3.5-1 in a subsequent tables and figures in the ODCM. Deviation are permitted from the required sampling schedule if samples are unobtainable due to circumstances such as hazardous conditions, extreme inclement weather, seasonable unavailability, and malfunction of automatic sampling equipment. If samples are unobtainable due to sampling equipment malfunction, efforts shall be made to complete corrective action prior to the end of the next sampling period. All deviations from the sampling schedule shall be documented in the Annual Radiological Environmental Operating Report pursuant to PNPS Technical Specification Administrative Control 5.6.2. It is recognized that, at times, it may not be possible or practicable to continue to obtain samples of the media of choice at the most desired location or time. In these instances suitable alternative media and locations may be chosen for the particular pathway in question and appropriate substitutions made within 30 days in the Radiological Environmental Monitoring Program outlined in ODCM Table 3.5-1 and subsequent tables. Pursuant to PNPS Technical Specification Administrative Control 5.5.1, submit in the next Annual Radioactive Effluent Release Report documentation for a change in the ODCM including revised figure(s) and table(s) for the ODCM reflecting the new location(s) with supporting information identifying the cause of the unavailability of samples for the pathway and justifying the selection of the new location(s) for obtaining samples.

(2) Minimum sensitivity for TLD exposure measurements is 1 μR/hr, or 2.19 mR/standard quarter .

(3) Airborne particulate sample filters shall be analyzed for gross beta radioactivity 24 hours or more after sampling to allow of radon and thoron daughter decay. If gross beta activity in air particulate samples is greater than 10 times the yearly mean of control samples, gamma isotopic analysis shall be performed on the individual samples.

(4) Gamma isotopic analysis means the identification and quantification of gamma-emitting radionuclides that may be attributable to the effluents from the facility.

(5) These locations may be altered in accordance with results of land use census surveys discussed in Effluent Control 4.5.2.

(6) Indicates control location.

(7) Groundwater flow at the plant site is into Cape Cod Bay; therefore, terrestrial monitoring of groundwater and/or drinking water is not included in this program.

(8) Fish analyses will be performed on samples from each of the following groups:

I. Bottom Oriented	II. Near Bottom Distribution	III. Anadromous	IV. Coastal Migratory
Winter Flounder	Tautog	Alewife	Bluefish
Yellowtail Flounder	Cunner	Rainbow Smelt	Atlantic Herring
	Atlantic Cod	Striped Bass	Atlantic Menhaden
	Pollock		Atlantic Mackerel
	Hakes		

TABLE 3.5-2

ENVIRONMENTAL TLD LOCATIONS

TLD Station		Location[1]	TLD Station		Location[1]
Description	Code	Distance/Direction	Description	Code	Distance/Direction
TLDs Within Protected Area			Zone 1 TLDs: 0-3 km		
O&M/RXB. BREEZEWAY	P21	50 m SE	EMERSON ROAD	EM	1.53 km SSE
EXEC.BUILDING	P24	57 m W	EMERSON/PRISCILLA	EP	1.55 km SE
FENCE-R SCREENHOUSE	P04	66 m N	ACCESS ROAD	AR	1.59 km SSE
O&M - 2ND W WALL	P20	67 m SE	BAYSHORE	BS	1.76 km W
EXEC.BUILDING LAWN	P25	76 m WNW	STATION E	E	1.86 km S
FENCE-WATER TANK	P05	81 m NNE	JOHN GAULEY	JG	1.99 km W
FENCE-OIL STORAGE	P06	85 m NE	STATION J	J	2.04 km SSE
O&M - 2ND SW CORNER	P19	86 m S	WHITEHORSE ROAD	WH	2.09 km SSE
O&M - 1ST SW CORNER	P18	90 m S	PLYMOUTH YMCA	RC	2.09 km WSW
COMPRESSED GAS STOR	P08	92 m E	STATION K	K	2.17 km S
FENCE-L SCREENHOUSE	P03	100 m NW	TAYLOR/THOMAS	TT	2.26 km SE
FENCE-EXEC.BUILDING	P17	107 m W	YANKEE VILLAGE	YV	2.28 km WSW
O&M - 2ND S WALL	P23	121 m ENE	GOODWIN PROPERTY	GN	2.38 km SW
FENCE-INTAKE BAY	P07	121 m SSE	RIGHT OF WAY	RW	2.83 km S
FENCE-WAREHOUSE	P26	134 m ESE	TAYLOR/PEARL	TP	2.98 km SE
FENCE-SHOREFRONT	P02	135 m NW			
FENCE-W BOAT RAMP	P09	136 m E	Zone 2 TLDs: 3-8 km		
O&M - 2ND N WALL	P22	137 m SE	VALLEY ROAD	VR	3.26 km SSW
FENCE-W SWITCHYARD	P16	172 m SW	MANOMET ELEM	ME	3.29 km SE
FENCE-TCF GATE	P11	183 m ESE	WARREN/CLIFFORD	WC	3.31 km W
FENCE-TCF/BOAT RAMP	P27	185 m ESE	RT.3A/BARTLETT RD	BB	3.33 km SSE
FENCE-ACCESS GATE	P12	202 m SE	MANOMET POINT	MP	3.57 km SE
FENCE-E SWITCHYARD	P15	220 m S	MANOMET SUBSTATION	MS	3.60 km SSE
FENCE-TCF/INTAKE BAY	P10	223 m E	BEACHWOOD ROAD	BW	3.93 km SE
FENCE-MEDICAL BLDG.	P13	224 m SSE	PINES ESTATE	PT	4.44 km SSW
FENCE-BUTLER BLDG	P14	228 m S	EARL ROAD	EA	4.60 km SSE
FENCE-TCF/PRKNG LOT	P28	259 m ESE	S PLYMOUTH SUBST	SP	4.62 km W
			ROUTE 3 OVERPASS	RP	4.81 km SW
Zone 1 TLDs: 0-3 km			RUSSELL MILLS RD	RM	4.85 km WSW
BOAT LAUNCH WEST	BLW	0.11 km E	HILLDALE ROAD	HD	5.18 km W
OVERLOOK AREA	OA	0.15 km W	MANOMET BEACH	MB	5.43 km SSE
HEALTH CLUB	TC	0.15 km WSW	BEAVERDAM ROAD	BR	5.52 km S
BOAT LAUNCH EAST	BLE	0.16 km ESE	PLYMOUTH CENTER	PC	6.69 km W
PEDESTRIAN BRIDGE	PB	0.21 km N	LONG POND/DREW RD	LD	6.97 km WSW
SHOREFRONT SECURITY	P01	0.22 km NNW	HYANNIS ROAD	HR	7.33 km SSE
MEDICAL BUILDING	WS	0.23 km SSE	MEMORIAL HALL	MH	7.58 km WNW
PARKING LOT	CT	0.31 km SE	SAQUISH NECK	SN	7.58 km NNW
SHOREFRONT PARKING	PA	0.35 km NNW	COLLEGE POND	CP	7.59 km SW
STATION A	A	0.37 km WSW			
STATION F	F	0.43 km NW	Zone 3 TLDs: 8-15 km		
STATION B	B	0.44 km S	DEEP WATER POND	DW	8.59 km W
EAST BREAKWATER	EB	0.44 km ESE	LONG POND ROAD	LP	8.88 km SSW
PNPS MET TOWER	PMT	0.44 km WNW	NORTH PLYMOUTH	NP	9.38 km WNW
STATION H	H	0.47 km SW	STANDISH SHORES	SS	10.39 km NW
STATION I	I	0.48 km WNW	ELLISVILLE ROAD	EL	11.52 km SSE
STATION L	L	0.50 km ESE	UP COLLEGE POND RD	UC	11.78 km SW
STATION G	G	0.53 km W	SACRED HEART	SH	12.92 km W
STATION D	D	0.54 km NW	KING CAESAR ROAD	KC	13.11 km NNW
PROPERTY LINE	PL	0.54 km NNW	BOURNE ROAD	BE	13.37 km S
STATION C	C	0.57 km ESE	SHERMAN AIRPORT	SA	13.43 km WSW
HALL'S BOG	HB	0.63 km SE			
GREENWOOD HOUSE	GH	0.65 km ESE	Zone 4 TLDs: >15 km[2]		
W ROCKY HILL ROAD	WR	0.83 km WNW	CEDARVILLE SUBST	CS	15.93 km S
E ROCKY HILL ROAD	ER	0.89 km SE	KINGSTON SUBST	KS	16.15 km WNW
MICROWAVE TOWER	MT	1.03 km SSW	LANDING ROAD	LR	16.46 km NNW
CLEFT ROCK	CR	1.27 km SSW	CHURCH/WEST	CW	16.56 km NW
BAYSHORE/GATE RD	BD	1.34 km WNW	MAIN/MEADOW	MM	17.02 km WSW
MANOMET ROAD	MR	1.38 km S	DIV MARINE FISH	DMF	20.97 km SSE
DIRT ROAD	DR	1.48 km SW	EAST WEYMOUTH SUBST	EW	39.69 km NW

(1) Distance and direction are measured from the centerline of the Reactor Building to the monitoring location.
(2) Indicates control locations.

TABLE 3.5-3

ROUTINE RADIOLOGICAL ENVIRONMENTAL SAMPLING LOCATIONS

Description	No.	Code	Distance	Direction
Air Particulate Filters, Charcoal Cartridges				
Overlook Area	08	OA	0.1 km	W
Pedestrian Bridge	07	PB	0.2 km	N
Medical Building	00	WS	0.2 km	SSE
East Breakwater	09	EB	0.5 km	ESE
Property Line	06	PL	0.5 km	NNW
West Rocky Hill Road	03	WR	0.8 km	WNW
East Rocky Hill Road	01	ER	0.9 km	SE
Cleft Rock	10	CR	1.3 km	SSW
Manomet Substation	17	MS	3.6 km	SSE
Plymouth Center	15	PC	6.7 km	W
East Weymouth Control	21	EW	40 km	NW
Vegetation [1]				
Plymouth County Farm	11	CF	5.6 km	W
Bridgewater Farm Control	27	BF	31 km	W
Cranberries				
Manomet Point Bog	13	MR	3.9 km	SE
Bartlett Road Bog	14	BT	4.3 km	SSE
Pine Street Bog Control	23	PS	26 km	WNW

[1] Additional samples of vegetables/vegetation will be collected each year at or near selected gardens identified during the most recent land use census. The locations of these selected gardens are listed in the station procedure describing crop sampling.

TABLE 3.5-3 (CONTINUED)

ROUTINE RADIOLOGICAL ENVIRONMENTAL SAMPLING LOCATIONS

Description	No.	Code	Distance	Direction
Surface Water				
Discharge Canal	11	DIS	0.2 km	N
Bartlett Pond	17	BP	2.7 km	SE
Powder Point Control	23	PP	13 km	NNW
Sediment				
Discharge Canal Outfall	11	DIS	0.8 km	NE
Manomet Point	15	MP	3.3 km	ESE
Plymouth Beach	14	PLB	4.0 km	WNW
Plymouth Harbor	12	Ply-H	4.1 km	W
Duxbury Bay Control	13	Dux-Bay	14 km	NNW
Green Harbor Control	24	GH	16 km	NNW
Irish Moss				
Discharge Canal Outfall	11	DIS	0.7 km	NNE
Manomet Point	15	MP	4.0 km	ESE
Ellisville	22	EL	12 km	SSE
Brant Rock Control	34	BR	18 km	NNW
Mussels				
Discharge Canal Outfall	11	DIS	0.7 km	NNE
Plymouth Harbor	12	Ply-H	4.1 km	W
Green Harbor Control	24	GH	16 km	NNW
Soft-shelled Clams				
Plymouth Harbor	12	Ply-H	4.1 km	W
Duxbury Bay Control	13	Dux-Bay	13 km	NNW
Lobster				
Discharge Canal Outfall	11	DIS	0.5 km	N
Duxbury Bay Control	13	Dux-Bay	11 km	NNW
Fishes				
Discharge Canal Outfall	11	DIS	0.5 km	N
Jones River Control	30	JR	13 km	WNW
Cape Cod Bay Control	98	CC-Bay	24 km	ESE
Buzzard's Bay Control	90	BB	40 km	SSW
Priest Cove Control	29	PC	48 km	SW
Vineyard Sound Control	92	MV	64 km	SSW

(1) Additional samples of vegetables/vegetation will be collected each year at or near selected gardens identified during the most recent land use census. The locations of these selected gardens are listed in the station procedure describing crop sampling.

Figure 3.5-1

Environmental TLD Locations Within the PNPS Protected Area

TLD Station		Location*
Description	Code	Distance/Direction
TLDs Within Protected Area		
O&M/RXB. BREEZEWAY	P21	50 m SE
EXEC.BUILDING	P24	57 m W
FENCE-R SCREENHOUSE	P04	66 m N
O&M - 2ND W WALL	P20	67 m SE
EXEC.BUILDING LAWN	P25	76 m WNW
FENCE-WATER TANK	P05	81 m NNE
FENCE-OIL STORAGE	P06	85 m NE
O&M - 2ND SW CORNER	P19	86 m S
O&M - 1ST SW CORNER	P18	90 m S
COMPRESSED GAS STOR	P08	92 m E
FENCE-L SCREENHOUSE	P03	100 m NW
FENCE-EXEC.BUILDING	P17	107 m W
O&M - 2ND S WALL	P23	121 m ENE
FENCE-INTAKE BAY	P07	121 m SSE
FENCE-WAREHOUSE	P26	134 m ESE
FENCE-SHOREFRONT	P02	135 m NW
FENCE-W BOAT RAMP	P09	136 m E
O&M - 2ND N WALL	P22	137 m SE
FENCE-W SWITCHYARD	P16	172 m SW
FENCE-TCF GATE	P11	183 m ESE
FENCE-TCF/BOAT RAMP	P27	185 m ESE
FENCE-ACCESS GATE	P12	202 m SE
FENCE-E SWITCHYARD	P15	220 m S
FENCE-TCF/INTAKE BAY	P10	223 m E
FENCE-MEDICAL BLDG.	P13	224 m SSE
FENCE-BUTLER BLDG	P14	228 m S
FENCE-TCF/PRKNG LOT	P28	259 m ESE

* Distance and direction are measured from the centerline of the Reactor Building to the monitoring location.

Figure 3.5-1 (continued)
Environmental TLD Locations Within the PNPS Protected Area

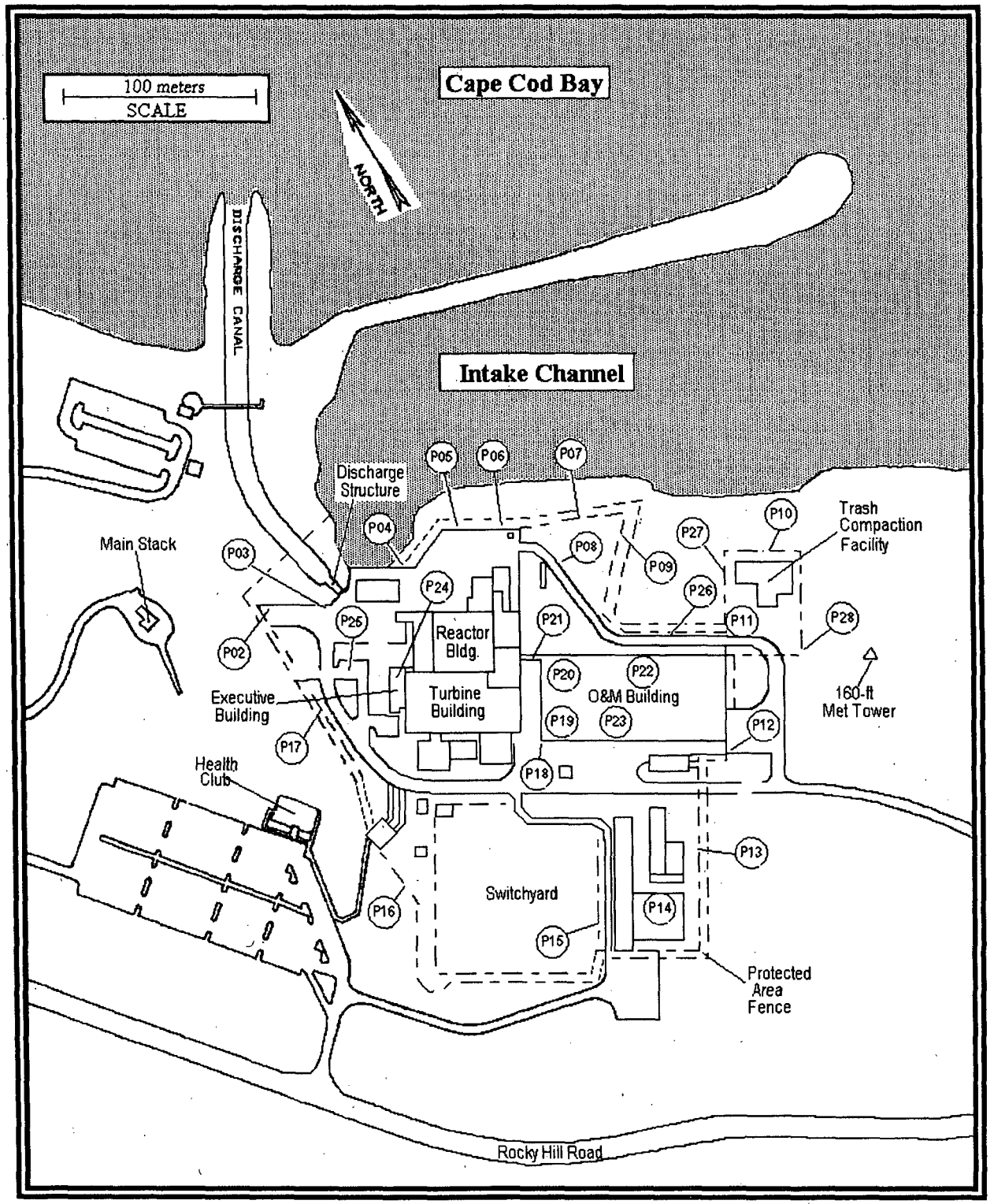


Figure 3.5-2

TLD and Air Sampling Locations: Within 1 Kilometer

TLD Station		Location*	Air Sampling Station		Location*
Description	Code	Distance/Direction	Description	Code	Distance/Direction
Zone 1 TLDs: 0-3 km					
BOAT LAUNCH WEST	BLW	0.11 km E	OVERLOOK AREA	OA	0.15 km W
OVERLOOK AREA	OA	0.15 km W	PEDESTRIAN BRIDGE	PB	0.21 km N
HEALTH CLUB	TC	0.15 km WSW	MEDICAL BUILDING	WS	0.23 km SSE
BOAT LAUNCH EAST	BLE	0.16 km ESE	EAST BREAKWATER	EB	0.44 km ESE
PEDESTRIAN BRIDGE	PB	0.21 km N	PROPERTY LINE	PL	0.54 km NNW
SHOREFRONT SECURITY	P01	0.22 km NNW	W ROCKY HILL ROAD	WR	0.83 km WNW
MEDICAL BUILDING	WS	0.23 km SSE	E ROCKY HILL ROAD	ER	0.89 km SE
PARKING LOT	CT	0.31 km SE			
SHOREFRONT PARKING	PA	0.35 km NNW			
STATION A	A	0.37 km WSW			
STATION F	F	0.43 km NW			
STATION B	B	0.44 km S			
EAST BREAKWATER	EB	0.44 km ESE			
PNPS MET TOWER	PMT	0.44 km WNW			
STATION H	H	0.47 km SW			
STATION I	I	0.48 km WNW			
STATION L	L	0.50 km ESE			
STATION G	G	0.53 km W			
STATION D	D	0.54 km NW			
PROPERTY LINE	PL	0.54 km NNW			
STATION C	C	0.57 km ESE			
HALL'S BOG	HB	0.63 km SE			
GREENWOOD HOUSE	GH	0.65 km ESE			
W ROCKY HILL ROAD	WR	0.83 km WNW			
E ROCKY HILL ROAD	ER	0.89 km SE			

* Distance and direction are measured from the centerline of the Reactor Building to the monitoring location.

Figure 3.5-2 (continued)

TLD and Air Sampling Locations: Within 1 Kilometer

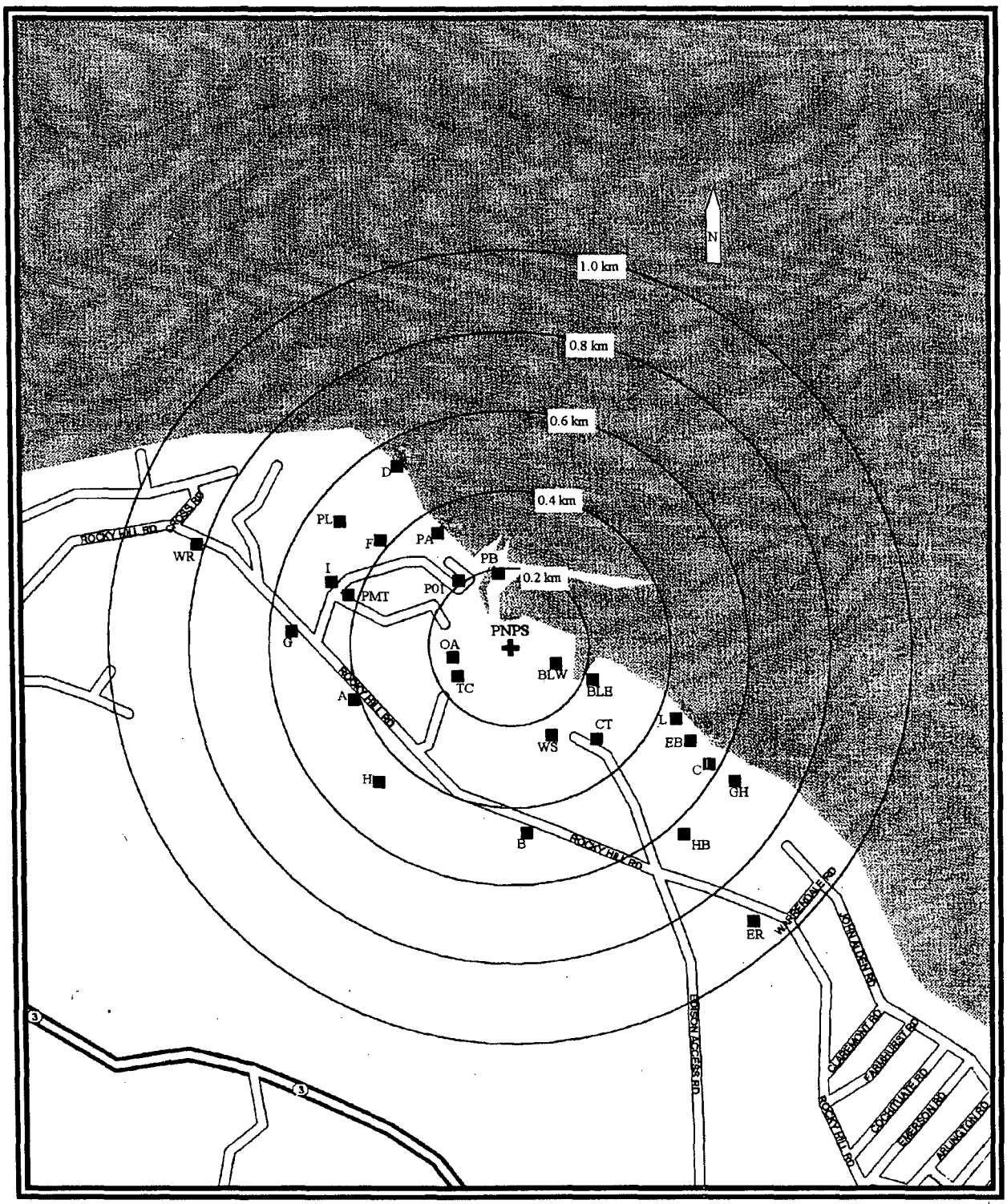


Figure 3.5-3

TLD and Air Sampling Locations: 1 to 5 Kilometers

TLD Station		Location*	Air Sampling Station		Location*
Description	Code	Distance/Direction	Description	Code	Distance/Direction
Zone 1 TLDs: 0-3 km					
MICROWAVE TOWER	MT	1.03 km SSW	CLEFT ROCK	CR	1.27 km SSW
CLEFT ROCK	CR	1.27 km SSW	MANOMET SUBSTATION	MS	3.60 km SSE
BAYSHORE/GATE RD	BD	1.34 km WNW			
MANOMET ROAD	MR	1.38 km S			
DIRT ROAD	DR	1.48 km SW			
EMERSON ROAD	EM	1.53 km SSE			
EMERSON/PRISCILLA	EP	1.55 km SE			
ACCESS ROAD	AR	1.59 km SSE			
BAYSHORE	BS	1.76 km W			
STATION E	E	1.86 km S			
JOHN GAULEY	JG	1.99 km W			
STATION J	J	2.04 km SSE			
WHITEHORSE ROAD	WH	2.09 km SSE			
PLYMOUTH YMCA	RC	2.09 km WSW			
STATION K	K	2.17 km S			
TAYLOR/THOMAS	TT	2.26 km SE			
YANKEE VILLAGE	YV	2.28 km WSW			
GOODWIN PROPERTY	GN	2.38 km SW			
RIGHT OF WAY	RW	2.83 km S			
TAYLOR/PEARL	TP	2.98 km SE			
Zone 2 TLDs: 3-8 km					
VALLEY ROAD	VR	3.26 km SSW			
MANOMET ELEM	ME	3.29 km SE			
WARREN/CLIFFORD	WC	3.31 km W			
RT.3A/BARTLETT RD	BB	3.33 km SSE			
MANOMET POINT	MP	3.57 km SE			
MANOMET SUBSTATION	MS	3.60 km SSE			
BEACHWOOD ROAD	BW	3.93 km SE			
PINES ESTATE	PT	4.44 km SSW			
EARL ROAD	EA	4.60 km SSE			
S PLYMOUTH SUBST	SP	4.62 km W			
ROUTE 3 OVERPASS	RP	4.81 km SW			
RUSSELL MILLS RD	RM	4.85 km WSW			

* Distance and direction are measured from the centerline of the Reactor Building to the monitoring location.

Figure 3.5-3 (continued)

TLD and Air Sampling Locations: 1 to 5 Kilometers

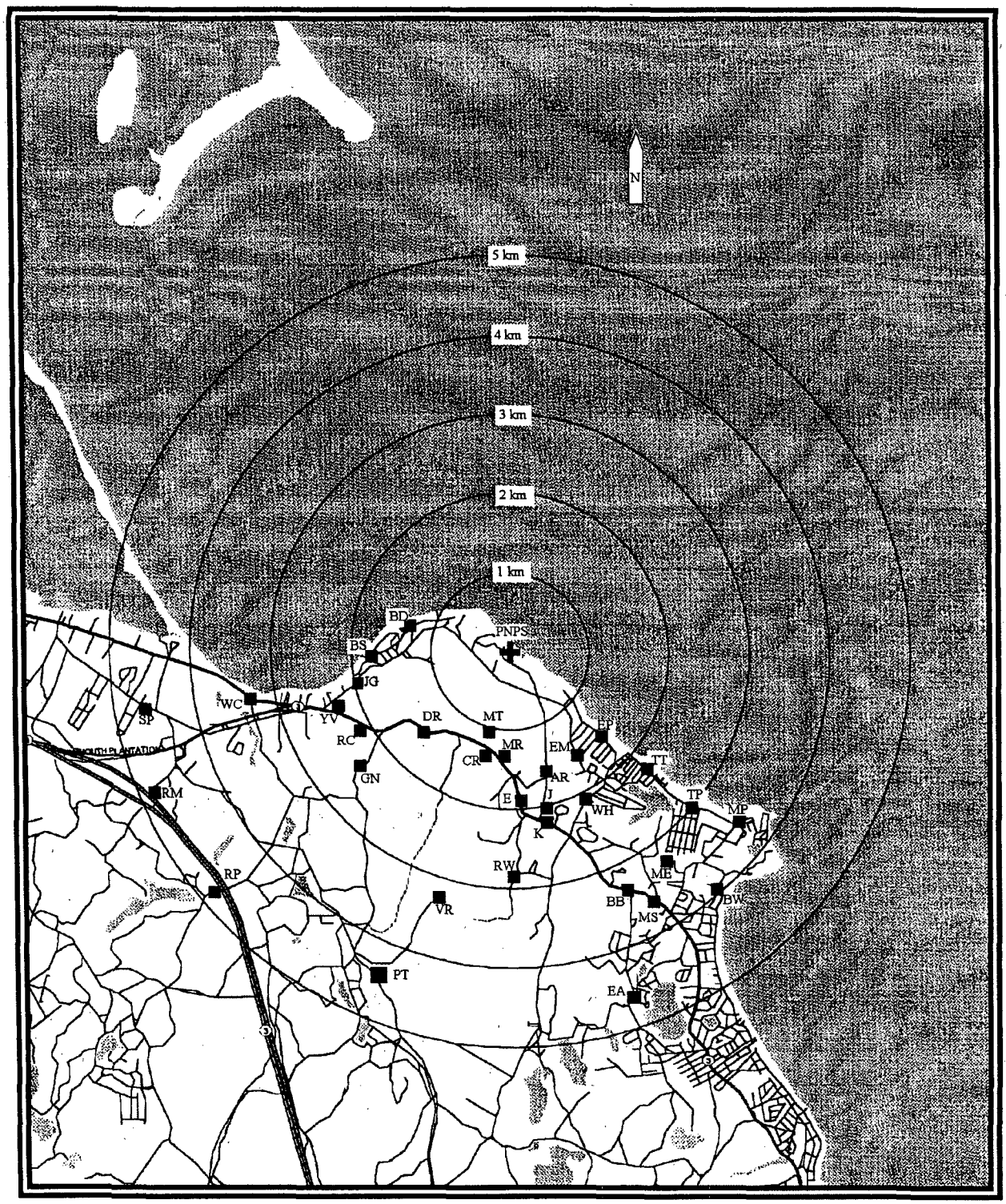


Figure 3.5-4

TLD and Air Sampling Locations: Greater Than 5 Kilometers

TLD Station		Location*	Air Sampling Station		Location*
Description	Code	Distance/Direction	Description	Code	Distance/Direction
Zone 2 TLDs: 3-8 km					
HILLDALE ROAD	HD	5.18 km W	PLYMOUTH CENTER	PC	6.69 km W
MANOMET BEACH	MB	5.43 km SSE	EAST WEYMOUTH SUBST	EW	39.69 km NW
BEAVERDAM ROAD	BR	5.52 km S			
PLYMOUTH CENTER	PC	6.69 km W			
LONG POND/DREW RD	LD	6.97 km WSW			
HYANNIS ROAD	HR	7.33 km SSE			
MEMORIAL HALL	MH	7.58 km WNW			
SAQUISH NECK	SN	7.58 km NNW			
COLLEGE POND	CP	7.59 km SW			
Zone 3 TLDs: 8-15 km					
DEEP WATER POND	DW	8.59 km W			
LONG POND ROAD	LP	8.88 km SSW			
NORTH PLYMOUTH	NP	9.38 km WNW			
STANDISH SHORES	SS	10.39 km NW			
ELLISVILLE ROAD	EL	11.52 km SSE			
UP COLLEGE POND RD	UC	11.78 km SW			
SACRED HEART	SH	12.92 km W			
KING CAESAR ROAD	KC	13.11 km NNW			
BOURNE ROAD	BE	13.37 km S			
SHERMAN AIRPORT	SA	13.43 km WSW			
Zone 4 TLDs: >15 km					
CEDARVILLE SUBST	CS	15.93 km S			
KINGSTON SUBST	KS	16.15 km WNW			
LANDING ROAD	LR	16.46 km NNW			
CHURCH/WEST	CW	16.56 km NW			
MAIN/MEADOW	MM	17.02 km WSW			
DIV MARINE FISH	DMF	20.97 km SSE			
EAST WEYMOUTH SUBST	EW	39.69 km NW			

* Distance and direction are measured from the centerline of the Reactor Building to the monitoring location.

Figure 3.5-4 (continued)

TLD and Air Sampling Locations: Greater Than 5 Kilometers

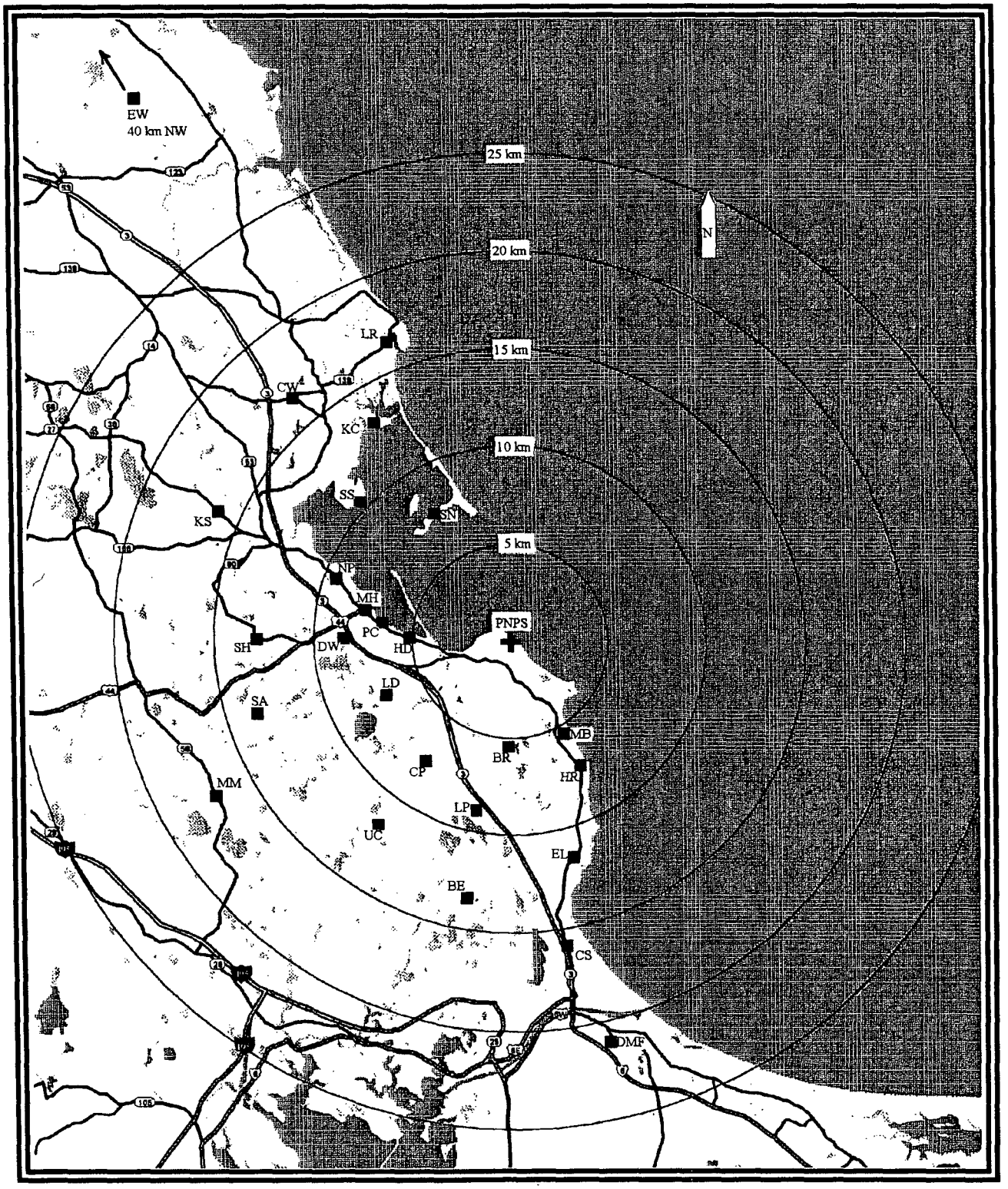


Figure 3.5-5

Terrestrial and Marine/Aquatic Sampling Locations

Description	Code	Distance/Direction*
FORAGE		
Whipple Farm	WH	2.9 km SW
Plymouth County Farm	CF	5.6 km W
Whitman Farm Control	WF	34 km WNW
VEGETABLES/VEGETATION		
Plymouth County Farm	CF	5.6 km W
Bridgewater Farm Control	BF	31 km W
CRANBERRIES		
Manomet Point Bog	MR	3.9 km SE
Bartlett Road Bog	BT	4.3 km SSE
Pine Street Bog Control	PS	26 km WNW

Description	Code	Distance/Direction*
SURFACE WATER		
Discharge Canal	DIS	0.2 km N
Bartlett Pond	BP	2.7 km SE
Powder Point Control	PP	13 km NNW
SEDIMENT		
Discharge Canal Outfall	DIS	0.8 km NE
Manomet Point	MP	3.3 km ESE
Plymouth Beach	PLB	4.0 km WNW
Plymouth Harbor	PLY-H	4.1 km W
Duxbury Bay Control	DUX-BAY	14 km NNW
Green Harbor Control	GH	16 km NNW
IRISH MOSS		
Discharge Canal Outfall	DIS	0.7 km NNE
Manomet Point	MP	4.0 km ESE
Ellisville	EL	12 km SSE
Brant Rock Control	BK	18 km NNW
MUSSELS		
Discharge Canal Outfall	DIS	0.7 km NNE
Plymouth Harbor	PLY-H	4.1 km W
Green Harbor Control	GH	16 km NNW
SOFT-SHELLED CLAMS		
Plymouth Harbor	PLY-H	4.1 km W
Duxbury Bay Control	DUX-BAY	13 km NNW
LOBSTER		
Discharge Canal Outfall	DIS	0.5 km N
Duxbury Bay Control	DUX-BAY	11 km NNW
FISHES		
Discharge Canal Outfall	DIS	0.5 km N
Plymouth Beach	PLB	4.0 km W
Jones River Control	JR	13 km WNW
Cape Cod Bay Control	CC-BAY	24 km ESE
N River-Hanover Control	NR	24 km NNW
Cataumet Control	CA	32 km SSW
Provincetown Control	PT	32 km NE
Buzzards Bay Control	BB	40 km SSW
Priest Cove Control	PC	48 km SW
Nantucket Sound Control	NS	48 km SSE
Atlantic Ocean Control	AO	48 km E
Vineyard Sound Control	MV	64 km SSW

* Distance and direction are measured from the centerline of the Reactor Building to the sampling/monitoring location.

Figure 3.5-5 (continued)

Terrestrial and Marine/Aquatic Sampling Locations

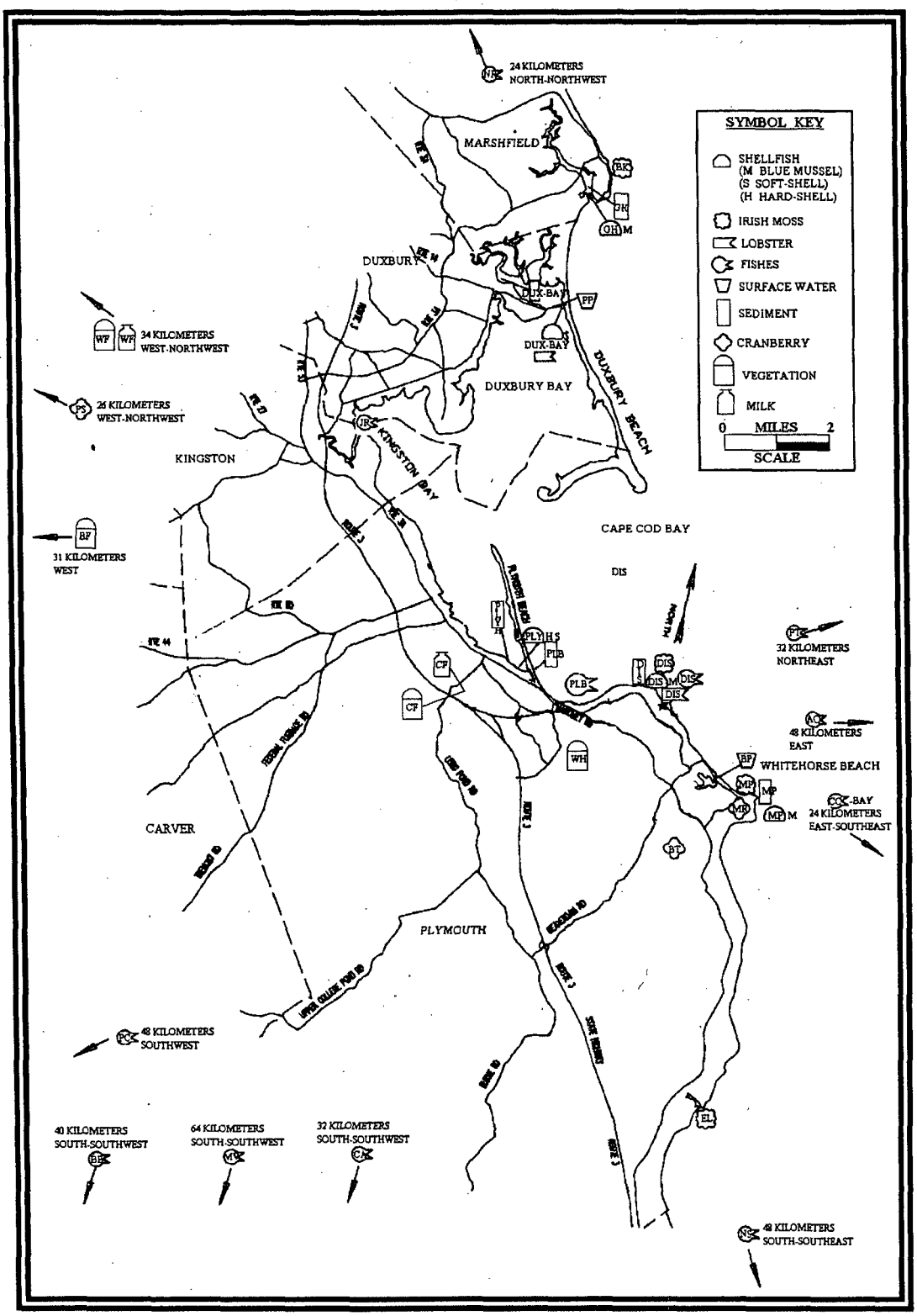


Figure 3.5-6

Environmental Sampling And Measurement Control Locations

Description	Code	Distance/Direction*
TLD		
Cedarville Substation	CS	16 km S
Kingston Substation	KS	16 km WNW
Landing Road	LR	16 km NNW
Church & West Street	CW	17 km NW
Main & Meadow Street	MM	17 km WSW
Div. Marine Fisheries	DMF	21 km SSE
East Weymouth Substation	EW	40 km NW
AIR SAMPLING		
East Weymouth Substation	EW	40 km NW
VEGETABLES/VEGETATION		
Bridgewater Farm Control	BF	31 km W
CRANBERRIES		
Pine Street Bog Control	PS	26 km WNW

Description	Code	Distance/Direction*
SURFACE WATER		
Powder Point Control	PP	13 km NNW
SEDIMENT		
Duxbury Bay Control	DUX-BAY	14 km NNW
Green Harbor Control	GH	16 km NNW
IRISH MOSS		
Brant Rock Control	BK	18 km NNW
MUSSELS		
Green Harbor Control	GH	16 km NNW
SOFT-SHELLED CLAMS		
Duxbury Bay Control	DUX-BAY	13 km NNW
LOBSTER		
Duxbury Bay Control	DUX-BAY	11 km NNW
FISHES		
Jones River Control	JR	13 km WNW
Cape Cod Bay Control	CC-BAY	24 km ESE
N River-Hanover Control	NR	24 km NNW
Cataumet Control	CA	32 km SSW
Provincetown Control	PT	32 km NE
Buzzards Bay Control	BB	40 km SSW
Priest Cove Control	PC	48 km SW
Nantucket Sound Control	NS	48 km SSE
Atlantic Ocean Control	AO	48 km E
Vineyard Sound Control	MV	64 km SSW

* Distance and direction are measured from the centerline of the Reactor Building to the sampling/monitoring location.

Figure 3.5-6 (continued)

Environmental Sampling And Measurement Control Locations

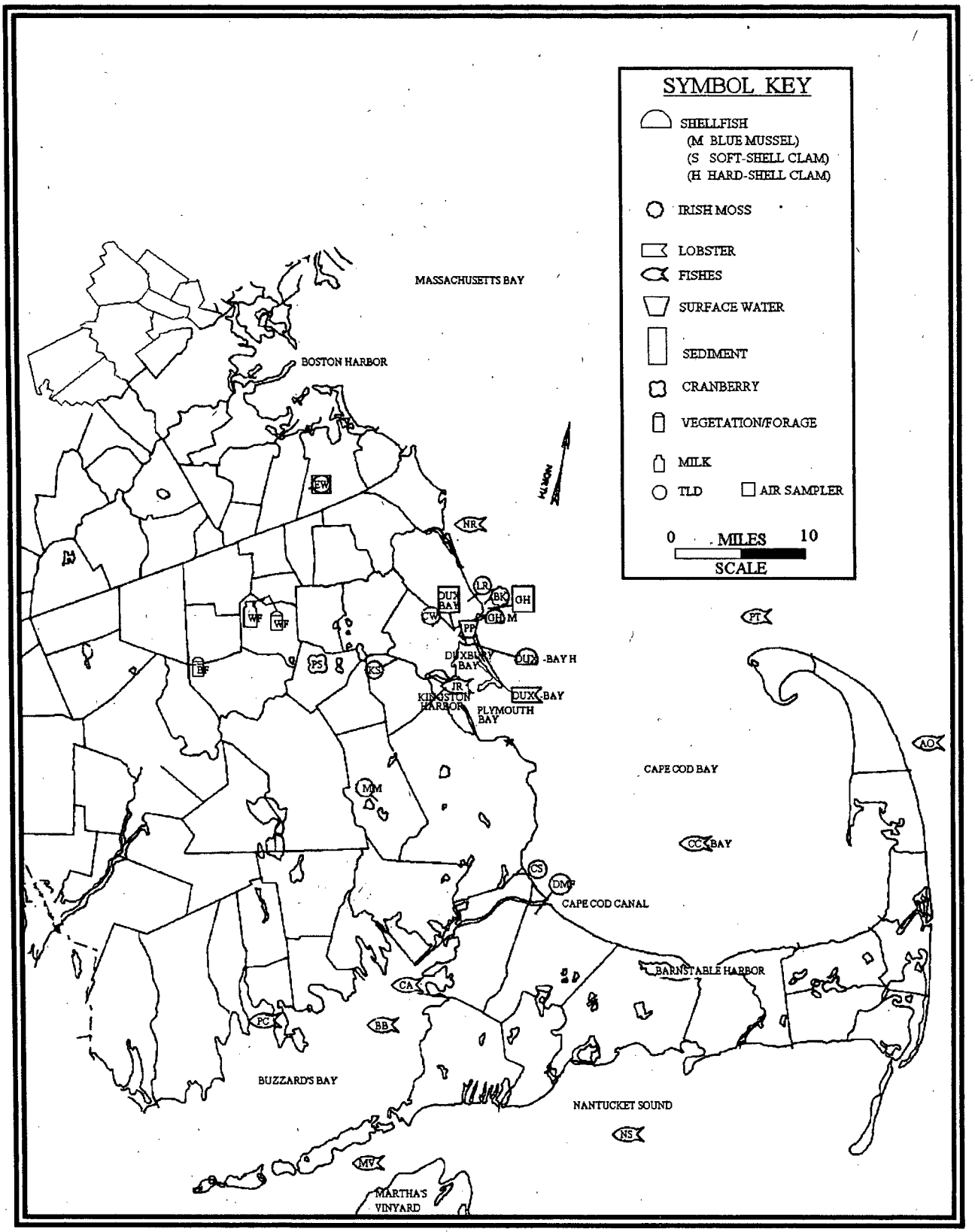


TABLE 3.5-4

REPORTING LEVELS FOR RADIOACTIVITY CONCENTRATIONS IN ENVIRONMENTAL SAMPLES

Analysis	Water pCi/L	Airborne Particulate or Gases pCi/m^3	Fish pCi/kg, wet	Milk pCi/L	Food Products pCi/kg, wet
H-3	30,000 (1)	--	--	--	--
Mn-54	1,000	--	30,000	--	--
Fe-59	400	--	10,000	--	--
Co-58	1,000	--	30,000	--	--
Co-60	300	--	10,000	--	--
Zn-65	300	--	20,000	--	--
Zr-95	400	--	--	--	--
Nb-95	400	--	--	--	--
I-131	20 (1)	0.9	--	3	100
Cs-134	30	10	1,000	60	1,000
Cs-137	50	20	2,000	70	2,000
Ba-140	200	--	--	300	--
La-140	200	--	--	300	--

(1) Value adjusted for fact that no drinking water pathway exists at Pilgrim Station.

TABLE 4.5-1

DETECTION CAPABILITIES FOR ENVIRONMENTAL SAMPLE ANALYSIS

LOWER LIMIT OF DETECTION (LLD)[1]

Analysis	Surface Water pCi/L	Airborne Particulate or Gases pCi/m^3	Marine and Aquatic Foods pCi/kg,wet	Milk pCi/L	Food Products pCi/kg,wet	Sediment pCi/kg,dry
Gross Beta	--	0.01	--	--	--	--
H-3	3000 [2]	--	--	--	--	--
Mn-54	15	--	130	--	--	--
Fe-59	30	--	260	--	--	--
Co-58	15	--	130	--	--	--
Co-60	15	--	130	--	--	--
Zn-65	30	--	260	--	--	--
Zr-95	30	--	--	--	--	--
Nb-95	15	--	--	--	--	--
I-131	15 [2]	0.07	--	1	60	--
Cs-134	15	0.05	130	15	60	150
Cs-137	18	0.06	150	18	80	180
Ba-140	60	--	--	60	--	--
La-140	15	--	--	15	--	--

[1] Refer to Appendix B of the ODCM for definition of lower limit of detection (LLD).

[2] Value adjusted for fact that no drinking water pathway exists at Pilgrim Station.

3/4.5 RADIOLOGICAL ENVIRONMENTAL MONITORING

3/4.5.2 Land Use Census

CONTROLS

3.5.2 A land use census shall be conducted and shall identify, within a distance of 8 km (5 miles), the location in each of the 16 meteorological sectors of the nearest milk animal, the nearest residence and the nearest garden of greater than 50 m^2 (500 ft^2) producing broad leaf vegetation. For elevated releases as defined in Regulatory Guide 1.111, Revision 1, July 1977, the land use census shall also identify, within a distance of 5 km (3 miles), the locations in each of the 16 meteorological sectors of all milk animals and all gardens of greater than 50 m^2 producing broad leaf vegetation.

APPLICABILITY: At all times.

ACTION:

a. With a land use census identifying a location(s) that yields a calculated dose or dose commitment greater than the values currently being calculated in Control 4.3.3, identify the new location(s) in the next Annual Radiological Environmental Monitoring Report.

b. With a land use census identifying a location(s) that yields a calculated dose or dose commitment (via the same exposure pathway) 20 percent greater than at a location from which samples are currently being obtained in accordance with Control 3.5.1, add the new location(s) to the Radiological Environmental Monitoring Program within 30 days. The sampling location(s), excluding the control station location, having the lowest calculated dose or dose commitment(s), via the same exposure pathway, may be deleted from this monitoring program after October 31 of the year in which this land use census was conducted. Identify the new location(s) in the next Annual Radiological Environmental Monitoring Report and also include in the report a revised figure(s) and table for the ODCM reflecting the new location(s).

SURVEILLANCE REQUIREMENTS

4.5.2 The land use census shall be conducted during the growing season, at least once per 12 months using that information that will provide the best results, such as by a door-to-door survey, aerial survey, or by consulting local agriculture authorities. The results of the land use census shall be included in the Annual Radiological Environmental Monitoring Report.

Broad leaf vegetation sampling of at least three different kinds of vegetation may be performed at the SITE BOUNDARY in each of the two different direction sectors with the highest predicted D/Qs, in lieu of the garden census. Specifications for broad leaf vegetation sampling in Table 3.5-1 shall be followed, including analysis of control samples.

BASES

3/4.5.2 Land Use Census

This section 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 10CFR50, Appendix I, Section IV.B.3. Restricting the census to gardens of greater than 50 m^2 provides assurance that significant exposure pathways via leafy vegetables will be identified and monitored, since a garden of this size is the minimum required to produce the quantity (26 kg/year) of leafy vegetables 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 vegetation yield of 2 kg/m^2.

5.0 RADIOLOGICAL EFFLUENT CONTROLS CROSS REFERENCE

Table 5-1 presents a summary of the limits contained in the PNPS Effluent Controls, Sections 3/4.2.1, 3/4.2.2, 3/4.2.3, 3/4.3.1, 3/4.3.2, 3/4.3.3, and 3/4.4.1. This table also presents cross-references to applicable portions of Methodology Section 9.0.

This table is intended to serve as a summary of the PNPS Effluent Controls and does not, in itself, establish limits. The specific effluent controls presented in Section 3/4 should be consulted for exact wording and specifics.

TABLE 5-1

PNPS EFFLUENT CONTROLS AND METHODOLOGY CROSS-REFERENCE

Effluent Control Section	Methodology Section	Applicable Limit or Objective	Exposure Period	Required Action
3/4.2.1 Liquid Effluent Concentration	9.1	10CFR20, App. B, Table 2 Column 2, and $2x10^{-4}$ µCi/mL for dissolved noble gases	Instantaneous	Restore concentration to within limits
3/4.2.2 Dose- Liquids	9.2	1.5 mrem T.B. 5 mrem Organ ..... 3 mrem T.B. 10 mrem Organ	Calendar Quarter ..... Calendar Year	30-day report if exceeded
3/4.2.3 Liquid Radwaste Treatment	9.2	0.06 mrem T.B. 0.2 mrem Organ	Projected for 31 days	Operate Liquid Waste Treatment System
3/4.3.1 Gaseous Effluents Dose Rate	9.3.1.3 --- 9.3.1.4 --- 9.3.2	500 mrem/yr T.B. from Noble Gases ..... 3000 mrem/yr Skin from Noble Gases ..... 1500 mrem/yr Organ from particulates with T½ > 8d., I-131, I-133 and tritium	Instantaneous	Restore release rates to within specifications
3/4.3.2 Dose- Noble Gases	9.3.1.1 and 9.3.1.2	5 mrad gamma air 10 mrad beta air ..... 10 mrad gamma air 20 mrad beta air	Calendar Quarter ..... Calendar Year	30-day report if exceeded
3/4.3.3 Dose- I-131, I-133 Particulates, H-3	9.3.2	7.5 mrem Organ ..... 15 mrem Organ	Calendar Quarter ..... Calendar Year	30-day report if exceeded
3/4.4.1 Total Dose	9.2, 9.3.1, 9.3.2, and 9.4	25 mrem T.B. 25 mrem Organ 75 mrem Thyroid	Calendar Year	30-day report if controls 3/4.2.2, 3/4.3.2, or 3/4.3.3 are exceeded by a factor of 2. Restore dose to public to within the applicable EPA limit(s) or obtain a variance.

NOTE: T.B. means total body.

6.0 DESCRIPTION OF RADWASTE SYSTEMS

6.1 Liquid Radwaste System

Liquid wastes from Pilgrim Station originates from a variety of sources which have a considerable disparity in chemical and radio-chemical composition and concentration (see section 9.2 of Reference 3). Normally these wastes are collected and treated separately. The liquid wastes fall into the following categories:

1) High Purity

2) Low Purity

3) Detergent

High purity clean wastes are typically characterized by having variable solids content, low conductivity, and variable radioactivity. They come from equipment drain sumps, ultrasonic resin cleaner (URC) operation, and the backwash and resin transfer water used to change out the condensate demineralizers. Reuse of processed high-purity waste is highly desirable.

Low purity chemical wastes have moderate conductivity and solids content. They come from building floor sumps and are generally high-purity wastes which have been contaminated by dirt, oil, etc. When processed, this stream may or may not be reused depending on the water balance in the plant and the quality of the product.

Detergent wastes are low radioactivity concentration wastes that have the potential to contain detergents. This waste is generated from washing and decontamination of equipment, the plant, and personnel. This detergent waste is collected in the miscellaneous waste tank and is not treatable. The waste is passed through strainers, prior to discharge through the radwaste discharge header and into the circulating water discharge canal.

A schematic of the system as determined in Reference 4 is shown in Figure 4.2-1, in Section 3/4.2. In the system, the high purity waste is collected in one of two 15,000-gal clean waste tanks. Low purity waste is collected in one of two 15,000 gallon chemical waste tanks. This low purity waste is batched to the clean waste tanks where both types of waste are processed through a mixed bed ion exchange demineralizer. The processed liquid is collected in one of four 18,000 gal treated water holdup tanks. It is reused to the greatest extent possible.

6.2 Treated Gaseous Radwaste System

The air ejector and augmented offgas system (see Section 9.4 of Reference 3) includes the subsystems that process and/or dispose of the gases from the main condenser air ejectors, the startup mechanical vacuum pump, and the gland seal condensers. All such gases from the unit are routed to the main stack for dilution and elevated release to the atmosphere. Discharges from the air ejector, the charcoal vault, and the stack are continuously monitored by radiation monitors.

Gases routed to the main stack include air ejector and gland seal offgases, and gases from the standby gas treatment system (SGTS). Dilution air input to the stack is supplied by one of two fans located in the filter building at the base of the main stack. The stack is designed such that prompt mixing of all gas inlet streams occurs in the base to allow location of sample points as near the base as possible.

The augmented offgas system uses a high temperature catalytic recombiner to recombine radiolytically dissociated hydrogen and oxygen from the air ejector system. Noncondensable radioactive offgas is continuously removed from the main condenser by the air ejector during plant operation. The air ejector offgas normally contains activation gases, principally N-16, 0-19, and N-13. The N-16 and 0-19 have short half-lives and quickly decay. The 10 min half-life N-13 is present in small amounts which is further reduced by decay. The air ejector offgas also contains Sr-90, Ba-140, and Cs-137. After hydrogen/oxygen recombination and chilling to strip the condensable to reduce the volume, the remaining noncondensables, principally the kryptons, xenons, and air, are delayed in a 30 minute holdup system before reaching the adsorption bed. Radioactive particulate daughters of the noble gases are retained on the HEPA filters and on the charcoal. The charcoal adsorption bed, operating in a constant temperature vault, selectively adsorbs and delays the xenons and kryptons from the bulk carrier gas, principally air. This delay on the charcoal permits the xenons and kryptons to decay in place. The offgas is discharged to the environs via the main stack. The activity of the gas leaving the offgas treatment system is continuously monitored as described in Section 7.2.2. This system results in a reduction of the offgas activity (Curies) released by factor of approximately 185 relative to a 30 minute holdup system.

The system as determined in Reference 4 for handling gaseous waste is shown in Figure 4.3-1, in Section 3/4.3.

7.0 RELEASE POINT AND MONITOR DESCRIPTION

7.1 Radioactive Effluent Release Point Description (Reference 3)

7.1.1 Liquid Radioactive Waste Effluent Release

The liquid radwaste discharge header receives discharge from the chemical radwaste monitor tank pumps, the clean radwaste treated water transfer pumps, and the miscellaneous waste drain tank pump (see Figure 4.2-1). The header provides controlled discharge through either a low flow discharge path or a high flow discharge path. The high flow path is normally used with a variable liquid radwaste effluent flow from 1-200 gpm. The common discharge header extends from both the low and high flow-paths and is monitored for radiation prior to discharge (see Section 7.2.1).

The monitor trips the discharge pumps, closes the flow control valves, and provides an alarm on high radiation. The liquid radwaste effluent is finally discharged through an outlet diffuser to the circulating water discharge canal. Liquid effluent releases enter the Cape Cod Bay at the outfall of the discharge canal which is located about 1100 feet north from the center of the reactor building.

In addition, batch releases from sources other than the radwaste tanks are permitted provided at least two independent samples are analyzed in accordance with PNPS Effluent Control Section 4.1.1.a, an independent verification of the release rate calculations is performed, and an independent verification of the discharge valving is performed. Concentrations released to unrestricted areas must be limited to the values specified in 10CFR20.

All batch releases which are not processed through the liquid radwaste treatment system are also discharged through an outlet to the circulating water discharge canal. These untreated liquid effluent releases also enter the Cape Cod Bay at the outfall of the discharge canal.

7.1.2 Main Stack Gas Release

The processed gases from the unit are routed to the main stack for dilution and elevated release to the atmosphere (see Figure 4.3-1). The main stack is continuously monitored by a radiation monitor (see Section 7.2.2).

Dilution air input to the stack is provided to reduce the hydrogen in the air ejector offgases to a concentration of less than 4 percent by volume. Dilution air is supplied by one of two fans located in the filter building at the base of the main stack. The stack is designed such that prompt mixing of all gas inlet streams occurs in the base to provide prompt dilution of hydrogen and to allow location of sample points as near to the base as possible.

The main stack is a pipe with a top elevation of about 400 feet mean sea level (MSL). The main stack is supported by the filter building. The filter building is a reinforced concrete structure which houses the dilution fans (16,860 cfm each fan), offgas filters, and heaters. The main stack is located about 700 feet west northwest of the reactor building.

7.1.3 Reactor Building Exhaust Vent Release

Air from areas containing potential sources of radioactive contamination such as the reactor building, radwaste building basement, and turbine building basement are discharged through the reactor building exhaust vent (see Figure 4.3-1). Normal airflow is routed from lesser to progressively greater areas of radioactive contamination potential prior to final exhaust. The reactor building exhaust vent is continuously monitored by a radiation monitor (see Section 7.2.3).

The operating floor ventilation is normally supplied with 40,000 cfm of filtered and tempered outside air which enters the reactor building through louvers in the east wall. Air is exhausted from the operating floor through ducts located in the roof truss area and the south wall; adjacent to the floor (54,000 cfm per fan). Additional exhaust ducts are located above the water level in the fuel pool, steam dryer/separator storage pool, and the reactor cavity.

Two contaminated area exhaust fans (25,000 cfm per fan), each rated at design capacity, are located in the reactor building. The fans discharge to the main exhaust plenum at the base of the reactor building. An additional smaller exhaust fan (5,000 cfm), located in the reactor building, exhausts only from the control rod drive maintenance shop and discharges to the main exhaust plenum. Constant volume control is maintained by inlet vanes which are automatically positioned.

The reactor building exhaust vent is a square plenum extending from the top of the west corner of the reactor building. The exhaust plenum releases to the atmosphere at an elevation of 182 feet MSL.

7.1.4 Turbine Building and Reactor Feed Pump Ventilation Releases

Air from areas above the main turbine and reactor feed pumps containing potential sources of radioactive contamination are discharged via roof exhausters above each of these plant components. The air exhausted from these roof exhausters is continuously monitored by a radiation monitor (see Section 7.2.4).

Six roof exhausters are located in the overhead above the main turbine. Each exhauster is rated at 35,000 scfm. Although these exhausters can be operated individually, the typical configuration is to only have one or two fans running to maintain proper ventilation balance in the building. Isokinetic sample probes are located under the two roof fans (VREX-102A, VREX-102B) nearest the west end of the building. These fans are operated preferentially to ensure sampling of air exhausted from the building.

Three roof exhausters are located above the reactor feed pumps, each rated at 28,000 scfm. These three fans exhaust into a common horizontal exhaust plenum located on the roof of the building. A single isokinetic probe is located in the plenum to collect a representative sample of air being exhausted.

7.2 Radioactive Effluent Monitoring System Description (References 3, 5, and 6)

7.2.1 Liquid Radioactive Waste Effluent Monitoring System

The liquid radiation waste effluent monitoring system consists of a single channel (see Section 7.12 of Reference 3). This channel includes a scintillation detector, a seven decade logarithmic radiation monitor, and a strip chart recorder. The detector is located in a shielded sampler that is located in a section of the radwaste liquid discharge header to minimize background radiation. The meter and recorder are located in the main control room. This channel is connected to the 24 volt DC power bus.

The channel has an upscale trip to indicate high radiation level and a downscale trip to indicate instrument trouble. The upscale trip alarms in the main control room (see Section 8.1 for liquid effluent monitor setpoints), trips the monitor tank pumps, and terminates the discharge. The downscale trip alarms in the main control room. The waste discharge valve is the isolation control device for the liquid radwaste effluent stream and it is automatically closed when the alarm is tripped. There are two waste discharge valves, one is situated on a two inch line and the other is situated on a one inch line. Both valves are located prior to the radiation waste effluent monitor and prior to the discharge canal. The valves are air operated valves. The waste discharge valves are: AO7216A and SV7216A, which are on the 2 inch line; and AO7216B and SV7216B, on the 1 inch line. The power source is the 24 volt DC power bus.

Alarm trip circuits can be tested using test signals. The channel is calibrated by laboratory analysis of a grab sample from the liquid radwaste system.

7.2.2 Main Stack Gas Monitoring System

The main stack gas monitoring system consists of two individual channels (see Section 7.12 of Reference 3) to monitor the release of noble gases. Each channel consists of a gamma-sensitive scintillation detector and a seven decade logarithmic count rate monitor that includes a power supply and a meter. Both channels are recorded on a two-pen recorder located in the main control room. Both channels are connected to the 24 volt DC power bus and to the AC radiation protection system via a transfer switch to the emergency diesel generators.

Each monitor has two upscale alarms and one downscale alarm. Exceeding a setpoint initiates an alarm in the main control room, but no control action is provided. The upscale alarms indicate high radiation (see Section 8-2 for gaseous effluent monitor setpoint), and the downscale alarm indicates instrument trouble.

To monitor noble gases in the gaseous effluent from the main stack, a sample is drawn through an isokinetic probe which is located in the stream to assure representative sampling. The sample passes through a particulate filter and charcoal cartridge. The filtered gas then flows to two shielded chambers where the radiation level of the noble gases is measured by two scintillation detectors, one located in each shielded chamber.

The system also provides for sampling of particulates and iodines by the use of a filter and charcoal cartridge located upstream of the gas being monitored in the shielded chambers. The filter and cartridge are routinely analyzed in a chemistry laboratory in accordance with PNPS Effluent Controls.

Each individual channel includes a built-in check source and a purge line to purge the stack gas from the sampling chamber. Both the purge valve and the check source are operated from the main control room. Each channel is calibrated by laboratory analysis of a grab sample in the offgas line. Alarm trip circuits can be tested using a test source.

7.2.3 Reactor Building Exhaust Vent Monitoring System

The reactor building exhaust vent monitoring system consists of two channels (see Section 7.12 of Reference 3). Each channel consists of a gamma-sensitive detector and a seven decade logarithmic count rate monitor that includes a power supply and a meter. Both channels are recorded on a two-pen recorder located in the main control room. Both channels are connected to the 24 volt DC power bus and the AC radiation protection system via a transfer switch to the emergency diesel generators.

Each monitor has two upscale alarms and one downscale alarm. Exceeding a setpoint initiates an alarm in the main control room, but no control action is provided. The upscale alarms indicate high radiation and the downscale alarm indicates instrument trouble.

To monitor noble gases from the gaseous effluent in the reactor building exhaust vent, a sample is drawn through an isokinetic probe which is located to assure representative sampling. The sample passes through a particulate filter and iodine cartridge. The filtered gas then flows to two shielded chambers where the radiation level of the gas is measured by two scintillation detectors, one located in each shielded chamber.

The system also provides for sampling of particulates and iodines by the use of a filter and charcoal cartridge located upstream of the gas being monitored in the shielded chamber. The filter and cartridge are routinely analyzed in a chemistry laboratory in accordance with PNPS Effluent Controls.

Each individual channel includes a built-in check source and a purge line to purge the gas from the sampling chamber. Both the purge valve and the check source are operable from the main control room. Each channel is calibrated by laboratory analysis of a grab sample from the reactor building ventilation system. Alarm trip circuits are tested using test signals.

7.2.4 Turbine Building and Feed Pump Gaseous Effluent Monitoring System (GEMS)

The turbine building and reactor feed pump gaseous effluent monitoring systems (GEMS) each contain a single-channel radiation detector. Each detector consists of a beta-sensitive plastic scintillation detector coupled to a photomultiplier tube. Power is supplied locally to each unit from local 120 VAC power.

Each monitor has two upscale alarms and one instrument failure (downscale) alarm. Exceeding a setpoint initiates an a local alarm, with no control action provided. The upscale alarm indicates high radiation and the downscale alarm indicates instrument trouble.

To monitor noble gases from the gaseous effluent in the air exhausted over the turbine deck or reactor feed pumps, a sample is drawn through an isokinetic probe which is located to assure representative sampling. The sample passes through a particulate filter and iodine cartridge. The filtered gas then flows to a shielded chamber where the radiation level of the gas is measured by a scintillation detector.

The system also provides for sampling of particulates and iodines by the use of a filter and charcoal cartridge located upstream of the gas being monitored in the shielded chamber. The filter and cartridge are routinely analyzed in a chemistry laboratory in accordance with PNPS Effluent Controls.

Each GEMS system noble gas detector channel includes a built-in check source, operated via local control. Each channel is calibrated by laboratory analysis of a grab sample from the monitored effluent stream. Alarm trip circuits are tested using test signals.

One radiological air sampling (RAS) pump is situated with intakes in the vicinity of each of the GEMS intakes to provide for continuous collection of particulate and iodine samples in the event of failure of either of the GEMS units.

TABLE 7-1

RADIOACTIVE EFFLUENT MONITOR DATA

Item	Stack Gas		Reactor Building Vent		Liquid Effluent
	Channel 1	Channel 2	Channel A	Channel B	
Manufacturer	GE	GE	GE	GE	GE
Model Number	194X900G9	194X900G11	194X900G11	194X900G11	194X900G9
Serial Number	6,343,901 PPA 6,342,790 PRM	6,550,PA6,343 907	6,550,733	6,550,789	6,342,995 PPA 6,342,788 PRM
Scale	cps	cps	cps	cps	cps
Range	1E-1 to 1E+6	1E-1 to 1E+6	1E-1 to 1E+6	1E-1 to 1E+6	1E-1 to 1E+6
Power	24 VDC	24 VDC	24 VDC	24 VDC	24 VDC
Location	Panel C910	Panel C910	Panel C910	Panel C910	Panel C910
Installation Date	8/20/71	8/20/71	8/20/71	8/20/71	9/13/71
Surveillance Test a. Daily b. Monthly c. Quarterly	Channel Check Source Check Channel Functional Test		Channel Check Source Check Channel Functional Test		Channel Check --- Channel Functional Test
Calibration a. Quarterly b. 24-month	Check Source Known radiation source		Check Source Known radiation source		Check Source Known radiation source
Alarm Set Points a. Hi Alarm b. Hi-Hi Alarm	See Section 8.2		See Section 8.2		See Section 8.1
Isolation Control Device	None		None		Waste Discharge Valve

7.3 Measurement Method During Release (References 3 and 7)

7.3.1 Liquid Effluent

Prior to the release of any liquid waste, a sample of the release is collected and the specific activity is determined by isotopic analysis. The waste discharge tank is recirculated at least 60 minutes prior to the collection of a sample. The release of any liquid waste is controlled on a mixed effluent concentration limit (ECL) basis, where the sum of the ratios between the isotopic concentration and the ECL is less than one. The specified waste discharge flow rate must be at least 10% less than the maximum waste discharge flow rate which shall not exceed 200 gpm. The discharge of the liquid effluent is made from the liquid radwaste discharge header.

7.3.2 Gaseous Effluent

The gaseous effluent radiation level is continuously monitored as it is being vented to the atmosphere. Periodic samples are collected from the turbine building, reactor building vent and the main stack. The particulate filters, charcoal cartridges, gas samples, and condensed water samples are analyzed for isotopic identification and quantification, in accordance with the PNPS Effluent Controls.

7.3.3 Limitations

a. Gaseous Effluent

1) PNPS Effluent Controls for gaseous release values.

b. Liquid Effluent

1) PNPS Effluent Controls for liquid release values.

2) If one pump is used to discharge the liquid waste and fails, the release is immediately discontinued.

3) If the discharge flow rate recorder fails, the release is immediately discontinued.

8.0 MONITOR SET POINTS

Radiation monitors are typically used to measure levels of radioactivity in given process and effluent streams. In the case of effluent monitors, various setpoints can be established to cause an annunciator alarm to sound to warn an operator to take a specific action, or in other cases to cause an automated system to isolate the system to curtail the release of radioactivity from that system.

In most cases, two levels of alarm are established. Typically, the highest level, or 'Hi-Hi' alarm, is established at or below the level that would correspond to exceeding one of the effluent controls in Section 3/4. In the cases of the liquid radwaste effluent monitor, steam jet air ejector monitor, and post-treatment radiation monitor, such a high level alarm would cause the system to automatically isolate to prevent additional release.

A second level of alert, or 'Hi' alarm, is often set at a lower level to provide early warning of unanticipated elevated levels of radioactivity in the system. This level of alarm is meant to alert the operators of the level of radioactivity, so that evaluations can be performed or additional samples collected to characterize the effluent or process stream. This 'Hi' alarm is typically set at some level that is a fraction of the limit, and is often administratively controlled through procedure guidance.

8.1 Liquid Effluent Monitor

The setpoint for the liquid effluent monitor (see Section 7.2.1) is established as follows:

1) Prior to a liquid batch release, the waste discharge tank is recirculated for at least 60 minutes and a sample is taken.

2) The liquid effluent sample is analyzed (see Section 7.3) to determine the concentrations of each detectable isotope in µCi/mL. (See Appendix B for the definitions of lower limit of detection.)

3) The efficiency (in counts/sec per µCi/mL) of the liquid discharge monitor is calculated based on prior release experience.

4) The setpoint for the liquid effluent monitor is calculated as follows:

a) Monitor setpoint based on activity concentration

$$c = \frac{C(F+f)}{f}$$

where:

c = the setpoint of the radioactivity monitor measuring the radioactivity concentration in the effluent line prior to dilution and subsequent release; the setpoint, which is proportional to the volumetric flow of the effluent line and inversely 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 10CFR20 in the unrestricted area, (µCi/mL);

C = the effluent concentration limit implementing10CFR20 for the site (µCi/mL);

F = the dilution water flow setpoint as measured at the release point, (gpm);

f = the effluent flow setpoint as measured at the radiation monitor location, (gpm);

where:

$$C = \frac{\sum_i C_{wi}}{\sum_i \frac{C_{wi}}{ECL_i}}$$

C_{wi} = concentration of nuclide i in the liquid waste discharge volume prior to any dilution as determined by current isotopic analysis for gamma emitting nuclides and most recent results from pure beta emitters as specified in Table 4.2-1 of PNPS Effluent Controls, (μCi/mL);

ECL_i = Effluent Concentration Limit of each nuclide i from 10CFR20 Appendix B, Table 2, Column 2, (μCi/mL);

b) Monitor setpoint based on monitor count rate

$$c_s = (c * x) + z$$

where:

c_s = the setpoint of the radioactivity monitor measuring the radionuclide concentration in the effluent line prior to dilution, (counts/sec);

c = the liquid effluent monitor setpoint based on activity concentration as calculated in step 4.a above, (μCi/mL);

x = the liquid effluent monitor efficiency/conversion factor for activity concentration to count rate, (counts-mL/μCi-sec);

z = the liquid effluent monitor background count rate, (counts/sec).

The setpoint will ensure that the concentration of liquid effluents discharged does not increase above the value for which the maximum permissible discharge flow rate was established (see Section 9.1 of this manual).

8.2 Gaseous Effluent Monitors

The only components of the station's gaseous effluent and discharge which are continuously monitored are the noble gases. The method of determining the main stack gas monitor (see Section 7.2.2) and reactor building exhaust vent monitor (see Section 7.2.3) Hi and Hi-Hi alarms is as follows:

1) At the time a gas grab sample is taken at the discharge point, the gross monitor reading is recorded (in counts/sec).

2) The results of the isotopic analyses on this sample in terms of μCi/cc of each isotope detected are used along with estimates of gaseous discharge flow rate (SCFM) to determine the current release rate of each detected isotope in μCi/sec.

3) These calculated release rates (μCi/sec) are used along with the equations given in Sections 9.3.1.3 and 9.3.1.4 of this manual to calculate the maximum offsite dose rate due to noble gases.

4) The ratio of this calculated dose rate to the PNPS Effluent Control instantaneous dose rate limit (500 mrem/yr for the total body and 3000 mrem/yr for the skin, or some fraction thereof) is used to scale the observed monitor reading at the time at which the grab sample was obtained as follows:

$$S_G = \frac{(C_s - B_g)\, DR_{Limit}}{DR_{Calc}} + B_g$$

where:

S_G = gaseous monitor setpoint corresponding to 500 mrem/yr to the total body or 3000 mrem/yr to the skin, whichever is more limiting (in counts/sec)

C_s = observed monitor reading at the time of the grab sample (in counts/sec)

B_g = measured background count rate at the sampler with no sample present (in counts/sec)

DR_{Limit} = the applicable dose rate limit, 500 mrem/yr for the total body or 3000 mrem/yr for the skin or some fraction thereof

DR_{Calc} = the calculated dose rate for the maximum individual from the methods of Section 9.3.1.3 and 9.3.1.4 of this manual using the release rates determined from the grab sample, mrem/yr

The resulting setpoint will be valid until the next grab sample is taken from the release point.

This method will be used to establish the Hi-Hi alarm at 500 mrem/yr to the total body or 3000 mrem/yr to the skin, whichever is more restrictive.

Since two release points exist for noble gas effluents, the setpoints may be varied to allow greater release rates from one point than the other, provided the total limit is below 500 mrem/yr for the total body or 3000 mrem/yr for the skin, whichever is more restrictive.

The Hi-Hi alarm setpoint for the gaseous monitors will be based on the equation in this section. The Hi alarm setpoint may be set at or below, but in no case above, the Hi-Hi alarm setpoint.

8.3 Steam Jet Air Ejector Monitor

The steam jet air ejector (SJAE) monitor is used to measure the release rate of noble gases in main condenser offgas prior to its further treatment and release from the main stack. This monitor's primary function is to provide alarm and isolation of this process flow stream in the event of excessively high release rates of noble gases from the condenser and recombiner. The maximum allowable release rate of noble gases in the SJAE offgas is 500,000 μCi/sec, as established in Technical Specification 3.8.1. For conservatism, the Hi-Hi alarm is set at 75% of this limit, or 375,000 μCi/sec. In association with changing to a 24-month refueling cycle, the frequency of equipment calibrations has also been extended from the typical 18-month cycle. In order to accommodate for any drift which may occur in SJAE monitor response during the

additional 6-months in the calibration interval, the Hi-Hi alarm has been further derated to a release rate of 300,000 μCi/sec. In response to guidance from the Institute of Nuclear Power Operations outlined in SOER 90-02, Pilgrim Station has chosen to administratively control the SJAE noble gas rate to a lower value to determine the desirability of a plant derate.

Since this gaseous stream undergoes further processing downstream of the SJAE monitor and is ultimately released via the main stack and monitored by the main stack gaseous effluent monitor, the SJAE monitor does not strictly qualify as a primary effluent monitor. Therefore, it is not normally recognized as such. However, the methodology for establishment of alarm setpoints is included in this section for completeness. These setpoints are established as follows:

1) A grab sample of the SJAE offgas is collected. The SJAE monitor reading (mR/hr) is recorded in conjunction with this sample.

2) Isotopic analyses are performed on the offgas sample and the total noble gas concentration (μCi/cc) is coupled with the flow rate (CFM) to calculate the SJAE release rate (μCi/sec).

3) The release rate (μCi/sec) is divided by the monitor reading (mR/hr) to determine the SJAE monitor conversion factor (μCi/sec/mR/hr).

4) The Hi-Hi alarm setpoint (mR/hr) is determined by dividing the administratively-determined maximum tolerable release rate by the SJAE monitor conversion factor (μCi/sec/mR/hr).

5) The Hi alarm setpoint is set at a maximum of 50% of the corresponding Hi-Hi alarm setpoint, or at other levels procedurally controlled to initiate evaluation of the system (e.g., sampling to determine noble gas mix and/or evaluate conversion factors).

Grab samples of the SJAE offgas are collected: 1) at least once every 31 days; or, 2) if the gross radioactivity release rate increases by 50% or more over the nominal steady state fission gas release after factoring out increases due to changes in thermal power level and hydrogen injection. Upon collection of these grab samples, new values are established for the total noble gas concentration, SJAE monitor conversion factor, and alarm setpoints. Typically, existing setpoints will be used unless the newly calculated setpoints yield lower values. In this case, the setpoints will be lowered to the newer, more conservative values.

8.4 Post-Treatment Radiation Monitor

The post-treatment radiation monitoring system takes a continuous sample from the outlet of the augmented offgas treatment system. This system has two instrumentation channels, each of which is equipped with a gamma-sensitive scintillation detector, a pulse preamplifier, a logarithmic radiation monitor, and an electroluminescent display. Both channels are recorded on a two-pen recorder located in the main control room. The two scintillation detectors are mounted in two shielded sample chambers. The sample is drawn from the offgas line through the sample line by the sample pump.

Each monitor has two upscale trips and a downscale trip. Any one upscale high radiation trip of the augmented offgas monitor closes the carbon bed filter bypass valve, if open, and opens the offgas line to the carbon bed, if closed, in the augmented offgas system. This upscale high radiation trip also provides an annunciator alarm in the control room.

Any combination of two high-high upscale radiation trips, one high-high upscale trip and one downscale trip, or two downscale trips of each monitor will actuate a time delay switch through a

keylock selector switch. This is the same 0-15 minute time delay switch located in the SJAE radiation monitor which closes the drain valve and the outlet valve in the offgas discharge line.

Since the gaseous stream from the augmented offgas treatment system undergoes further processing (delay decay) downstream of the post-treatment radiation monitor and is ultimately released via the main stack and monitored by the main stack gaseous effluent monitor, the post-treatment radiation monitor does not strictly qualify as a primary effluent monitor. Therefore, it is not normally recognized as such. The methodology for establishing alarm setpoints for the post-treatment radiation monitor is similar to that described in Section 8.3 for the SJAE monitors.

9.0 CALCULATIONAL METHODS

This section presents the calculational specifics required to demonstrate compliance with each of the Effluent Controls identified in Section 3/4 of this document.

The equations in this section are based on the equations and calculational methods described in Reference 8, unless otherwise specified. These equations have, in some cases, been presented in a slightly different form in an effort to simplify their use. The subscripts used are "a" for age group, "j" for organ, "i" for radionuclide, "p" for pathway and "l" for location. Capital letters have been used on the dose/dose rate, use factor, concentration, and dose conversion factor abbreviations to designate pathways. "A" is for aquatic foods, "S" for shoreline deposits, "W" for swimming, "Y" for yachting/boating, "N" for noble gas, "G" for ground plane deposition, "B" for breathing/inhalation, "L" for leafy vegetation, "R" for root crops/non-leafy vegetation, "M" for milk, and "C" for meat.

The descriptions of constants, variables, and parameters in this section are also based on those described in Reference 8, unless otherwise specified. The descriptions have, in some cases, been modified to describe the constant, variable, and parameter specific application in the corresponding equation. In addition, some of the constant and variable values have been revised to include more site specific values, to include more technically correct information, or to provide uniformity (e.g., λ_i values always presented in hr^{-1}). Values for parameters which only have a single value will appear along with the definition. For those parameters which can take on different values for different conditions, the appropriate value will appear in the referenced tables. All numerical constants have been derived from the indicated base conversion factors and are represented in scientific notation to the third significant digit.

9.1 Concentrations of Liquid Effluents

The following equation shall be used to determine the discharge flow rate such that concentrations of radioactive effluents released to unrestricted areas do not exceed the concentration limits specified in 10CFR20 Appendix B, Table 2, Column 2:

$$DFR = \frac{CW}{\sum_i \frac{C_{wi}}{ECL_i}}$$

where:

DFR = Maximum discharge release rate of liquid effluent, (gal/min).

CW = Flow rate of dilution water, (sum of waste discharge pumps, circulating water pumps, and/or salt service water pumps), (gal/min).

C_{wi} = Concentration of nuclide i in the liquid waste discharge volume prior to any dilution as determined by current isotopic analysis for gamma emitting nuclides and most recent results from pure beta and alpha emitters, (μCi/mL).

ECL_i = Effluent Concentration Limit of each nuclide *i* from 10CFR20 Appendix B, Table 2, Column 2, (μCi/mL).

9.2 Liquid Effluents Dose Assessment Methodology

The following equations shall be used to estimate the annual dose rates due to a release of radioactive liquid effluents. All input parameters (i.e., activity and volume) must be normalized to a 1 year release period. Modification of the final results is necessary for comparison to dose rate limits for periods different than one year. For comparison to monthly limits and quarterly limits, results would be scaled by 1/12 and 1/4, respectively. To determine the dose or dose commitment for a desired period, multiply the annual dose rate by the fraction of the year for the dose period desired. For purposes of projecting resulting dose estimates for the subsequent month, the release rates and concentrations are assumed to be equal to the previous month's release.

Pathways assuming internal deposition of radionuclides (i.e., ingestion) involve the use of a 50-year committed dose conversion factor. This entire prospective dose will be assigned to the individual for the year of intake (Reference 8). In the original version of the ODCM, values from Regulatory Guide 1.109 (Reference 8) were used for calculating doses. Upon incorporation of the Generic Letter 89-01 change (Revision 8), and conversion to an electronic document, dose conversion factors were obtained from updated tables used by the NRC in the computer program GASPAR-II (Reference 9). For pathways involving external radiation to the total body (i.e., shoreline activity, swimming, boating), the dose to all other organs is assumed equal to that for the total body (Reference 8, Appendix E).

Summation of the dose rates from the equations below should be performed for all significant pathways.

9.2.1 Liquid Pathways Annual Dose Rates

9.2.1.1 Aquatic Food Ingestion (Fish, Shellfish)

$$DA_{ajp} = UA_{ap} \sum_i \left[CA_{ip}\ DFI_{aij} \right]$$

where:

$$CA_{ip} = CW_{il}\ B_{ip}\ e^{-\lambda_i t_h}$$

$$CW_{il} = \frac{1.00E12\ Q_l\ M_l\ e^{-\lambda_i t_l}}{V}$$

Above equations derived from Reference 8, equations 2 and A-3.

9.2.1.2 Shoreline Deposits (Discharge Canal and Recreational Area)

$$DS_{ajl} = US_{al}\ W_l \sum_i \left[CS_{il}\ DFG_{ij} \right]$$

where:

$$CS_{il} = 2.89\ CW_{il}\ \frac{\left(1 - e^{-\lambda_i t_b}\right)}{\lambda_i}$$

CW_{il} = same as indicated in Equation 9.2.1.1

Above equation derived from Reference 8, equations A-4 through A-7.

9.2.1.3 Swimming (White Horse Beach)

$$DW_{ajl} = UW_{al} \sum_i \left[CW_{il}\ DFW_{ij} \right]$$

where:

CW_{il} = same as indicated in Equation 9.2.1.1

Above equations derived from Reference 10, equation 41 on page 151.

9.2.1.4 Yachting/Boating (Cape Cod Bay)

$$DY_{ajl} = 0.5\ UY_{al} \sum_i \left[CW_{il}\ DFW_{ij} \right]$$

where:

CW_{il} = same as indicated in Equation 9.2.1.1

Above equations derived from Reference 10, equation 41 on page 151.

9.2.2 Definitions:

B_{ip} = equilibrium bioaccumulation factor for radionuclide i, in aquatic foods pathway p, expressed as the concentration in biota (pCi/kg), divided by the concentration in water (pCi/liter) from Table A-1, (liters/kg);

Ca_{ip} = concentration of radionuclide i in pathway p of aquatic foods, (pCi/kg);

CS_{il} = effective surface concentration of radionuclide i in sediments at location l, (pCi/m^2);

CW_{il} = concentration of radionuclide i in seawater at location l, (pCi/liter);

DA_{ajp} = total annual dose rate from ingestion of aquatic foods to organ j, of individuals of age group a, from pathway p, (mrem/yr);

DFG_{ij} = open field ground plane dose conversion factor for organ j, from radionuclide i, from Table A-10, (mrem-m^2/pCi-hr);

DFI_{aij} = ingestion 50-year committed dose conversion factor for organ j, of individuals in age group a, from radionuclide i, from Table A-15 through A-18 (mrem/pCi ingested);

DFW_{ij} = submersion dose conversion factor in water, for organ j, of individuals in age group a, from radionuclide i, from Table A-2, (mrem-liter/pCi-hr);

DS_{ajl} = total annual dose rate from exposure received during shoreline activities, to organ j, of individuals of age group a, at location l, (mrem/yr);

DW_{ajl} = total annual dose rate from exposure received during swimming, to organ j, of individuals of age group a, at location l, (mrem/yr);

DY_{ajl} = total annual dose rate from exposure received during yachting/boating, to organ j, of individuals in age group a, at location l, (mrem/yr);

M_l = mixing ratio (reciprocal of dilution factor) at location l of exposure or harvest of aquatic food, from Table A-3, (dimensionless);

Q_i = annual release rate of radionuclide i in liquid effluents, (Ci/yr);

t_b = period of time for which sediment is exposed to radionuclides in seawater, including buildup, (hr, assumed to be 1.31E5 hr = 15y);

t_h = time between exposure of aquatic foods to radionuclides in sea water and their consumption by an individual, from Table A-3, (hr);

t_l = transit time required for radionuclides to reach location l, (hr, assumed to be 0.0 hr from the liquid waste tank to the discharge canal);

UA_{ap} = use factor of aquatic foods from pathway p, by individuals in age group a, from Table A-9 for maximum individual, Table A-8 for average individual, (kg/yr);

US_{al} = use factor (amount of time) an individual in age group a, engages in shoreline activities at location l, from Table A-9 for maximum individual, Table A-8 for average individual, (hr/yr);

UW_{al} = use factor (amount of time) an individual in age group a, engages in swimming at location l, from Table A-9 for maximum individual, Table A-8 for average individual, (hr/yr);

UY_{al} = use factor (amount of time) an individual in age group a, engages in yachting/boating at location l, from Table A-9 for maximum individual, Table A-8 for average individual, (hr/yr);

V = total annual discharge rate of liquids, represented by the sum of liquid effluents, circulating water pumps, and/or salt service water pumps, (liters/yr);

W_l = shoreline width factor for location l, from Table A-3, (dimensionless);

λ_i = radioactive decay constant of radionuclide i, (hr^{-1});

0.50 = scaling factor for yachting/boating assuming that doses received while on the surface of the water are 1/2 of doses received while immersed in water from Reference 10, (dimensionless);

2.89 = factor to convert for transfer of nuclides from water to sediment, equal to 100 liters/m^2-day from Reference 11 multiplied by 1 day/24 hr and by natural log of 2 (to convert reciprocal λ_i to half-life), as calculated in Reference 8, equation A-5, (liter/m^2-hr);

1.00E12 = factor to convert from Ci to pCi, (pCi/Ci);

9.3 Gaseous Effluents Dose Assessment Methodology

The following equations shall be used to estimate the annual dose rates due to release of radioactive gaseous effluents. All input parameters (i.e., activity and volume) must be normalized to a 1 year release period. Modification of final results is necessary for comparison to dose rate limits for periods different than one year. For comparison to monthly limits and quarterly limits, results would be scaled by 1/12 and 1/4, respectively. To determine the dose or dose commitment for a desired period multiply the annual dose rate by the fraction of the year for the dose period desired.

For conservatism, the shielding factor (S) used for calculating total body dose and skin dose from noble gases is normally assumed to be unity (1.0), as specified in NUREG-0133 (Reference 12). Also, although iodine deposition on vegetation is assumed to be 50% (Reference 8), 100% of airborne iodine is assumed to be deposited on the ground surface when calculating direct radiation (ground plane) exposure.

Pathways assuming internal deposition of radionuclides (i.e., inhalation, ingestion) involve the use of a 50-year committed dose conversion factor. This entire prospective dose will be assigned to the individual for the year of intake (Reference 8). In the original version of the ODCM, values from Regulatory Guide 1.109 (Reference 8) were used for calculating doses. Upon incorporation of the Generic Letter 89-01 change (Revision 8), and conversion to an electronic document, dose conversion factors were obtained from updated tables used by the NRC in the computer program GASPAR-II (Reference 9). For pathways involving external radiation to the total body (i.e., noble gas total body dose, ground plane deposition), the dose to all other organs is assumed equal to that for the total body (Reference 8, Appendix E).

Summation of the doses rates from the equations below should be performed for all significant pathways and all release points from which significant radioactive effluent releases have occurred (i.e., Main Stack and Reactor Building Exhaust Vent).

9.3.1 Gaseous Pathways Annual Dose Rates from Noble Gases

9.3.1.1 Gamma Air Dose

$$DN_\gamma = \sum_i \left[c_{i\gamma} \; DFN_{i\gamma} \right]$$

where:

$$C_{i\gamma} = 3.17E4 \left[\chi/Q \right]_\gamma \; Q_i$$

Above equations derived from Reference 8, equations 6, 7, B-1, B-2, B-4, and B-5, as well as References 13 and 14.

9.3.1.2 Beta Air Dose

$$DN_{\beta} = \sum_{i} \left[c_{i\beta} \; DFN_{i\beta} \right]$$

where:

$$C_{i\beta} = 3.17E4 \left[\chi/Q \right]_c \; Q_i$$

Above equations derived from Reference 8, equations 7, B-4, and B-5.

9.3.1.3 Total Body Dose

$$DN_{TB} = S \sum_{i} \left[c_{i\gamma} \; DFN_{iTB} \right]$$

where:

$C_{i\gamma}$ = Same as indicated in Equation 9.3.1.1.

Above equations derived from Reference 8, equations 8, 10, B-1, B-2, B-4, B-5, B-6, and B-8, as well as References 13 and 14.

9.3.1.4 Skin Dose

$$DN_S = \left(1.11 \, S \; DN_{\gamma} \right) + \sum_{i} \left[c_{i\beta} \; DFN_{iS} \right]$$

where:

$DN\gamma, C_{i\beta}$ = same as indicated in Equations 9.3.1.1 and 9.3.1.2, respectively.

Above equations derived from Reference 8, equations 6, 7, 9, 11, B-1, B-2, B-4, B-7, and B-9, as well as References 13 and 14.

9.3.2 Gaseous Pathways Annual Dose Rates from Iodine 131 and 133, Particulates with a Half-life Greater than 8 Days, and Tritium.

PNPS Effluent Controls do not consider doses from C-14 and I-135 for compliance. However, equations for these radionuclides are included in this section for completeness.

9.3.2.1 Ground Plane Deposition

$$DG_j = S \sum_i \left[CG_i \; DFG_{ij} \right]$$

where:

$$CG_i = 1.00E12 \left[{}^{D}/_{Q} \right] Q_i \frac{\left(1 - e^{-\lambda_i t_b}\right)}{\lambda_i}$$

Above equations derived from Reference 8 equations 12, C-1, and C-2.

9.3.2.2 Breathing/Inhalation

$$DB_{aj} = UB_a \sum_i \left[CB_i \; DFB_{aij} \right]$$

where:

$CB_i = 3.17E4 \left[{}^{\chi}/_{Q} \right]_c Q_i$ for H-3, C-14

$CB_i = 3.17E4 \left[{}^{\chi}/_{Q} \right]_d Q_i$ for particulates with $T_{1/2}$ >8d, I-131, I-133, and I-135

Above equations derived from Reference 8, equations 13, C-3, and C-4.

9.3.2.3 Leafy Vegetation Ingestion

$$DL_{aj} = UL_a \; f_l \sum_i \left[CL_i \; DFI_{aij} \right]$$

where:

CL_i = leafy vegetation concentration as calculated below.

Above equation derived from Reference 8, equations 14 and C-13.

where:

$$CH_i, CL_i, CP_i, CR_i = \frac{1.19E7 \; Q_i \left[\chi/Q \right]_c}{H} \qquad \text{for H-3}$$

$$CH_i, CL_i, CP_i, CR_i = 2.18E7 \; p \; Q_i \left[\chi/Q \right]_c \qquad \text{for C-14}$$

$$CH_i, CL_i, CP_i, CR_i = 5.71E7 \; Q_i \left[D/Q \right] * \left[\frac{r_l \left(1 - e^{-\lambda_{Ei} t_e} \right)}{Y_v \; \lambda_{Ei}} + \frac{B_{iv} \left(1 - e^{-\lambda_i t_b} \right)}{\mathrm{P} \; \lambda_i} \right] * e^{-\lambda_i t_h}$$

for I-131, I-133, and I-135

$$CH_i, CL_i, CP_i, CR_i = 1.14E8 \; Q_i \left[D/Q \right] * \left[\frac{r_p \left(1 - e^{-\lambda_{Ei} t_e} \right)}{Y_v \; \lambda_{Ei}} + \frac{B_{iv} \left(1 - e^{-\lambda_i t_b} \right)}{\mathrm{P} \; \lambda_i} \right] * e^{-\lambda_i t_h}$$

for particulates with $T_{1/2}$ >8 days,

Above equations derived from Reference 8, equations C-5 through C-9.

9.3.2.4 Root Crop Non-Leafy Vegetation Ingestion

$$DR_{aj} = UR_a \; f_r \sum_i \left[CR_i \; DFI_{aij} \right]$$

where:

CR_i = root crop concentration as calculated in Equation 9.3.2.3.

Above equations derived from Reference 8, equations 14 and C-13.

9.3.2.5 Milk Ingestion

$$DM_{aj} = UM_a \sum_i \left[CM_i \; DFI_{aij} \right]$$

where:

$$CM_i = F_{im} \; CF_i \; Q_f \; e^{-\lambda_i t_f}$$

$$CF_i = f_p \; f_s \; CP_i + \left(CH_i \left(1 - f_p \right) \right) + CH_i \; f_p \left(1 - f_s \right)$$

CP_i, CH_i = concentration in pasture grass and harvested/stored feed as calculated in Equation 9.3.2.3.

Above equations derived from Reference 8, equations 14, C-10, C-11, and C-13

9.3.2.6 Meat Ingestion

$$DC_{aj} = UC_a \sum_i \left[CC_i \; DFI_{aij} \right]$$

where:

$$CC_i = F_{if} \; CF_i \; Q_f \; e^{-\lambda_i t_s}$$

CF_i = concentration in forage as calculated in Equation 9.3.2.5

Above equations derived from Reference 8, equations 14, C-12, and C-13

9.3.3 Definitions

B_{iv} = concentration factor for uptake of radionuclide i, from soil in the edible portions of crops, in pCi/kg (wet weight) per pCi/kg dry soil, from Table A-5, (kg/kg);

$C_{i\beta}$ = effective semi-infinite cloud concentration of noble gas i, for the purpose of calculating beta air dose, (pCi/m^3);

$C_{i\gamma}$ = effective finite cloud concentration of noble gas i for the purpose of calculating gamma air dose, (pCi/m^3);

CB_i = ground-level airborne concentration of radionuclide i, (pCi/m^3);

CC_i = concentration of radionuclide i in meat, (pCi/kg);

CF_i = concentration of radionuclide i on forage, (pCi/kg);

CG_i = ground plane concentration of radionuclide i, (pCi-hr/m^2-yr);

CH_i = concentration of radionuclide i on harvested/stored feed, (pCi/kg);

CM_i = concentration of radionuclide i in milk, (pCi/liter);

CL_i = concentration of radionuclide i in leafy vegetables, (pCi/kg);

CP_i = concentration of radionuclide i on pasture grass, (pCi/kg);

CR_i = concentration of radionuclide i in root crops/non-leafy vegetables, (pCi/kg);

DB_{aj} = total annual dose rate from breathing/ inhalation to organ j, of an individual in age group a, (mrem/yr);

DC_{aj} = total annual dose rate from ingestion of meat to organ j; of an individual in age group a, (mrem/yr);

DFB_{aij} = inhalation 50-year committed dose conversion factor for organ j, of individuals in age group a, from radionuclide i, from Tables A-11 through A-14, (mrem/pCi);

DFG_{ij} = open field ground plane dose conversion factor for organ j, from radionuclide i, from Table A-10, (mrem -m^2/pCi-hr);

DFI_{aij} = ingestion 50-year committed dose conversion factor for organ j, for individuals in age group a, from radionuclide i, from Tables A-15 through A-18, (mrem/pCi);

DFN_{iS} = beta skin dose conversion factor for a semi-infinite cloud of noble gas i, which includes the attenuation by the outer "dead" layer of skin, from Table A-4, (mrem-m^3/pCi-yr);

DFN_{iTB} = total body dose conversion factor for a semi-infinite cloud of noble gas i, which includes the attenuation of 5 g/cm^2 of tissue, from Table A-4, (mrem-m^3/pCi-yr);

$DFN_{i\beta}$ = beta air dose conversion factor from a semi-infinite cloud of noble gas i, from Table A-4, (mrad-m^3/pCi-yr);

$DFN_{i\gamma}$ = gamma air dose conversion factor from a semi-infinite cloud of noble gas i, from Table A-4, (mrad-m^3/pCi-yr);

DG_j = total annual dose rate to organ j from direct exposure to the contaminated ground plane from all radionuclides, (mrem/yr);

DL_{aj} = total annual dose rate from ingestion of leafy vegetables to organ j, of an individual in age group a, (mrem/yr);

DM_{aj} = total annual dose rate from ingestion of milk to organ j, of an individual in age group a, (mrem/yr);

DN_S = total annual skin dose rate due to immersion in a finite cloud of noble gases, (mrem/yr);

DN_{TB} = annual total body dose rate due to immersion in a finite cloud of noble gases, (mrem/yr);

DN_β = annual beta air dose rate to a semi-infinite cloud of noble gases, (mrad/yr);

DN_γ = annual gamma air dose rate due to a finite cloud of noble gases, (mrad/yr);

DR_{aj} = total annual dose rate from ingestion of root crop or non-leafy vegetables to organ j, of an individual in age group a, (mrem/yr);

[D/Q] = deposition rate considering depletion at the receptor location in question, from Table 10-1, (m^{-2});

f_l = fraction of the ingestion rate of a leafy vegetable that is produced in the garden of interest, (dimensionless; assumed to be 1.0);

f_p = fraction of the year the animals graze on pasture, (dimensionless; assumed to be 1.0);

f_r = fraction of root crops/non-leafy vegetable that are produced in the garden of interest, (dimensionless; assumed to be 0.76);

f_s = fraction of daily feed that is pasture grass when the animal grazes on pasture, (dimensionless; assumed to be 1.0);

F_{if} = average fraction of the animal's daily intake of radionuclide i which appears in each kilogram of meat, from Table A-5, (days/kg);

F_{im} = average fraction of the animal's daily intake of radionuclide i which appears in each liter of milk, from Table A-5 for cows, Table A-6 for goats, (days/liter);

H = absolute humidity of the atmosphere from Reference 15, (g/m^3; assumed to be 5.6 g/m^3);

p = fractional equilibrium ratio, (dimensionless; assumed to be 1.0 for continuous release);

P = effective surface density for dry soil, (kg/m^2; assumed to be 240 kg/m^2);

Q_f = amount of feed consumed by the animal per day from Table A-7, (kg/day);

Q_i = annual release rate of radionuclide i in gaseous effluents (Ci/yr);

r_I = fraction of deposited radioiodine retained on crops, (dimensionless; assumed to be 1.0 from References 16-19);

r_p = fraction of deposited particulates retained on crops, (dimensionless; assumed to be 0.2 from References 20 and 21);

S = attenuation factor that accounts for the dose reduction due to shielding provided by residential structures from Table A-19, (dimensionless);

t_b = time period over which the radionuclide buildup is evaluated, (hr; assumed to be 1.31E5 hr = 15 yr);

t_e = time period that crops are exposed to radionuclide deposition during the growing season, from Table A-19, (hr);

t_f = average transport time of the activity from the feed into the milk and to the receptor from Table A-19, (hr);

t_h = holdup time that represents the time interval between harvest and consumption of the food, from Table A-19, (hr);

t_s = average time for radionuclides to pass from feed through meat to the consuming individual, (hr; assumed to be 480 hr = 20 days);

UB_a = annual breathing rate, for individuals in the age group a, from Table A-9 for maximum individual, Table A-8 for average individual, (m^3/yr);

UC_a = annual intake of meat, for individuals in age group a, from Table A-9 for maximum individual, Table A-8 for average individual, (kg/yr);

UL_a = annual intake of leafy vegetables, for individuals in the age group a, from Table A-9 for maximum individual, Table A-8 for average individual, (kg/yr);

UM_a = annual intake of milk, for individuals in the age group a, from Table A-9 for maximum individual, Table A-8 for average individual, (liter/yr);

UR_a = annual intake of root crops/non-leafy vegetables, for individuals in the age group a, from Table A-9 for maximum individual, Table A-8 for average individual, (kg/yr);

Y_v = agricultural productivity/yield, from Table A-19, (kg/m^2, wet weight);

$[\chi/Q]_c$ = appropriate value of undepleted atmospheric dispersion factor used to estimate ground level airborne concentration of gaseous, (i.e., non-particulate) radionuclides, from Table 10-1, (sec/m^3);

$[\chi/Q]_d$ = appropriate value of the average gaseous dispersion factor corrected for depletion of particulates and radioiodines, from Table 10-1, (sec/m^3);

$[\chi/Q]\gamma$ = appropriate value of gamma atmospheric dispersion factor used to estimate ground level gamma dose rate from an elevated or ground level plume as calculated in References 13 and 14, from Table 10-1, (sec/m^3);

λ_i = radioactive decay constant of radionuclide i, (hr^{-1});

λ_{Ei} = effective removal rate constant for radionuclide i from crops, in hr^{-1}, where $\lambda_{Ei} = \lambda_i + \lambda_w$. λ_i is the radioactive decay constant, and λ_w is the removal rate constant for physical loss by weathering. $\lambda_w = 0.0021\ hr^{-1}$, ($hr^{-1}$);

1.11 = average ratio of the tissue to air energy absorption coefficients, (mrem/mrad);

3.17E4 = 1.00E12 pCi/Ci divided by 3.15E7 sec/yr, (pCi-yr/Ci-Sec)

1.19E7 = 1.00E12 pCi/Ci divided by 3.15E7 sec/yr and multiplied by 1.00E3 g/kg and by 0.5 g H-3 in plant water per g H-3 in atmospheric water from Reference 22 (dimensionless) and by 0.75 g water per g plant (dimensionless), as calculated in Reference 8 equation C-9, (pCi-yr-g/Ci-sec-kg);

2.18E7 = 1.00E12 pCi/Ci divided by 3.15E7 sec/yr and multiplied by 1.00E3 g/kg and by 0.11 g Carbon/g plant mass from References 23 and 24 divided by 0.16 g Carbon/m^3 of air, as calculated in Reference 8 equation C-8, (pCi-yr-m^3/Ci-sec-kg):

5.71E7 = conversion factor to correct for activity, time units, and elemental forms of radioiodines, equal to the particulate radionuclide conversion factor 1.14E8 multiplied by an elemental iodine fraction of 0.5 from Reference 25, (pCi-yr/Ci-hr);

1.14E8 = conversion factor to correct activity units and time units for particulate radionuclides, equal to 1.00E12 pCi/Ci multiplied by 1 yr/8760 hr, (pCi-yr/Ci-hr);

1.00E12 = conversion factor to correct for activity units, (pCi/Ci);

9.4 Total Dose to a Member of the Public

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 PNPS Effluent Controls 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 PNPS Effluent Controls 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 operational objectives in PNPS Effluent Controls Sections 3.2.2, 3.3.2, and/or 3.3.3 being exceeded by a factor of two, a special analysis must be performed. The purpose of this special analysis is to demonstrate if the total dose to any member of the public (real individual) from all uranium fuel cycle sources (including all real pathways and direct radiation) is limited to less than or equal to 25 mrem per year to the total body or any organ except for 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. Only effluent releases from PNPS (Pilgrim Station) need to be considered since no other nuclear fuel cycle facilities exist within a 50 mile radius. The calculations will be based on the equations contained in this section, with the exception that the usage factors and other site specific parameters will be modified using more realistic assumptions, where appropriate.

The direct radiation component from the facility can be determined by using environmental TLD results. These results will be corrected for natural background and for actual occupancy time of the recreational 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 noble gases, 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 general public.

10.0 RECEPTOR LOCATIONS, HYDROLOGY, AND METEOROLOGY

The purpose of this section is to identify those receptor locations which represent critical pathway locations and the methods used to estimate dilution and dispersion factors for these locations.

For the dose calculations from liquid effluents, the maximum individual is assumed to: 1) ingest fish and shellfish from the discharge canal, 2) receive direct radiation from shoreline deposits at both the discharge canal and PNPS shoreline recreational area, and 3) receive external radiation while swimming at White Horse Beach as well as while boating on the Cape Cod Bay. The doses are calculated for the various age groups (i.e., infant, child, teenager and adult), as well as for the various organs, (i.e., bone, liver, thyroid, kidney, lung, gastrointestinal tract/lower large intestine, skin, and total body). The maximum total body and organ doses are selected from the totals of the various age groups and organ doses calculated as described above.

For liquid effluent pathways, Table A-3 lists the conservative values for the mixing ratio and shore width factor for the various aquatic receptor locations.

For the dose calculations for gaseous effluents, the maximum individual is assumed to reside at the receptor location that provides the highest dose from the dose contributions from all gaseous release points where significant releases have occurred. The locations selected in Table 10-1 are the site boundary, a garden at the site boundary, and the nearest milk animal at the Plimoth Plantation. The dose calculations are performed for each release point and totaled for the following dose pathways; 1) noble gas immersion, 2) ground plane deposition, 3) inhalation, and 4) ingestion of leafy vegetable, root crops/non-leafy vegetables, milk, and meat. The doses are also calculated for the various age groups and for the various organs as described for liquid effluents. The maximum total body, skin, and organ doses are selected from the totals of the various age groups and organ doses calculated as described above.

In order to estimate atmospheric dispersion and deposition factors for each of these locations, a computer code supplied by the Yankee Atomic Electric Company was used. The code, AEOLUS (Reference 13), was used to calculate quarterly average values of dispersion and deposition factors.

Meteorological data for a three year period, January 1, 1977 to December 31, 1979, were used for these analyses. The most conservative quarterly average values of ground level average atmospheric dispersion factor before depletion $[\chi/Q]_C$, ground level average atmospheric dispersion factor after depletion $[\chi/Q]_d$, average gamma dilution factor $[\chi/Q]_\gamma$, and average deposition rate [D/Q] for the three year period were chosen for each of the critical receptor locations.

The technique used to estimate ground level gamma doses from an elevated or ground level plume is based on the sector average finite cloud model of Regulatory Guide 1.109 (Reference 8). The equation has been rearranged into a form similar to the standard semi-infinite cloud equation thereby allowing the use of a "gamma Chi/Q" which includes the effects of plume dimensions, gamma energy mix, atmospheric and geometric attenuation, etc. (See References 13 and 14 for a detailed discussion.)

For gaseous effluent pathways, Table10-1 lists the critical locations for receptors and conservative atmospheric dispersion factors for each atmospheric receptor location.

TABLE 10-1

CRITICAL RECEPTOR LOCATIONS AND ATMOSPHERIC DISPERSION FACTORS

Effluent Control Section	$[\chi/Q]_c$ (sec/m^3)	$[\chi/Q]_d$ (sec/m^3)	$[\chi/Q]_\gamma$ (sec/m^3)	[D/Q] ($1/m^2$)
GROUND-LEVEL RELEASES: Reactor Building Vent, Turbine Building, etc.				
3/4.3.1: Gaseous Effluent Dose Rate				
Site Boundary (1)	7.40E-06	7.04E-06	4.69E-06	5.22E-08
Nearest Garden (2)	7.40E-06	7.04E-06	4.69E-06	5.22E-08
Nearest Milk Animal (3)	4.29E-07	4.21E-07	1.70E-07	7.93E-10
3/4.3.2: Dose - Noble Gases				
Site Boundary (1)	7.40E-06	N/A	4.69E-06	N/A
3/4.3.3: Dose - Iodine-131, Iodine-133, Radioactive Materials in Particulate Form, and Tritium				
Site Boundary (1)	7.40E-06	7.04E-06	N/A	5.22E-08
Nearest Garden (2)	7.40E-06	7.04E-06	N/A	5.22E-08
Nearest Milk Animal (3)	4.29E-07	4.21E-07	N/A	7.93E-10
3/4.4.1: Total Dose				
Site Boundary (1)	7.40E-06	7.04E-06	4.69E-06	5.22E-08
Nearest Garden (2)	7.40E-06	7.04E-06	4.69E-06	5.22E-08
Nearest Milk Animal (3)	4.29E-07	4.21E-07	1.70E-07	7.93E-10
ELEVATED RELEASES: Main Stack				
3/4.3.1: Gaseous Effluent Dose Rate				
Site Boundary (1)	4.69E-07	4.69E-07	1.68E-06	2.92E-09
Nearest Garden (2)	4.69E-07	4.69E-07	1.68E-06	2.92E-09
Nearest Milk Animal (3)	3.73E-08	3.70E-08	3.22E-08	2.46E-10
3/4.3.2: Dose - Noble Gases				
Site Boundary (1)	4.69E-07	N/A	1.68E-06	N/A
3/4.3.3: Dose - Iodine-131, Iodine-133, Radioactive Materials in Particulate Form, and Tritium				
Site Boundary (1)	4.69E-07	4.69E-07	N/A	2.92E-09
Nearest Garden (2)	4.69E-07	4.69E-07	N/A	2.92E-09
Nearest Milk Animal (3)	3.73E-08	3.70E-08	N/A	2.46E-10
3/4.4.1: Total Dose				
Site Boundary (1)	4.69E-07	4.69E-07	1.68E-06	2.92E-09
Nearest Garden (2)	4.69E-07	4.69E-07	1.68E-06	2.92E-09
Nearest Milk Animal (3)	3.73E-08	3.70E-08	3.22E-08	2.46E-10

(1) "Site Boundary" means the location at or beyond the boundary of the restricted area with the highest calculated dispersion and/or deposition factor.

(2) "Nearest Garden" is considered to be the same as the site boundary due to the abundance of small gardens near Pilgrim Station.

(3) "Nearest Milk Animal" is presently considered to be at the Plimoth Plantation, 3.7 km (2.3 mi) west of Pilgrim Station.

11.0 RADIOLOGICAL ENVIRONMENTAL SAMPLING AND MEASUREMENT LOCATIONS

Sampling and measurement locations have been established for Pilgrim Station considering meteorology, population distribution, hydrology, and land use characteristics of the Plymouth area. The sampling locations are divided into two classes: indicator and control. Indicator locations are those which are expected to show effects from PNPS operations, if any exist. These locations were selected primarily on the basis of where the highest predicted environmental concentrations were calculated to occur. While the indicator locations are typically within a few kilometers of the plant, the control stations are generally located so as to be outside the influence of Pilgrim Station. They provide a basis on which to evaluate fluctuations at indicator locations relative to natural background radiation, natural radioactivity, and fallout from prior nuclear weapons tests.

The environmental sampling media collected in the vicinity of Pilgrim Station include air particulate filters, charcoal cartridges, seawater, shellfish, Irish moss, American lobster, fishes, sediment, cranberries, vegetation, and animal forage. The media, sample designation location, description, distance, and direction for indicator and control samples are listed in Tables 3.5-1 and 3.5-3 under Control 3/4.5.1. These sampling locations are also displayed on the maps shown in Figures 3.5-1 through 3.5-5. The frequency of collection and types of radioactivity analysis are described in the PNPS Effluent Control 3/4.5.1, Table 3.5-1. The maximum lower limits of detection (LLD) for the analytical measurements are specified in the PNPS Effluent Controls Table 4.5-1 (see Appendix B for the definitions of the lower limit of detection).

The environmental TLD location designations, distance, and direction from the reactor are listed in Table 3.5-2. The radiation measurement locations for the environmental TLDs are shown in Figures 3.5-1 through 3.5-5. The frequency and type of radiation measurement is described in the PNPS Effluent Control 3/4.5.1, Table 3.5-1.

The pressurized ion chamber measurement locations, distance, and direction from the reactor are listed in Table 3.5-3. These radiation measurement locations for the surveys performed on local beaches. The frequency and type of radiation measurement is described in PNPS Effluent Control 3/4.5.1, Table 3.5-1.

The atmospheric and land-based samples are collected by Entergy personnel. The aquatic samples are collected by the an external contractor experienced with diving and marine sampling. The radioactivity analysis of samples and the processing of the environmental TLDs is performed by Entergy personnel at the J.A. Fitzpatrick Environmental Laboratory.

The PNPS staff reviews the radioactivity analysis results from the contractor laboratory. Reporting levels for radioactivity concentrations in environmental samples are listed in PNPS Effluent Controls Table 3.5-4. If the radioactivity concentrations are above the reporting levels, the NRC is notified in writing within 30 days. A determination of the cumulative dose contribution for the current year will be performed for radioactivity which is detected that is attributable to PNPS operation. Depending upon the circumstances, a special study may also be conducted.

If radioactivity levels in the environment become elevated as a result of the station's operation, an investigation is performed, and corrective actions are recommended to reduce the amount of radioactivity to as far below the legal limits as is reasonably achievable.

The radiological environmental sampling and measurement locations are reviewed annually, and modified if necessary. A garden and milk animal census is performed every year to identify changes in the use of the environment in the vicinity of the station to permit modification of the sampling and measurement locations.

The original radiological monitoring program was modeled after guidance from the NRC presented in Regulatory Guide 4.8 (reference 29). Shortly after the inception of Regulatory Guide 4.8 in 1975, the NRC began to solicit comments on the environmental monitoring guidelines. The NRC working group modified the environmental monitoring guidelines, and issued the revised guidance in the form of Revision 1 to the Branch Technical Position on an acceptable radiological environmental monitoring program (reference 28). In turn, the Branch Technical Position became the model for environmental monitoring put forth in NUREG-1302. Notable changes in the Branch Technical Position were the elimination of soil sampling, and increased reliance on direct radiation monitoring using environmental thermoluminescent dosimeters (TLDs).

Upon review of the PNPS radiological environmental monitoring program in 2002, several departures from the model program outlined in NUREG-1302 were noted. PNPS was still using the soil sampling program of once per three years outlined in Regulatory Guide 4.8. Also, PNPS was using an annual assessment of direct radiation at six locations using a pressurized ion chamber, in addition to the 110 TLDs posted around the plant. Based on the extensive monitoring of airborne particulates and iodines above and beyond that prescribed by NUREG-1302, any buildup of plant-related activity in soil would be first indicated in airborne monitoring. Due to the extent and sensitivity of the airborne monitoring efforts, soil sampling and analysis was dropped from the sampling program. In a similar fashion, the integrating nature of TLDs makes this approach to monitoring direct radiation the preferred method, and industry standard. Again, since the PNPS TLD placement far exceeds that prescribed by NUREG-1302, assessment of direct radiation through use of pressurized ion chamber measurements was dropped in lieu of the extensive TLD monitoring effort.

In 1977, Boston Edison Company was pursuing construction of a second unit on the PNPS site. As part of the preliminary licensing efforts for this second unit, Pilgrim Station committed to an special marine sampling program under the REMP. This program was much more aggressive than that outlined in standard NRC guidance for an environmental monitoring program, and included collecting many more samples, duplicate/split sampling, analysis of special radionuclides, and analysis to detection limits lower than those recommended by the NRC. This specialized sampling program was agreed to by Boston Edison Company for a period not to exceed 10 years. Due to the inclusion of the REMP in the Technical Specifications at that time, the program was carried forward beyond the 10-year period.

Following an evaluation of results obtained by this specialized marine sampling program over the past 25 years, it has been determined that the results have shown that the impact of radioactivity in liquid discharges on the general public and environment is negligible. In light of the fact that the terms of the sampling program have expired, the specialized program is no longer warranted. Furthermore, replacement of the specialized program with a marine sampling program such as that prescribed by the NRC in NUREG-1302 and the Branch Technical Position on Environmental Monitoring will still allow PNPS personnel to evaluate the impact of its operations on the environment and general public. Therefore, PNPS has dropped most of the specialized requirements and has adopted the standard model for marine sampling prescribed by the NRC.

12.0 ANNUAL REPORT PREPARATION

12.1 Radioactive Effluent Release Report

The annual Radioactive Effluent Release Report covering the operation of Pilgrim Nuclear Power Station during the previous calendar year shall be submitted by May 15 of each year. The report shall include a summary of the quantities of radioactive liquid and gaseous effluents and solid wastes released from the facility. This report shall be submitted in accordance with 10CFR50.36a.

General guidance for the preparation of this report can be found in Regulatory Guide 1.21 (Reference 26). In addition to effluent and disposal data, this report should also include summaries of meteorological data in the form of joint frequency distribution tables. This report should present an evaluation of the doses received by members of the public resulting from operation of Pilgrim Station. Liquid and airborne effluent pathways, as discussed in ODCM Section 9, should be used to assess the doses, as well as ambient (direct) radiation exposure resulting from plant operation.

In addition to summarizing effluents and their resulting doses, the annual Radioactive Effluent Release Report serves as the vehicle to notify the NRC of any changes in the ODCM. Changes to the ODCM during the previous calendar year shall be submitted in the annual Radioactive Effluent Release Report.

12.2 Annual Radiological Environmental Operating Report

The Annual Radiological Environmental Operating Report covering the operation of Pilgrim Nuclear Power Station during the previous calendar year shall be submitted by May 15 of each year. The report shall include summaries, interpretations, and analyses of trends of the results of the Radiological Environmental Monitoring Program for the reporting period. The material provided shall be consistent with the objectives outlined in other sections of the ODCM, as well as 10CFR50 Appendix I, Sections IV.B.2, IV.B.3, and IV.C.

The Annual Radiological Environmental Operating Report shall include tables summarizing the results of analyses of radiological environmental samples and environmental radiation measurements taken during the period, pursuant to the locations specified in Section 3/4.5 of the ODCM. Summarized and tabulated results of these analyses and measurements shall be similar in format to guidance provided in the Radiological Assessment Branch Technical Position, Revision 1, November 1979. In the event that some individual results are not available for inclusion in the report, the report shall be submitted noting and explaining the reasons for the missing results. The missing data shall be submitted in a supplementary report as soon as possible.

13.0 REFERENCES

1) PNPS Technical Specifications.

2) U. S. Nuclear Regulatory Commission, Generic Letter 89-01, "Implementation of Programmatic Controls for Radioactive Effluent Technical Specifications in the Administrative Controls Section of the Technical Specifications and the Relocation of Procedural Details of RETS to the Offsite Dose Calculation Manual or to the Process Control Program", January 1989.

3) Updated Final Safety Analysis Report for Pilgrim Nuclear Power Station, Volumes 1 through 7.

4) Boston Edison Company, Pilgrim Station Unit 1 Appendix I Evaluation, April, 1977.

5) General Electric Company, GEK-32445A, Pilgrim Process Radiation Monitoring System Manual.

6) PNPS Maintenance Department Recalibration and Malfunction Records.

7) PNPS Operations Manual, Volume 7, Book 2: Chemical and Radiochemical Procedures.

8) U. S. Nuclear Regulatory Commission, Regulatory Guide 1.109, "Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10CFR50, Appendix I", Revision 1, October, 1977.

9) D.L. Strenge, T.J. Bander, and J.K. Soldat, NUREG/CR-4653, "GASPAR II Technical Reference and User Guide", March 1987.

10) "HERMES", A Digital Computer Code for Estimating Regional Radiological Effects from the Nuclear Power Industry, HEDL-TME-N1-168, December 1971.

11) G. L. Toombs and P. B. Culter, "Comprehensive Final Report for the Lower Columbia River Environmental Survey in Oregon June 5, 1961 - July 31, 1967," Oregon State Board of Health, Division of Sanitation and Engineering, 1968.

12) U. S. Nuclear Regulatory Commission, NUREG-0133, "Preparation of Radiological Effluent Technical Specifications for Nuclear Power Plants", Revision 2, May, 1982.

13) J.N. Hamawi, "AEOLUS", Yankee Atomic Electric Company YAEC-1120, 1977.

14) J. N. Hamawi, "SKIRON", Yankee Atomic Electric Company YAEC-1138, 1977.

15) U. S. Nuclear Regulatory Commission, NUREG/CR-3332, "Radiological Assessment", December 1983.

16) D. F. Bunck (ed.), USAEC Report IDO-12063, "Controlled Environmental Radioiodine Test, Progress Report Number Two", January 1968.

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18) F. O. Hoffman, IRS-W-6, "Environmental Variables Involved with the Estimation of the Amount of ^{131}I in Milk and the Subsequent Dose to the Thyroid," Institute fur Reaktorsicherheit, June 1973.

19) F. O. Hoffman, IRS-W-13, "A Reassessment of the Parameters Used To Predict the Environmental Transport of ^{131}I from Air to Milk," Institute fur Reaktorsicherheit, April 1975.

20) C. A. Pelletier and P. G. Voilleque, Health Physics, Vol. 21, p. 777, "The Behavior of ^{137}Cs and Other Fallout Radionuclides on a Michigan Dairy Farm," 1971.

21) P. G. Voilleque and C. A. Pelletier, Health Physics, Vol. 27, p. 189, "Comparison of External Irradiation and Consumption of Cow's Milk as Critical Pathways for ^{137}Cs, ^{54}Mn, and ^{144}Ce-^{144}Pr Released to the Atmosphere", 1974.

22) L. R. Anspaugh et al., USAEC Report UCRL-73195, Rev. 1, "The Dose to Man via the Food-Chain Transfer Resulting from Exposure to Tritiated Water Vapor", 1972.

23) Y. C. Ng et al., USAEC Report UCRL-50163, Part IV, "Prediction of the Maximum Dosage to Man from the Fallout of Nuclear Devices, IV Handbook for Estimating the Maximum Internal Dose from Radionuclides Released to the Biosphere," 1968.

24) R. C. Weast (ed.), "Handbook of Chemistry and Physics," CRC Press, 1970.

25) U.S. Nuclear Regulatory Commission, NUREG-75/021, "Detailed Measurement of I-131 in Air, Vegetation and Milk Around Three Operating Reactor Sites," March 1975.

26) U.S. Nuclear Regulatory Commission, Regulatory Guide 1.21, "Measuring, Evaluating, and Reporting Radioactivity in Solid Wastes and Releases of Radioactive Materials in Liquid and Gaseous Effluents from Light-Water Cooled Nuclear Power Plants", Revision 1, June 1974.

27) U.S. Nuclear Regulatory Commission, NUREG-1302, "Offsite Dose Calculation Manual Guidance: Standard Radiological Effluent Controls for Boiling Water Reactors", April 1991.

28) U.S. Nuclear Regulatory Commission, Radiological Assessment Branch Technical Position, Revision 1, November 1979.

29) U.S. Nuclear Regulatory Commission, Regulatory Guide 4.8, "Environmental Technical Specifications for Nuclear Power Plants", December 1975.

APPENDIX A

DATA REQUIRED FOR EFFLUENT CALCULATIONS

TABLE A-1

BIOACCUMULATION FACTORS TO BE USED IN THE ABSENCE OF SITE-SPECIFIC DATA

pCi/kg per pCi/liter[1]

ELEMENT	FRESHWATER		SALTWATER	
	FISH	INVERTEBRATE	FISH	INVERTEBRATE
H	9.0E-01	9.0E-01	9.0E-01	9.3E-01
C	4.6E+03	9.1E+03	1.8E+03	1.4E+03
Na	1.0E+02	2.0E+02	6.7E-02	1.9E-01
P	1.0E+05	2.0E+04	2.9E+04	3.0E+04
Cr	2.0E+02	2.0E+03	4.0E+02	2.0E+03
Mn	4.0E+02	9.0E+04	5.5E+02	4.0E+02
Fe	1.0E+02	3.2E+03	3.0E+03	2.0E+04
Co	5.0E+01	2.0E+02	1.0E+02	1.0E+03
Ni	1.0E+02	1.0E+02	1.0E+02	2.5E+02
Cu	5.0E+01	4.0E+02	6.7E+02	1.7E+03
Zn	2.0E+03	1.0E+04	2.0E+03	5.0E+04
Br	4.2E+02	3.3E+02	1.5E-02	3.1E+00
Rb	2.0E+03	1.0E+03	8.3E+00	1.7E+01
Sr	3.0E+01	1.0E+02	2.0E+00	2.0E+01
Y	2.5E+01	1.0E+03	2.5E+01	1.0E+03
Zr	3.3E+00	6.7E+00	2.0E+02	8.0E+01
Nb	3.0E+04	1.0E+02	3.0E+04	1.0E+02
Mo	1.0E+01	1.0E+01	1.0E+01	1.0E+01
Tc	1.5E+01	5.0E+00	1.0E+01	5.0E+01
Ru	1.0E+01	3.0E+02	3.0E+00	1.0E+03
Rh	1.0E+01	3.0E+02	1.0E+01	2.0E+03
Te	4.0E+02	6.1E+03	1.0E+01	1.0E+02
I	1.5E+01	5.0E+00	1.0E+01	5.0E+01
Cs	2.0E+03	1.0E+03	4.0E+01	2.5E+01
Ba	4.0E+00	2.0E+02	1.0E+01	1.0E+02
La	2.5E+01	1.0E+03	2.5E+01	1.0E+03
Ce	1.0E+00	1.0E+03	1.0E+01	6.0E+02
Pr	2.5E+01	1.0E+03	2.5E+01	1.0E+03
Nd	2.5E+01	1.0E+03	2.5E+01	1.0E+03
W	1.2E+03	1.0E+01	3.0E+01	3.0E+01
Np	1.0E+01	4.0E+02	1.0E+01	1.0E+01

[1] Data presented in this table are from Reference 8.

TABLE A-2

DOSE FACTORS FOR IMMERSION IN WATER[1]

mrem/hr per pCi/Liter[2]

NUCLIDE	SKIN	TOTAL BODY[3]
H-3[4]	0.0E+00	0.0E+00
N-13	2.6E-06	1.9E-06
C-14[4]	3.8E-06	0.0E+00
Na-22	4.8E-06	4.0E-06
Na-24	9.3E-06	7.8E-06
Cr-51	6.4E-08	5.2E-08
Mn-54	1.8E-06	1.5E-06
Fe-55[5]	3.6E-10	6.4E-11
Fe-59	2.6E-06	2.2E-06
Co-58	2.3E-06	1.8E-06
Co-60	5.4E-06	4.6E-06
Ni-63	0.0E+00	0.0E+00
Cu-64	5.2E-07	3.7E-07
Zn--65	1.2E-06	1.1E-06
Sr-89[5]	5.4E-07	4.6E-09
Sr-90[5]	1.5E-07	5.4E-10
Y-90[5]	9.6E-07	1.3E-08
Sr+Y-90[5],[6]	1.1E-06	1.3E-08
Zr-95	1.8E-06	1.5E-06
Nb-95	1.6E-06	1.4E-06
Mo-99	9.1E-07	4.7E-07
Ru-103	1.1E-06	8.9E-07
Ru-106	1.9E-06	3.8E-07
Te-132	4.8E-07	4.0E-07
I-129	6.1E-09	2.1E-09
I-131	9.5E-07	6.8E-07
I-132	5.5E-06	4.4E-06
I-133	1.5E-06	9.6E-07
I-135	4.0E-06	3.3E-06
Cs-134	3.5E-06	2.9E-06
Cs-137	1.4E-06	1.0E-06
Ba-140	7.6E-07	4.6E-07
La-140	5.3E-06	4.1E-06
Ce-141	2.4E-07	1.3E-07
Ce-144	6.2E-08	3.0E-08
Pr-144	1.3E-06	5.6E-08
Ce+Pr-144[7]	1.4E-06	8.6E-08

(1) Data presented in this table are from Reference 10.
(2) The same factors apply to adult, teenager, and child.
(3) Total body factors also apply to other internal organs.
(4) Not including penetration of oxide into skin.
(5) Includes *bremsstrahlung*.
(6) Use these factors for Sr-90 unless Y-90 concentration is given separately.
(7) Use these factors for Ce-144 unless Pr-144 concentration is given separately.

TABLE A-3

RECOMMENDED VALUES FOR LIQUID EFFLUENTS[1]

Parameter Symbol	Parameter Description	Values
M_l	Mixing ratio at location l of exposure or harvest of aquatic foods**	0.2 (Aquatic foods taken from Discharge Canal Outfall) [2]
		0.05 (Shoreline, Pilgrim Station Recreational Area) [3]
		1.0 (Shoreline, Discharge Canal)
		0.03 (Swimming, White Horse Beach)
		0.03 (Boating, Cape Cod Bay)
t_h	Period of time between exposure of aquatic foods to radionuclides in water and their consumption	24 hr for maximum individual
		168 hr for average individual, sport fish doses
		240 hr for average individual, commercial fish doses
W_l	Shoreline width factor for location l	0.5 (Recreational Area) [4]
		0.1 (Discharge Canal) [4]

[1] Data presented in this table are from Reference 8 unless otherwise noted.

[2] Collection of aquatic foods from within the Discharge Canal is prohibited.

[3] Swimming is prohibited at Pilgrim Station Recreational Area.

[4] From Reference 4.

TABLE A-4

DOSE FACTORS FOR EXPOSURE TO A SEMI-INFINITE CLOUD OF NOBLE GASES[1]

Nuclide	β-air ($DFN_i\beta$) mrad-m^3/pCi-yr	β-skin (DFN_{iS}) mrem-m^3/pCi-yr	γ-air ($DFN_i\gamma$) mrad-m^3/pCi-yr	γ-body (DFN_{iTB}) mrem-m^3/pCi-yr
Kr-83m	2.88E-04	- - -	1.93E-05	7.56E-08
Kr-85m	1.97E-03	1.46E-03	1.23E-03	1.17E-03
Kr-85	1.95E-03	1.34E-03	1.72E-05	1.61E-05
Kr-87	1.03E-02	9.73E-03	6.17E-03	5.92E-03
Kr-88	2.93E-03	2.37E-03	1.52E-02	1.47E-02
Kr-89	1.06E-02	1.01E-02	1.73E-02	1.66E-02
Kr-90	7.83E-03	7.29E-03	1.63E-02	1.56E-02
Xe-131m	1.11E-03	4.76E-04	1.56E-04	9.15E-05
Xe-133m	1.48E-03	9.94E-04	3.27E-04	2.51E-04
Xe-133	1.05E-03	3.06E-04	3.53E-04	2.94E-04
Xe-135m	7.39E-04	7.11E-04	3.36E-03	3.12E-03
Xe-135	2.46E-03	1.86E-03	1.92E-03	1.81E-03
Xe-137	1.27E-02	1.22E-02	1.51E-03	1.42E-03
Xe-138	4.75E-03	4.13E-03	9.21E-03	8.83E-03
Ar-41	3.28E-03	2.69E-03	9.30E-03	8.84E-03

[1] Data presented in this table are from Reference 8.

TABLE A-5

STABLE ELEMENT TRANSFER DATA[1]

Element	B_{iv} Veg/Soil	F_m(Cow) Milk (day/liter)	F_f Meat (day/kg)
H	4.8E+00	1.0E-02	1.2E-02
C	5.5E+00	1.2E-02	3.1E-02
Na	5.2E-02	4.0E-02	3.0E-02
P	1.1E+00	2.5E-02	4.6E-02
Cr	2.5E-04	2.2E-03	2.4E-03
Mn	2.9E-02	2.5E-04	8.0E-04
Fe	6.6E-04	1.2E-03	4.0E-02
Co	9.4E-03	1.0E-03	1.3E-02
Ni	1.9E-02	6.7E-03	5.3E-02
Cu	1.2E-01	1.4E-02	8.0E-03
Zn	4.0E-01	3.9E-02	3.0E-02
Rb	1.3E-01	3.0E-02	3.1E-02
Sr	1.7E-02	8.0E-04	6.0E-04
Y	2.6E-03	1.0E-05	4.6E-03
Zr	1.7E-04	5.0E-06	3.4E-02
Nb	9.4E-03	2.5E-03	2.8E-01
Mo	1.2E-01	7.5E-03	8.0E-03
Tc	2.5E-01	2.5E-02	4.0E-01
Ru	5.0E-02	1.0E-06	4.0E-01
Rh	1.3E+01	1.0E-02	1.5E-03
Ag	1.5E-01	5.0E-02	1.7E-02
Te	1.3E+00	1.0E-03	7.7E-02
I	2.0E-02	6.0E-03	2.9E-03
Cs	1.0E-02	1.2E-02	4.0E-03
Ba	5.0E-03	4.0E-04	3.2E-03
La	2.5E-03	5.0E-06	2.0E-04
Ce	2.5E-03	1.0E-04	1.2E-03
Pr	2.5E-03	5.0E-06	4.7E-03
Nd	2.4E-03	5.0E-06	3.3E-03
W	1.8E-02	5.0E-04	1.3E-03
Np	2.5E-03	5.0E-06	2.0E-04

[1] Data presented in this table are from Reference 8.

TABLE A-6

NUCLIDE TRANSFER PARAMETERS FOR GOAT'S MILK[1]

Element	F_m (day/liter)
H	1.70E-01
C	1.00E-01
P	2.50E-01
Fe	1.30E-04
Cu	1.30E-02
Sr	1.40E-02
I	6.00E-02
Cs	3.00E-01

TABLE A-7

ANIMAL CONSUMPTION RATES[1]

Animal	Q_F Feed or Forage (kg/day [wet weight])	Q_{AW} Water (liter/day)
Milk Cow	50	60
Beef Cattle	50	50
Goats	6	8

[1] Data presented in these tables are from Reference 8.

TABLE A-8

RECOMMENDED USE FACTORS TO BE APPLIED FOR THE AVERAGE INDIVIDUAL[1], [2]

Pathway	Adult	Teen	Child	Infant
Fruits, vegetables, & grain (kg/yr)	190	240	200	-
Milk (liter/yr)	110	200	170	330
Meat & poultry (kg/yr)	95	59	37	-
Fish (kg/yr)	6.9	5.2	2.2	-
Seafood (kg/yr)	1.0	0.75	0.33	-
Drinking Water (liter/yr)	370	260	260	330
Shoreline recreation (hr/yr) [3]				
Discharge Canal	8.3	47	9.5	-
Pilgrim Station Recreational Area	8.3	47	9.5	-
Swimming (hr/yr) [3] White Horse Beach	52	52	29	-
Boating - Cape Cod Bay (hr/yr) [3]	52	52	29	-
Inhalation (m^3/yr)	8000	8000	3700	1400

[1] Data presented in this table are from Reference 8, unless otherwise indicated.

[2] Usage factors for the average individual are used to determine the annual dose to the total body and thyroid of an average individual and the annual integrated dose to the population within a 50 mile radius.

[3] From Reference 4.

TABLE A-9

RECOMMENDED USE FACTORS TO BE APPLIED FOR THE MAXIMUM EXPOSED INDIVIDUAL[1]

Pathway	Adult	Teen	Child	Infant
Fruits, vegetables, & grain (kg/yr)	520	630	520	-
Leafy Vegetables (kg/yr))	64	42	26	-
Milk (liter/yr)	310	400	330	330
Meat & poultry (kg/yr)	110	65	41	-
Fish (fresh or salt) (kg/yr)	21	16	6.9	-
Shellfish (kg/yr) [2]	9	6	3	-
Drinking Water (liter/yr)	730	510	510	330
Shoreline recreation (hr/yr) [2]				
Discharge Canal	12	67	14	-
Pilgrim Station Recreational Area	12	67	14	-
Swimming (hr/yr) [2] White Horse Beach	52	52	29	-
Boating-Cape Cod Bay (hr/yr) [2]	52	52	29	-
Inhalation (m^3/yr)	8000	8000	3700	1400

[1] Data presented in this table are from Reference 8, unless otherwise indicated.

[2] From Reference 4.

TABLE A-10

EXTERNAL DOSE FACTORS FOR STANDING ON CONTAMINATED GROUND [1]

mrem/hr per pCi/m^2

Nuclide	Total Body	Skin	Nuclide	Total Body	Skin
H-3	0.00E+00	0.00E+00	Zr-93	0.00E+00	0.00E+00
Be-10	0.00E+00	0.00E+00	Zr-95	5.00E-09	5.80E-09
C-14	0.00E+00	0.00E+00	Zr-97	5.50E-09	6.40E-09
N-13	7.60E-09	8.80E-09	Nb-93m	8.20E-13	1.00E-10
F-18	6.80E-09	8.00E-09	Nb-95	5.10E-09	6.00E-09
Na-22	1.60E-08	1.80E-08	Nb-97	4.60E-09	5.40E-09
Na-24	2.50E-08	2.90E-08	Mo-93	2.29E-11	9.32E-10
P-32	0.00E+00	0.00E+00	Mo-99	1.90E-09	2.20E-09
Ca-41	3.41E-09	4.01E-09	Tc-99m	9.60E-10	1.10E-09
Sc-46	1.30E-08	1.50E-08	Tc-99	0.00E+00	0.00E+00
Cr-51	2.20E-10	2.60E-10	Tc-101	2.70E-09	3.00E-09
Mn-54	5.80E-09	6.80E-09	Ru-103	3.60E-09	4.20E-09
Mn-56	1.10E-08	1.30E-08	Ru-105	4.50E-09	5.10E-09
Fe-55	0.00E+00	0.00E+00	Ru-106	1.50E-09	1.80E-09
Fe-59	8.00E-09	9.40E-09	Rh-105	6.60E-10	7.70E-10
Co-57	9.10E-10	1.00E-09	Pd-107	0.00E+00	0.00E+00
Co-58	7.00E-09	8.20E-09	Pd-109	3.50E-11	4.00E-11
Co-60	1.70E-08	2.00E-08	Ag-110m	1.80E-08	2.10E-08
Ni-59	0.00E+00	0.00E+00	Ag-111	1.80E-10	2.10E-10
Ni-63	0.00E+00	0.00E+00	Cd-113m	2.30E-12	2.60E-12
Ni-65	3.70E-09	4.30E-09	Cd-115m	0.00E+00	0.00E+00
Cu-64	1.50E-09	1.70E-09	Sn-123	0.00E+00	6.46E-08
Zn-65	4.00E-09	4.60E-09	Sn-125	5.70E-10	6.60E-10
Zn-69m	2.90E-09	3.40E-09	Sn-126	9.00E-09	1.00E-08
Zn-69	0.00E+00	0.00E+00	Sb-124	1.30E-08	1.50E-08
Se-79	0.00E+00	0.00E+00	Sb-125	3.10E-09	3.50E-09
Br-82	1.90E-08	2.20E-08	Sb-126	8.90E-09	1.00E-08
Br-83	6.40E-11	9.30E-11	Sb-127	5.70E-09	6.60E-09
Br-84	1.20E-08	1.40E-08	Te-125m	3.50E-11	4.80E-11
Br-85	0.00E+00	0.00E+00	Te-127m	1.10E-12	1.30E-12
Rb-86	6.30E-10	7.20E-10	Te-127	1.00E-11	1.10E-11
Rb-87	0.00E+00	0.00E+00	Te-129m	7.70E-10	9.00E-10
Rb-88	3.50E-09	4.00E-09	Te-129	7.10E-10	8.40E-10
Rb-89	1.50E-08	1.80E-08	Te-131m	8.40E-09	9.90E-09
Sr-89	5.60E-13	6.50E-13	Te-131	2.20E-09	2.60E-06
Sr-90	0.00E+00	0.00E+00	Te-132	1.70E-09	2.00E-09
Sr-91	7.10E-09	8.30E-09	Te-133m	1.50E-08	1.70E-08
Sr-92	9.00E-09	1.00E-08	Te-134	1.00E-09	1.20E-09
Y-90	2.20E-12	2.60E-12			
Y-91m	3.80E-09	4.40E-09			
Y-91	2.40E-11	2.70E-11			
Y-92	1.60E-09	1.90E-09			
Y-93	5.70E-10	7.80E-10			

[1] Data presented in this table are from Reference 9.

TABLE A-10 (continued)

EXTERNAL DOSE FACTORS FOR STANDING ON CONTAMINATED GROUND [1]

mrem/hr per pCi/m^2

Nuclide	Total Body	Skin	Nuclide	Total Body	Skin
I-129	4.50E-10	7.50E-10	Pb-210	1.30E-11	1.70E-11
I-130	1.40E-08	1.70E-08	Bi-210	0.00E+00	0.00E+00
I-131	2.80E-09	3.40E-09	Po-210	5.40E-14	6.20E-14
I-132	1.70E-08	2.00E-08	Ra-223	1.50E-09	1.80E-09
I-133	3.70E-09	4.50E-09	Ra-224	8.90E-09	1.00E-08
I-134	1.60E-08	1.90E-08	Ra-225	8.40E-11	1.20E-10
I-135	1.20E-08	1.40E-08	Ra-226	6.40E-09	7.40E-09
Cs-134m	6.20E-10	7.30E-10	Ra-228	1.20E-08	1.40E-08
Cs-134	1.20E-08	1.40E-08	Ac-225	1.60E-09	1.80E-09
Cs-135	0.00E+00	0.00E+00	Ac-227	2.00E-09	2.40E-09
Cs-136	1.50E-08	1.70E-08	Th-227	5.10E-10	6.30E-10
Cs-137	4.20E-09	4.90E-09	Th-228	8.90E-09	1.00E-08
Cs-138	2.10E-08	2.40E-08	Th-229	2.20E-09	2.70E-09
Cs-139	6.30E-09	7.20E-09	Th-230	6.50E-09	7.50E-09
Ba-139	2.40E-09	2.70E-09	Th-232	3.00E-09	4.00E-09
Ba-140	2.10E-09	2.40E-09	Th-234	1.10E-10	1.30E-10
Ba-141	4.30E-09	4.90E-09	Pa-231	2.20E-09	2.70E-09
Ba-142	7.90E-09	9.00E-09	Pa-233	1.30E-09	1.50E-09
La-140	1.50E-08	1.70E-08	U-232	2.59E-12	2.69E-11
La-141	2.50E-10	2.80E-10	U-233	2.30E-09	2.80E-09
La-142	1.50E-08	1.80E-08	U-234	6.32E-13	1.59E-10
Ce-141	5.50E-10	6.20E-10	U-235	3.20E-09	4.00E-09
Ce-143	2.20E-09	2.50E-09	U-236	2.10E-14	1.80E-11
Ce-144	3.20E-10	3.70E-10	U-237	1.00E-09	1.30E-09
Pr-143	0.00E+00	0.00E+00	U-238	1.10E-10	1.50E-10
Pr-144	2.00E-10	2.30E-10	Np-237	1.40E-09	1.60E-09
Nd-147	1.00E-09	1.20E-09	Np-238	2.80E-09	3.20E-09
Pm-147	0.00E+00	0.00E+00	Np-239	9.50E-10	1.10E-09
Pm-148m	1.41E-08	8.16E-08	Pu-238	1.30E-12	1.80E-11
Pm-148	4.60E-09	5.30E-09	Pu-239	7.90E-13	7.70E-12
Pm-149	2.50E-11	2.90E-11	Pu-240	1.30E-12	1.80E-11
Pm-151	2.20E-09	2.30E-09	Pu-241	4.60E-12	6.80E-12
Sm-151	4.80E-11	2.10E-10	Pu-242	1.10E-12	1.60E-11
Sm-153	2.70E-10	3.00E-10	Pu-244	8.95E-10	9.62E-10
Eu-152	7.37E-09	8.53E-09	Am-241	1.80E-10	2.60E-10
Eu-154	7.80E-09	9.00E-09	Am-242m	2.60E-11	1.80E-10
Eu-155	3.81E-10	4.33E-10	Am-243	1.30E-09	1.50E-09
Eu-156	7.60E-09	8.70E-09	Cm-242	5.50E-12	2.30E-11
Tb-160	8.60E-09	1.00E-08	Cm-243	2.30E-09	2.90E-09
Ho-166m	8.90E-09	1.00E-08	Cm-244	2.90E-12	1.80E-11
W-181	2.10E-12	2.80E-12	Cm-245	9.50E-10	1.20E-09
W-185	0.00E+00	0.00E+00	Cm-246	1.00E-12	1.50E-11
W-187	3.10E-09	3.60E-09	Cm-247	2.20E-09	2.60E-09
			Cm-248	6.81E-09	5.23E-09
			Cf-252	6.60E-08	7.20E-08

[1] Data presented in this table are from Reference 9.

TABLE A-11

INHALATION DOSE FACTORS FOR ADULT[1]

mrem/pCi Inhaled

Nuclide	Bone	Liver	Total Body	Thyroid	Kidney	Lung	GI-LLI
H-3	No Data	8.98E-08	8.98E-08	8.98E-08	8.98E-08	8.98E-08	8.98E-08
Be-10	1.98E-04	3.06E-05	4.96E-06	No Data	No Data	2.22E-04	1.67E-05
C-14	2.27E-06	4.26E-07	4.26E-07	4.26E-07	4.26E-07	4.26E-07	4.26E-07
N-13	6.27E-09	6.27E-09	6.27E-09	6.27E-09	6.27E-09	6.27E-09	6.27E-09
F-18	4.71E-07	No Data	5.19E-08	No Data	No Data	No Data	9.24E-09
Na-22	1.30E-05	1.30E-05	1.30E-05	1.30E-05	1.30E-05	1.30E-05	1.30E-05
Na-24	1.28E-06	1.28E-06	1.28E-06	1.28E-06	1.28E-06	1.28E-06	1.28E-06
P-32	1.65E-04	9.64E-06	6.26E-06	No Data	No Data	No Data	1.08E-05
Ca-41	3.83E-05	No Data	4.13E-06	No Data	No Data	3.83E-06	2.86E-07
Sc-46	5.51E-05	1.07E-04	3.11E-05	No Data	9.99E-05	No Data	3.23E-05
Cr-51	No Data	No Data	1.25E-08	7.44E-09	2.85E-09	1.80E-06	4.15E-07
Mn-54	No Data	4.95E-06	7.87E-07	No Data	1.23E-06	1.75E-04	9.67E-06
Mn-56	No Data	1.55E-10	2.29E-11	No Data	1.63E-10	1.18E-06	2.53E-06
Fe-55	3.07E-06	2.12E-06	4.93E-07	No Data	No Data	9.01E-06	7.54E-07
Fe-59	1.47E-06	3.47E-06	1.32E-06	No Data	No Data	1.27E-04	2.35E-05
Co-57	No Data	8.65E-08	8.39E-08	No Data	No Data	4.62E-05	3.93E-06
Co-58	No Data	1.98E-07	2.59E-07	No Data	No Data	1.16E-04	1.33E-05
Co-60	No Data	1.44E-06	1.85E-06	No Data	No Data	7.46E-04	3.56E-05
Ni-59	4.06E-06	1.46E-06	6.77E-07	No Data	No Data	8.20E-06	6.11E-07
Ni-63	5.40E-05	3.93E-06	1.81E-06	No Data	No Data	2.23E-05	1.67E-06
Ni-65	1.92E-10	2.62E-11	1.14E-11	No Data	No Data	7.00E-07	1.54E-06
Cu-64	No Data	1.83E-10	7.69E-11	No Data	5.78E-10	8.48E-07	6.12E-06
Zn-65	4.05E-06	1.29E-05	5.82E-06	No Data	8.62E-06	1.08E-04	6.68E-06
Zn-69m	1.02E-09	2.45E-09	2.24E-10	No Data	1.48E-09	2.38E-06	1.71E-05
Zn-69	4.23E-12	8.14E-12	5.65E-13	No Data	5.27E-12	1.15E-07	2.04E-09
Se-79	No Data	3.83E-07	6.09E-08	No Data	5.69E-07	4.47E-05	3.33E-06
Br-82	No Data	No Data	1.69E-06	No Data	No Data	No Data	1.30E-06
Br-83	No Data	No Data	3.01E-08	No Data	No Data	No Data	2.90E-08
Br-84	No Data	No Data	3.91E-08	No Data	No Data	No Data	2.05E-13
Br-85	No Data	No Data	1.60E-09	No Data	No Data	No Data	No Data
Rb-86	No Data	1.69E-05	7.37E-06	No Data	No Data	No Data	2.08E-06
Rb-87	No Data	9.86E-06	3.21E-06	No Data	No Data	No Data	2.88E-07
Rb-88	No Data	4.84E-08	2.41E-08	No Data	No Data	No Data	4.18E-19
Rb-89	No Data	3.20E-08	2.12E-08	No Data	No Data	No Data	1.16E-21
Sr-89	3.80E-05	No Data	1.09E-06	No Data	No Data	1.75E-04	4.37E-05
Sr-90	3.59E-03	No Data	7.21E-05	No Data	No Data	1.20E-03	9.02E-05
Sr-91	7.74E-09	No Data	3.13E-10	No Data	No Data	4.56E-06	2.39E-05
Sr-92	8.43E-10	No Data	3.64E-11	No Data	No Data	2.06E-06	5.38E-06
Y-90	2.61E-07	No Data	7.01E-09	No Data	No Data	2.12E-05	6.32E-05
Y-91m	3.26E-11	No Data	1.27E-12	No Data	No Data	2.40E-07	1.66E-10
Y-91	5.78E-05	No Data	1.55E-06	No Data	No Data	2.13E-04	4.81E-05
Y-92	1.29E-09	No Data	3.77E-11	No Data	No Data	1.96E-06	9.19E-06
Y-93	1.18E-08	No Data	3.26E-10	No Data	No Data	6.06E-06	5.27E-05

[1] Data presented in this Table are from Reference 9.

TABLE A-11 (continued)

INHALATION DOSE FACTORS FOR ADULT[1]

mrem/pCi Inhaled

Nuclide	Bone	Liver	Total Body	Thyroid	Kidney	Lung	GI-LLI
Zr-93	5.22E-05	2.92E-06	1.37E-06	No Data	1.11E-05	2.13E-05	1.51E-06
Zr-95	1.34E-05	4.30E-06	2.91E-06	No Data	6.77E-06	2.21E-04	1.88E-05
Zr-97	1.21E-08	2.45E-09	1.13E-09	No Data	3.71E-09	9.84E-06	6.54E-05
Nb-93m	3.10E-05	1.01E-05	2.49E-06	No Data	1.16E-05	3.11E-05	2.38E-06
Nb-95	1.76E-06	9.77E-07	5.26E-07	No Data	9.67E-07	6.31E-05	1.30E-05
Nb-97	2.78E-11	7.03E-12	2.56E-12	No Data	8.18E-12	3.00E-07	3.02E-08
Mo-93	No Data	1.17E-06	3.17E-08	No Data	3.55E-07	5.11E-05	3.79E-06
Mo-99	No Data	1.51E-08	2.87E-09	No Data	3.64E-08	1.14E-05	3.10E-05
Tc-99m	1.29E-13	3.64E-13	4.63E-12	No Data	5.52E-12	9.55E-08	5.20E-07
Tc-99	3.13E-08	4.64E-08	1.25E-08	No Data	5.85E-07	1.01E-04	7.54E-06
Tc-101	5.22E-15	7.52E-15	7.38E-14	No Data	1.35E-13	4.99E-08	1.36E-21
Ru-103	1.91E-07	No Data	8.23E-08	No Data	7.29E-07	6.31E-05	1.38E-05
Ru-105	9.88E-11	No Data	3.89E-11	No Data	1.27E-10	1.37E-06	6.02E-06
Ru-106	8.64E-06	No Data	1.09E-06	No Data	1.67E-05	1.17E-03	1.14E-04
Rh-105	9.24E-10	6.73E-10	4.43E-10	No Data	2.86E-09	2.41E-06	1.09E-05
Pd-107	No Data	8.27E-08	5.87E-09	No Data	6.57E-07	9.47E-06	7.06E-07
Pd-109	No Data	4.63E-10	1.16E-10	No Data	2.35E-09	1.85E-06	1.52E-05
Ag-110m	1.35E-06	1.25E-06	7.43E-07	No Data	2.46E-06	5.79E-04	3.78E-05
Ag-111	4.25E-08	1.78E-08	8.87E-09	No Data	5.74E-08	2.33E-05	2.79E-05
Cd-113m	No Data	1.54E-04	4.97E-06	No Data	1.71E-04	2.08E-04	1.59E-05
Cd-115m	No Data	2.46E-05	7.95E-07	No Data	1.98E-05	1.76E-04	4.80E-05
Sn-123	3.02E-05	6.67E-07	9.82E-07	5.67E-07	No Data	2.88E-04	3.92E-05
Sn-125	1.16E-06	3.12E-08	7.03E-08	2.59E-08	No Data	7.37E-05	6.81E-05
Sn-126	1.58E-04	4.18E-06	6.00E-06	1.23E-06	No Data	1.17E-03	1.59E-05
Sb-124	3.90E-06	7.36E-08	1.55E-06	9.44E-09	No Data	3.10E-04	5.08E-05
Sb-125	6.67E-06	7.44E-08	1.58E-06	6.75E-09	No Data	2.18E-04	1.26E-05
Sb-126	4.50E-07	9.13E-09	1.62E-07	2.75E-09	No Data	9.57E-05	6.01E-05
Sb-127	3.30E-08	7.22E-10	1.27E-08	3.97E-10	No Data	2.05E-05	3.77E-05
Te-125m	4.27E-07	1.98E-07	5.84E-08	1.31E-07	1.55E-06	3.92E-05	8.83E-06
Te-127m	1.58E-06	7.21E-07	1.96E-07	4.11E-07	5.72E-06	1.20E-04	1.87E-05
Te-127	1.75E-10	8.03E-11	3.87E-11	1.32E-10	6.37E-10	8.14E-07	7.17E-06
Te-129m	1.22E-06	5.84E-07	1.98E-07	4.30E-07	4.57E-06	1.45E-04	4.79E-05
Te-129	6.22E-12	2.99E-12	1.55E-12	4.87E-12	2.34E-11	2.42E-07	1.96E-08
Te-131m	8.74E-09	5.45E-09	3.63E-09	6.88E-09	3.86E-08	1.82E-05	6.95E-05
Te-131	1.39E-12	7.44E-13	4.49E-13	1.17E-12	5.46E-12	1.74E-07	2.30E-09
Te-132	3.25E-08	2.69E-08	2.02E-08	2.37E-08	1.82E-07	3.60E-05	6.37E-05
Te-133m	7.24E-12	5.40E-12	4.17E-12	6.27E-12	3.74E-11	5.51E-07	7.65E-09
Te-134	3.84E-12	3.22E-12	1.57E-12	3.44E-12	2.18E-11	4.34E-07	2.97E-11
I-129	2.48E-06	2.11E-06	6.91E-06	5.54E-03	4.53E-06	No Data	2.22E-07
I-130	5.72E-07	1.68E-06	6.60E-07	1.42E-04	2.61E-06	No Data	9.61E-07
I-131	3.15E-06	4.47E-06	2.56E-06	1.49E-03	7.66E-06	No Data	7.85E-07
I-132	1.45E-07	4.07E-07	1.45E-07	1.43E-05	6.48E-07	No Data	5.08E-08
I-133	1.08E-06	1.85E-06	5.65E-07	2.69E-04	3.23E-06	No Data	1.11E-06
I-134	8.05E-08	2.16E-07	7.69E-08	3.73E-06	3.44E-07	No Data	1.26E-10
I-135	3.35E-07	8.73E-07	3.21E-07	5.60E-05	1.39E-06	No Data	6.56E-07

[1] Data presented in this Table are from Reference 9.

TABLE A-11 (continued)

INHALATION DOSE FACTORS FOR ADULT[1]

mrem/pCi Inhaled

Nuclide	Bone	Liver	Total Body	Thyroid	Kidney	Lung	GI-LLI
Cs-134m	1.59E-08	3.20E-08	1.72E-08	No Data	1.83E-08	2.93E-09	7.92E-09
Cs-134	4.66E-05	1.06E-04	9.10E-05	No Data	3.59E-05	1.22E-05	1.30E-06
Cs-135	1.46E-05	1.29E-05	5.99E-06	No Data	5.11E-06	1.57E-06	2.11E-07
Cs-136	4.88E-06	1.83E-05	1.38E-05	No Data	1.07E-05	1.50E-06	1.46E-06
Cs-137	5.98E-05	7.76E-05	5.35E-05	No Data	2.78E-05	9.40E-06	1.05E-06
Cs-138	4.14E-08	7.76E-08	4.05E-08	No Data	6.00E-08	6.07E-09	2.33E-13
Cs-139	2.56E-08	3.63E-08	1.39E-08	No Data	3.05E-08	2.84E-09	5.49E-31
Ba-139	1.17E-10	8.32E-14	3.42E-12	No Data	7.78E-14	4.70E-07	1.12E-07
Ba-140	4.88E-06	6.13E-09	3.21E-07	No Data	2.09E-09	1.59E-04	2.73E-05
Ba-141	1.25E-11	9.41E-15	4.20E-13	No Data	8.75E-15	2.42E-07	1.45E-17
Ba-142	3.29E-12	3.38E-15	2.07E-13	No Data	2.86E-15	1.49E-07	1.96E-26
La-140	4.30E-08	2.17E-08	5.73E-09	No Data	No Data	1.70E-05	5.73E-05
La-141	5.34E-10	1.66E-10	2.71E-11	No Data	No Data	1.35E-06	7.31E-06
La-142	8.54E-11	3.88E-11	9.65E-12	No Data	No Data	7.91E-07	2.64E-07
Ce-141	2.49E-06	1.69E-06	1.91E-07	No Data	7.83E-07	4.52E-05	1.50E-05
Ce-143	2.33E-08	1.72E-08	1.91E-09	No Data	7.60E-09	9.97E-06	2.83E-05
Ce-144	4.29E-04	1.79E-04	2.30E-05	No Data	1.06E-04	9.72E-04	1.02E-04
Pr-143	1.17E-06	4.69E-07	5.80E-08	No Data	2.70E-07	3.51E-05	2.50E-05
Pr-144	3.76E-12	1.56E-12	1.91E-13	No Data	8.81E-13	1.27E-07	2.69E-18
Nd-147	6.59E-07	7.62E-07	4.56E-08	No Data	4.45E-07	2.76E-05	2.16E-05
Pm-147	8.37E-05	7.87E-06	3.19E-06	No Data	1.49E-05	6.60E-05	5.54E-06
Pm-148m	9.82E-06	2.54E-06	1.94E-06	No Data	3.85E-06	2.14E-04	4.18E-05
Pm-148	3.84E-07	6.37E-08	3.20E-08	No Data	1.20E-07	3.91E-05	5.80E-05
Pm-149	3.44E-08	4.87E-09	1.99E-09	No Data	9.19E-09	7.21E-06	2.50E-05
Pm-151	8.50E-09	1.42E-09	7.21E-10	No Data	2.55E-09	3.94E-06	2.00E-05
Sm-151	8.59E-05	1.48E-05	3.55E-06	No Data	1.66E-05	4.45E-05	3.25E-06
Sm-153	1.70E-08	1.42E-08	1.04E-09	No Data	4.59E-09	4.14E-06	1.58E-05
Eu-152	2.38E-04	5.41E-05	4.76E-05	No Data	3.35E-04	3.43E-04	1.59E-05
Eu-154	7.40E-04	9.10E-05	6.48E-05	No Data	4.36E-04	5.84E-04	3.40E-05
Eu-155	1.01E-04	1.43E-05	9.21E-06	No Data	6.59E-05	9.46E-05	5.95E-06
Eu-156	1.93E-06	1.48E-06	2.40E-07	No Data	9.95E-07	8.56E-05	4.50E-05
Tb-160	2.21E-05	No Data	2.75E-06	No Data	9.10E-06	1.92E-04	2.68E-05
Ho-166m	3.37E-04	1.05E-04	8.00E-05	No Data	1.57E-04	3.94E-04	1.59E-05
W-181	6.23E-09	2.03E-09	2.17E-10	No Data	No Data	1.71E-06	2.53E-07
W-185	1.95E-07	6.47E-08	6.81E-09	No Data	No Data	5.57E-05	1.07E-05
W-187	1.06E-09	8.85E-10	3.10E-10	No Data	No Data	3.63E-06	1.94E-05
Pb-210	2.64E-02	6.73E-03	8.37E-04	No Data	2.12E-02	2.62E-02	1.51E-06
Bi-210	2.31E-07	1.59E-06	1.32E-07	No Data	1.92E-05	1.11E-03	2.95E-05
Po-210	3.97E-04	8.60E-04	9.58E-05	No Data	2.95E-03	3.14E-02	4.19E-05
Ra-223	1.80E-04	2.77E-07	3.60E-05	No Data	7.85E-06	2.55E-02	2.84E-04
Ra-224	1.98E-05	4.78E-08	3.96E-06	No Data	1.35E-06	8.77E-03	3.01E-04
Ra-225	3.00E-04	3.56E-07	5.99E-05	No Data	1.01E-05	2.92E-02	2.71E-04
Ra-226	1.25E-01	2.39E-06	9.14E-02	No Data	6.77E-05	1.17E-01	2.94E-04
Ra-228	4.41E-02	1.23E-06	4.78E-02	No Data	3.48E-05	1.61E-01	5.00E-05

[1] Data presented in this Table are from Reference 9.

TABLE A-11 (continued)

INHALATION DOSE FACTORS FOR ADULT[1]

mrem/pCi Inhaled

Nuclide	Bone	Liver	Total Body	Thyroid	Kidney	Lung	GI-LLI
Ac-225	4.23E-04	5.82E-04	2.84E-05	No Data	6.63E-05	2.21E-02	2.52E-04
Ac-227	2.30E+00	3.05E-01	1.36E-01	No Data	9.82E-02	2.41E-01	5.08E-05
Th-227	2.17E-04	3.92E-06	6.25E-06	No Data	2.22E-05	3.77E-02	3.34E-04
Th-228	2.00E-01	3.39E-03	6.77E-03	No Data	1.89E-02	1.01E+00	3.49E-04
Th-229	1.51E+01	4.34E-01	2.51E-01	No Data	2.13E+00	3.62E+00	4.83E-05
Th-230	2.29E+00	1.31E-01	6.36E-02	No Data	6.40E-01	6.21E-01	3.73E-05
Th-232	2.56E+00	1.12E-01	9.04E-04	No Data	5.47E-01	5.96E-01	3.17E-05
Th-234	1.63E-06	9.56E-08	4.70E-08	No Data	5.41E-07	1.89E-04	7.03E-05
Pa-231	5.08E+00	1.91E-01	1.98E-01	No Data	1.07E+00	5.75E-02	4.44E-05
Pa-233	1.21E-06	2.42E-07	2.09E-07	No Data	9.15E-07	3.52E-05	1.02E-05
U-232	5.14E-02	No Data	3.66E-03	No Data	5.56E-03	2.22E-01	4.21E-05
U-233	1.09E-02	No Data	6.60E-04	No Data	2.54E-03	5.32E-02	3.89E-05
U-234	1.04E-02	No Data	6.46E-04	No Data	2.49E-03	5.22E-02	3.81E-05
U-235	1.00E-02	No Data	6.07E-04	No Data	2.34E-03	4.90E-02	4.84E-05
U-236	1.00E-02	No Data	6.20E-04	No Data	2.39E-03	5.00E-02	3.57E-05
U-237	3.67E-08	No Data	9.77E-09	No Data	1.51E-07	1.02E-05	1.20E-05
U-238	9.58E-03	No Data	5.67E-04	No Data	2.18E-03	4.58E-02	3.41E-05
Np-237	1.56E+00	1.00E+00	6.87E-02	No Data	5.10E-01	5.22E-02	4.92E-05
Np-238	2.96E-07	7.20E-08	4.61E-09	No Data	2.72E-08	1.02E-05	2.13E-05
Np-239	2.87E-08	2.54E-08	1.55E-09	No Data	8.75E-09	4.70E-06	1.49E-05
Pu-238	1.43E+00	9.71E-01	6.90E-02	No Data	2.96E-01	1.82E-01	4.52E-05
Pu-239	1.66E+00	1.07E+00	7.75E-02	No Data	3.30E-01	1.72E-01	4.13E-05
Pu-240	1.65E+00	1.07E+00	7.73E-02	No Data	3.29E-01	1.72E-01	4.21E-05
Pu-241	3.42E-02	8.69E-03	1.29E-03	No Data	5.93E-03	1.52E-04	8.65E-07
Pu-242	1.53E+00	1.03E+00	7.46E-02	No Data	3.17E-01	1.65E-01	4.05E-05
Pu-244	1.79E+00	1.18E+00	8.54E-02	No Data	3.64E-01	1.89E-01	6.03E-05
Am-241	1.68E+00	1.13E+00	6.71E-02	No Data	5.04E-01	6.06E-02	4.60E-05
Am-242m	1.70E+00	1.06E+00	6.73E-02	No Data	5.01E-01	2.44E-02	5.79E-05
Am-243	1.68E+00	1.10E+00	6.57E-02	No Data	4.95E-01	5.75E-02	5.40E-05
Cm-242	2.22E-02	1.77E-02	9.84E-04	No Data	4.48E-03	3.92E-02	4.91E-05
Cm-243	1.10E+00	7.61E-01	4.61E-02	No Data	2.15E-01	6.31E-02	4.84E-05
Cm-244	8.37E-01	5.88E-01	3.51E-02	No Data	1.64E-01	6.06E-02	4.68E-05
Cm-245	1.74E+00	1.14E+00	7.14E-02	No Data	3.33E-01	5.85E-02	4.36E-05
Cm-246	1.73E+00	1.14E+00	7.13E-02	No Data	3.33E-01	5.96E-02	4.29E-05
Cm-247	1.68E+00	1.12E+00	7.03E-02	No Data	3.28E-01	5.85E-02	5.63E-05
Cm-248	1.40E+01	9.26E+00	5.79E-01	No Data	2.70E+00	4.82E-01	9.09E-04
Cf-252	5.43E-01	No Data	2.33E-02	No Data	No Data	1.99E-01	1.78E-04

[1] Data presented in this Table are from Reference 9.

TABLE A-12

INHALATION DOSE FACTORS FOR TEEN[1]

mrem/pCi Inhaled

Nuclide	Bone	Liver	Total Body	Thyroid	Kidney	Lung	GI-LLI
H-3	No Data	9.06E-08	9.06E-08	9.06E-08	9.06E-08	9.06E-08	9.06E-08
Be-10	2.78E-04	4.33E-05	7.09E-06	No Data	No Data	3.84E-04	1.77E-05
C-14	3.25E-06	6.09E-07	6.09E-07	6.09E-07	6.09E-07	6.09E-07	6.09E-07
N-13	8.65E-09	8.65E-09	8.65E-09	8.65E-09	8.65E-09	8.65E-09	8.65E-09
F-18	6.52E-07	No Data	7.10E-08	No Data	No Data	No Data	3.89E-08
Na-22	1.76E-05	1.76E-05	1.76E-05	1.76E-05	1.76E-05	1.76E-05	1.76E-05
Na-24	1.72E-06	1.72E-06	1.72E-06	1.72E-06	1.72E-06	1.72E-06	1.72E-06
P-32	2.36E-04	1.37E-05	8.95E-06	No Data	No Data	No Data	1.16E-05
Ca-41	4.05E-05	No Data	4.38E-06	No Data	No Data	1.01E-01	3.03E-07
Sc-46	7.24E-05	1.41E-04	4.18E-05	No Data	1.35E-04	No Data	2.98E-05
Cr-51	No Data	No Data	1.69E-08	9.37E-09	3.84E-09	2.62E-06	3.75E-07
Mn-54	No Data	6.39E-06	1.05E-06	No Data	1.59E-06	2.48E-04	8.35E-06
Mn-56	No Data	2.12E-10	3.15E-11	No Data	2.24E-10	1.90E-06	7.18E-06
Fe-55	4.18E-06	2.98E-06	6.93E-07	No Data	No Data	1.55E-05	7.99E-07
Fe-59	1.99E-06	4.62E-06	1.79E-06	No Data	No Data	1.91E-04	2.23E-05
Co-57	No Data	1.18E-07	1.15E-07	No Data	No Data	7.33E-05	3.93E-06
Co-58	No Data	2.59E-07	3.47E-07	No Data	No Data	1.68E-04	1.19E-05
Co-60	No Data	1.89E-06	2.48E-06	No Data	No Data	1.09E-03	3.24E-05
Ni-59	5.44E-06	2.02E-06	9.24E-07	No Data	No Data	1.41E-05	6.48E-07
Ni-63	7.25E-05	5.43E-06	2.47E-06	No Data	No Data	3.84E-05	1.77E-06
Ni-65	2.73E-10	3.66E-11	1.59E-11	No Data	No Data	1.17E-06	4.59E-06
Cu-64	No Data	2.54E-10	1.06E-10	No Data	8.01E-10	1.39E-06	7.68E-06
Zn-65	4.82E-06	1.67E-05	7.80E-06	No Data	1.08E-05	1.55E-04	5.83E-06
Zn-69m	1.44E-09	3.39E-09	3.11E-10	No Data	2.06E-09	3.92E-06	2.14E-05
Zn-69	6.04E-12	1.15E-11	8.07E-13	No Data	7.53E-12	1.98E-07	3.56E-08
Se-79	No Data	5.43E-07	8.71E-08	No Data	8.13E-07	7.71E-05	3.53E-06
Br-82	No Data	No Data	2.28E-06	No Data	No Data	No Data	No Data
Br-83	No Data	No Data	4.30E-08	No Data	No Data	No Data	No Data
Br-84	No Data	No Data	5.41E-08	No Data	No Data	No Data	No Data
Br-85	No Data	No Data	2.29E-09	No Data	No Data	No Data	No Data
Rb-86	No Data	2.38E-05	1.05E-05	No Data	No Data	No Data	2.21E-06
Rb-87	No Data	1.40E-05	4.58E-06	No Data	No Data	No Data	3.05E-07
Rb-88	No Data	6.82E-08	3.40E-08	No Data	No Data	No Data	3.65E-15
Rb-89	No Data	4.40E-08	2.91E-08	No Data	No Data	No Data	4.22E-17
Sr-89	5.43E-05	No Data	1.56E-06	No Data	No Data	3.02E-04	4.64E-05
Sr-90	4.14E-03	No Data	8.33E-05	No Data	No Data	2.06E-03	9.56E-05
Sr-91	1.10E-08	No Data	4.39E-10	No Data	No Data	7.59E-06	3.24E-05
Sr-92	1.19E-09	No Data	5.08E-11	No Data	No Data	3.43E-06	1.49E-05
Y-90	3.73E-07	No Data	1.00E-08	No Data	No Data	3.66E-05	6.99E-05
Y-91m	4.63E-11	No Data	1.77E-12	No Data	No Data	4.00E-07	3.77E-09
Y-91	8.26E-05	No Data	2.21E-06	No Data	No Data	3.67E-04	5.11E-05
Y-92	1.84E-09	No Data	5.36E-11	No Data	No Data	3.35E-06	2.06E-05
Y-93	1.69E-08	No Data	4.65E-10	No Data	No Data	1.04E-05	7.24E-05

[1] Data presented in this Table are from Reference 9.

TABLE A-12 (continued)

INHALATION DOSE FACTORS FOR TEEN[1]

mrem/pCi Inhaled

Nuclide	Bone	Liver	Total Body	Thyroid	Kidney	Lung	GI-LLI
Zr-93	6.83E-05	3.38E-06	1.84E-06	No Data	1.16E-05	3.67E-05	1.60E-06
Zr-95	1.82E-05	5.73E-06	3.94E-06	No Data	8.42E-06	3.36E-04	1.86E-05
Zr-97	1.72E-08	3.40E-09	1.57E-09	No Data	5.15E-09	1.62E-05	7.88E-05
Nb-93m	4.14E-05	1.36E-05	3.41E-06	No Data	1.59E-05	5.36E-05	2.52E-06
Nb-95	2.32E-06	1.29E-06	7.08E-07	No Data	1.25E-06	9.39E-05	1.21E-05
Nb-97	3.92E-11	9.72E-12	3.55E-12	No Data	1.14E-11	4.91E-07	2.71E-07
Mo-93	No Data	1.66E-06	4.52E-08	No Data	5.06E-07	8.81E-05	3.99E-06
Mo-99	No Data	2.11E-08	4.03E-09	No Data	5.14E-08	1.92E-05	3.36E-05
Tc-99m	1.73E-13	4.83E-13	6.24E-12	No Data	7.20E-12	1.44E-07	7.66E-07
Tc-99	4.48E-08	6.58E-08	1.79E-08	No Data	8.35E-07	1.74E-04	7.99E-06
Tc-101	7.40E-15	1.05E-14	1.03E-13	No Data	1.90E-13	8.34E-08	1.09E-16
Ru-103	2.63E-07	No Data	1.12E-07	No Data	9.29E-07	9.79E-05	1.36E-05
Ru-105	1.40E-10	No Data	5.42E-11	No Data	1.76E-10	2.27E-06	1.13E-05
Ru-106	1.23E-05	No Data	1.55E-06	No Data	2.38E-05	2.01E-03	1.20E-04
Rh-105	1.32E-09	9.48E-10	6.24E-10	No Data	4.04E-09	4.09E-06	1.23E-05
Pd-107	No Data	1.17E-07	8.39E-09	No Data	9.39E-07	1.63E-05	7.49E-07
Pd-109	No Data	6.56E-10	1.66E-10	No Data	3.36E-09	3.19E-06	1.96E-05
Ag-110m	1.73E-06	1.64E-06	9.99E-07	No Data	3.13E-06	8.44E-04	3.41E-05
Ag-111	6.07E-08	2.52E-08	1.26E-08	No Data	8.17E-08	4.00E-05	3.00E-05
Cd-113m	No Data	2.17E-04	7.10E-06	No Data	2.43E-04	3.59E-04	1.68E-05
Cd-115m	No Data	3.48E-05	1.14E-06	No Data	2.82E-05	3.03E-04	5.10E-05
Sn-123	4.31E-05	9.44E-07	1.40E-06	7.55E-07	No Data	4.96E-04	4.16E-05
Sn-125	1.66E-06	4.42E-08	9.99E-08	3.45E-08	No Data	1.26E-04	7.29E-05
Sn-126	2.18E-04	5.39E-06	8.24E-06	1.42E-06	No Data	1.72E-03	1.68E-05
Sb-124	5.38E-06	9.92E-08	2.10E-06	1.22E-08	No Data	4.81E-04	4.98E-05
Sb-125	9.23E-06	1.01E-07	2.15E-06	8.80E-09	No Data	3.42E-04	1.24E-05
Sb-126	6.19E-07	1.27E-08	2.23E-07	3.50E-09	No Data	1.55E-04	6.01E-05
Sb-127	4.64E-08	9.92E-10	1.75E-08	5.21E-10	No Data	3.31E-05	3.94E-05
Te-125m	6.10E-07	2.80E-07	8.34E-08	1.75E-07	No Data	6.70E-05	9.38E-06
Te-127m	2.25E-06	1.02E-06	2.73E-07	5.48E-07	8.17E-06	2.07E-04	1.99E-05
Te-127	2.51E-10	1.14E-10	5.52E-11	1.77E-10	9.10E-10	1.40E-06	1.01E-05
Te-129m	1.74E-06	8.23E-07	2.81E-07	5.72E-07	6.49E-06	2.47E-04	5.06E-05
Te-129	8.87E-12	4.22E-12	2.20E-12	6.48E-12	3.32E-11	4.12E-07	2.02E-07
Te-131m	1.23E-08	7.51E-09	5.03E-09	9.06E-09	5.49E-08	2.97E-05	7.76E-05
Te-131	1.97E-12	1.04E-12	6.30E-13	1.55E-12	7.72E-12	2.92E-07	1.89E-09
Te-132	4.50E-08	3.63E-08	2.74E-08	3.07E-08	2.44E-07	5.61E-05	5.79E-05
Te-133m	1.01E-11	7.33E-12	5.71E-12	8.18E-12	5.07E-11	8.71E-07	1.23E-07
Te-134	5.31E-12	4.35E-12	3.64E-12	4.46E-12	2.91E-11	6.75E-07	1.37E-09
I-129	3.53E-06	2.94E-06	4.90E-06	3.66E-03	5.26E-06	No Data	2.29E-07
I-130	7.80E-07	2.24E-06	8.96E-07	1.86E-04	3.44E-06	No Data	1.14E-06
I-131	4.43E-06	6.14E-06	3.30E-06	1.83E-03	1.05E-05	No Data	8.11E-07
I-132	1.99E-07	5.47E-07	1.97E-07	1.89E-05	8.65E-07	No Data	1.59E-07
I-133	1.52E-06	2.56E-06	7.78E-07	3.65E-04	4.49E-06	No Data	1.29E-06
I-134	1.11E-07	2.90E-07	1.05E-07	4.94E-06	4.58E-07	No Data	2.55E-09
I-135	4.62E-07	1.18E-06	4.36E-07	7.76E-05	1.86E-06	No Data	8.69E-07

[1] Data presented in this Table are from Reference 9.

TABLE A-12 (continued)

INHALATION DOSE FACTORS FOR TEEN[1]

mrem/pCi Inhaled

Nuclide	Bone	Liver	Total Body	Thyroid	Kidney	Lung	GI-LLI
Cs-134m	2.20E-08	4.35E-08	2.35E-08	No Data	2.54E-08	4.56E-09	2.02E-08
Cs-134	6.28E-05	1.41E-04	6.86E-05	No Data	4.69E-05	1.83E-05	1.22E-06
Cs-135	2.08E-05	1.82E-05	4.47E-06	No Data	7.30E-06	2.70E-06	2.23E-07
Cs-136	6.44E-06	2.42E-05	1.71E-05	No Data	1.38E-05	2.22E-06	1.36E-06
Cs-137	8.38E-05	1.06E-04	3.89E-05	No Data	3.80E-05	1.51E-05	1.06E-06
Cs-138	5.82E-08	1.07E-07	5.58E-08	No Data	8.28E-08	9.84E-09	3.38E-11
Cs-139	3.65E-08	5.12E-08	1.97E-08	No Data	4.34E-08	4.86E-09	1.66E-23
Ba-139	1.67E-10	1.18E-13	4.87E-12	No Data	1.11E-13	8.08E-07	8.06E-07
Ba-140	6.84E-06	8.38E-09	4.40E-07	No Data	2.85E-09	2.54E-04	2.86E-05
Ba-141	1.78E-11	1.32E-14	5.93E-13	No Data	1.23E-14	4.11E-07	9.33E-14
Ba-142	4.62E-12	4.63E-15	2.84E-13	No Data	3.92E-15	2.39E-07	5.99E-20
La-140	5.99E-08	2.95E-08	7.82E-09	No Data	No Data	2.68E-05	6.09E-05
La-141	7.63E-10	2.35E-10	3.87E-11	No Data	No Data	2.31E-06	1.54E-05
La-142	1.20E-10	5.31E-11	1.32E-11	No Data	No Data	1.27E-06	1.50E-06
Ce-141	3.55E-06	2.37E-06	2.71E-07	No Data	1.11E-06	7.67E-05	1.58E-05
Ce-143	3.32E-08	2.42E-08	2.70E-09	No Data	1.08E-08	1.63E-05	3.19E-05
Ce-144	6.11E-04	2.53E-04	3.28E-05	No Data	1.51E-04	1.67E-03	1.08E-04
Pr-143	1.67E-06	6.64E-07	8.28E-08	No Data	3.86E-07	6.04E-05	2.67E-05
Pr-144	5.37E-12	2.20E-12	2.72E-13	No Data	1.26E-12	2.19E-07	2.94E-14
Nd-147	9.83E-07	1.07E-06	6.41E-08	No Data	6.28E-07	4.65E-05	2.28E-05
Pm-147	1.15E-04	1.10E-05	4.50E-06	No Data	2.10E-05	1.14E-04	5.87E-06
Pm-148m	1.32E-05	3.35E-06	2.62E-06	No Data	5.07E-06	3.20E-04	4.10E-05
Pm-148	5.44E-07	8.88E-08	4.48E-08	No Data	1.60E-07	6.52E-05	6.14E-05
Pm-149	4.91E-08	6.89E-09	2.84E-09	No Data	1.31E-08	1.24E-05	2.79E-05
Pm-151	1.20E-08	1.99E-09	1.01E-09	No Data	3.57E-09	6.56E-06	2.27E-05
Sm-151	1.07E-04	2.10E-05	4.86E-06	No Data	2.27E-05	7.68E-05	3.53E-06
Sm-153	2.43E-08	2.01E-08	1.47E-09	No Data	6.56E-09	7.11E-06	1.77E-05
Eu-152	2.96E-04	7.19E-05	6.30E-05	No Data	3.34E-04	5.01E-04	1.35E-05
Eu-154	9.43E-04	1.23E-04	8.60E-05	No Data	5.44E-04	9.12E-04	3.34E-05
Eu-155	2.00E-04	1.96E-05	1.21E-05	No Data	7.65E-05	1.51E-03	5.97E-05
Eu-156	2.70E-06	2.03E-06	3.30E-07	No Data	1.36E-06	1.37E-04	4.56E-05
Tb-160	3.04E-05	No Data	3.79E-06	No Data	1.20E-05	2.97E-04	2.60E-05
Ho-166m	4.40E-04	1.36E-04	9.87E-05	No Data	2.00E-04	6.24E-04	1.68E-05
W-181	8.90E-09	2.88E-09	3.01E-10	No Data	No Data	2.95E-06	2.69E-07
W-185	2.78E-07	9.17E-08	9.73E-09	No Data	No Data	9.60E-05	1.14E-05
W-187	1.50E-09	1.22E-09	4.29E-10	No Data	No Data	5.92E-06	2.21E-05
Pb-210	3.09E-02	8.28E-03	1.07E-03	No Data	2.95E-02	4.52E-02	1.60E-06
Bi-210	3.30E-07	2.26E-06	1.89E-07	No Data	2.74E-05	1.91E-03	3.19E-05
Po-210	5.68E-04	1.22E-03	1.37E-04	No Data	4.21E-03	5.41E-02	4.45E-05
Ra-223	2.57E-04	3.93E-07	5.14E-05	No Data	1.12E-05	4.39E-02	3.04E-04
Ra-224	2.83E-05	6.77E-08	5.65E-06	No Data	1.93E-06	1.51E-02	3.29E-04
Ra-225	4.28E-04	5.04E-07	8.56E-05	No Data	1.44E-05	5.04E-02	2.89E-04
Ra-226	1.33E-01	3.38E-06	9.87E-02	No Data	9.67E-05	2.02E-01	3.11E-04
Ra-228	5.34E-02	1.74E-06	5.88E-02	No Data	4.97E-05	2.78E-01	5.30E-05

[1] Data presented in this Table are from Reference 9.

TABLE A-12 (continued)

INHALATION DOSE FACTORS FOR TEEN[1]

mrem/pCi Inhaled

Nuclide	Bone	Liver	Total Body	Thyroid	Kidney	Lung	GI-LLI
Ac-225	6.04E-04	8.25E-04	4.06E-05	No Data	9.47E-05	3.81E-02	2.70E-04
Ac-227	2.49E+00	3.69E-01	1.48E-01	No Data	1.07E-01	4.16E-01	5.38E-05
Th-227	3.09E-04	5.56E-06	8.93E-06	No Data	3.18E-05	6.50E-02	3.57E-04
Th-228	2.60E-01	4.37E-03	8.78E-03	No Data	2.45E-02	1.69E+00	3.70E-04
Th-229	1.54E+01	4.44E-01	2.56E-01	No Data	2.18E+00	5.24E+00	5.12E-05
Th-230	2.34E+00	1.34E-01	6.49E-02	No Data	6.55E-01	8.98E-01	3.95E-05
Th-232	2.61E+00	1.14E-01	9.21E-04	No Data	5.60E-01	8.60E-01	3.36E-05
Th-234	2.32E-06	1.35E-07	6.71E-08	No Data	7.73E-07	3.26E-04	7.49E-05
Pa-231	5.32E+00	2.00E-01	2.07E-01	No Data	1.12E+00	9.91E-02	4.71E-05
Pa-233	1.68E-06	3.24E-07	2.89E-07	No Data	1.22E-06	5.39E-05	1.00E-05
U-232	7.31E-02	No Data	5.23E-03	No Data	7.94E-03	3.84E-01	4.46E-05
U-233	1.55E-02	No Data	9.42E-04	No Data	3.63E-03	9.18E-02	4.12E-05
U-234	1.48E-02	No Data	9.23E-04	No Data	3.55E-03	8.99E-02	4.04E-05
U-235	1.42E-02	No Data	8.67E-04	No Data	3.34E-03	8.44E-02	5.13E-05
U-236	1.42E-02	No Data	8.86E-04	No Data	3.41E-03	8.62E-02	3.79E-05
U-237	5.25E-08	No Data	1.40E-08	No Data	2.16E-07	1.76E-05	1.29E-05
U-238	1.36E-02	No Data	8.10E-04	No Data	3.12E-03	7.89E-02	3.62E-05
Np-237	1.64E+00	1.06E+00	7.21E-02	No Data	5.35E-01	8.99E-02	5.22E-05
Np-238	4.23E-07	1.02E-07	6.59E-09	No Data	3.88E-08	1.75E-05	2.38E-05
Np-239	4.23E-08	3.60E-08	2.21E-09	No Data	1.25E-08	8.11E-06	1.65E-05
Pu-238	1.50E+00	1.03E+00	7.22E-02	No Data	3.10E-01	3.12E-01	4.79E-05
Pu-239	1.73E+00	1.12E+00	8.05E-02	No Data	3.44E-01	2.93E-01	4.37E-05
Pu-240	1.72E+00	1.12E+00	8.04E-02	No Data	3.43E-01	2.93E-01	4.46E-05
Pu-241	3.74E-02	9.56E-03	1.40E-03	No Data	6.47E-03	2.60E-04	9.17E-07
Pu-242	1.60E+00	1.08E+00	7.75E-02	No Data	3.31E-01	2.82E-01	4.29E-05
Pu-244	1.87E+00	1.24E+00	8.88E-02	No Data	3.79E-01	3.23E-01	6.39E-05
Am-241	1.77E+00	1.20E+00	7.10E-02	No Data	5.32E-01	1.05E-01	4.88E-05
Am-242m	1.79E+00	1.13E+00	7.15E-02	No Data	5.30E-01	4.21E-02	6.14E-05
Am-243	1.77E+00	1.17E+00	6.95E-02	No Data	5.21E-01	9.91E-02	5.72E-05
Cm-242	3.17E-02	2.51E-02	1.41E-03	No Data	6.40E-03	6.76E-02	5.21E-05
Cm-243	1.19E+00	8.30E-01	5.00E-02	No Data	2.34E-01	1.09E-01	5.13E-05
Cm-244	9.19E-01	6.53E-01	3.88E-02	No Data	1.81E-01	1.05E-01	4.96E-05
Cm-245	1.83E+00	1.22E+00	7.53E-02	No Data	3.52E-01	1.01E-01	4.63E-05
Cm-246	1.81E+00	1.22E+00	7.52E-02	No Data	3.51E-01	1.03E-01	4.54E-05
Cm-247	1.77E+00	1.19E+00	7.41E-02	No Data	3.46E-01	1.01E-01	5.97E-05
Cm-248	1.47E+01	9.83E+00	6.11E-01	No Data	2.85E+00	8.32E-01	9.63E-04
Cf-252	7.16E-01	No Data	3.07E-02	No Data	No Data	3.43E-01	1.89E-04

[1] Data presented in this Table are from Reference 9.

TABLE A-13

INHALATION DOSE FACTORS FOR CHILD[1]

mrem/pCi Inhaled

Nuclide	Bone	Liver	Total Body	Thyroid	Kidney	Lung	GI-LLI
H-3	No Data	1.73E-07	1.73E-07	1.73E-07	1.73E-07	1.73E-07	1.73E-07
Be-10	8.43E-04	9.83E-05	2.12E-05	No Data	No Data	7.41E-04	1.72E-05
C-14	9.70E-06	1.82E-06	1.82E-06	1.82E-06	1.82E-06	1.82E-06	1.82E-06
N-13	2.33E-08	2.33E-08	2.33E-08	2.33E-08	2.33E-08	2.33E-08	2.33E-08
F-18	1.88E-06	No Data	1.85E-07	No Data	No Data	No Data	3.37E-07
Na-22	4.41E-05	4.41E-05	4.41E-05	4.41E-05	4.41E-05	4.41E-05	4.41E-05
Na-24	4.35E-06	4.35E-06	4.35E-06	4.35E-06	4.35E-06	4.35E-06	4.35E-06
P-32	7.04E-04	3.09E-05	2.67E-05	No Data	No Data	No Data	1.14E-05
Ca-41	7.06E-05	No Data	7.70E-06	No Data	No Data	7.21E-02	2.94E-07
Sc-46	1.97E-04	2.70E-04	1.04E-04	No Data	2.39E-04	No Data	2.45E-05
Cr-51	No Data	No Data	4.17E-08	2.31E-08	6.57E-09	4.59E-06	2.93E-07
Mn-54	No Data	1.16E-05	2.57E-06	No Data	2.71E-06	4.26E-04	6.19E-06
Mn-56	No Data	4.48E-10	8.43E-11	No Data	4.52E-10	3.55E-06	3.33E-05
Fe-55	1.28E-05	6.80E-06	2.10E-06	No Data	No Data	3.00E-05	7.75E-07
Fe-59	5.59E-06	9.04E-06	4.51E-06	No Data	No Data	3.43E-04	1.91E-05
Co-57	No Data	2.44E-07	2.88E-07	No Data	No Data	1.37E-04	3.58E-06
Co-58	No Data	4.79E-07	8.55E-07	No Data	No Data	2.99E-04	9.29E-06
Co-60	No Data	3.55E-06	6.12E-06	No Data	No Data	1.91E-03	2.60E-05
Ni-59	1.66E-05	4.67E-06	2.83E-06	No Data	No Data	2.73E-05	6.29E-07
Ni-63	2.22E-04	1.25E-05	7.56E-06	No Data	No Data	7.43E-05	1.71E-06
Ni-65	8.08E-10	7.99E-11	4.44E-11	No Data	No Data	2.21E-06	2.27E-05
Cu-64	No Data	5.39E-10	2.90E-10	No Data	1.63E-09	2.59E-06	9.92E-06
Zn-65	1.15E-05	3.06E-05	1.90E-05	No Data	1.93E-05	2.69E-04	4.41E-06
Zn-69m	4.26E-09	7.28E-09	8.59E-10	No Data	4.22E-09	7.36E-06	2.71E-05
Zn-69	1.81E-11	2.61E-11	2.41E-12	No Data	1.58E-11	3.84E-07	2.75E-06
Se-79	No Data	1.23E-06	2.60E-07	No Data	1.71E-06	1.49E-04	3.43E-06
Br-82	No Data	No Data	5.66E-06	No Data	No Data	No Data	No Data
Br-83	No Data	No Data	1.28E-07	No Data	No Data	No Data	No Data
Br-84	No Data	No Data	1.48E-07	No Data	No Data	No Data	No Data
Br-85	No Data	No Data	6.84E-09	No Data	No Data	No Data	No Data
Rb-86	No Data	5.36E-05	3.09E-05	No Data	No Data	No Data	2.16E-06
Rb-87	No Data	3.16E-05	1.37E-05	No Data	No Data	No Data	2.96E-07
Rb-88	No Data	1.52E-07	9.90E-08	No Data	No Data	No Data	4.66E-09
Rb-89	No Data	9.33E-08	7.83E-08	No Data	No Data	No Data	5.11E-10
Sr-89	1.62E-04	No Data	4.66E-06	No Data	No Data	5.83E-04	4.52E-05
Sr-90	1.04E-02	No Data	2.07E-04	No Data	No Data	3.99E-03	9.28E-05
Sr-91	3.28E-08	No Data	1.24E-09	No Data	No Data	1.44E-05	4.70E-05
Sr-92	3.54E-09	No Data	1.42E-10	No Data	No Data	6.49E-06	6.55E-05
Y-90	1.11E-06	No Data	2.99E-08	No Data	No Data	7.07E-05	7.24E-05
Y-91m	1.37E-10	No Data	4.98E-12	No Data	No Data	7.60E-07	4.64E-07
Y-91	2.47E-04	No Data	6.59E-06	No Data	No Data	7.10E-04	4.97E-05
Y-92	5.50E-09	No Data	1.57E-10	No Data	No Data	6.46E-06	6.46E-05
Y-93	5.04E-08	No Data	1.38E-09	No Data	No Data	2.01E-05	1.05E-04

[1] Data presented in this Table are from Reference 9.

TABLE A-13 (continued)

INHALATION DOSE FACTORS FOR CHILD[1]

mrem/pCi Inhaled

Nuclide	Bone	Liver	Total Body	Thyroid	Kidney	Lung	GI-LLI
Zr-93	2.07E-04	7.80E-06	5.55E-06	No Data	3.00E-05	7.10E-05	1.47E-06
Zr-95	5.13E-05	1.13E-05	1.00E-05	No Data	1.61E-05	6.03E-04	1.65E-05
Zr-97	5.07E-08	7.34E-09	4.32E-09	No Data	1.05E-08	3.06E-05	9.49E-05
Nb-93m	1.27E-04	3.17E-05	1.04E-05	No Data	3.44E-05	1.04E-04	2.45E-06
Nb-95	6.35E-06	2.48E-06	1.77E-06	No Data	2.33E-06	1.66E-04	1.00E-05
Nb-97	1.16E-10	2.08E-11	9.74E-12	No Data	2.31E-11	9.23E-07	7.52E-06
Mo-93	No Data	3.76E-06	1.35E-07	No Data	1.06E-06	1.70E-04	3.78E-06
Mo-99	No Data	4.66E-08	1.15E-08	No Data	1.06E-07	3.66E-05	3.42E-05
Tc-99m	4.81E-13	9.41E-13	1.56E-11	No Data	1.37E-11	2.57E-07	1.30E-06
Tc-99	1.34E-07	1.49E-07	5.35E-08	No Data	1.75E-06	3.37E-04	7.75E-06
Tc-101	2.19E-14	2.30E-14	2.91E-13	No Data	3.92E-13	1.58E-07	4.41E-09
Ru-103	7.55E-07	No Data	2.90E-07	No Data	1.90E-06	1.79E-04	1.21E-05
Ru-105	4.13E-10	No Data	1.50E-10	No Data	3.63E-10	4.30E-06	2.69E-05
Ru-106	3.68E-05	No Data	4.57E-06	No Data	4.97E-05	3.87E-03	1.16E-04
Rh-105	3.91E-09	2.10E-09	1.79E-09	No Data	8.39E-09	7.82E-06	1.33E-05
Pd-107	No Data	2.65E-07	2.51E-08	No Data	1.97E-06	3.16E-05	7.26E-07
Pd-109	No Data	1.48E-09	4.95E-10	No Data	7.06E-09	6.16E-06	2.59E-05
Ag-110m	4.56E-06	3.08E-06	2.47E-06	No Data	5.74E-06	1.48E-03	2.71E-05
Ag-111	1.81E-07	5.68E-08	3.75E-08	No Data	1.71E-07	7.73E-05	2.98E-05
Cd-113m	No Data	4.93E-04	2.12E-05	No Data	5.13E-04	6.94E-04	1.63E-05
Cd-115m	No Data	7.88E-05	3.39E-06	No Data	5.93E-05	5.86E-04	4.97E-05
Sn-123	1.29E-04	2.14E-06	4.19E-06	2.27E-06	No Data	9.59E-04	4.05E-05
Sn-125	4.95E-06	9.94E-08	2.95E-07	1.03E-07	No Data	2.43E-04	7.17E-05
Sn-126	6.23E-04	1.04E-05	2.36E-05	2.84E-06	No Data	3.02E-03	1.63E-05
Sb-124	1.55E-05	2.00E-07	5.41E-06	3.41E-08	No Data	8.76E-04	4.43E-05
Sb-125	2.66E-05	2.05E-07	5.59E-06	2.46E-08	No Data	6.27E-04	1.09E-05
Sb-126	1.72E-06	2.62E-08	6.16E-07	1.00E-08	No Data	2.86E-04	5.67E-05
Sb-127	1.36E-07	2.09E-09	4.70E-08	1.51E-09	No Data	6.17E-05	3.82E-05
Te-125m	1.82E-06	6.29E-07	2.47E-07	5.20E-07	No Data	1.29E-04	9.13E-06
Te-127m	6.72E-06	2.31E-06	8.16E-07	1.64E-06	1.72E-05	4.00E-04	1.93E-05
Te-127	7.49E-10	2.57E-10	1.65E-10	5.30E-10	1.91E-09	2.71E-06	1.52E-05
Te-129m	5.19E-06	1.85E-06	8.22E-07	1.71E-06	1.36E-05	4.76E-04	4.91E-05
Te-129	2.64E-11	9.45E-12	6.44E-12	1.93E-11	6.94E-11	7.93E-07	6.89E-06
Te-131m	3.63E-08	1.60E-08	1.37E-08	2.64E-08	1.08E-07	5.56E-05	8.32E-05
Te-131	5.87E-12	2.28E-12	1.78E-12	4.59E-12	1.59E-11	5.55E-07	3.60E-07
Te-132	1.30E-07	7.36E-08	7.12E-08	8.58E-08	4.79E-07	1.02E-04	3.72E-05
Te-133m	2.93E-11	1.51E-11	1.50E-11	2.32E-11	1.01E-10	1.60E-06	4.77E-06
Te-134	1.53E-11	8.81E-12	9.40E-12	1.24E-11	5.71E-11	1.23E-06	4.87E-07
I-129	1.05E-05	6.40E-06	5.71E-06	4.28E-03	1.08E-05	No Data	2.15E-07
I-130	2.21E-06	4.43E-06	2.28E-06	4.99E-04	6.61E-06	No Data	1.38E-06
I-131	1.30E-05	1.30E-05	7.37E-06	4.39E-03	2.13E-05	No Data	7.68E-07
I-132	5.72E-07	1.10E-06	5.07E-07	5.23E-05	1.69E-06	No Data	8.65E-07
I-133	4.48E-06	5.49E-06	2.08E-06	1.04E-03	9.13E-06	No Data	1.48E-06
I-134	3.17E-07	5.84E-07	2.69E-07	1.37E-05	8.92E-07	No Data	2.58E-07
I-135	1.33E-06	2.36E-06	1.12E-06	2.14E-04	3.62E-06	No Data	1.20E-06

[1] Data presented in this Table are from Reference 9.

TABLE A-13 (continued)

INHALATION DOSE FACTORS FOR CHILD[1]

mrem/pCi Inhaled

Nuclide	Bone	Liver	Total Body	Thyroid	Kidney	Lung	GI-LLI
Cs-134m	6.33E-08	8.92E-08	6.12E-08	No Data	4.94E-08	8.35E-09	7.92E-08
Cs-134	1.76E-04	2.74E-04	6.07E-05	No Data	8.93E-05	3.27E-05	1.04E-06
Cs-135	6.23E-05	4.13E-05	4.45E-06	No Data	1.53E-05	5.22E-06	2.17E-07
Cs-136	1.76E-05	4.62E-05	3.14E-05	No Data	2.58E-05	3.93E-06	1.13E-06
Cs-137	2.45E-04	2.23E-04	3.47E-05	No Data	7.63E-05	2.81E-05	9.78E-07
Cs-138	1.71E-07	2.27E-07	1.50E-07	No Data	1.68E-07	1.84E-08	7.29E-08
Cs-139	1.09E-07	1.15E-07	5.80E-08	No Data	9.08E-08	9.36E-09	7.23E-12
Ba-139	4.98E-10	2.66E-13	1.45E-11	No Data	2.33E-13	1.56E-06	1.56E-05
Ba-140	2.00E-05	1.75E-08	1.17E-06	No Data	5.71E-09	4.71E-04	2.75E-05
Ba-141	5.29E-11	2.95E-14	1.72E-12	No Data	2.56E-14	7.89E-07	7.44E-08
Ba-142	1.35E-11	9.73E-15	7.54E-13	No Data	7.87E-15	4.44E-07	7.41E-10
La-140	1.74E-07	6.08E-08	2.04E-08	No Data	No Data	4.94E-05	6.10E-05
La-141	2.28E-09	5.31E-10	1.15E-10	No Data	No Data	4.48E-06	4.37E-05
La-142	3.50E-10	1.11E-10	3.49E-11	No Data	No Data	2.35E-06	2.05E-05
Ce-141	1.06E-05	5.28E-06	7.83E-07	No Data	2.31E-06	1.47E-04	1.53E-05
Ce-143	9.89E-08	5.37E-08	7.77E-09	No Data	2.26E-08	3.12E-05	3.44E-05
Ce-144	1.83E-03	5.72E-04	9.77E-05	No Data	3.17E-04	3.23E-03	1.05E-04
Pr-143	4.99E-06	1.50E-06	2.47E-07	No Data	8.11E-07	1.17E-04	2.63E-05
Pr-144	1.61E-11	4.99E-12	8.10E-13	No Data	2.64E-12	4.23E-07	5.32E-08
Nd-147	2.92E-06	2.36E-06	1.84E-07	No Data	1.30E-06	8.87E-05	2.22E-05
Pm-147	3.52E-04	2.52E-05	1.36E-05	No Data	4.45E-05	2.20E-04	5.70E-06
Pm-148m	3.31E-05	6.55E-06	6.55E-06	No Data	9.74E-06	5.72E-04	3.58E-05
Pm-148	1.61E-06	1.94E-07	1.25E-07	No Data	3.30E-07	1.24E-04	6.01E-05
Pm-149	1.47E-07	1.56E-08	8.45E-09	No Data	2.75E-08	2.40E-05	2.92E-05
Pm-151	3.57E-08	4.33E-09	2.82E-09	No Data	7.35E-09	1.24E-05	2.50E-05
Sm-151	3.14E-04	4.75E-05	1.49E-05	No Data	4.89E-05	1.48E-04	3.43E-06
Sm-153	7.24E-08	4.51E-08	4.35E-09	No Data	1.37E-08	1.37E-05	1.87E-05
Eu-152	7.42E-04	1.37E-04	1.61E-04	No Data	5.73E-04	9.00E-04	1.14E-05
Eu-154	2.74E-03	2.49E-04	2.27E-04	No Data	1.09E-03	1.66E-03	2.98E-05
Eu-155	5.60E-04	4.05E-05	3.18E-05	No Data	1.51E-04	2.79E-04	5.39E-05
Eu-156	7.89E-06	4.23E-06	8.75E-07	No Data	2.72E-06	2.54E-04	4.24E-05
Tb-160	7.79E-05	No Data	9.67E-06	No Data	2.32E-05	5.34E-04	2.28E-05
Ho-166m	1.34E-03	2.81E-04	2.37E-04	No Data	4.01E-04	1.13E-03	1.63E-05
W-181	2.66E-08	6.52E-09	8.99E-10	No Data	No Data	5.71E-06	2.61E-07
W-185	8.31E-07	2.08E-07	2.91E-08	No Data	No Data	1.86E-04	1.11E-05
W-187	4.41E-09	2.61E-09	1.17E-09	No Data	No Data	1.11E-05	2.46E-05
Pb-210	8.03E-02	1.85E-02	3.18E-03	No Data	6.31E-02	8.74E-02	1.55E-06
Bi-210	9.85E-07	5.11E-06	5.65E-07	No Data	5.76E-05	3.70E-03	3.21E-05
Po-210	1.70E-03	2.76E-03	4.09E-04	No Data	8.85E-03	1.05E-01	4.32E-05
Ra-223	7.69E-04	8.89E-07	1.54E-04	No Data	2.36E-05	8.48E-02	3.00E-04
Ra-224	8.44E-05	1.53E-07	1.69E-05	No Data	4.06E-06	2.92E-02	3.34E-04
Ra-225	1.28E-03	1.14E-06	2.56E-04	No Data	3.02E-05	9.74E-02	2.84E-04
Ra-226	2.34E-01	7.66E-06	1.92E-01	No Data	2.03E-04	3.90E-01	3.02E-04
Ra-228	1.49E-01	3.94E-06	1.68E-01	No Data	1.04E-04	5.37E-01	5.14E-05

[1] Data presented in this Table are from Reference 9.

TABLE A-13 (continued)

INHALATION DOSE FACTORS FOR CHILD[1]

mrem/pCi Inhaled

Nuclide	Bone	Liver	Total Body	Thyroid	Kidney	Lung	GI-LLI
Ac-225	1.81E-03	1.87E-03	1.21E-04	No Data	1.99E-04	7.37E-02	2.67E-04
Ac-227	4.96E+00	8.05E-01	3.07E-01	No Data	1.77E-01	8.04E-01	5.22E-05
Th-227	9.24E-04	1.26E-05	2.67E-05	No Data	6.67E-05	1.26E-01	3.49E-04
Th-228	8.06E-01	1.04E-02	2.72E-02	No Data	5.41E-02	3.34E+00	3.59E-04
Th-229	2.18E+01	5.74E-01	3.63E-01	No Data	2.83E+00	1.08E+01	4.99E-05
Th-230	3.30E+00	1.73E-01	9.20E-02	No Data	8.52E-01	1.85E+00	3.84E-05
Th-232	3.68E+00	1.47E-01	1.28E-03	No Data	7.28E-01	1.77E+00	3.27E-05
Th-234	6.94E-06	3.07E-07	2.00E-07	No Data	1.62E-06	6.31E-04	7.32E-05
Pa-231	8.62E+00	2.86E-01	3.43E-01	No Data	1.56E+00	1.92E-01	4.57E-05
Pa-233	4.14E-06	6.48E-07	7.25E-07	No Data	2.38E-06	9.77E-05	8.95E-06
U-232	2.19E-01	No Data	1.56E-02	No Data	1.67E-02	7.42E-01	4.33E-05
U-233	4.64E-02	No Data	2.82E-03	No Data	7.62E-03	1.77E-01	4.00E-05
U-234	4.46E-02	No Data	2.76E-03	No Data	7.47E-03	1.74E-01	3.92E-05
U-235	4.27E-02	No Data	2.59E-03	No Data	7.01E-03	1.63E-01	4.98E-05
U-236	4.27E-02	No Data	2.65E-03	No Data	7.16E-03	1.67E-01	3.67E-05
U-237	1.57E-07	No Data	4.17E-08	No Data	4.53E-07	3.40E-05	1.29E-05
U-238	4.09E-02	No Data	2.42E-03	No Data	6.55E-03	1.53E-01	3.51E-05
Np-237	2.72E+00	1.62E+00	1.19E-01	No Data	7.41E-01	1.74E-01	5.06E-05
Np-238	1.26E-06	2.30E-07	1.97E-08	No Data	8.16E-08	3.39E-05	2.50E-05
Np-239	1.26E-07	8.14E-08	6.35E-09	No Data	2.63E-08	1.57E-05	1.73E-05
Pu-238	2.55E+00	1.60E+00	1.21E-01	No Data	4.47E-01	6.08E-01	4.65E-05
Pu-239	2.79E+00	1.68E+00	1.28E-01	No Data	4.78E-01	5.72E-01	4.24E-05
Pu-240	2.79E+00	1.68E+00	1.27E-01	No Data	4.77E-01	5.71E-01	4.33E-05
Pu-241	7.94E-02	1.75E-02	2.93E-03	No Data	1.10E-02	5.06E-04	8.90E-07
Pu-242	2.59E+00	1.62E+00	1.23E-01	No Data	4.60E-01	5.50E-01	4.16E-05
Pu-244	3.02E+00	1.85E+00	1.41E-01	No Data	5.27E-01	6.30E-01	6.20E-05
Am-241	2.97E+00	1.84E+00	1.24E-01	No Data	7.63E-01	2.02E-01	4.73E-05
Am-242m	3.07E+00	1.76E+00	1.27E-01	No Data	7.71E-01	8.14E-02	5.96E-05
Am-243	2.94E+00	1.78E+00	1.20E-01	No Data	7.42E-01	1.92E-01	5.55E-05
Cm-242	9.48E-02	5.68E-02	4.20E-03	No Data	1.34E-02	1.31E-01	5.06E-05
Cm-243	2.32E+00	1.42E+00	9.95E-02	No Data	3.74E-01	2.10E-01	4.98E-05
Cm-244	1.94E+00	1.18E+00	8.31E-02	No Data	3.06E-01	2.02E-01	4.82E-05
Cm-245	3.05E+00	1.84E+00	1.28E-01	No Data	5.03E-01	1.95E-01	4.49E-05
Cm-246	3.02E+00	1.84E+00	1.28E-01	No Data	5.03E-01	1.99E-01	4.41E-05
Cm-247	2.94E+00	1.82E+00	1.26E-01	No Data	4.95E-01	1.95E-01	5.80E-05
Cm-248	2.45E+01	1.50E+01	1.04E+00	No Data	4.08E+00	1.61E+00	9.35E-04
Cf-252	2.18E+00	No Data	9.33E-02	No Data	No Data	6.62E-01	1.84E-04

[1] Data presented in this Table are from Reference 9.

TABLE A-14

INHALATION DOSE FACTORS FOR INFANT[1]

mrem/pCi Inhaled

Nuclide	Bone	Liver	Total Body	Thyroid	Kidney	Lung	GI-LLI
H-3	No Data	2.63E-07	2.63E-07	2.63E-07	2.63E-07	2.63E-07	2.63E-07
Be-10	9.49E-04	1.25E-04	2.65E-05	No Data	No Data	1.49E-03	1.73E-05
C-14	1.89E-05	3.79E-06	3.79E-06	3.79E-06	3.79E-06	3.79E-06	3.79E-06
N-13	4.39E-08	4.39E-08	4.39E-08	4.39E-08	4.39E-08	4.39E-08	4.39E-08
F-18	3.92E-06	No Data	3.33E-07	No Data	No Data	No Data	6.10E-07
Na-22	7.37E-05	7.37E-05	7.37E-05	7.37E-05	7.37E-05	7.37E-05	7.37E-05
Na-24	7.54E-06	7.54E-06	7.54E-06	7.54E-06	7.54E-06	7.54E-06	7.54E-06
P-32	1.45E-03	8.03E-05	5.53E-05	No Data	No Data	No Data	1.15E-05
Ca-41	7.48E-05	No Data	8.16E-06	No Data	No Data	6.94E-02	2.96E-07
Sc-46	3.75E-04	5.41E-04	1.69E-04	No Data	3.56E-04	No Data	2.19E-05
Cr-51	No Data	No Data	6.39E-08	4.11E-08	9.45E-09	9.17E-06	2.55E-07
Mn-54	No Data	1.81E-05	3.56E-06	No Data	3.56E-06	7.14E-04	5.04E-06
Mn-56	No Data	1.10E-09	1.58E-10	No Data	7.86E-10	8.95E-06	5.12E-05
Fe-55	1.41E-05	8.39E-06	2.38E-06	No Data	No Data	6.21E-05	7.82E-07
Fe-59	9.69E-06	1.68E-05	6.77E-06	No Data	No Data	7.25E-04	1.77E-05
Co-57	No Data	4.65E-07	4.58E-07	No Data	No Data	2.71E-04	3.47E-06
Co-58	No Data	8.71E-07	1.30E-06	No Data	No Data	5.55E-04	7.95E-06
Co-60	No Data	5.73E-06	8.41E-06	No Data	No Data	3.22E-03	2.28E-05
Ni-59	1.81E-05	5.44E-06	3.10E-06	No Data	No Data	5.48E-05	6.34E-07
Ni-63	2.42E-04	1.46E-05	8.29E-06	No Data	No Data	1.49E-04	1.73E-06
Ni-65	1.71E-09	2.03E-10	8.79E-11	No Data	No Data	5.80E-06	3.58E-05
Cu-64	No Data	1.34E-09	5.53E-10	No Data	2.84E-09	6.64E-06	1.07E-05
Zn-65	1.38E-05	4.47E-05	2.22E-05	No Data	2.32E-05	4.62E-04	3.67E-05
Zn-69m	8.98E-09	1.84E-08	1.67E-09	No Data	7.45E-09	1.91E-05	2.92E-05
Zn-69	3.85E-11	6.91E-11	5.13E-12	No Data	2.87E-11	1.05E-06	9.44E-06
Se-79	No Data	2.25E-06	4.20E-07	No Data	2.47E-06	2.99E-04	3.46E-06
Br-82	No Data	No Data	9.49E-06	No Data	No Data	No Data	No Data
Br-83	No Data	No Data	2.72E-07	No Data	No Data	No Data	No Data
Br-84	No Data	No Data	2.86E-07	No Data	No Data	No Data	No Data
Br-85	No Data	No Data	1.46E-08	No Data	No Data	No Data	No Data
Rb-86	No Data	1.36E-04	6.30E-05	No Data	No Data	No Data	2.17E-06
Rb-87	No Data	7.11E-05	2.64E-05	No Data	No Data	No Data	2.99E-07
Rb-88	No Data	3.98E-07	2.05E-07	No Data	No Data	No Data	2.42E-07
Rb-89	No Data	2.29E-07	1.47E-07	No Data	No Data	No Data	4.87E-08
Sr-89	2.84E-04	No Data	8.15E-06	No Data	No Data	1.45E-03	4.57E-05
Sr-90	1.11E-02	No Data	2.23E-04	No Data	No Data	8.03E-03	9.36E-05
Sr-91	6.83E-08	No Data	2.47E-09	No Data	No Data	3.76E-05	5.24E-05
Sr-92	7.50E-09	No Data	2.79E-10	No Data	No Data	1.70E-05	1.00E-04
Y-90	2.35E-06	No Data	6.30E-08	No Data	No Data	1.92E-04	7.43E-05
Y-91m	2.91E-10	No Data	9.90E-12	No Data	No Data	1.99E-06	1.68E-06
Y-91	4.20E-04	No Data	1.12E-05	No Data	No Data	1.75E-03	5.02E-05
Y-92	1.17E-08	No Data	3.29E-10	No Data	No Data	1.75E-05	9.04E-05
Y-93	1.07E-07	No Data	2.91E-09	No Data	No Data	5.46E-05	1.19E-04

[1] Data presented in this Table are from Reference 9.

TABLE A-14 (continued)

INHALATION DOSE FACTORS FOR INFANT[1]

mrem/pCi Inhaled

Nuclide	Bone	Liver	Total Body	Thyroid	Kidney	Lung	GI-LLI
Zr-93	2.24E-04	9.51E-06	6.18E-06	No Data	3.19E-05	1.37E-04	1.48E-06
Zr-95	8.24E-05	1.99E-05	1.45E-05	No Data	2.22E-05	1.25E-03	1.55E-05
Zr-97	1.07E-07	1.83E-08	8.36E-09	No Data	1.85E-08	7.88E-05	1.00E-04
Nb-93m	1.38E-04	3.59E-05	1.15E-05	No Data	3.68E-05	2.09E-04	2.47E-06
Nb-95	1.12E-05	4.59E-06	2.70E-06	No Data	3.37E-06	3.42E-04	9.05E-06
Nb-97	2.44E-10	5.21E-11	1.88E-11	No Data	4.07E-11	2.37E-06	1.92E-05
Mo-93	No Data	6.46E-06	2.22E-07	No Data	1.54E-06	3.40E-04	3.76E-06
Mo-99	No Data	1.18E-07	2.31E-08	No Data	1.89E-07	9.63E-05	3.48E-05
Tc-99m	9.98E-13	2.06E-12	2.66E-11	No Data	2.22E-11	5.79E-07	1.45E-06
Tc-99	2.09E-07	2.68E-07	8.85E-08	No Data	2.49E-06	6.77E-04	7.82E-06
Tc-101	4.65E-14	5.88E-14	5.80E-13	No Data	6.99E-13	4.17E-07	6.03E-07
Ru-103	1.44E-06	No Data	4.85E-07	No Data	3.03E-06	3.94E-04	1.15E-05
Ru-105	8.74E-10	No Data	2.93E-10	No Data	6.42E-10	1.12E-05	3.46E-05
Ru-106	6.20E-05	No Data	7.77E-06	No Data	7.61E-05	8.26E-03	1.17E-04
Rh-105	8.26E-09	5.41E-09	3.63E-09	No Data	1.50E-08	2.08E-05	1.37E-05
Pd-107	No Data	4.92E-07	4.11E-08	No Data	2.75E-06	6.34E-05	7.33E-07
Pd-109	No Data	3.92E-09	1.05E-09	No Data	1.28E-08	1.68E-05	2.85E-05
Ag-110m	7.13E-06	5.16E-06	3.57E-06	No Data	7.80E-06	2.62E-03	2.36E-05
Ag-111	3.75E-07	1.45E-07	7.75E-08	No Data	3.05E-07	2.06E-04	3.02E-05
Cd-113m	No Data	6.67E-04	2.64E-05	No Data	5.80E-04	1.40E-03	1.65E-05
Cd-115m	No Data	1.73E-04	6.19E-06	No Data	9.41E-05	1.47E-03	5.02E-05
Sn-123	2.09E-04	4.21E-06	7.28E-06	4.27E-06	No Data	2.22E-03	4.08E-05
Sn-125	1.01E-05	2.51E-07	6.00E-07	2.47E-07	No Data	6.43E-04	7.26E-05
Sn-126	8.30E-04	1.44E-05	3.52E-05	3.84E-06	No Data	4.93E-03	1.65E-05
Sb-124	2.71E-05	3.97E-07	8.56E-06	7.18E-08	No Data	1.89E-03	4.22E-05
Sb-125	3.69E-05	3.41E-07	7.78E-06	4.45E-08	No Data	1.17E-03	1.05E-05
Sb-126	3.08E-06	6.01E-08	1.11E-06	2.35E-08	No Data	6.88E-04	5.33E-05
Sb-127	2.82E-07	5.04E-09	8.76E-08	3.60E-09	No Data	1.54E-04	3.78E-05
Te-125m	3.40E-06	1.42E-06	4.70E-07	1.16E-06	No Data	3.19E-04	9.22E-06
Te-127m	1.19E-05	4.93E-06	1.48E-06	3.48E-06	2.68E-05	9.37E-04	1.95E-05
Te-127	1.59E-09	6.81E-10	3.49E-10	1.32E-09	3.47E-09	7.39E-06	1.74E-05
Te-129m	1.01E-05	4.35E-06	1.59E-06	3.91E-06	2.27E-05	1.20E-03	4.93E-05
Te-129	5.63E-11	2.48E-11	1.34E-11	4.82E-11	1.25E-10	2.14E-06	1.88E-05
Te-131m	7.62E-08	3.93E-08	2.59E-08	6.38E-08	1.89E-07	1.42E-04	8.51E-05
Te-131	1.24E-11	5.87E-12	3.57E-12	1.13E-11	2.85E-11	1.47E-06	5.87E-06
Te-132	2.66E-07	1.69E-07	1.26E-07	1.99E-07	7.39E-07	2.43E-04	3.15E-05
Te-133m	6.13E-11	3.59E-11	2.74E-11	5.52E-11	1.72E-10	3.92E-06	1.59E-05
Te-134	3.18E-11	2.04E-11	1.68E-11	2.91E-11	9.59E-11	2.93E-06	2.53E-06
I-129	2.16E-05	1.59E-05	1.16E-05	1.04E-02	1.88E-05	No Data	2.12E-07
I-130	4.54E-06	9.91E-06	3.98E-06	1.14E-03	1.09E-05	No Data	1.42E-06
I-131	2.71E-05	3.17E-05	1.40E-05	1.06E-02	3.70E-05	No Data	7.56E-07
I-132	1.21E-06	2.53E-06	8.99E-07	1.21E-04	2.82E-06	No Data	1.36E-06
I-133	9.46E-06	1.37E-05	4.00E-06	2.54E-03	1.60E-05	No Data	1.54E-06
I-134	6.58E-07	1.34E-06	4.75E-07	3.18E-05	1.49E-06	No Data	9.21E-07
I-135	2.76E-06	5.43E-06	1.98E-06	4.97E-04	6.05E-06	No Data	1.31E-06

[1] Data presented in this Table are from Reference 9.

TABLE A-14 (continued)

INHALATION DOSE FACTORS FOR INFANT[1]

mrem/pCi Inhaled

Nuclide	Bone	Liver	Total Body	Thyroid	Kidney	Lung	GI-LLI
Cs-134m	1.32E-07	2.10E-07	1.11E-07	No Data	8.50E-08	2.00E-08	1.16E-07
Cs-134	2.83E-04	5.02E-04	5.32E-05	No Data	1.36E-04	5.69E-05	9.53E-07
Cs-135	1.00E-04	8.66E-05	4.73E-06	No Data	2.58E-05	1.01E-05	2.18E-07
Cs-136	3.45E-05	9.61E-05	3.78E-05	No Data	4.03E-05	8.40E-06	1.02E-06
Cs-137	3.92E-04	4.37E-04	3.25E-05	No Data	1.23E-04	5.09E-05	9.53E-07
Cs-138	3.61E-07	5.58E-07	2.84E-07	No Data	2.93E-07	4.67E-08	6.26E-07
Cs-139	2.32E-07	3.03E-07	1.22E-07	No Data	1.65E-07	2.53E-08	1.33E-08
Ba-139	1.06E-09	7.03E-13	3.07E-11	No Data	4.23E-13	4.25E-06	3.64E-05
Ba-140	4.00E-05	4.00E-08	2.07E-06	No Data	9.59E-09	1.14E-03	2.74E-05
Ba-141	1.12E-10	7.70E-14	3.55E-12	No Data	4.64E-14	2.12E-06	3.39E-06
Ba-142	2.84E-11	2.36E-14	1.40E-12	No Data	1.36E-14	1.11E-06	4.95E-07
La-140	3.61E-07	1.43E-07	3.68E-08	No Data	No Data	1.20E-04	6.06E-05
La-141	4.85E-09	1.40E-09	2.45E-10	No Data	No Data	1.22E-05	5.96E-05
La-142	7.36E-10	2.69E-10	6.46E-11	No Data	No Data	5.87E-06	4.25E-05
Ce-141	1.98E-05	1.19E-05	1.42E-06	No Data	3.75E-06	3.69E-04	1.54E-05
Ce-143	2.09E-07	1.38E-07	1.58E-08	No Data	4.03E-08	8.30E-05	3.55E-05
Ce-144	2.28E-03	8.65E-04	1.26E-04	No Data	3.84E-04	7.03E-03	1.06E-04
Pr-143	1.00E-05	3.74E-06	4.99E-07	No Data	1.41E-06	3.09E-04	2.66E-05
Pr-144	3.42E-11	1.32E-11	1.72E-12	No Data	4.80E-12	1.15E-06	3.06E-06
Nd-147	5.67E-06	5.81E-06	3.57E-07	No Data	2.25E-06	2.30E-04	2.23E-05
Pm-147	3.91E-04	3.07E-05	1.56E-05	No Data	4.93E-05	4.55E-04	5.75E-06
Pm-148m	5.00E-05	1.24E-05	9.94E-06	No Data	1.45E-05	1.22E-03	3.37E-05
Pm-148	3.34E-06	4.82E-07	2.44E-07	No Data	5.76E-07	3.20E-04	6.04E-05
Pm-149	3.10E-07	4.08E-08	1.78E-08	No Data	4.96E-08	6.50E-05	3.01E-05
Pm-151	7.52E-08	1.10E-08	5.55E-09	No Data	1.30E-08	3.25E-05	2.58E-05
Sm-151	3.38E-04	6.45E-05	1.63E-05	No Data	5.24E-05	2.98E-04	3.46E-06
Sm-153	1.53E-07	1.18E-07	9.06E-09	No Data	2.47E-08	3.70E-05	1.93E-05
Eu-152	7.83E-04	1.77E-04	1.72E-04	No Data	5.94E-04	1.48E-03	9.88E-06
Eu-154	2.96E-03	3.46E-04	2.45E-04	No Data	1.14E-03	3.05E-03	2.84E-05
Eu-155	5.97E-04	5.72E-05	3.46E-05	No Data	1.58E-04	5.20E-04	5.19E-05
Eu-156	1.56E-05	9.59E-06	1.54E-06	No Data	4.48E-06	6.12E-04	4.14E-05
Tb-160	1.12E-04	No Data	1.40E-05	No Data	3.20E-05	1.11E-03	2.14E-05
Ho-166m	1.45E-03	3.07E-04	2.51E-04	No Data	4.22E-04	2.05E-03	1.65E-05
W-181	4.86E-08	1.46E-08	1.67E-09	No Data	No Data	1.33E-05	2.63E-07
W-185	1.57E-06	4.83E-07	5.58E-08	No Data	No Data	4.48E-04	1.12E-05
W-187	9.26E-09	6.44E-09	2.23E-09	No Data	No Data	2.83E-05	2.54E-05
Pb-210	8.62E-02	2.02E-02	3.43E-03	No Data	6.85E-02	1.76E-01	1.57E-06
Bi-210	2.06E-06	1.33E-05	1.18E-06	No Data	1.03E-04	9.96E-03	3.27E-05
Po-210	2.98E-03	5.63E-03	7.12E-04	No Data	1.30E-02	2.40E-01	4.36E-05
Ra-223	1.56E-03	2.26E-06	3.12E-04	No Data	4.16E-05	2.25E-01	3.04E-04
Ra-224	1.77E-04	4.00E-07	3.54E-05	No Data	7.30E-06	7.91E-02	3.42E-04
Ra-225	2.57E-03	2.88E-06	5.13E-04	No Data	5.31E-05	2.57E-01	2.87E-04
Ra-226	2.48E-01	1.46E-05	2.05E-01	No Data	2.94E-04	7.83E-01	3.05E-04
Ra-228	1.60E-01	7.61E-06	1.80E-01	No Data	1.53E-04	1.09E+00	5.19E-05

[1] Data presented in this Table are from Reference 9.

TABLE A-14 (continued)

INHALATION DOSE FACTORS FOR INFANT[1]

mrem/pCi Inhaled

Nuclide	Bone	Liver	Total Body	Thyroid	Kidney	Lung	GI-LLI
Ac-225	3.69E-03	4.72E-03	2.48E-04	No Data	3.49E-04	1.96E-01	2.71E-04
Ac-227	5.29E+00	8.76E-01	3.28E-01	No Data	1.86E-01	1.62E+00	5.27E-05
Th-227	1.82E-03	3.03E-05	5.24E-05	No Data	1.13E-04	3.27E-01	3.53E-04
Th-228	8.46E-01	1.10E-02	2.86E-02	No Data	5.61E-02	4.65E+00	3.62E-04
Th-229	2.28E+01	5.94E-01	3.81E-01	No Data	9.32E-01	1.27E+01	5.02E-05
Th-230	3.46E+00	1.79E-01	9.65E-02	No Data	8.82E-01	2.18E+00	3.87E-05
Th-232	3.86E+00	1.53E-01	2.29E-03	No Data	7.54E-01	2.09E+00	3.29E-05
Th-234	1.33E-05	7.17E-07	3.84E-07	No Data	2.70E-06	1.62E-03	7.40E-05
Pa-231	9.10E+00	3.00E-01	3.62E-01	No Data	1.62E+00	3.85E-01	4.61E-05
Pa-233	6.84E-06	1.32E-06	1.19E-06	No Data	3.68E-06	2.19E-04	9.04E-06
U-232	2.57E-01	No Data	2.13E-02	No Data	2.40E-02	1.49E+00	4.36E-05
U-233	5.44E-02	No Data	3.83E-03	No Data	1.09E-02	3.56E-01	4.03E-05
U-234	5.22E-02	No Data	3.75E-03	No Data	1.07E-02	3.49E-01	3.95E-05
U-235	5.01E-02	No Data	3.52E-03	No Data	1.01E-02	3.28E-01	5.02E-05
U-236	5.01E-02	No Data	3.60E-03	No Data	1.03E-02	3.35E-01	3.71E-05
U-237	3.25E-07	No Data	8.65E-08	No Data	8.08E-07	9.13E-05	1.31E-05
U-238	4.79E-02	No Data	3.29E-03	No Data	9.40E-03	3.06E-01	3.54E-05
Np-237	2.88E+00	1.71E+00	1.26E-01	No Data	7.69E-01	3.49E-01	5.10E-05
Np-238	2.67E-06	6.05E-07	4.16E-08	No Data	1.47E-07	9.19E-05	2.58E-05
Np-239	2.65E-07	2.13E-07	1.34E-08	No Data	4.73E-08	4.25E-05	1.78E-05
Pu-238	2.69E+00	1.68E+00	1.27E-01	No Data	4.64E-01	9.03E-01	4.69E-05
Pu-239	2.93E+00	1.76E+00	1.34E-01	No Data	4.95E-01	8.47E-01	4.28E-05
Pu-240	2.93E+00	1.75E+00	1.34E-01	No Data	4.94E-01	8.47E-01	4.36E-05
Pu-241	8.43E-02	1.85E-02	3.11E-03	No Data	1.15E-02	7.62E-04	8.97E-07
Pu-242	2.72E+00	1.69E+00	1.29E-01	No Data	4.77E-01	8.15E-01	4.20E-05
Pu-244	3.17E+00	1.94E+00	1.48E-01	No Data	5.46E-01	9.33E-01	6.26E-05
Am-241	3.15E+00	1.95E+00	1.31E-01	No Data	7.94E-01	4.06E-01	4.78E-05
Am-242m	3.25E+00	1.86E+00	1.35E-01	No Data	8.03E-01	1.64E-01	6.01E-05
Am-243	3.10E+00	1.88E+00	1.27E-01	No Data	7.72E-01	3.85E-01	5.60E-05
Cm-242	1.28E-01	8.65E-02	5.70E-03	No Data	1.69E-02	2.97E-01	5.10E-05
Cm-243	2.47E+00	1.52E+00	1.06E-01	No Data	3.91E-01	4.24E-01	5.02E-05
Cm-244	2.07E+00	1.27E+00	8.89E-02	No Data	3.21E-01	4.08E-01	4.86E-05
Cm-245	3.22E+00	1.96E+00	1.36E-01	No Data	5.23E-01	3.92E-01	4.53E-05
Cm-246	3.20E+00	1.96E+00	1.36E-01	No Data	5.23E-01	3.99E-01	4.45E-05
Cm-247	3.11E+00	1.93E+00	1.33E-01	No Data	5.15E-01	3.92E-01	5.85E-05
Cm-248	2.58E+01	1.59E+01	1.10E+00	No Data	4.24E+00	3.23E+00	9.43E-04
Cf-252	2.37E+00	No Data	1.01E-01	No Data	No Data	1.37E+00	1.85E-04

[1] Data presented in this Table are from Reference 9.

TABLE A-15

INGESTION DOSE FACTORS FOR ADULT[1]

mrem/pCi Ingested

Nuclide	Bone	Liver	Total Body	Thyroid	Kidney	Lung	GI-LLI
H-3	No Data	5.99E-08	5.99E-08	5.99E-08	5.99E-08	5.99E-08	5.99E-08
Be-10	3.18E-06	4.91E-07	7.94E-08	No Data	3.71E-07	No Data	2.68E-05
C-14	2.84E-06	5.68E-07	5.68E-07	5.68E-07	5.68E-07	5.68E-07	5.68E-07
N-13	8.36E-09	8.36E-09	8.36E-09	8.36E-09	8.36E-09	8.36E-09	8.36E-09
F-18	6.24E-07	No Data	6.92E-08	No Data	No Data	No Data	1.85E-08
Na-22	1.74E-05	1.74E-05	1.74E-05	1.74E-05	1.74E-05	1.74E-05	1.74E-05
Na-24	1.70E-06	1.70E-06	1.70E-06	1.70E-06	1.70E-06	1.70E-06	1.70E-06
P-32	1.93E-04	1.20E-05	7.46E-06	No Data	No Data	No Data	2.17E-05
Ca-41	1.85E-04	No Data	2.00E-05	No Data	No Data	No Data	1.84E-07
Sc-46	5.51E-09	1.07E-08	3.11E-09	No Data	9.99E-09	No Data	5.21E-05
Cr-51	No Data	No Data	2.66E-09	1.59E-09	5.86E-10	3.53E-09	6.69E-07
Mn-54	No Data	4.57E-06	8.72E-07	No Data	1.36E-06	No Data	1.40E-05
Mn-56	No Data	1.15E-07	2.04E-08	No Data	1.46E-07	No Data	3.67E-06
Fe-55	2.75E-06	1.90E-06	4.43E-07	No Data	No Data	1.06E-06	1.09E-06
Fe-59	4.34E-06	1.02E-05	3.91E-06	No Data	No Data	2.85E-06	3.40E-05
Co-57	No Data	1.75E-07	2.91E-07	No Data	No Data	No Data	4.44E-06
Co-58	No Data	7.45E-07	1.67E-06	No Data	No Data	No Data	1.51E-05
Co-60	No Data	2.14E-06	4.72E-06	No Data	No Data	No Data	4.02E-05
Ni-59	9.76E-06	3.35E-06	1.63E-06	No Data	No Data	No Data	6.90E-07
Ni-63	1.30E-04	9.01E-06	4.36E-06	No Data	No Data	No Data	1.88E-06
Ni-65	5.28E-07	6.86E-08	3.13E-08	No Data	No Data	No Data	1.74E-06
Cu-64	No Data	8.33E-08	3.91E-08	No Data	2.10E-07	No Data	7.10E-06
Zn-65	4.84E-06	1.54E-05	6.96E-06	No Data	1.03E-05	No Data	9.70E-06
Zn-69m	1.70E-07	4.08E-07	3.73E-08	No Data	2.47E-07	No Data	2.49E-05
Zn-69	1.03E-08	1.97E-08	1.37E-09	No Data	1.28E-08	No Data	2.96E-09
Se-79	No Data	2.63E-06	4.39E-07	No Data	4.55E-06	No Data	5.38E-07
Br-82	No Data	No Data	2.26E-06	No Data	No Data	No Data	2.59E-06
Br-83	No Data	No Data	4.02E-08	No Data	No Data	No Data	5.79E-08
Br-84	No Data	No Data	5.21E-08	No Data	No Data	No Data	4.09E-13
Br-85	No Data	No Data	2.14E-09	No Data	No Data	No Data	No Data
Rb-86	No Data	2.11E-05	9.83E-06	No Data	No Data	No Data	4.16E-06
Rb-87	No Data	1.23E-05	4.28E-06	No Data	No Data	No Data	5.76E-07
Rb-88	No Data	6.05E-08	3.21E-08	No Data	No Data	No Data	8.36E-19
Rb-89	No Data	4.01E-08	2.82E-08	No Data	No Data	No Data	2.33E-21
Sr-89	3.08E-04	No Data	8.84E-06	No Data	No Data	No Data	4.94E-05
Sr-90	8.71E-03	No Data	1.75E-04	No Data	No Data	No Data	2.19E-04
Sr-91	5.67E-06	No Data	2.29E-07	No Data	No Data	No Data	2.70E-05
Sr-92	2.15E-06	No Data	9.30E-08	No Data	No Data	No Data	4.26E-05
Y-90	9.62E-09	No Data	2.58E-10	No Data	No Data	No Data	1.02E-04
Y-91m	9.09E-11	No Data	3.52E-12	No Data	No Data	No Data	2.67E-10
Y-91	1.41E-07	No Data	3.77E-09	No Data	No Data	No Data	7.76E-05
Y-92	8.45E-10	No Data	2.47E-11	No Data	No Data	No Data	1.48E-05
Y-93	2.68E-09	No Data	7.40E-11	No Data	No Data	No Data	8.50E-05

[1] Data presented in this Table are from Reference 9.

TABLE A-15 (continued)

INGESTION DOSE FACTORS FOR ADULT[1]

mrem/pCi Ingested

Nuclide	Bone	Liver	Total Body	Thyroid	Kidney	Lung	GI-LLI
Zr-93	4.18E-08	2.34E-09	1.09E-09	No Data	8.87E-09	No Data	2.43E-06
Zr-95	3.04E-08	9.75E-09	6.60E-09	No Data	1.53E-08	No Data	3.09E-05
Zr-97	1.68E-09	3.39E-10	1.55E-10	No Data	5.12E-10	No Data	1.05E-04
Nb-93m	2.55E-08	8.32E-09	2.05E-09	No Data	9.57E-09	No Data	3.84E-06
Nb-95	6.22E-09	3.46E-09	1.86E-09	No Data	3.42E-09	No Data	2.10E-05
Nb-97	5.22E-11	1.32E-11	4.82E-12	No Data	1.54E-11	No Data	4.87E-08
Mo-93	No Data	7.51E-06	2.03E-07	No Data	2.13E-06	No Data	1.22E-06
Mo-99	No Data	4.31E-06	8.20E-07	No Data	9.76E-06	No Data	9.99E-06
Tc-99m	2.47E-10	6.98E-10	8.89E-09	No Data	1.06E-08	3.42E-10	4.13E-07
Tc-99	1.25E-07	1.86E-07	5.02E-08	No Data	2.34E-06	1.58E-08	6.08E-06
Tc-101	2.54E-10	3.66E-10	3.59E-09	No Data	6.59E-09	1.87E-10	1.10E-21
Ru-103	1.85E-07	No Data	7.97E-08	No Data	7.06E-07	No Data	2.16E-05
Ru-105	1.54E-08	No Data	6.08E-09	No Data	1.99E-07	No Data	9.42E-06
Ru-106	2.75E-06	No Data	3.48E-07	No Data	5.31E-06	No Data	1.78E-04
Rh-105	1.21E-07	8.85E-08	5.83E-08	No Data	3.76E-07	No Data	1.41E-05
Pd-107	No Data	1.47E-07	9.40E-09	No Data	1.32E-06	No Data	9.11E-07
Pd-109	No Data	1.77E-07	3.99E-08	No Data	1.01E-06	No Data	1.96E-05
Ag-110m	1.60E-07	1.48E-07	8.79E-08	No Data	2.91E-07	No Data	6.04E-05
Ag-111	5.81E-08	2.43E-08	1.21E-08	No Data	7.84E-08	No Data	4.46E-05
Cd-113m	No Data	3.18E-06	1.02E-07	No Data	3.50E-06	No Data	2.56E-05
Cd-115m	No Data	1.84E-06	5.87E-08	No Data	1.46E-06	No Data	7.74E-05
Sn-123	3.11E-05	5.15E-07	7.59E-07	4.38E-07	No Data	No Data	6.33E-05
Sn-125	8.33E-06	1.68E-07	3.78E-07	1.39E-07	No Data	No Data	1.04E-04
Sn-126	8.45E-05	1.67E-06	2.40E-06	4.92E-07	No Data	No Data	2.43E-05
Sb-124	2.80E-06	5.29E-08	1.11E-06	6.79E-09	No Data	2.18E-06	7.95E-05
Sb-125	1.79E-06	2.00E-08	4.26E-07	1.82E-09	No Data	1.38E-06	1.97E-05
Sb-126	1.15E-06	2.34E-08	4.15E-07	7.04E-09	No Data	7.05E-07	9.40E-05
Sb-127	2.58E-07	5.65E-09	9.90E-08	3.10E-09	No Data	1.53E-07	5.90E-05
Te-125m	2.68E-06	9.71E-07	3.59E-07	8.06E-07	1.09E-05	No Data	1.07E-05
Te-127m	6.77E-06	2.42E-06	8.25E-07	1.73E-06	2.75E-05	No Data	2.27E-05
Te-127	1.10E-07	3.95E-08	2.38E-08	8.15E-08	4.48E-07	No Data	8.68E-06
Te-129m	1.15E-05	4.29E-06	1.82E-06	3.95E-06	4.80E-05	No Data	5.79E-05
Te-129	3.14E-08	1.18E-08	7.65E-09	2.41E-08	1.32E-07	No Data	2.37E-08
Te-131m	1.73E-06	8.46E-07	7.05E-07	1.34E-06	8.57E-06	No Data	8.40E-05
Te-131	1.97E-08	8.23E-09	6.22E-09	1.62E-08	8.63E-08	No Data	2.79E-09
Te-132	2.52E-06	1.63E-06	1.53E-06	1.80E-06	1.57E-05	No Data	7.71E-05
Te-133m	4.62E-08	2.70E-08	2.60E-08	3.91E-08	2.67E-07	No Data	9.26E-09
Te-134	3.24E-08	2.12E-08	1.30E-08	2.83E-08	2.05E-07	No Data	3.59E-11
I-129	3.27E-06	2.81E-06	9.21E-06	7.23E-03	6.04E-06	No Data	4.44E-07
I-130	7.56E-07	2.23E-06	8.80E-07	1.89E-04	3.48E-06	No Data	1.92E-06
I-131	4.16E-06	5.95E-06	3.41E-06	1.95E-03	1.02E-05	No Data	1.57E-06
I-132	2.03E-07	5.43E-07	1.90E-07	1.90E-05	8.65E-07	No Data	1.02E-07
I-133	1.42E-06	2.47E-06	7.53E-07	3.63E-04	4.31E-06	No Data	2.22E-06
I-134	1.06E-07	2.88E-07	1.03E-07	4.99E-06	4.58E-07	No Data	2.51E-10
I-135	4.43E-07	1.16E-06	4.28E-07	7.65E-05	1.86E-06	No Data	1.31E-06

[1] Data presented in this Table are from Reference 9.

TABLE A-15 (continued)

INGESTION DOSE FACTORS FOR ADULT[1]

mrem/pCi Ingested

Nuclide	Bone	Liver	Total Body	Thyroid	Kidney	Lung	GI-LLI
Cs-134m	2.13E-08	4.48E-08	2.29E-08	No Data	2.43E-08	3.83E-09	1.58E-08
Cs-134	6.22E-05	1.48E-04	1.21E-04	No Data	4.79E-05	1.59E-05	2.59E-06
Cs-135	1.95E-05	1.80E-05	7.99E-06	No Data	6.81E-06	2.04E-06	4.21E-07
Cs-136	6.51E-06	2.57E-05	1.85E-05	No Data	1.43E-05	1.96E-06	2.92E-06
Cs-137	7.97E-05	1.09E-04	7.14E-05	No Data	3.70E-05	1.23E-05	2.11E-06
Cs-138	5.52E-08	1.09E-07	5.40E-08	No Data	8.01E-08	7.91E-09	4.65E-13
Cs-139	3.41E-08	5.08E-08	1.85E-08	No Data	4.07E-08	3.70E-09	1.10e-30
Ba-139	9.70E-08	6.91E-11	2.84E-09	No Data	6.46E-11	3.92E-11	1.72E-07
Ba-140	2.03E-05	2.55E-08	1.33E-06	No Data	8.67E-09	1.46E-08	4.18E-05
Ba-141	4.71E-08	3.56E-11	1.59E-09	No Data	3.31E-11	2.02E-11	2.22E-17
Ba-142	2.13E-08	2.19E-11	1.34E-09	No Data	1.85E-11	1.24E-11	3.00e-26
La-140	2.50E-09	1.26E-09	3.33E-10	No Data	No Data	No Data	9.25E-05
La-141	3.19E-10	9.90E-11	1.62E-11	No Data	No Data	No Data	1.18E-05
La-142	1.28E-10	5.82E-11	1.45E-11	No Data	No Data	No Data	4.25E-07
Ce-141	9.36E-09	6.33E-09	7.18E-10	No Data	2.94E-09	No Data	2.42E-05
Ce-143	1.65E-09	1.22E-06	1.35E-10	No Data	5.37E-10	No Data	4.56E-05
Ce-144	4.88E-07	2.04E-07	2.62E-08	No Data	1.21E-07	No Data	1.65E-04
Pr-143	9.20E-09	3.69E-09	4.56E-10	No Data	2.13E-09	No Data	4.03E-05
Pr-144	3.01E-11	1.25E-11	1.53E-12	No Data	7.05E-12	No Data	4.33E-18
Nd-147	6.29E-09	7.27E-09	4.35E-10	No Data	4.25E-09	No Data	3.49E-05
Pm-147	7.54E-08	7.09E-09	2.87E-09	No Data	1.34E-08	No Data	8.93E-06
Pm-148m	3.07E-08	7.95E-09	6.08E-09	No Data	1.20E-08	No Data	6.74E-05
Pm-148	7.17E-09	1.19E-09	5.99E-10	No Data	2.25E-09	No Data	9.35E-05
Pm-149	1.52E-09	2.15E-10	8.78E-11	No Data	4.06E-10	No Data	4.03E-05
Pm-151	6.97E-10	1.17E-10	5.91E-11	No Data	2.09E-10	No Data	3.22E-05
Sm-151	6.90E-08	1.19E-08	2.85E-09	No Data	1.33E-08	No Data	5.25E-06
Sm-153	8.57E-10	7.15E-10	5.22E-11	No Data	2.31E-10	No Data	2.55E-05
Eu-152	1.95E-07	4.44E-08	3.90E-08	No Data	2.75E-07	No Data	2.56E-05
Eu-154	6.15E-07	7.56E-08	5.38E-08	No Data	3.62E-07	No Data	5.48E-05
Eu-155	8.60E-08	1.22E-08	7.87E-09	No Data	5.63E-08	No Data	9.60E-06
Eu-156	1.37E-08	1.06E-08	1.71E-09	No Data	7.08E-09	No Data	7.26E-05
Tb-160	4.70E-08	No Data	5.86E-09	No Data	1.94E-08	No Data	4.33E-05
Ho-166m	2.70E-07	8.43E-08	6.40E-08	No Data	1.26E-07	No Data	2.56E-05
W-181	9.91E-09	3.23E-09	3.46E-10	No Data	No Data	No Data	3.68E-07
W-185	4.05E-07	1.35E-07	1.42E-08	No Data	No Data	No Data	1.56E-05
W-187	1.03E-07	8.61E-08	3.01E-08	No Data	No Data	No Data	2.82E-05
Pb-210	1.53E-02	4.37E-03	5.44E-04	No Data	1.23E-02	No Data	2.24E-06
Bi-210	4.61E-07	3.18E-06	2.64E-07	No Data	3.83E-05	No Data	4.75E-05
Po-210	3.56E-04	7.56E-04	8.59E-05	No Data	2.52E-03	No Data	6.36E-05
Ra-223	4.97E-03	7.65E-06	9.94E-04	No Data	2.17E-04	No Data	3.21E-04
Ra-224	1.61E-03	3.90E-06	3.23E-04	No Data	1.10E-04	No Data	3.40E-04
Ra-225	6.56E-03	7.78E-06	1.31E-03	No Data	2.21E-04	No Data	3.06E-04
Ra-226	3.02E-01	5.74E-06	2.20E-01	No Data	1.63E-04	No Data	3.32E-04
Ra-228	1.12E-01	3.12E-06	1.21E-01	No Data	8.83E-05	No Data	5.64E-05

[1] Data presented in this Table are from Reference 9.

TABLE A-15 (continued)

INGESTION DOSE FACTORS FOR ADULT[1]

mrem/pCi Ingested

Nuclide	Bone	Liver	Total Body	Thyroid	Kidney	Lung	GI-LLI
Ac-225	4.40E-06	6.06E-06	2.96E-07	No Data	6.90E-07	No Data	4.07E-04
Ac-227	1.87E-03	2.48E-04	1.11E-04	No Data	8.00E-05	No Data	8.19E-05
Th-227	1.37E-05	2.48E-07	3.95E-07	No Data	1.41E-06	No Data	5.40E-04
Th-228	4.96E-04	8.40E-06	1.68E-05	No Data	4.67E-05	No Data	5.63E-04
Th-229	1.36E-02	3.89E-04	2.25E-04	No Data	1.88E-03	No Data	7.81E-05
Th-230	2.06E-03	1.17E-04	5.70E-05	No Data	5.65E-04	No Data	6.02E-05
Th-232	2.30E-03	1.00E-04	1.50E-06	No Data	4.82E-04	No Data	5.12E-05
Th-234	8.01E-08	4.71E-09	2.31E-09	No Data	2.67E-08	No Data	1.13E-04
Pa-231	4.10E-03	1.54E-04	1.59E-04	No Data	8.64E-04	No Data	7.17E-05
Pa-233	5.26E-09	1.06E-09	9.12E-10	No Data	3.99E-09	No Data	1.64E-05
U-232	4.13E-03	No Data	2.95E-04	No Data	4.47E-04	No Data	6.78E-05
U-233	8.71E-04	No Data	5.28E-05	No Data	2.03E-04	No Data	6.27E-05
U-234	8.36E-04	No Data	5.17E-05	No Data	1.99E-04	No Data	6.14E-05
U-235	8.01E-04	No Data	4.86E-05	No Data	1.87E-04	No Data	7.81E-05
U-236	8.01E-04	No Data	4.96E-05	No Data	1.91E-04	No Data	5.76E-05
U-237	5.52E-08	No Data	1.47E-08	No Data	2.27E-07	No Data	1.94E-05
U-238	7.67E-04	No Data	4.54E-05	No Data	1.75E-04	No Data	5.50E-05
Np-237	1.26E-03	8.96E-05	5.54E-05	No Data	4.12E-04	No Data	7.94E-05
Np-238	1.37E-08	3.69E-10	2.13E-10	No Data	1.25E-09	No Data	3.43E-05
Np-239	1.19E-09	1.17E-10	6.45E-11	No Data	3.65E-10	No Data	2.40E-05
Pu-238	6.30E-04	7.98E-05	1.71E-05	No Data	7.32E-05	No Data	7.30E-05
Pu-239	7.25E-04	8.71E-05	1.91E-05	No Data	8.11E-05	No Data	6.66E-05
Pu-240	7.24E-04	8.70E-05	1.91E-05	No Data	8.10E-05	No Data	6.78E-05
Pu-241	1.57E-05	7.45E-07	3.32E-07	No Data	1.53E-06	No Data	1.40E-06
Pu-242	6.72E-04	8.39E-05	1.84E-05	No Data	7.81E-05	No Data	6.53E-05
Pu-244	7.84E-04	9.61E-05	2.11E-05	No Data	8.95E-05	No Data	9.73E-05
Am-241	7.55E-04	7.05E-04	5.41E-05	No Data	4.07E-04	No Data	7.42E-05
Am-242m	7.61E-04	6.63E-04	5.43E-05	No Data	4.05E-04	No Data	9.34E-05
Am-243	7.54E-04	6.90E-04	5.30E-05	No Data	3.99E-04	No Data	8.70E-05
Cm-242	2.06E-05	2.19E-05	1.37E-06	No Data	6.22E-06	No Data	7.92E-05
Cm-243	5.99E-04	5.49E-04	3.75E-05	No Data	1.75E-04	No Data	7.81E-05
Cm-244	4.56E-04	4.27E-04	2.87E-05	No Data	1.34E-04	No Data	7.55E-05
Cm-245	9.38E-04	8.17E-04	5.76E-05	No Data	2.69E-04	No Data	7.04E-05
Cm-246	9.30E-04	8.16E-04	5.75E-05	No Data	2.68E-04	No Data	6.91E-05
Cm-247	9.07E-04	8.04E-04	5.67E-05	No Data	2.64E-04	No Data	9.09E-05
Cm-248	7.54E-03	6.63E-03	4.67E-04	No Data	2.18E-03	No Data	1.47E-03
Cf-252	2.61E-04	No Data	6.29E-06	No Data	No Data	No Data	2.88E-04

[1] Data presented in this Table are from Reference 9.

TABLE A-16

INGESTION DOSE FACTORS FOR TEEN[1]

mrem/pCi Ingested

Nuclide	Bone	Liver	Total Body	Thyroid	Kidney	Lung	GI-LLI
H-3	No Data	6.04E-08	6.04E-08	6.04E-08	6.04E-08	6.04E-08	6.04E-08
Be-10	4.48E-06	6.94E-07	1.13E-07	No Data	5.30E-07	No Data	2.84E-05
C-14	4.06E-06	8.12E-07	8.12E-07	8.12E-07	8.12E-07	8.12E-07	8.12E-07
N-13	1.15E-08	1.15E-08	1.15E-08	1.15E-08	1.15E-08	1.15E-08	1.15E-08
F-18	8.64E-07	No Data	9.47E-08	No Data	No Data	No Data	7.78E-08
Na-22	2.34E-05	2.34E-05	2.34E-05	2.34E-05	2.34E-05	2.34E-05	2.34E-05
Na-24	2.30E-06	2.30E-06	2.30E-06	2.30E-06	2.30E-06	2.30E-06	2.30E-06
P-32	2.76E-04	1.71E-05	1.07E-05	No Data	No Data	No Data	2.32E-05
Ca-41	1.97E-04	No Data	2.13E-05	No Data	No Data	No Data	1.95E-07
Sc-46	7.24E-09	1.41E-08	4.18E-09	No Data	1.35E-08	No Data	4.80E-05
Cr-51	No Data	No Data	3.60E-09	2.00E-09	7.89E-10	5.14E-09	6.05E-07
Mn-54	No Data	5.90E-06	1.17E-06	No Data	1.76E-06	No Data	1.21E-05
Mn-56	No Data	1.58E-07	2.81E-08	No Data	2.00E-07	No Data	1.04E-05
Fe-55	3.78E-06	2.68E-06	6.25E-07	No Data	No Data	1.70E-06	1.16E-06
Fe-59	5.87E-06	1.37E-05	5.29E-06	No Data	No Data	4.32E-06	3.24E-05
Co-57	No Data	2.38E-07	3.99E-07	No Data	No Data	No Data	4.44E-06
Co-58	No Data	9.72E-07	2.24E-06	No Data	No Data	No Data	1.34E-05
Co-60	No Data	2.81E-06	6.33E-06	No Data	No Data	No Data	3.66E-05
Ni-59	1.32E-05	4.66E-06	2.24E-06	No Data	No Data	No Data	7.31E-07
Ni-63	1.77E-04	1.25E-05	6.00E-06	No Data	No Data	No Data	1.99E-06
Ni-65	7.49E-07	9.57E-08	4.36E-08	No Data	No Data	No Data	5.19E-06
Cu-64	No Data	1.15E-07	5.41E-08	No Data	2.91E-07	No Data	8.92E-06
Zn-65	5.76E-06	2.00E-05	9.33E-06	No Data	1.28E-05	No Data	8.47E-06
Zn-69m	2.40E-07	5.66E-07	5.19E-08	No Data	3.44E-07	No Data	3.11E-05
Zn-69	1.47E-08	2.80E-08	1.96E-09	No Data	1.83E-08	No Data	5.16E-08
Se-79	No Data	3.73E-06	6.27E-07	No Data	6.50E-06	No Data	5.70E-07
Br-82	No Data	No Data	3.04E-06	No Data	No Data	No Data	No Data
Br-83	No Data	No Data	5.74E-08	No Data	No Data	No Data	No Data
Br-84	No Data	No Data	7.22E-08	No Data	No Data	No Data	No Data
Br-85	No Data	No Data	3.05E-09	No Data	No Data	No Data	No Data
Rb-86	No Data	2.98E-05	1.40E-05	No Data	No Data	No Data	4.41E-06
Rb-87	No Data	1.75E-05	6.11E-06	No Data	No Data	No Data	6.11E-07
Rb-88	No Data	8.52E-08	4.54E-08	No Data	No Data	No Data	7.30E-15
Rb-89	No Data	5.50E-08	3.89E-08	No Data	No Data	No Data	8.43E-17
Sr-89	4.40E-04	No Data	1.26E-05	No Data	No Data	No Data	5.24E-05
Sr-90	1.02E-02	No Data	2.04E-04	No Data	No Data	No Data	2.33E-04
Sr-91	8.07E-06	No Data	3.21E-07	No Data	No Data	No Data	3.66E-05
Sr-92	3.05E-06	No Data	1.30E-07	No Data	No Data	No Data	7.77E-05
Y-90	1.37E-08	No Data	3.69E-10	No Data	No Data	No Data	1.13E-04
Y-91m	1.29E-10	No Data	4.93E-12	No Data	No Data	No Data	6.09E-09
Y-91	2.01E-07	No Data	5.39E-09	No Data	No Data	No Data	8.24E-05
Y-92	1.21E-09	No Data	3.50E-11	No Data	No Data	No Data	3.32E-05
Y-93	3.83E-09	No Data	1.05E-10	No Data	No Data	No Data	1.17E-04

[1] Data presented in this Table are from Reference 9.

TABLE A-16 (continued)

INGESTION DOSE FACTORS FOR TEEN[1]

mrem/pCi Ingested

Nuclide	Bone	Liver	Total Body	Thyroid	Kidney	Lung	GI-LLI
Zr-93	5.53E-08	2.73E-09	1.49E-09	No Data	9.65E-09	No Data	2.58E-06
Zr-95	4.12E-08	1.30E-08	8.94E-09	No Data	1.91E-08	No Data	3.00E-05
Zr-97	2.37E-09	4.69E-10	2.16E-10	No Data	7.11E-10	No Data	1.27E-04
Nb-93m	3.44E-08	1.13E-08	2.83E-09	No Data	1.32E-08	No Data	4.07E-06
Nb-95	8.22E-09	4.56E-09	2.51E-09	No Data	4.42E-09	No Data	1.95E-05
Nb-97	7.37E-11	1.83E-11	6.68E-12	No Data	2.14E-11	No Data	4.37E-07
Mo-93	No Data	1.06E-05	2.90E-07	No Data	3.04E-06	No Data	1.29E-06
Mo-99	No Data	6.03E-06	1.15E-06	No Data	1.38E-05	No Data	1.08E-05
Tc-99m	3.32E-10	9.26E-10	1.20E-08	No Data	1.38E-08	5.14E-10	6.08E-07
Tc-99	1.79E-07	2.63E-07	7.17E-08	No Data	3.34E-06	2.72E-08	6.44E-06
Tc-101	3.60E-10	5.12E-10	5.03E-09	No Data	9.26E-09	3.12E-10	8.75E-17
Ru-103	2.55E-07	No Data	1.09E-07	No Data	8.99E-07	No Data	2.13E-05
Ru-105	2.18E-08	No Data	8.46E-09	No Data	2.75E-07	No Data	1.76E-05
Ru-106	3.92E-06	No Data	4.94E-07	No Data	7.56E-06	No Data	1.88E-04
Rh-105	1.73E-07	1.25E-07	8.20E-08	No Data	5.31E-07	No Data	1.59E-05
Pd-107	No Data	2.08E-07	1.34E-08	No Data	1.88E-06	No Data	9.66E-07
Pd-109	No Data	2.51E-07	5.70E-08	No Data	1.45E-06	No Data	2.53E-05
Ag-110m	2.05E-07	1.94E-07	1.18E-07	No Data	3.70E-07	No Data	5.45E-05
Ag-111	8.29E-08	3.44E-08	1.73E-08	No Data	1.12E-07	No Data	4.80E-05
Cd-113m	No Data	4.51E-06	1.45E-07	No Data	4.99E-06	No Data	2.71E-05
Cd-115m	No Data	2.60E-06	8.39E-08	No Data	2.08E-06	No Data	8.23E-05
Sn-123	4.44E-05	7.29E-07	1.08E-06	5.84E-07	No Data	No Data	6.71E-05
Sn-125	1.19E-05	2.37E-07	5.37E-07	1.86E-07	No Data	No Data	1.12E-04
Sn-126	1.16E-04	2.16E-06	3.30E-06	5.69E-07	No Data	No Data	2.58E-05
Sb-124	3.87E-06	7.13E-08	1.51E-06	8.78E-09	No Data	3.38E-06	7.80E-05
Sb-125	2.48E-06	2.71E-08	5.80E-07	2.37E-09	No Data	2.18E-06	1.93E-05
Sb-126	1.59E-06	3.25E-08	5.71E-07	8.99E-09	No Data	1.14E-06	9.41E-05
Sb-127	3.63E-07	7.76E-09	1.37E-07	4.08E-09	No Data	2.47E-07	6.16E-05
Te-125m	3.83E-06	1.38E-06	5.12E-07	1.07E-06	No Data	No Data	1.13E-05
Te-127m	9.67E-06	3.43E-06	1.15E-06	2.30E-06	3.92E-05	No Data	2.41E-05
Te-127	1.58E-07	5.60E-08	3.40E-08	1.09E-07	6.40E-07	No Data	1.22E-05
Te-129m	1.63E-05	6.05E-06	2.58E-06	5.26E-06	6.82E-05	No Data	6.12E-05
Te-129	4.48E-08	1.67E-08	1.09E-08	3.20E-08	1.88E-07	No Data	2.45E-07
Te-131m	2.44E-06	1.17E-06	9.76E-07	1.76E-06	1.22E-05	No Data	9.39E-05
Te-131	2.79E-08	1.15E-08	8.72E-09	2.15E-08	1.22E-07	No Data	2.29E-09
Te-132	3.49E-06	2.21E-06	2.08E-06	2.33E-06	2.12E-05	No Data	7.00E-05
Te-133m	6.44E-08	3.66E-08	3.56E-08	5.11E-08	3.62E-07	No Data	1.48E-07
Te-134	4.47E-08	2.87E-08	3.00E-08	3.67E-08	2.74E-07	No Data	1.66E-09
I-129	4.66E-06	3.92E-06	6.54E-06	4.77E-03	7.01E-06	No Data	4.57E-07
I-130	1.03E-06	2.98E-06	1.19E-06	2.43E-04	4.59E-06	No Data	2.29E-06
I-131	5.85E-06	8.19E-06	4.40E-06	2.39E-03	1.41E-05	No Data	1.62E-06
I-132	2.79E-07	7.30E-07	2.62E-07	2.46E-05	1.15E-06	No Data	3.18E-07
I-133	2.01E-06	3.41E-06	1.04E-06	4.76E-04	5.98E-06	No Data	2.58E-06
I-134	1.46E-07	3.87E-07	1.39E-07	6.45E-06	6.10E-07	No Data	5.10E-09
I-135	6.10E-07	1.57E-06	5.82E-07	1.01E-04	2.48E-06	No Data	1.74E-06

[1] Data presented in this Table are from Reference 9.

TABLE A-16 (continued)

INGESTION DOSE FACTORS FOR TEEN[1]

mrem/pCi Ingested

Nuclide	Bone	Liver	Total Body	Thyroid	Kidney	Lung	GI-LLI
Cs-134m	2.94E-08	6.09E-08	3.13E-08	No Data	3.39E-08	5.95E-09	4.05E-08
Cs-134	8.37E-05	1.97E-04	9.14E-05	No Data	6.26E-05	2.39E-05	2.45E-06
Cs-135	2.78E-05	2.55E-05	5.96E-06	No Data	9.73E-06	3.52E-06	4.46E-07
Cs-136	8.59E-06	3.38E-05	2.27E-05	No Data	1.84E-05	2.90E-06	2.72E-06
Cs-137	1.12E-04	1.49E-04	5.19E-05	No Data	5.07E-05	1.97E-05	2.12E-06
Cs-138	7.76E-08	1.49E-07	7.45E-08	No Data	1.10E-07	1.28E-08	6.76E-11
Cs-139	4.87E-08	7.17E-08	2.63E-08	No Data	5.79E-08	6.34E-09	3.33E-23
Ba-139	1.39E-07	9.78E-11	4.05E-09	No Data	9.22E-11	6.74E-11	1.24E-06
Ba-140	2.84E-05	3.48E-08	1.83E-06	No Data	1.18E-08	2.34E-08	4.38E-05
Ba-141	6.71E-08	5.01E-11	2.24E-09	No Data	4.65E-11	3.43E-11	1.43E-13
Ba-142	2.99E-08	2.99E-11	1.84E-09	No Data	2.53E-11	1.99E-11	9.18E-20
La-140	3.48E-09	1.71E-09	4.55E-10	No Data	No Data	No Data	9.82E-05
La-141	4.55E-10	1.40E-10	2.31E-11	No Data	No Data	No Data	2.48E-05
La-142	1.79E-10	7.95E-11	1.98E-11	No Data	No Data	No Data	2.42E-06
Ce-141	1.33E-08	8.88E-09	1.02E-09	No Data	4.18E-09	No Data	2.54E-05
Ce-143	2.35E-09	1.71E-06	1.91E-10	No Data	7.67E-10	No Data	5.14E-05
Ce-144	6.96E-07	2.88E-07	3.74E-08	No Data	1.72E-07	No Data	1.75E-04
Pr-143	1.31E-08	5.23E-09	6.52E-10	No Data	3.04E-09	No Data	4.31E-05
Pr-144	4.30E-11	1.76E-11	2.18E-12	No Data	1.01E-11	No Data	4.74E-14
Nd-147	9.38E-09	1.02E-08	6.11E-10	No Data	5.99E-09	No Data	3.68E-05
Pm-147	1.05E-07	9.96E-09	4.06E-09	No Data	1.90E-08	No Data	9.47E-06
Pm-148m	4.14E-08	1.05E-08	8.21E-09	No Data	1.59E-08	No Data	6.61E-05
Pm-148	1.02E-08	1.66E-09	8.36E-10	No Data	3.00E-09	No Data	9.90E-05
Pm-149	2.17E-09	3.05E-10	1.25E-10	No Data	5.81E-10	No Data	4.49E-05
Pm-151	9.87E-10	1.63E-10	8.25E-11	No Data	2.93E-10	No Data	3.66E-05
Sm-151	8.73E-08	1.68E-08	3.94E-09	No Data	1.84E-08	No Data	5.70E-06
Sm-153	1.22E-09	1.01E-09	7.43E-11	No Data	3.30E-10	No Data	2.85E-05
Eu-152	2.45E-07	5.90E-08	5.20E-08	No Data	2.74E-07	No Data	2.17E-05
Eu-154	7.91E-07	1.02E-07	7.19E-08	No Data	4.56E-07	No Data	5.39E-05
Eu-155	1.74E-07	1.68E-08	1.04E-08	No Data	6.57E-08	No Data	9.63E-05
Eu-156	1.92E-08	1.44E-08	2.35E-09	No Data	9.69E-09	No Data	7.36E-05
Tb-160	6.47E-08	No Data	8.07E-09	No Data	2.56E-08	No Data	4.19E-05
Ho-166m	3.57E-07	1.10E-07	7.96E-08	No Data	1.61E-07	No Data	2.71E-05
W-181	1.42E-08	4.58E-09	4.79E-10	No Data	No Data	No Data	3.90E-07
W-185	5.79E-07	1.91E-07	2.02E-08	No Data	No Data	No Data	1.65E-05
W-187	1.46E-07	1.19E-07	4.17E-08	No Data	No Data	No Data	3.22E-05
Pb-210	1.81E-02	5.44E-03	7.01E-04	No Data	1.72E-02	No Data	2.37E-06
Bi-210	6.59E-07	4.51E-06	3.77E-07	No Data	5.48E-05	No Data	5.15E-05
Po-210	5.09E-04	1.07E-03	1.23E-04	No Data	3.60E-03	No Data	6.75E-05
Ra-223	7.11E-03	1.08E-05	1.42E-03	No Data	3.10E-04	No Data	3.43E-04
Ra-224	2.31E-03	5.52E-06	4.61E-04	No Data	1.58E-04	No Data	3.71E-04
Ra-225	9.37E-03	1.10E-05	1.87E-03	No Data	3.15E-04	No Data	3.27E-04
Ra-226	3.22E-01	8.13E-06	2.39E-01	No Data	2.32E-04	No Data	3.51E-04
Ra-228	1.37E-01	4.41E-06	1.51E-01	No Data	1.26E-04	No Data	5.98E-05

[1] Data presented in this Table are from Reference 9.

TABLE A-16 (continued)

INGESTION DOSE FACTORS FOR TEEN [1]

mrem/pCi Ingested

Nuclide	Bone	Liver	Total Body	Thyroid	Kidney	Lung	GI-LLI
Ac-225	6.29E-06	8.59E-06	4.22E-07	No Data	9.85E-07	No Data	4.36E-04
Ac-227	2.05E-03	3.03E-04	1.22E-04	No Data	8.81E-05	No Data	8.68E-05
Th-227	1.96E-05	3.52E-07	5.65E-07	No Data	2.01E-06	No Data	5.75E-04
Th-228	6.80E-04	1.14E-05	2.30E-05	No Data	6.41E-05	No Data	5.97E-04
Th-229	1.43E-02	4.11E-04	2.37E-04	No Data	1.99E-03	No Data	8.28E-05
Th-230	2.16E-03	1.23E-04	6.00E-05	No Data	5.99E-04	No Data	6.38E-05
Th-232	2.42E-03	1.05E-04	1.63E-06	No Data	5.11E-04	No Data	5.43E-05
Th-234	1.14E-07	6.68E-09	3.31E-09	No Data	3.81E-08	No Data	1.21E-04
Pa-231	4.31E-03	1.62E-04	1.68E-04	No Data	9.10E-04	No Data	7.60E-05
Pa-233	7.33E-09	1.41E-09	1.26E-09	No Data	5.32E-09	No Data	1.61E-05
U-232	5.89E-03	No Data	4.21E-04	No Data	6.38E-04	No Data	7.19E-05
U-233	1.24E-03	No Data	7.54E-05	No Data	2.90E-04	No Data	6.65E-05
U-234	1.19E-03	No Data	7.39E-05	No Data	2.85E-04	No Data	6.51E-05
U-235	1.14E-03	No Data	6.94E-05	No Data	2.67E-04	No Data	8.28E-05
U-236	1.14E-03	No Data	7.09E-05	No Data	2.73E-04	No Data	6.11E-05
U-237	7.89E-08	No Data	2.10E-08	No Data	3.24E-07	No Data	2.09E-05
U-238	1.09E-03	No Data	6.49E-05	No Data	2.50E-04	No Data	5.83E-05
Np-237	1.33E-03	9.55E-05	5.85E-05	No Data	4.33E-04	No Data	8.41E-05
Np-238	1.95E-08	5.22E-10	3.04E-10	No Data	1.79E-09	No Data	3.83E-05
Np-239	1.76E-09	1.66E-10	9.22E-11	No Data	5.21E-10	No Data	2.67E-05
Pu-238	6.70E-04	8.58E-05	1.82E-05	No Data	7.80E-05	No Data	7.73E-05
Pu-239	7.65E-04	9.29E-05	2.01E-05	No Data	8.57E-05	No Data	7.06E-05
Pu-240	7.64E-04	9.27E-05	2.01E-05	No Data	8.56E-05	No Data	7.19E-05
Pu-241	1.75E-05	8.40E-07	3.69E-07	No Data	1.71E-06	No Data	1.48E-06
Pu-242	7.09E-04	8.94E-05	1.94E-05	No Data	8.25E-05	No Data	6.92E-05
Pu-244	8.28E-04	1.02E-04	2.22E-05	No Data	9.45E-05	No Data	1.03E-04
Am-241	7.98E-04	7.53E-04	5.75E-05	No Data	4.31E-04	No Data	7.87E-05
Am-242m	8.07E-04	7.11E-04	5.80E-05	No Data	4.30E-04	No Data	9.90E-05
Am-243	7.96E-04	7.35E-04	5.62E-05	No Data	4.22E-04	No Data	9.23E-05
Cm-242	2.94E-05	3.10E-05	1.95E-06	No Data	8.89E-06	No Data	8.40E-05
Cm-243	6.50E-04	6.03E-04	4.09E-05	No Data	1.91E-04	No Data	8.28E-05
Cm-244	5.04E-04	4.77E-04	3.19E-05	No Data	1.49E-04	No Data	8.00E-05
Cm-245	9.90E-04	8.71E-04	6.10E-05	No Data	2.85E-04	No Data	7.46E-05
Cm-246	9.82E-04	8.70E-04	6.09E-05	No Data	2.84E-04	No Data	7.33E-05
Cm-247	9.57E-04	8.57E-04	6.00E-05	No Data	2.80E-04	No Data	9.63E-05
Cm-248	7.95E-03	7.06E-03	4.95E-04	No Data	2.31E-03	No Data	1.55E-03
Cf-252	3.47E-04	No Data	8.37E-06	No Data	No Data	No Data	3.05E-04

[1] Data presented in this Table are from Reference 9.

TABLE A-17

INGESTION DOSE FACTORS FOR CHILD [1]

mrem/pCi Ingested

Nuclide	Bone	Liver	Total Body	Thyroid	Kidney	Lung	GI-LLI
H-3	No Data	1.16E-07	1.16E-07	1.16E-07	1.16E-07	1.16E-07	1.16E-07
Be-10	1.35E-05	1.57E-06	3.39E-07	No Data	1.11E-06	No Data	2.75E-05
C-14	1.21E-05	2.42E-06	2.42E-06	2.42E-06	2.42E-06	2.42E-06	2.42E-06
N-13	3.10E-08	3.10E-08	3.10E-08	3.10E-08	3.10E-08	3.10E-08	3.10E-08
F-18	2.49E-06	No Data	2.47E-07	No Data	No Data	No Data	6.74E-07
Na-22	5.88E-05	5.88E-05	5.88E-05	5.88E-05	5.88E-05	5.88E-05	5.88E-05
Na-24	5.80E-06	5.80E-06	5.80E-06	5.80E-06	5.80E-06	5.80E-06	5.80E-06
P-32	8.25E-04	3.86E-05	3.18E-05	No Data	No Data	No Data	2.28E-05
Ca-41	3.47E-04	No Data	3.79E-05	No Data	No Data	No Data	1.90E-07
Sc-46	1.97E-08	2.70E-08	1.04E-08	No Data	2.39E-08	No Data	3.95E-05
Cr-51	No Data	No Data	8.90E-09	4.94E-09	1.35E-09	9.02E-09	4.72E-07
Mn-54	No Data	1.07E-05	2.85E-06	No Data	3.00E-06	No Data	8.98E-06
Mn-56	No Data	3.34E-07	7.54E-08	No Data	4.04E-07	No Data	4.84E-05
Fe-55	1.15E-05	6.10E-06	1.89E-06	No Data	No Data	3.45E-06	1.13E-06
Fe-59	1.65E-05	2.67E-05	1.33E-05	No Data	No Data	7.74E-06	2.78E-05
Co-57	No Data	4.93E-07	9.98E-07	No Data	No Data	No Data	4.04E-06
Co-58	No Data	1.80E-06	5.51E-06	No Data	No Data	No Data	1.05E-05
Co-60	No Data	5.29E-06	1.56E-05	No Data	No Data	No Data	2.93E-05
Ni-59	4.02E-05	1.07E-05	6.82E-06	No Data	No Data	No Data	7.10E-07
Ni-63	5.38E-04	2.88E-05	1.83E-05	No Data	No Data	No Data	1.94E-06
Ni-65	2.22E-06	2.09E-07	1.22E-07	No Data	No Data	No Data	2.56E-05
Cu-64	No Data	2.45E-07	1.48E-07	No Data	5.92E-07	No Data	1.15E-05
Zn-65	1.37E-05	3.65E-05	2.27E-05	No Data	2.30E-05	No Data	6.41E-06
Zn-69m	7.10E-07	1.21E-06	1.43E-07	No Data	7.03E-07	No Data	3.94E-05
Zn-69	4.38E-08	6.33E-08	5.85E-09	No Data	3.84E-08	No Data	3.99E-06
Se-79	No Data	8.43E-06	1.87E-06	No Data	1.37E-05	No Data	5.53E-07
Br-82	No Data	No Data	7.55E-06	No Data	No Data	No Data	No Data
Br-83	No Data	No Data	1.71E-07	No Data	No Data	No Data	No Data
Br-84	No Data	No Data	1.98E-07	No Data	No Data	No Data	No Data
Br-85	No Data	No Data	9.12E-09	No Data	No Data	No Data	No Data
Rb-86	No Data	6.70E-05	4.12E-05	No Data	No Data	No Data	4.31E-06
Rb-87	No Data	3.95E-05	1.83E-05	No Data	No Data	No Data	5.92E-07
Rb-88	No Data	1.90E-07	1.32E-07	No Data	No Data	No Data	9.32E-09
Rb-89	No Data	1.17E-07	1.04E-07	No Data	No Data	No Data	1.02E-09
Sr-89	1.32E-03	No Data	3.77E-05	No Data	No Data	No Data	5.11E-05
Sr-90	2.56E-02	No Data	5.15E-04	No Data	No Data	No Data	2.29E-04
Sr-91	2.40E-05	No Data	9.06E-07	No Data	No Data	No Data	5.30E-05
Sr-92	9.03E-06	No Data	3.62E-07	No Data	No Data	No Data	1.71E-04
Y-90	4.11E-08	No Data	1.10E-09	No Data	No Data	No Data	1.17E-04
Y-91m	3.82E-10	No Data	1.39E-11	No Data	No Data	No Data	7.48E-07
Y-91	6.02E-07	No Data	1.61E-08	No Data	No Data	No Data	8.02E-05
Y-92	3.60E-09	No Data	1.03E-10	No Data	No Data	No Data	1.04E-04
Y-93	1.14E-08	No Data	3.13E-10	No Data	No Data	No Data	1.70E-04

[1] Data presented in this Table are from Reference 9.

TABLE A-17 (continued)

INGESTION DOSE FACTORS FOR CHILD [1]

mrem/pCi Ingested

Nuclide	Bone	Liver	Total Body	Thyroid	Kidney	Lung	GI-LLI
Zr-93	1.67E-07	6.25E-09	4.45E-09	No Data	2.42E-08	No Data	2.37E-06
Zr-95	1.16E-07	2.55E-08	2.27E-08	No Data	3.65E-08	No Data	2.66E-05
Zr-97	6.99E-09	1.01E-09	5.96E-10	No Data	1.45E-09	No Data	1.53E-04
Nb-93m	1.05E-07	2.62E-08	8.61E-09	No Data	2.83E-08	No Data	3.95E-06
Nb-95	2.25E-08	8.76E-09	6.26E-09	No Data	8.23E-09	No Data	1.62E-05
Nb-97	2.17E-10	3.92E-11	1.83E-11	No Data	4.35E-11	No Data	1.21E-05
Mo-93	No Data	2.41E-05	8.65E-07	No Data	6.35E-06	No Data	1.22E-06
Mo-99	No Data	1.33E-05	3.29E-06	No Data	2.84E-05	No Data	1.10E-05
Tc-99m	9.23E-10	1.81E-09	3.00E-08	No Data	2.63E-08	9.19E-10	1.03E-06
Tc-99	5.35E-07	5.96E-07	2.14E-07	No Data	7.02E-06	5.27E-08	6.25E-06
Tc-101	1.07E-09	1.12E-09	1.42E-08	No Data	1.91E-08	5.92E-10	3.56E-09
Ru-103	7.31E-07	No Data	2.81E-07	No Data	1.84E-06	No Data	1.89E-05
Ru-105	6.45E-08	No Data	2.34E-08	No Data	5.67E-07	No Data	4.21E-05
Ru-106	1.17E-05	No Data	1.46E-06	No Data	1.58E-05	No Data	1.82E-04
Rh-105	5.14E-07	2.76E-07	2.36E-07	No Data	1.10E-06	No Data	1.71E-05
Pd-107	No Data	4.72E-07	4.01E-08	No Data	3.95E-06	No Data	9.37E-07
Pd-109	No Data	5.67E-07	1.70E-07	No Data	3.04E-06	No Data	3.35E-05
Ag-110m	5.39E-07	3.64E-07	2.91E-07	No Data	6.78E-07	No Data	4.33E-05
Ag-111	2.48E-07	7.76E-08	5.12E-08	No Data	2.34E-07	No Data	4.75E-05
Cd-113m	No Data	1.02E-05	4.34E-07	No Data	1.05E-05	No Data	2.63E-05
Cd-115m	No Data	5.89E-06	2.51E-07	No Data	4.38E-06	No Data	8.01E-05
Sn-123	1.33E-04	1.65E-06	3.24E-06	1.75E-06	No Data	No Data	6.52E-05
Sn-125	3.55E-05	5.35E-07	1.59E-06	5.55E-07	No Data	No Data	1.10E-04
Sn-126	3.33E-04	4.15E-06	9.46E-06	1.14E-06	No Data	No Data	2.50E-05
Sb-124	1.11E-05	1.44E-07	3.89E-06	2.45E-08	No Data	6.16E-06	6.94E-05
Sb-125	7.16E-06	5.52E-08	1.50E-06	6.63E-09	No Data	3.99E-06	1.71E-05
Sb-126	4.40E-06	6.73E-08	1.58E-06	2.58E-08	No Data	2.10E-06	8.87E-05
Sb-127	1.06E-06	1.64E-08	3.68E-07	1.18E-08	No Data	4.60E-07	5.97E-05
Te-125m	1.14E-05	3.09E-06	1.52E-06	3.20E-06	No Data	No Data	1.10E-05
Te-127m	2.89E-05	7.78E-06	3.43E-06	6.91E-06	8.24E-05	No Data	2.34E-05
Te-127	4.71E-07	1.27E-07	1.01E-07	3.26E-07	1.34E-06	No Data	1.84E-05
Te-129m	4.87E-05	1.36E-05	7.56E-06	1.57E-05	1.43E-04	No Data	5.94E-05
Te-129	1.34E-07	3.74E-08	3.18E-08	9.56E-08	3.92E-07	No Data	8.34E-06
Te-131m	7.20E-06	2.49E-06	2.65E-06	5.12E-06	2.41E-05	No Data	1.01E-04
Te-131	8.30E-08	2.53E-08	2.47E-08	6.35E-08	2.51E-07	No Data	4.36E-07
Te-132	1.01E-05	4.47E-06	5.40E-06	6.51E-06	4.15E-05	No Data	4.50E-05
Te-133m	1.87E-07	7.56E-08	9.37E-08	1.45E-07	7.18E-07	No Data	5.77E-06
Te-134	1.29E-07	5.80E-08	7.74E-08	1.02E-07	5.37E-07	No Data	5.89E-07
I-129	1.39E-05	8.53E-06	7.62E-06	5.58E-03	1.44E-05	No Data	4.29E-07
I-130	2.92E-06	5.90E-06	3.04E-06	6.50E-04	8.82E-06	No Data	2.76E-06
I-131	1.72E-05	1.73E-05	9.83E-06	5.72E-03	2.84E-05	No Data	1.54E-06
I-132	8.00E-07	1.47E-06	6.76E-07	6.82E-05	2.25E-06	No Data	1.73E-06
I-133	5.92E-06	7.32E-06	2.77E-06	1.36E-03	1.22E-05	No Data	2.95E-06
I-134	4.19E-07	7.78E-07	3.58E-07	1.79E-05	1.19E-06	No Data	5.16E-07
I-135	1.75E-06	3.15E-06	1.49E-06	2.79E-04	4.83E-06	No Data	2.40E-06

[1] Data presented in this Table are from Reference 9.

TABLE A-17 (continued)

INGESTION DOSE FACTORS FOR CHILD [1]

mrem/pCi Ingested

Nuclide	Bone	Liver	Total Body	Thyroid	Kidney	Lung	GI-LLI
Cs-134m	8.44E-08	1.25E-07	8.16E-08	No Data	6.59E-08	1.09E-08	1.58E-07
Cs-134	2.34E-04	3.84E-04	8.10E-05	No Data	1.19E-04	4.27E-05	2.07E-06
Cs-135	8.30E-05	5.78E-05	5.93E-06	No Data	2.04E-05	6.81E-06	4.33E-07
Cs-136	2.35E-05	6.46E-05	4.18E-05	No Data	3.44E-05	5.13E-06	2.27E-06
Cs-137	3.27E-04	3.13E-04	4.62E-05	No Data	1.02E-04	3.67E-05	1.96E-06
Cs-138	2.28E-07	3.17E-07	2.01E-07	No Data	2.23E-07	2.40E-08	1.46E-07
Cs-139	1.45E-07	1.61E-07	7.74E-08	No Data	1.21E-07	1.22E-08	1.45E-11
Ba-139	4.14E-07	2.21E-10	1.20E-08	No Data	1.93E-10	1.30E-10	2.39E-05
Ba-140	8.31E-05	7.28E-08	4.85E-06	No Data	2.37E-08	4.34E-08	4.21E-05
Ba-141	2.00E-07	1.12E-10	6.51E-09	No Data	9.69E-11	6.58E-10	1.14E-07
Ba-142	8.74E-08	6.29E-11	4.88E-09	No Data	5.09E-11	3.70E-11	1.14E-09
La-140	1.01E-08	3.53E-09	1.19E-09	No Data	No Data	No Data	9.84E-05
La-141	1.36E-09	3.17E-10	6.88E-11	No Data	No Data	No Data	7.05E-05
La-142	5.24E-10	1.67E-10	5.23E-11	No Data	No Data	No Data	3.31E-05
Ce-141	3.97E-08	1.98E-08	2.94E-09	No Data	8.68E-09	No Data	2.47E-05
Ce-143	6.99E-09	3.79E-06	5.49E-10	No Data	1.59E-09	No Data	5.55E-05
Ce-144	2.08E-06	6.52E-07	1.11E-07	No Data	3.61E-07	No Data	1.70E-04
Pr-143	3.93E-08	1.18E-08	1.95E-09	No Data	6.39E-09	No Data	4.24E-05
Pr-144	1.29E-10	3.99E-11	6.49E-12	No Data	2.11E-11	No Data	8.59E-08
Nd-147	2.79E-08	2.26E-08	1.75E-09	No Data	1.24E-08	No Data	3.58E-05
Pm-147	3.18E-07	2.27E-08	1.22E-08	No Data	4.01E-08	No Data	9.19E-06
Pm-148m	1.03E-07	2.05E-08	2.05E-08	No Data	3.04E-08	No Data	5.78E-05
Pm-148	3.02E-08	3.63E-09	2.35E-09	No Data	6.17E-09	No Data	9.70E-05
Pm-149	6.49E-09	6.90E-10	3.74E-10	No Data	1.22E-09	No Data	4.71E-05
Pm-151	2.92E-09	3.55E-10	2.31E-10	No Data	6.02E-10	No Data	4.03E-05
Sm-151	2.56E-07	3.81E-08	1.20E-08	No Data	3.94E-08	No Data	5.53E-06
Sm-153	3.65E-09	2.27E-09	2.19E-10	No Data	6.91E-10	No Data	3.02E-05
Eu-152	6.15E-07	1.12E-07	1.33E-07	No Data	4.73E-07	No Data	1.84E-05
Eu-154	2.30E-06	2.07E-07	1.89E-07	No Data	9.09E-07	No Data	4.81E-05
Eu-155	4.82E-07	3.47E-08	2.72E-08	No Data	1.30E-07	No Data	8.69E-05
Eu-156	5.62E-08	3.01E-08	6.23E-09	No Data	1.94E-08	No Data	6.83E-05
Tb-160	1.66E-07	No Data	2.06E-08	No Data	4.94E-08	No Data	3.68E-05
Ho-166m	1.08E-06	2.26E-07	1.91E-07	No Data	3.22E-07	No Data	2.63E-05
W-181	4.23E-08	1.04E-08	1.43E-09	No Data	No Data	No Data	3.79E-07
W-185	1.73E-06	4.32E-07	6.05E-08	No Data	No Data	No Data	1.61E-05
W-187	4.29E-07	2.54E-07	1.14E-07	No Data	No Data	No Data	3.57E-05
Pb-210	4.75E-02	1.22E-02	2.09E-03	No Data	3.67E-02	No Data	2.30E-06
Bi-210	1.97E-06	1.02E-05	1.13E-06	No Data	1.15E-04	No Data	5.17E-05
Po-210	1.52E-03	2.43E-03	3.67E-04	No Data	7.56E-03	No Data	6.55E-05
Ra-223	2.12E-02	2.45E-05	4.24E-03	No Data	6.50E-04	No Data	3.38E-04
Ra-224	6.89E-03	1.25E-05	1.38E-03	No Data	3.31E-04	No Data	3.78E-04
Ra-225	2.80E-02	2.50E-05	5.59E-03	No Data	6.62E-04	No Data	3.21E-04
Ra-226	5.75E-01	1.84E-05	4.72E-01	No Data	4.88E-04	No Data	3.41E-04
Ra-228	3.85E-01	9.99E-06	4.32E-01	No Data	2.65E-04	No Data	5.81E-05

[1] Data presented in this Table are from Reference 9.

TABLE A-17 (continued)

INGESTION DOSE FACTORS FOR CHILD [1]

mrem/pCi Ingested

Nuclide	Bone	Liver	Total Body	Thyroid	Kidney	Lung	GI-LLI
Ac-225	1.88E-05	1.94E-05	1.26E-06	No Data	2.07E-06	No Data	4.31E-04
Ac-227	4.12E-03	6.63E-04	2.55E-04	No Data	1.46E-04	No Data	8.43E-05
Th-227	5.85E-05	7.96E-07	1.69E-06	No Data	4.22E-06	No Data	5.63E-04
Th-228	2.07E-03	2.65E-05	7.00E-05	No Data	1.38E-04	No Data	5.79E-04
Th-229	2.35E-02	5.91E-04	3.92E-04	No Data	2.89E-03	No Data	8.04E-05
Th-230	3.55E-03	1.78E-04	9.91E-05	No Data	8.67E-04	No Data	6.19E-05
Th-232	3.96E-03	1.52E-04	3.01E-06	No Data	7.41E-04	No Data	5.27E-05
Th-234	3.42E-07	1.51E-08	9.88E-09	No Data	8.01E-08	No Data	1.18E-04
Pa-231	7.07E-03	2.34E-04	2.81E-04	No Data	1.28E-03	No Data	7.37E-05
Pa-233	1.81E-08	2.82E-09	3.16E-09	No Data	1.04E-08	No Data	1.44E-05
U-232	1.76E-02	No Data	1.26E-03	No Data	1.34E-03	No Data	6.98E-05
U-233	3.72E-03	No Data	2.25E-04	No Data	6.10E-04	No Data	6.45E-05
U-234	3.57E-03	No Data	2.21E-04	No Data	5.98E-04	No Data	6.32E-05
U-235	3.42E-03	No Data	2.07E-04	No Data	5.61E-04	No Data	8.03E-05
U-236	3.42E-03	No Data	2.12E-04	No Data	5.73E-04	No Data	5.92E-05
U-237	2.36E-07	No Data	6.27E-08	No Data	6.81E-07	No Data	2.08E-05
U-238	3.27E-03	No Data	1.94E-04	No Data	5.24E-04	No Data	5.66E-05
Np-237	2.23E-03	1.47E-04	9.79E-05	No Data	6.05E-04	No Data	8.16E-05
Np-238	5.83E-08	1.18E-09	9.08E-10	No Data	3.76E-09	No Data	4.04E-05
Np-239	5.25E-09	3.77E-10	2.65E-10	No Data	1.09E-09	No Data	2.79E-05
Pu-238	1.19E-03	1.38E-04	3.16E-05	No Data	1.15E-04	No Data	7.50E-05
Pu-239	1.29E-03	1.38E-04	3.31E-05	No Data	1.22E-04	No Data	6.85E-05
Pu-240	1.28E-03	1.43E-04	3.31E-05	No Data	1.22E-04	No Data	6.98E-05
Pu-241	3.87E-05	1.58E-06	8.04E-07	No Data	2.96E-06	No Data	1.44E-06
Pu-242	1.19E-03	1.38E-04	3.19E-05	No Data	1.17E-04	No Data	6.71E-05
Pu-244	1.39E-03	1.58E-03	3.65E-05	No Data	1.35E-04	No Data	1.00E-04
Am-241	1.36E-03	1.17E-03	1.02E-04	No Data	6.23E-04	No Data	7.64E-05
Am-242m	1.40E-03	1.12E-03	1.04E-04	No Data	6.30E-04	No Data	9.61E-05
Am-243	1.34E-03	1.13E-03	9.83E-05	No Data	6.06E-04	No Data	8.95E-05
Cm-242	8.78E-05	7.01E-05	5.84E-06	No Data	1.87E-05	No Data	8.16E-05
Cm-243	1.28E-03	1.04E-03	8.24E-05	No Data	3.08E-04	No Data	8.03E-05
Cm-244	1.08E-03	8.74E-04	6.93E-05	No Data	2.54E-04	No Data	7.77E-05
Cm-245	1.67E-03	1.34E-03	1.05E-04	No Data	4.11E-04	No Data	7.24E-05
Cm-246	1.65E-03	1.34E-03	1.05E-04	No Data	4.10E-04	No Data	7.11E-05
Cm-247	1.61E-03	1.32E-03	1.03E-04	No Data	4.04E-04	No Data	9.35E-05
Cm-248	1.34E-02	1.09E-02	8.52E-04	No Data	3.33E-03	No Data	1.51E-03
Cf-252	1.05E-03	No Data	2.54E-05	No Data	No Data	No Data	2.96E-04

[1] Data presented in this Table are from Reference 9.

TABLE A-18

INGESTION DOSE FACTORS FOR INFANT [1]

mrem/pCi Ingested

Nuclide	Bone	Liver	Total Body	Thyroid	Kidney	Lung	GI-LLI
H-3	No Data	1.76E-07	1.76E-07	1.76E-07	1.76E-07	1.76E-07	1.76E-07
Be-10	1.71E-05	2.49E-06	5.16E-07	No Data	1.64E-06	No Data	2.78E-05
C-14	2.37E-05	5.06E-06	5.06E-06	5.06E-06	5.06E-06	5.06E-06	5.06E-06
N-13	5.85E-08	5.85E-08	5.85E-08	5.85E-08	5.85E-08	5.85E-08	5.85E-08
F-18	5.19E-06	No Data	4.43E-07	No Data	No Data	No Data	1.22E-06
Na-22	9.83E-05	9.83E-05	9.83E-05	9.83E-05	9.83E-05	9.83E-05	9.83E-05
Na-24	1.01E-05	1.01E-05	1.01E-05	1.01E-05	1.01E-05	1.01E-05	1.01E-05
P-32	1.70E-03	1.00E-04	6.59E-05	No Data	No Data	No Data	2.30E-05
Ca-41	3.74E-04	No Data	4.08E-05	No Data	No Data	No Data	1.91E-07
Sc-46	3.75E-08	5.41E-08	1.69E-08	No Data	3.56E-08	No Data	3.53E-05
Cr-51	No Data	No Data	1.41E-08	9.20E-09	2.01E-09	1.79E-08	4.11E-07
Mn-54	No Data	1.99E-05	4.51E-06	No Data	4.41E-06	No Data	7.31E-06
Mn-56	No Data	8.18E-07	1.41E-07	No Data	7.03E-07	No Data	7.43E-05
Fe-55	1.39E-05	8.98E-06	2.40E-06	No Data	No Data	4.39E-06	1.14E-06
Fe-59	3.08E-05	5.38E-05	2.12E-05	No Data	No Data	1.59E-05	2.57E-05
Co-57	No Data	1.15E-06	1.87E-06	No Data	No Data	No Data	3.92E-06
Co-58	No Data	3.60E-06	8.98E-06	No Data	No Data	No Data	8.97E-06
Co-60	No Data	1.08E-05	2.55E-05	No Data	No Data	No Data	2.57E-05
Ni-59	4.73E-05	1.45E-05	8.17E-06	No Data	No Data	No Data	7.16E-07
Ni-63	6.34E-04	3.92E-05	2.20E-05	No Data	No Data	No Data	1.95E-06
Ni-65	4.70E-06	5.32E-07	2.42E-07	No Data	No Data	No Data	4.05E-05
Cu-64	No Data	6.09E-07	2.82E-07	No Data	1.03E-06	No Data	1.25E-05
Zn-65	1.84E-05	6.31E-05	2.91E-05	No Data	3.06E-05	No Data	5.33E-05
Zn-69m	1.50E-06	3.06E-06	2.79E-07	No Data	1.24E-06	No Data	4.24E-05
Zn-69	9.33E-08	1.68E-07	1.25E-08	No Data	6.98E-08	No Data	1.37E-05
Se-79	No Data	2.10E-05	3.90E-06	No Data	2.43E-05	No Data	5.58E-07
Br-82	No Data	No Data	1.27E-05	No Data	No Data	No Data	No Data
Br-83	No Data	No Data	3.63E-07	No Data	No Data	No Data	No Data
Br-84	No Data	No Data	3.82E-07	No Data	No Data	No Data	No Data
Br-85	No Data	No Data	1.94E-08	No Data	No Data	No Data	No Data
Rb-86	No Data	1.70E-04	8.40E-05	No Data	No Data	No Data	4.35E-06
Rb-87	No Data	8.88E-05	3.52E-05	No Data	No Data	No Data	5.98E-07
Rb-88	No Data	4.98E-07	2.73E-07	No Data	No Data	No Data	4.85E-07
Rb-89	No Data	2.86E-07	1.97E-07	No Data	No Data	No Data	9.74E-08
Sr-89	2.51E-03	No Data	7.20E-05	No Data	No Data	No Data	5.16E-05
Sr-90	2.83E-02	No Data	5.74E-04	No Data	No Data	No Data	2.31E-04
Sr-91	5.00E-05	No Data	1.81E-06	No Data	No Data	No Data	5.92E-05
Sr-92	1.92E-05	No Data	7.13E-07	No Data	No Data	No Data	2.07E-04
Y-90	8.69E-08	No Data	2.33E-09	No Data	No Data	No Data	1.20E-04
Y-91m	8.10E-10	No Data	2.76E-11	No Data	No Data	No Data	2.70E-06
Y-91	1.13E-06	No Data	3.01E-08	No Data	No Data	No Data	8.10E-05
Y-92	7.65E-09	No Data	2.15E-10	No Data	No Data	No Data	1.46E-04
Y-93	2.43E-08	No Data	6.62E-10	No Data	No Data	No Data	1.92E-04

[1] Data presented in this Table are from Reference 9.

TABLE A-18 (continued)

INGESTION DOSE FACTORS FOR INFANT [1]

mrem/pCi Ingested

Nuclide	Bone	Liver	Total Body	Thyroid	Kidney	Lung	GI-LLI
Zr-93	1.93E-07	9.19E-09	5.54E-09	No Data	2.71E-08	No Data	2.39E-06
Zr-95	2.06E-07	5.02E-08	3.56E-08	No Data	5.41E-08	No Data	2.50E-05
Zr-97	1.48E-08	2.54E-09	1.16E-09	No Data	2.56E-09	No Data	1.62E-04
Nb-93m	1.23E-07	3.33E-08	1.04E-08	No Data	3.25E-08	No Data	3.98E-06
Nb-95	4.20E-08	1.73E-08	1.00E-08	No Data	1.24E-08	No Data	1.46E-05
Nb-97	4.59E-10	9.79E-11	3.53E-11	No Data	7.65E-11	No Data	3.09E-05
Mo-93	No Data	5.65E-05	1.82E-06	No Data	1.13E-05	No Data	1.21E-06
Mo-99	No Data	3.40E-05	6.63E-06	No Data	5.08E-05	No Data	1.12E-05
Tc-99m	1.92E-09	3.96E-09	5.10E-08	No Data	4.26E-08	2.07E-09	1.15E-06
Tc-99	1.08E-06	1.46E-06	4.55E-07	No Data	1.23E-05	1.42E-07	6.31E-06
Tc-101	2.27E-09	2.86E-09	2.83E-08	No Data	3.40E-08	1.56E-09	4.86E-07
Ru-103	1.48E-06	No Data	4.95E-07	No Data	3.08E-06	No Data	1.80E-05
Ru-105	1.36E-07	No Data	4.58E-08	No Data	1.00E-06	No Data	5.41E-05
Ru-106	2.41E-05	No Data	3.01E-06	No Data	2.85E-05	No Data	1.83E-04
Rh-105	1.09E-06	7.13E-07	4.79E-07	No Data	1.98E-06	No Data	1.77E-05
Pd-107	No Data	1.19E-06	8.45E-08	No Data	6.79E-06	No Data	9.46E-07
Pd-109	No Data	1.50E-06	3.62E-07	No Data	5.51E-06	No Data	3.68E-05
Ag-110m	9.96E-07	7.27E-07	4.81E-07	No Data	1.04E-06	No Data	3.77E-05
Ag-111	5.20E-07	2.02E-07	1.07E-07	No Data	4.22E-07	No Data	4.82E-05
Cd-113m	No Data	1.77E-05	6.52E-07	No Data	1.34E-05	No Data	2.66E-05
Cd-115m	No Data	1.42E-05	4.93E-07	No Data	7.41E-06	No Data	8.09E-05
Sn-123	2.49E-04	3.89E-06	6.50E-06	3.91E-06	No Data	No Data	6.58E-05
Sn-125	7.41E-05	1.38E-06	3.29E-06	1.36E-06	No Data	No Data	1.11E-04
Sn-126	5.53E-04	7.26E-06	1.80E-05	1.91E-06	No Data	No Data	2.52E-05
Sb-124	2.14E-05	3.15E-07	6.63E-06	5.68E-08	No Data	1.34E-05	6.60E-05
Sb-125	1.23E-05	1.19E-07	2.53E-06	1.54E-08	No Data	7.12E-06	1.64E-05
Sb-126	8.06E-06	1.58E-07	2.91E-06	6.19E-08	No Data	5.07E-06	8.35E-05
Sb-127	2.23E-06	3.98E-08	6.90E-07	2.84E-08	No Data	1.15E-06	5.91E-05
Te-125m	2.33E-05	7.79E-06	3.15E-06	7.84E-06	No Data	No Data	1.11E-05
Te-127m	5.85E-05	1.94E-05	7.08E-06	1.69E-05	1.44E-04	No Data	2.36E-05
Te-127	1.00E-06	3.35E-07	2.15E-07	8.14E-07	2.44E-06	No Data	2.10E-05
Te-129m	1.00E-04	3.43E-05	1.54E-05	3.84E-05	2.50E-04	No Data	5.97E-05
Te-129	2.84E-07	9.79E-08	6.63E-08	2.38E-07	7.07E-07	No Data	2.27E-05
Te-131m	1.52E-05	6.12E-06	5.05E-06	1.24E-05	4.21E-05	No Data	1.03E-04
Te-131	1.76E-07	6.50E-08	4.94E-08	1.57E-07	4.50E-07	No Data	7.11E-06
Te-132	2.08E-05	1.03E-05	9.61E-06	1.52E-05	6.44E-05	No Data	3.81E-05
Te-133m	3.91E-07	1.79E-07	1.71E-07	3.45E-07	1.22E-06	No Data	1.93E-05
Te-134	2.67E-07	1.34E-07	1.38E-07	2.39E-07	9.03E-07	No Data	3.06E-06
I-129	2.86E-05	2.12E-05	1.55E-05	1.36E-02	2.51E-05	No Data	4.24E-07
I-130	6.00E-06	1.32E-05	5.30E-06	1.48E-03	1.45E-05	No Data	2.83E-06
I-131	3.59E-05	4.23E-05	1.86E-05	1.39E-02	4.94E-05	No Data	1.51E-06
I-132	1.66E-06	3.37E-06	1.20E-06	1.58E-04	3.76E-06	No Data	2.73E-06
I-133	1.25E-05	1.82E-05	5.33E-06	3.31E-03	2.14E-05	No Data	3.08E-06
I-134	8.69E-07	1.78E-06	6.33E-07	4.15E-05	1.99E-06	No Data	1.84E-06
I-135	3.64E-06	7.24E-06	2.64E-06	6.49E-04	8.07E-06	No Data	2.62E-06

[1] Data presented in this Table are from Reference 9.

TABLE A-18 (continued)

INGESTION DOSE FACTORS FOR INFANT [1]

mrem/pCi Ingested

Nuclide	Bone	Liver	Total Body	Thyroid	Kidney	Lung	GI-LLI
Cs-134m	1.76E-07	2.93E-07	1.48E-07	No Data	1.13E-07	2.60E-08	2.32E-07
Cs-134	3.77E-04	7.03E-04	7.10E-05	No Data	1.81E-04	7.42E-05	1.91E-06
Cs-135	1.33E-04	1.21E-04	6.30E-06	No Data	3.44E-05	1.31E-05	4.37E-07
Cs-136	4.59E-05	1.35E-04	5.04E-05	No Data	5.38E-05	1.10E-05	2.05E-06
Cs-137	5.22E-04	6.11E-04	4.33E-05	No Data	1.64E-04	6.64E-05	1.91E-06
Cs-138	4.81E-07	7.82E-07	3.79E-07	No Data	3.90E-07	6.09E-08	1.25E-06
Cs-139	3.10E-07	4.24E-07	1.62E-07	No Data	2.19E-07	3.30E-08	2.66E-08
Ba-139	8.81E-07	5.84E-10	2.55E-08	No Data	3.51E-10	3.54E-10	5.58E-05
Ba-140	1.71E-04	1.71E-07	8.81E-06	No Data	4.06E-08	1.05E-07	4.20E-05
Ba-141	4.25E-07	2.91E-10	1.34E-08	No Data	1.75E-10	1.77E-10	5.19E-06
Ba-142	1.84E-07	1.53E-10	9.06E-09	No Data	8.81E-11	9.26E-11	7.59E-07
La-140	2.11E-08	8.32E-09	2.14E-09	No Data	No Data	No Data	9.77E-05
La-141	2.89E-09	8.38E-10	1.46E-10	No Data	No Data	No Data	9.61E-05
La-142	1.10E-09	4.04E-10	9.67E-11	No Data	No Data	No Data	6.86E-05
Ce-141	7.87E-08	4.80E-08	5.65E-09	No Data	1.48E-08	No Data	2.48E-05
Ce-143	1.48E-08	9.82E-06	1.12E-09	No Data	2.86E-09	No Data	5.73E-05
Ce-144	2.98E-06	1.22E-06	1.67E-07	No Data	4.93E-07	No Data	1.71E-04
Pr-143	8.13E-08	3.04E-08	4.03E-09	No Data	1.13E-08	No Data	4.29E-05
Pr-144	2.74E-10	1.06E-10	1.38E-11	No Data	3.84E-11	No Data	4.93E-06
Nd-147	5.53E-08	5.68E-08	3.48E-09	No Data	2.19E-08	No Data	3.60E-05
Pm-147	3.88E-07	3.27E-08	1.59E-08	No Data	4.88E-08	No Data	9.27E-06
Pm-148m	1.65E-07	4.18E-08	3.28E-08	No Data	4.80E-08	No Data	5.44E-05
Pm-148	6.32E-08	9.13E-09	4.60E-09	No Data	1.09E-08	No Data	9.74E-05
Pm-149	1.38E-08	1.81E-09	7.90E-10	No Data	2.20E-09	No Data	4.86E-05
Pm-151	6.18E-09	9.01E-10	4.56E-10	No Data	1.07E-09	No Data	4.17E-05
Sm-151	2.90E-07	6.67E-08	1.44E-08	No Data	4.53E-08	No Data	5.58E-06
Sm-153	7.72E-09	5.97E-09	4.58E-10	No Data	1.25E-09	No Data	3.12E-05
Eu-152	6.74E-07	1.79E-07	1.51E-07	No Data	5.02E-07	No Data	1.59E-05
Eu-154	2.64E-06	3.67E-07	2.20E-07	No Data	9.95E-07	No Data	4.58E-05
Eu-155	5.42E-07	6.25E-08	3.23E-08	No Data	1.40E-07	No Data	8.37E-05
Eu-156	1.14E-07	7.06E-08	1.12E-08	No Data	3.26E-08	No Data	6.67E-05
Tb-160	2.59E-07	No Data	3.24E-08	No Data	7.37E-08	No Data	3.45E-05
Ho-166m	1.25E-06	2.69E-07	2.13E-07	No Data	3.57E-07	No Data	2.66E-05
W-181	8.85E-08	2.72E-08	3.04E-09	No Data	No Data	No Data	3.82E-07
W-185	3.62E-06	1.13E-06	1.29E-07	No Data	No Data	No Data	1.62E-05
W-187	9.03E-07	6.28E-07	2.17E-07	No Data	No Data	No Data	3.69E-05
Pb-210	5.28E-02	1.42E-02	2.38E-03	No Data	4.33E-02	No Data	2.32E-06
Bi-210	4.16E-06	2.68E-05	2.39E-06	No Data	2.08E-04	No Data	5.27E-05
Po-210	3.10E-03	5.93E-03	7.41E-04	No Data	1.26E-02	No Data	6.61E-05
Ra-223	4.41E-02	6.42E-05	8.82E-03	No Data	1.17E-03	No Data	3.43E-04
Ra-224	1.46E-02	3.29E-05	2.91E-03	No Data	6.00E-04	No Data	3.86E-04
Ra-225	5.78E-02	6.52E-05	1.15E-02	No Data	1.19E-03	No Data	3.24E-04
Ra-226	6.20E-01	4.76E-05	5.14E-01	No Data	8.71E-04	No Data	3.44E-04
Ra-228	4.32E-01	2.58E-05	4.86E-01	No Data	4.73E-04	No Data	5.86E-05

[1] Data presented in this Table are from Reference 9.

TABLE A-18 (continued)

INGESTION DOSE FACTORS FOR INFANT [1]

mrem/pCi Ingested

Nuclide	Bone	Liver	Total Body	Thyroid	Kidney	Lung	GI-LLI
Ac-225	3.92E-05	5.03E-05	2.63E-06	No Data	3.69E-06	No Data	4.36E-04
Ac-227	4.49E-03	7.67E-04	2.79E-04	No Data	1.56E-04	No Data	8.50E-05
Th-227	1.20E-04	2.01E-06	3.45E-06	No Data	7.41E-06	No Data	5.70E-04
Th-228	2.47E-03	3.38E-05	8.36E-05	No Data	1.58E-04	No Data	5.84E-04
Th-229	2.52E-02	6.33E-04	4.20E-04	No Data	3.03E-03	No Data	8.10E-05
Th-230	3.80E-03	1.90E-04	1.06E-04	No Data	9.12E-04	No Data	6.24E-05
Th-232	4.24E-03	1.63E-04	1.65E-06	No Data	7.79E-04	No Data	5.31E-05
Th-234	6.92E-07	3.77E-08	2.00E-08	No Data	1.39E-07	No Data	1.19E-04
Pa-231	7.57E-03	2.50E-04	3.02E-04	No Data	1.34E-03	No Data	7.44E-05
Pa-233	3.11E-08	6.09E-09	5.43E-09	No Data	1.67E-08	No Data	1.46E-05
U-232	2.42E-02	No Data	2.16E-03	No Data	2.37E-03	No Data	7.04E-05
U-233	5.08E-03	No Data	3.87E-04	No Data	1.08E-03	No Data	6.51E-05
U-234	4.88E-03	No Data	3.80E-04	No Data	1.06E-03	No Data	6.37E-05
U-235	4.67E-03	No Data	3.56E-04	No Data	9.93E-04	No Data	8.10E-05
U-236	4.67E-03	No Data	3.64E-04	No Data	1.01E-03	No Data	5.98E-05
U-237	4.95E-07	No Data	1.32E-07	No Data	1.23E-06	No Data	2.11E-05
U-238	4.47E-03	No Data	3.33E-04	No Data	9.28E-04	No Data	5.71E-05
Np-237	2.40E-03	1.59E-04	1.05E-04	No Data	6.34E-04	No Data	8.23E-05
Np-238	1.24E-07	3.12E-09	1.92E-09	No Data	6.81E-09	No Data	4.17E-05
Np-239	1.11E-08	9.93E-10	5.61E-10	No Data	1.98E-09	No Data	2.87E-05
Pu-238	1.28E-03	1.50E-04	3.40E-05	No Data	1.21E-04	No Data	7.57E-05
Pu-239	1.38E-03	1.55E-04	3.54E-05	No Data	1.28E-04	No Data	6.91E-05
Pu-240	1.38E-03	1.55E-04	3.54E-05	No Data	1.28E-04	No Data	7.04E-05
Pu-241	4.25E-05	1.76E-06	8.82E-07	No Data	3.17E-06	No Data	1.45E-06
Pu-242	1.28E-03	1.49E-04	3.41E-05	No Data	1.23E-04	No Data	6.77E-05
Pu-244	1.49E-03	1.71E-04	3.91E-05	No Data	1.41E-04	No Data	1.01E-04
Am-241	1.46E-03	1.27E-03	1.09E-04	No Data	6.55E-04	No Data	7.70E-05
Am-242m	1.51E-03	1.22E-03	1.13E-04	No Data	6.64E-04	No Data	9.69E-05
Am-243	1.44E-03	1.23E-03	1.06E-04	No Data	6.36E-04	No Data	9.03E-05
Cm-242	1.37E-04	1.27E-04	9.10E-06	No Data	2.62E-05	No Data	8.23E-05
Cm-243	1.40E-03	1.15E-03	8.98E-05	No Data	3.27E-04	No Data	8.10E-05
Cm-244	1.18E-03	9.70E-04	7.59E-05	No Data	2.71E-04	No Data	7.84E-05
Cm-245	1.79E-03	1.45E-03	1.13E-04	No Data	4.32E-04	No Data	7.30E-05
Cm-246	1.77E-03	1.45E-03	1.13E-04	No Data	4.31E-04	No Data	7.17E-05
Cm-247	1.73E-03	1.43E-03	1.11E-04	No Data	4.24E-04	No Data	9.43E-05
Cm-248	1.43E-02	1.18E-02	9.16E-04	No Data	3.50E-03	No Data	1.52E-03
Cf-252	1.22E-03	No Data	2.95E-05	No Data	No Data	No Data	2.99E-04

[1] Data presented in this Table are from Reference 9.

TABLE A-19

RECOMMENDED VALUES FOR GASEOUS EFFLUENTS [1]

Parameter Symbol	Parameter Description	Values
S	Attenuation factor that accounts for the shielding provided by residential structures	0.7 (maximum individual) 0.5 (average individual.) 1.0 (noble gas-gamma instantaneous dose) [2]
t_e	Time period that crops are exposed to contamination during growing season	
	i) for forage ingested by animals	720 hrs (30 days, for pasture grass) 1440 hr (60 days for stored feed) [3]
	ii) for crops ingested by man	1440 hrs (60 days)
t_f	Average transport time of activity from the feed into the milk and to the receptor	48 hr (2 days, maximum individual) 96 hr (4 days, average individual)
t_h	Time delay between harvest of vegetation or crops and ingestion	
	i) for forage ingested by animals	Zero (for pasture grass) 2160 hr (90 days for stored feed)
	ii) for crops ingested by man	24 hr (1 day, for leafy vegetables & max. individual) 1440 hr (60 days, for produce & max. individual) 336 hr (14 days, for average individual)
Y_v	Agricultural productivity by unit area (measured in wet weight)	
	i) for forage ingested by animals	0.42 kg/m^2 (for pasture grass) [3] 2.5 kg/m^2 (for stored feed) [3]
	ii) for crops ingested by man	2.0 kg/m^2

[1] All data presented in this table are from Reference 8, unless otherwise indicated.

[2] From Reference 12.

[3] From Reference 4.

APPENDIX B

DEFINITION OF THE LOWER LIMIT OF DETECTION

For purposes of analyzing effluents and environmental samples for radioactivity, the lower limit of detection (LLD) is defined 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.

It should be recognized that the listed LLD is defined as an *a priori* (before the fact) limit representing the capability of the measurement system or analytical process, and not as an *a posteriori* (after the fact) limit for a particular measurement. Analyses should be performed in such a manner that the stated LLDs will be achieved under routine conditions. Usually, samples are counted for a period of time sufficient to ensure that the listed LLDs, based on normal analytical and counting parameters, are achieved.

Printouts of analytical results typically list the *a posteriori* minimum detectable concentration (MDC) which was actually achieved on a particular measurement. In those cases where a given sample MDC is less than or equal to the listed *a priori* LLD, the required LLD has been achieved. Occasionally background fluctuations, unavoidable small sample sizes, the presence of interfering radionuclides, or other uncontrollable circumstances may result in the MDC for a particular measurement not meeting the listed LLD. In such cases, the contributing factors shall be identified and described in the Semiannual Radioactive Effluent and Waste Disposal Report (for effluents) or the Annual Radiological Environmental Monitoring Report (for environmental samples).

The value of the counting standard deviation (s_b) used in the calculation of the LLD for a particular measurement system should be based on the actual observed standard deviation of the background counting rate or of the counting rate of an appropriate blank sample, rather than on an unverified, theoretically-predicted variance. One acceptable method for deriving s_b is as follows:

$$s_b = \sqrt{B/T}$$

where:

s_b = standard deviation of the background counting rate or of the counting rate of an appropriate blank sample (counts/minute);

B = background counting rate or counting rate of an appropriate blank sample (counts/minute);

T = counting time interval for sample analysis (minutes).

Lower Limit of Detection For Effluent Samples

For a particular measurement system or analytical process which may include radiochemical separation used to analyze effluent samples, the lower limit of detection is calculated as follows:

$$LLD_i = \frac{4.66\ s_b}{E\ V\ 2.22E6\ Y\ e^{-\lambda_i t}}$$

where:

LLD_i = *a priori* lower limit of detection for radionuclide i, (µCi/mL or µCi/g);

4.66 = combined numerical constant corresponding to 95% probability of detection, with 5% probability of falsely identifying background as a "real" signal;

s_b = standard deviation of the background counting rate or of the counting rate of an appropriate blank sample, (counts/minute);

E = counting efficiency, (counts/disintegration);

V = sample size, (milliliters or grams);

2.22E6 = conversion factor for disintegrations/minute per µCi;

Y = fractional radiochemical yield, when applicable;

λ_i = radioactive decay constant for radionuclide i, (hr^{-1});

t = elapsed time between the midpoint of sample collection and time of counting, (hr).

Typical values of E, V, Y, and t used for normal effluent sample analyses should be used in this calculation.

Lower Limit of Detection For Environmental Samples

For a particular measurement system or analytical process which may include radiochemical separation used to analyze effluent samples, the lower limit of detection is calculated as follows:

$$LLD_i = \frac{4.66\ s_b}{E\ V\ 2.22\ Y\ e^{-\lambda_i t}}$$

where:

LLD_i = *a priori* lower limit of detection for radionuclide i, (pCi/liter, pCi/m^3, or pCi/kg);

4.66 = combined numerical constant corresponding to 95% probability of detection, with 5% probability of falsely identifying background as a "real" signal;

s_b = standard deviation of the background counting rate or of the counting rate of an appropriate blank sample, (counts/minute);

E = counting efficiency, (counts/disintegration);

V = sample size, (liters, cubic meters, or kilograms);

2.22 = conversion factor for disintegrations/minute per pCi;

Y = fractional radiochemical yield, when applicable;

λ_i = radioactive decay constant for radionuclide i, (hr^{-1});

t = elapsed time between environmental sample collection or end of the sample collection period, and time of counting, (hr).

Typical values of E, V, Y, and t used for normal effluent sample analyses should be used in this calculation.

APPENDIX C

NRC SAFETY EVALUATION FOR ONSITE DISPOSAL OF SLIGHTLY CONTAMINATED CONSTRUCTION SOIL

In May 1993, the NRC approved a permit under 10CFR20.302 to allow Pilgrim Station to dispose of construction soil containing small amounts of cobalt-60 and cesium-137. This soil was disposed of via onsite burial at a location on company property adjacent to the Pilgrim Station meteorological tower. Dose calculations performed as part of the permit application and within the NRC Safety Evaluation concluded that the maximum dose from the disposal area would be less than 0.1 mrem/year during the year of disposal. Doses during subsequent years through the time of site decommissioning would be less than 0.01 mrem/year. Such exposure levels are considered insignificant relative to radiation dose arising from naturally-occurring sources of radiation and radioactivity, and other exposure pathways arising from operation of Pilgrim Nuclear Power Station.

Complete details regarding the NRC permit for disposal, and the accompanying NRC Safety Evaluation, can be found in NRC Docket No. 50-293, "APPROVAL UNDER 10CFR20.302(a) RELOCATION AND PLACEMENT OF CONSTRUCTION SOIL WITH TRACES OF RESIDUAL RADIOACTIVITY ON SITE AT PILGRIM NUCLEAR POWER STATION (TAC NO. M85501)", dated May 4, 1993.